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ABSTRACT

A data warehouse consists of a set of materialized views that contain derived data from several data sources. Materialized views are beneficial because they allow efficient retrieval of summary data. However, materialized views need to be refreshed periodically in order to avoid staleness. During a materialized view refresh only changes to the base tables are transmitted from the data sources to the data warehouse, where the data warehouse should contain the data from the base tables that is relevant to the refresh. In this paper we explore how this additional data, which is commonly referred to as auxiliary views, can be reduced in size. Novel algorithms that exploit non-trivial integrity constraints and that can handle materialized views defined over queries with grouping and aggregation are presented.

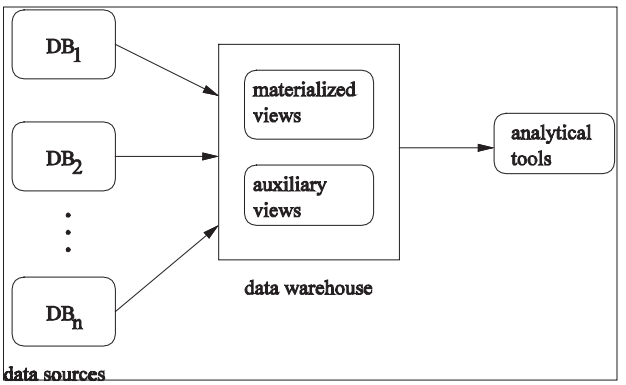
1. INTRODUCTION

A data warehouse contains aggregated data derived from a number of data sources and is usually used by OnLine Analytical Processing (OLAP) tools and data mining tools for the purpose of decision making (see Figure 1 and [GM95]).

The data sources consist of several databases, which usually contain huge amounts of data (e.g., the day-to-day transactions of a store chain). Conversely, *materialized views* (MVs) contain summary data compiled from several data sources. The main challenge in implementing the data warehouse architecture is keeping the materialized views up-to-date.

We will refer to the one time synchronization of a MV with the content of its underlying tables as a *view refresh* and to the continuous process of synchronization as *view maintenance*. In order to demonstrate how a MV can be refreshed, consider a MV V that is defined as the inner join of the base tables T_1 and T_2. If the changes ΔT_1 are applied to the table T_1, then the changes that need to be applied to V can be expressed as $\Delta T_1 \bowtie T_2$ [1]. However, in general it is impossible to calculate the value of T_2 knowing only the old value of V. Therefore, all the tuples in T_2 that can potentially join with ΔT_1 need to be stored in an *auxiliary view* on the data warehouse site.

Figure 1. The data warehouse model



In this paper we extend previous research on the subject (e.g., [QGMW96]) and explain how integrity constraints can be exploited to reduce the size of the created auxiliary views. In particular, our contributions include considering novel types of integrity constraints that can further reduce the size of the auxiliary views and algorithms for handling MVs defined over queries with grouping and aggregation.

2. RELATED RESEARCH

The problem of MV maintenance has been studied for over twenty years (see [BLT86]). The papers [GJM96] and [H96a] are excellent references on the problem of making MVs self-maintainable. MV maintenance over object-relational database schemas, similar to the one used in this paper, is presented in [ZM98], while [AHRVW98] describes how to maintain MVs over semi-structured data.

The paper [QGMW96] is an excellent source on exploiting integrity constraints to reduce the size of auxiliary views. However, it covers only candidate and foreign key integrity constraints and considers only conjunctive queries without grouping and aggregation. The paper [H96b] presents an algorithm for testing the self-maintainability of a MV in the presence of arbitrary functional dependencies.

3. PROBLEM DESCRIPTION

Our database schema consists of base tables and MVs, where only base tables can be updated by the users of the system. Each base table has the system attribute `ID`, which is a unique tuple identifier (and therefore a key for each table). The other attributes of a table are either *standard*, that is, from one of the predefined types (e.g., integer, string, etc.), or *reference* and contain the `ID` value of a tuple that is in the database (In other words, we require that all reference attribute define a referential non-null foreign key constraint). In addition, we impose the acyclicity requirement that there cannot exist reference attributes A_1, ..., A_n on tables T_1, ..., T_n, respectively, such that attribute A_i references table T_{i+1} for i = 1 to n-1 and attribute A_n references table T_1.

Given a MV V stored on the data warehouse, a database schema, and the type of changes that are allowed to the view's underlying tables, our goal is to find the smallest set of auxiliary views for V, where the precise definition of an auxiliary view follows. Note that we require that both the old and new values of updated tuples to be sent to the data warehouse.

Definition 1 (self-maintainable set of materialized views) The set of MVs $\overline{V}$ is self-maintainable iff every MV in the set can be refreshed using only the old values of $\overline{V}$ and the changes to the underlying base tables.

Definition 2 (auxiliary materialized views) The set of MVs $\overline{V}_1$ is an auxiliary set of MVs for the MV V iff $V \cup \overline{V}_1$ is a self-maintainable set of materialized views.

We will refer to the query that defines a MV as the *underlying query* for the view. In this paper we only consider MVs with underlying queries that are select-project-join queries (no self-joins allowed) with possible grouping and aggregation. We require that the selection condition of the underlying query is a conjunction of atomic predicates of the form "$T_1.Pf_1?P_1$" or "$T_1.Pf_1?T_2.Pf_2$", where *Pf* is used to denote a *path function* (precise definition follows), T - a base table, P - an atomic value, and "?" - an element of the set $\{>,\geq,=,<,\leq\}$.

Definition 3 (path function) A path function *Pf* has the general syntax $A_1^{a_1}.\ldots.A_n^{a_n}.A_{n+1}$, where $\{A_i\}_{i=1}^n$ are derived attributes and $\{a_i\}_{i=1}^n$ are elements of the set {1,-1}. Given a tuple t, we define $t.Pf$ to be equal to $((\ldots(t \Rightarrow A_1^{a_1}) \Rightarrow \ldots) \Rightarrow A_n^{a_n}).A_{n+1}$. Note that $\bar{t} \Rightarrow A$ is used to denote the set of tuples with `ID` $t.A$ for $t \in \bar{t}$. Similarly, $\bar{t}.A^{-1}$ is used to denote all tuples t' for which $t' \Rightarrow A$ is in the set $\bar{t}$. (We have used $t \Rightarrow A$ as a shorthand for $\{t\} \Rightarrow A$ and A as a shorthand for A^1.) The expression $t.Pf$ is *well defined* when it represents a set that contains a single value, where we will use $t.Pf$ to denote this value.

In addition to the key constraints defined by the ID attributes and the referential constraints defined by the reference attributes, our algorithms can take advantage of the following two integrity constraints:

(def $T.Pf$) $\Leftrightarrow$ ($\forall t \in T$) ($t.Pf$ is well defined) and

($T.Pf_1$=$T.Pf_2$) $\Leftrightarrow$ (def $T.Pf_1$) $\wedge$ (def $T.Pf_2$) $\wedge$ ($\forall t \in T$)($t.Pf_1 = t.Pf_2$).

The first constraint denotes that a path function is well defined and the second constraint states that we will reach the same value if we follow either of the two paths.

Our running example is based on the database schema shown in Figure 2. We have used ellipses around base table names and round rectangles around primitive types. Also, we have used dashed lines to denote standard attributes, solid lines to denote reference attributes, and the ID attributes of the tables are not shown. We assume that the following integrity constraints hold for the schema (in addition to the described key and foreign key constraints): (*SECT.dep = SECT.class.dep*) and (def *PROF*.*prof*$^{-1}$.*dep.group*).

Example 1 Suppose that only additions and deletions that are consistent (i.e., do not violate the integrity constraints) and primitive (i.e., single tuple) are allowed to the base tables of our example schema and consider a MV V defined using the following underlying query: $\pi^d_{S.number,C.code,P.name,D.name}\sigma_{D.group='ARTS' \text{and} C.number>300 \text{and} P.age>30}(S \bowtie C \bowtie D \bowtie P)$, where π^d is used to denote duplicate preserving projection, the first letters are used to denote the corresponding base tables, and the join conditions are on the respective reference attributes. The auxiliary views that are created by our algorithm are shown in Table 1.

Figure 2. The example database schema

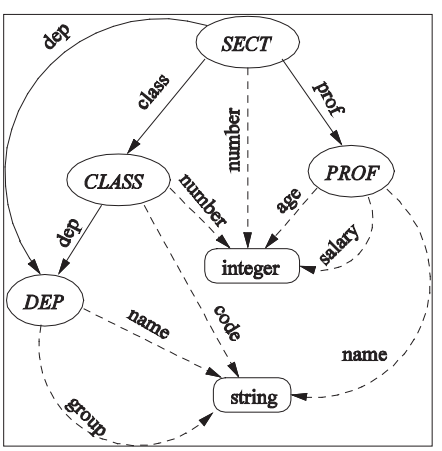


Table 1. Auxiliary views for motivating example

auxiliary view	underlying query
V_P	$\pi^d_{\text{ID, name}}(\sigma_{age>30 \wedge prof^{-1}.dep.group='ARTS'}(P))$
V_D	$\pi^d_{\text{ID, name}}(\sigma_{group='ARTS'}(D))$
V_C	$\pi^d_{\text{ID, code, dep}}(\sigma_{dep.group='ARTS' \wedge number>300}(C))$

In the paper we will show that V can be incrementally refreshed using the following formula:

$$V^{new}=V^{old}+\pi^d_{S.number,\ C.code,\ P.name,\ D.name}(V_P^{new} \bowtie V_D^{new} \bowtie V_C^{new} \bowtie \Delta S),$$

where "+" is used to denote the application of changes (bag version) and the superscripts *old* and *new* are used to denote the content of the table before and after an update, respectively.

We next demonstrate the potential benefit of our algorithm. Consider the four example base tables and suppose they contain the number of tuples shown in Table 2. Suppose that 2 of the departments are in the 'ARTS' group, 10% of the classes pass the predicate "*number*>300", and 80% of the professors pass the predicate "age>30". Also, suppose that 5% of the classes for which "*number*>300" are in a department that is part of the 'ARTS' group and 2% of the profs teach classes in a departments that is part of the 'ARTS' group.

The third column in Table 2 shows the sizes of the auxiliary views if only predicates from the underlying query of the MV are applied to the auxiliary views (i.e., the algorithm from [HZ96] is applied). The forth column shows the sizes of the auxiliary views if the algorithm from [QGMW96] is applied. It extends [HZ96] by removing the auxiliary view for the *SECT* table and storing only classes that are in a department that belongs to the 'ARTS' group. The last column shows the sizes of the auxiliary views when our algorithm is applied. It improves on the previous algorithm by storing only professors who teach courses in a department from the 'ARTS' group.

4. PROPOSED SOLUTION

Consider a MV V with the following underlying query: $\pi^d_{A_1,\ldots,A_o}(\sigma_{E_1 \wedge \ldots \wedge E_e}(T_1 \text{ x } \ldots \text{x } T_t))$ (x is used to denote a cross product), a database schema Σ, and suppose that only consistent primitive insertions and deletions to the tables $\{T_i\}_{i=1}^t$ are allowed. Then the following algorithm produces a set of auxiliary views for V.

Algorithm 1

Step 1. Create an undirected graph with vertices corresponding to the elements of the set $\{T_i\}_{i=1}^t$. For each condition in the set $\{E_i\}_{i=1}^e$, draw an edge between the tables involved in the condition. (In particular, if only a single table is involved in the condition, then draw a loop edge around it.) Next, delete

Table 2. Comparison on the number of tuples for our example

Base Relation	Tuples in Base Relation	Tuples in Auxiliary views ([HZ96])	Tuples in Auxiliary Views ([QGMW96])	Tuples in Auxiliary Views (our algorithm)
SECT	100 000	100 000	0	0
CLASS	50 000	5 000	250	250
DEP	30	2	2	2
PROF	2 000	1600	1600	32
	152 030	61 602	1852	284

all vertices that have no edges connected to them and no attributes in the set $\{A_i\}_{i=1}^{a}$. Then examine the subgraph induced by the edges labeled with equality predicates. If there is a vertex in this subgraph with the properties: (1) all its edges are in the subgraph, (2) removing the vertex will not change the number of connected components in the subgraph, and (3) the vertex's table does not contain attributes in the set $\{A_i\}_{i=1}^{a}$, then remove the vertex and repeat the procedure until possible. Finally, rewrite the underlying query Q of the MV V by deleting the tables that correspond to deleted vertices. (This also involves deleting from Q any predicates on the deleted tables.)

Step 2. For each table T_i in Q (i=1 to t), create an auxiliary view V_i that contains all the tuples of T_i. We will use Q_i to refer to the underlying query for V_i.

Step 3. Consider a table T_i in Q and the corresponds auxiliary view V_i created in the previous step. If the selection condition of Q contains one or more atomic predicates on the table T_i, then add these predicates to the selection condition of Q_i via conjunction. Similarly, add to Q_i a duplicate preserving projection on the attributes of T_i that are projected out in Q union the attributes of T_i that appear in an atomic selection predicate of Q that involves attributes from other tables. The described procedure is applied for i=1 to t.

Step 4. If there is a table T_i in Q that has the property that every table in Q can be reached starting from the table T_i and following reference attributes, then remove V_i from the set of auxiliary views.

Step 5. If there exist a table T_i and a path function $Pf = A_1^{a_1}. \ldots .A_n^{a_n}.A_{n+1}$ such that: (1) Step 4 was not applied to T_i, (2) (`def` $T_i.Pf$) and (3) The table reached by following the path $A_1^{a_1}. \ldots .A_n^{a_n}$ from the table T_i contains an atomic predicate $p(A_{n+1})$ in Q, then add $p(Pf)$, via conjunction, to the selection condition of Q_i.

Going back to Example 1, Step 1 was not applied. Step 2 was applied to create the auxiliary views: V_P, V_D, V_C, and V_S, which initially contain the respective base tables. Step 3 was applied to add the predicate "*age*>30" to V_P, the predicate "*group*='ARTS' " to V_D, and the predicate "number>300" to V_C. The step also applies the projections shown in Table 1. For example, the `ID` attributes are projected for all four tables because they appear in the join conditions. Step 4 was applied to remove the auxiliary view V_S. Finally, Step 5 added the predicate "$prof^{-1}.dep.group$='ARTS'" and "$dep.group$='ARTS' " to V_P and V_C, respectively.

The following theorem addresses the correctness of Algorithm 1.

Theorem 1: Algorithm 1 produces a set of auxiliary views that make V self-maintainable relative to the defined assumptions.

Proof: Step 1 uses the available integrity constraints to rewrite Q into an equivalent query that references fewer tables and therefore does not affect the correctness of the algorithm.

The created auxiliary views in Step 2 make V self-maintainable. In particular, since $\pi^{d}_{A_1,\ldots,A_n}\sigma_{g}(T+\Delta T) = \pi^{d}_{A_1,\ldots,A_n}\sigma_{g}(T)+\pi^{d}_{A_1,\ldots,A_n}\sigma_{g}(\Delta T)$, the changes to each auxiliary view can be calculated by applying the selection condition of its underlying query followed by the duplicate preserving projection operation of its underlying query to the changes of its underlying table. Then the new value of V can be calculated as $Q(V_1,\ldots,V_t)$ (we use $Q(R_1,\ldots,R_t)$ to denote the result of Q when the table T_i is substituted with table R_i for i=1 to t).

We will next examine two cases: when Step 4 was not applied and when it was applied.

Case 1 (*Step 4 was not applied*) We will use $V_{i,r}$ to denote the auxiliary view for V_i after Step r. Note that $V^{new}=Q(T_1^{new},\ldots,T_t^{new})=\pi^{d}\sigma(T_1^{new}\bowtie\ldots\bowtie T_t^{new})$. We will show that $\pi^{d}\sigma(T_1^{new}\bowtie\ldots\bowtie T_t^{new})=\pi^{d}\sigma(V_{1,j}^{new}\bowtie\ldots\bowtie T_{t,j}^{new})$ for j={2,3,5}, which proves that $V^{new}=\pi^{d}\sigma(V_{1,5}^{new}\bowtie\ldots\bowtie T_{t,5}^{new})=Q(V_1^{new},\ldots,V_t^{new})$ and therefore the selected auxiliary views make V self-maintainable.

First, note that $\pi^{d}\sigma(T_1^{new}\bowtie\ldots\bowtie T_t^{new})=\pi^{d}\sigma(V_{1,3}^{new}\bowtie\ldots\bowtie V_{t,3}^{new})$. The reason is that $\pi^{d}\sigma(T_1^{new}\bowtie\ldots\bowtie T_t^{new})=\pi^{d}\sigma(V_{1,2}^{new}\bowtie\ldots\bowtie V_{t,2}^{new})$ (direct consequence of Step 2) and applying Step 3 to $V_{i,2}$ for i = 1 to t does not change the value of the expression $\pi^{d}\sigma(V_{1,2}^{new}\bowtie\ldots\bowtie V_{t,2}^{new})$. In particular, Step 3 first applies to $V_{i,2}$ the single table predicates of Q. This will not change the above expression because $\sigma_E(R_1\bowtie R_2)=\sigma_E(\sigma_E(R_1)\bowtie R_2)$ if E is a predicate only on the attributes of R_1. Next, Step 3 removes from $V_{i,2}$ attributes that do not participate in the join condition and that are not projected in Q. This rule will not affect the expression because $\pi_{\bar{A}}(R_1\bowtie R_2)=\pi_{\bar{A}}(\pi_{\bar{B}}(R_1)\bowtie R_2)$ when $\bar{A}\subseteq\bar{B}$ and $\bar{B}$ are attributes of R_1 that do not participate in the join condition.

Next, consider what happens when step 5 is applied to the auxiliary views of the expression: $\pi^{d}\sigma(V_{1,3}^{new}\bowtie\ldots\bowtie V_{t,3}^{new})$. In particular, this step substitutes auxiliary views with more restrictive auxiliary views that contain only tuples that can join with the other auxiliary views. Therefore, since $R_1\bowtie R_2=\sigma_E(R_1)\bowtie R_2$ when E is a predicate that selects tuples of R_1 that join with R_2, our expression will not change after the application of Step 5 to its auxiliary views.

Case 2 (*Step 4 was applied to table* T_1). Note that

$$\begin{aligned}
&V^{new}=Q(T_1^{new},\ldots,T_t^{new})\\
&=\pi^{d}\sigma((T_1^{old}+\Delta T_1)\bowtie T_2^{new}\bowtie\ldots\bowtie T_t^{new})\\
&=\pi^{d}\sigma(T_1^{old}\bowtie(T_2^{old}+\Delta T_2)\bowtie\ldots\bowtie(T_t^{old}+\Delta T_t))+\pi^{d}\sigma(\Delta T_1^{old}\bowtie T_2^{new}\bowtie\ldots\bowtie T_t^{new})\\
&=V^{old}+\pi^{d}\sigma(T_1^{old}\bowtie\ldots\bowtie T_{n-1}^{old}\bowtie\Delta T_n+\ldots+T_1^{old}\bowtie\Delta T_2\bowtie\ldots\bowtie\Delta T_t)+Q(\Delta T_1, T_2^{new},\ldots,T_t^{new})
\end{aligned}$$

We will next show that the second expression in the above formula empty and therefore $V^{new}=V^{old}+Q(\Delta T_1, T_2^{new},\ldots,T_t^{new})$. Indeed, consider the join of T_1^{old} with an insertion or deletion to the table T_2. The fact that T_2 can be reached from T_1 following reference attributes guarantees that the result of this join will be empty.

It remains to show that $\pi^{d}\sigma(\Delta T_1, T_2^{new},\ldots,T_t^{new})=\pi^{d}\sigma(\Delta T_1, V_2^{new},\ldots, V_t^{new})$, which will prove the theorem. However, this can be proven the same way we proved that applying Steps 2, 3, and 5 to the auxiliary views in Case 1 do not change the value of the expression.

Note that the above theorem only shows that the selected by Algorithm 1 auxiliary views make the input MV V self maintainable, but does not explain how V can be incrementally refreshed. However, when Step 4 was applied, $V^{new}=V^{old}+Q(\Delta T_1, V_2^{new},\ldots,V_t^{new})$ and therefore $\Delta V = Q(\Delta T_1, V_2^{new},\ldots,V_t^{new})$. Of course, before ΔV can be calculated, the auxiliary views need to be refreshed.

When Step 4 was not applied, the formula for calculating ΔV is:

$$V^{new}=Q(V_1^{new}, V_2^{new},\ldots,V_t^{new})=V^{old}+\pi^{d}\sigma(V_1^{old}\bowtie\ldots\bowtie V_{t-1}^{old}\bowtie\Delta V_t+\ldots+\Delta V_1\bowtie\ldots\bowtie\Delta V_t),$$

where the brackets contain 2^n-1 expressions covering the cases where V_i is represented as V_i^{old} and as ΔV_i.

Before describing our algorithm for selecting auxiliary views for a MV with aggregation, we present an example.

Example 2 Consider the MV V with the underlying query:

$$_{D.name}\mathcal{F}_{\text{count(S.ID) as } sect\_count}(D\bowtie C\bowtie S)$$

and suppose that only consistent insertions and deletions are allowed to the underlying tables. We will first rewrite the query as the equivalent query:

$$_{D.name}\mathcal{F}_{\text{count(S.ID) as } sect\_count}(D\bowtie S).$$

Then we will create the auxiliary view $V_D=\pi^{d}_{name,\mathtt{ID}}(D)$. If a section is inserted/deleted, then we will use V_D to find the department's section and then add/subtract 1 to the value of the attribute *sect_count* of the corresponding tuple in V. If such a tuple does not exist in V, then one should be created with *sect_count*=1 (a tuple should exist when deletion is performed). Of course, if the *sect_count* of a tuple in V becomes 0, then the tuple should be deleted from the MV. If a department is inserted or deleted, then only V_D needs to be updated because a new or deleted department can not join with an existing section.

Next, consider a MV V defined with the following underlying query:

$$_{B_1,...,B_b}\mathcal{F}_{agg_1(C_1),\ ...,\ agg_s(C_e)}\ \pi^{d}_{A_1,...,A_a}\ (\sigma_{E_1\wedge...\wedge E_e}\ (T_1 \times ... \times T_t)),$$

where $agg \in \{\texttt{min}, \texttt{max}, \texttt{sum}, \texttt{count}, \texttt{avg}\}$. Suppose the MV is defined over a schema allowing only consistent insertions and deletions to the tables $\{T_i\}_{i=1}^{t}$, where we add the requirement that at most one operation can be performed on each tuple to disallow tuple updates. Then the following algorithm can be used to create the set of auxiliary views for V.

Algorithm 2

Step 1. Suppose that the MV V is defined using the query $Q(T_1,...,T_t)$ and let Q_C by the conjunctive query formed from Q by stripping its grouping and aggregation. Apply Step 1 from Algorithm 1 to rewrite Q_C and then rewrite Q accordingly.

Step 2. Modify Q and add a `count`(A) aggregation (if one does not already exists) if there exists the aggregation `sum`(A) or `avg`(A) for some attribute A and Q does not contain a *min* or *max* aggregation. (This step adopts the mechanism of managing views with aggregation from [MQM97].)

Step 3. If Q contains a *min* or *max* aggregation, then apply Steps 2, 3, and 5 from Algorithm 1 to Q_C to create the set of auxiliary views for V. Otherwise, apply to Q_C Steps 2, 3, 4, and 5 from Algorithm 1 to create the set of auxiliary views for V.

Going back to Example 2, Step 1 was applied to rewrite the query and Step 4 from Algorithm 1 was applied to remove the auxiliary view for the *SECT* table. Step 2 of Algorithm 2 was not applied.

Theorem 2. Algorithm 2 produces a set of auxiliary views that make V self maintainable relative to the defined assumptions.

Proof(Sketch): Note that Step 1 rewrites the original query. Step 2 just adds additional attributes to V. Therefore, we only need to show that the created in Step 3 auxiliary views make V self-maintainable.

First, consider the case when Step 4 from Algorithm 1 was not applied and let us use V^C to denote the MV with underlying query $Q_C(T_1,...,T_t)$. Then Theorem 1 implies that $V^{C\ new} = Q_C(V_1^{new},...,V_t^{new})$. The new value for V can be computed by applying the grouping and aggregation from Q to $Q_C(V_1^{new},...,V_t^{new})$ and therefore the selected set of auxiliary views makes V self-maintainable.

Next, consider the case when Step 4 from Algorithm 1 was applied. Then

$$V^{new} = V^{old} \oplus Q\ (\Delta T_1, V_2^{new},...,V_t^{new}),$$

where $\oplus$ is a new operation that calculates the correct value for the count, sum, and avg attributes. In particular, an addition/deletion of a tuple from $Q(\Delta T_1, V_2^{new},...,V_t^{new})$ causes the value of the count attribute in the matching tuple in V^{old} to be incremented/decremented by 1. Similarly, it causes the `sum` attribute in this tuple to be incremented/decremented by the value of the attribute on which the summation is performed in the tuple that is added/deleted from $Q\ (\Delta T_1, V_2^{new},...,V_t^{new})$. Note that tuples that have a 0 for the count attribute should be removed from the query result for V^{new}. Finally, the value of an `avg` attribute is calculated as the result of dividing the value of the `sum` attribute by the value of the count attribute.

Note that Algorithms 1 and 2 will have to be modified if updates are allowed. In particular, attributes can be classified as *protected* and *exposed* (see [QGMW96]). Protected attributes are projected in the underlying query of the MV, but no predicates are defined on them. Conversely, exposed attributes are the ones on which selection or join predicates are defined. Updating a protected attribute will not affect the two algorithms. However, in the presence of updates on exposed updates Step 4 of Algorithm 1 can not be applied. Similarly, Step 3 of Algorithm 1 cannot be applied to add predicates on exposed attributes. Finally, Steps 5 of Algorithm 1 cannot be applied if the path function *Pf* passes through tables that contain exposed attributes.

5. CONCLUSION

The paper presents novel algorithms for creating auxiliary views in the context of a data warehouse environment. The algorithm for MVs defined over queries without grouping and aggregation creates smaller auxiliary views than existing algorithms by exploring a richer set of integrity constraints. The algorithm for minimizing the size of auxiliary views for MVs defined over queries with aggregation solves a novel problem.

One topic for future research is focusing on the problem of completeness, that is, showing that the two algorithms produce a minimal set of auxiliary views relative to the explored types of integrity constraints.

REFERENCES

[AHRVW98] S. Abiteboul, J. McHugh, M. Rys, V. Vassalos, J. Wiener, Incremental Maintenance for Materialized Views over Semi structured Data, *VLDB*, 1998

[BLT86] J. Blakely, P. Larson, and F. Tompa, Efficiently Updating Materialized Views, *SIGMOD*, 1986

[GJM96] A. Gupta, H. Jagadish, I. Mumick, Data Integragtion using Self-Maintainable Views, *ICDT*, pp. 140-144, 1996

[GM95] A. Gupta and I. Mumick, Maintenance of Materialized Views: Problems, Techniques, and Applications, *IEEE Data Engineering Bulletin, Special Issue on Materialized Views and Data Warehousing*, June, 1995

[H96a] N. Huyn, Efficient View Self-Maintenance, *Stanford University technical report*, http://www-db.stanford.edu/pub/papers/fdvsm.ps, 1996

[H96b] N. Huyn, Efficient View Self-Maintenance, *Proceedings of ACM Workshop on Materialized Views: Techniques and Applications*, 1996

[HZ96] R. Hull and G. Zhou, A Framework for Supporting Data Integration using the Materialized and Virtual Approaches, *SIGMOD*, 1996

[MQM97] I. Mumick, D. Quass, B.Mumick, Maintenance of Data Cubes and Summary Tables in a Data Warehouse, *SIGMOD*, 1997

[QGMW96] D. Quass, A. Gupta, I. Mumick, and J. Widom, Making Views Self-Maintainable for Data Warehousing, *PDIS*, pp. 158-169, 1996

[ZM98] Y. Zhuge, H. Garcia-Molina, Graph Structures Views and their Incremental Maintenance, *ICDE*, 1998

ENDNOTE

[1] Note that in order for ΔT_1 to be a relational table, each tuple in it needs to be tagged as "to be inserted" or "to be deleted" and the relational algebra operations need to be redefined to handle marked tuples - for details see [BLT86].

Diagnosing the Context of Inter-Organizational Systems by Mapping Key-Players

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ABSTRACT

Inter-organizational systems (IOS) are generally used in a context of various interested parties. If these parties are not identified and if their power and interests related to the IOS are not explored and taken into consideration, implementation is likely to become a disappointing and troublesome affair. This paper presents a diagnostic method for the identification of stakeholders involved in IOS and the assessment of their power and interests with respect to these systems. The diagnostic approach is illustrated by means of an in-depth case study. The case study indicates that addressing power and interest relationships may help make the critical success factors in the implementation and improvement of inter-organizational systems more explicit. On the basis of the case study, conclusions are drawn regarding the application and usefulness of the diagnostic approach.

Keywords: inter-organizational system, stakeholder, interests, power, diagnosis

INTRODUCTION

Especially since the rise of the Internet, there has been a clear tendency toward the use of inter-organizational systems (IOS). Many organizations as well as industry boards and government departments are involved in the development and implementation of such systems. The possibilities of IOS are clear: closer links between value chains of organizations can lead to lower transaction costs and a quicker delivery of goods and services. Also intangible benefits of IOS are considered to be important, including an improvement in services and closer partnerships. Although the benefits seem to be attractive, many of the parties involved in the development and use of IOS have already experienced that the potential benefits are not always achieved easily. Although some systems have become success stories, others are not doing so well at all and can even be called failures. So, some IOS are taking off very quickly whereas others are only accepted hesitantly. Clearly, some systems have achieved high penetration among target users, whereas others appeal to a few intended users only. This illustrates that the implementation of IOS systems is a complicated endeavor, both from a technical point of view and from many other perspectives, including strategic, organizational, political, and cultural viewpoints. Moreover, a large number of stakeholders from different organizations are involved in developing and using IOS. For this reason, the question who participates in the analysis, development and implementation of IOS becomes even more difficult, since decisions are no longer only made internally (Pouloudi, 1997; Cavaye, 1995; Webster, 1995).

This paper therefore presents a diagnostic framework, which aims to assess the potential critical success factors from the power and interest perspectives of the various stakeholders. This framework can be used to predict the potential success and critical factors playing a role in the implementation and improvement of IOS. By applying the framework, IOS developers and implementers will be able to assess potential risks and identify barriers to the use of IOS. On the basis of that assessment, focused actions can be taken to alter power/interest positions in ways that stimulate a successful implementation.

THEORETICAL BACKGROUNDS

Perspectives on Stakeholders

It has been generally acknowledged in the literature that the development of information systems requires the participation of interested parties and that the willingness and the effectiveness of this participation influences whether the resulting system is successful. Normally these participants include developers, intended users and managers. However, in the case of an IOS this range of people and parties is much broader. It crosses organizational borders, which means that the stakeholders are more loosely coupled. Identifying these stakeholders and exploring their perspectives in terms of their interests in the system and their power to 'make or break' the system are essential steps in establishing a diagnostic framework aimed at assessing the critical factors of an IOS (Pan et al., 2003). As part of the diagnostic framework, a practical technique is required to identify these groups and individuals.

Stakeholders can be identified in many different ways (Mitchell et al., 1997). There are different kinds of stakeholders, such as persons as well as groups inside and outside an organization. In this research study we have adopted Freeman's classical definition of stakeholders to IOS: "A stakeholder is any group or individual who can affect or is affected by the IOS" (Freeman, 1984, adapted to IOS by the authors).

Relevant questions that help identify relevant groups and individuals in this context are for example (Pouloudi, 1997; Cavaye, 1995):

- Who are the sponsors and the initiators of the system?
- Who have to adopt the system and make it work?
- Who are the intended users?

Answers to these questions may reveal stakeholders not yet identified by the top-down approach or make it possible to refine certain categories of stakeholders into relevant subgroups.

Stakeholders' Interests

When the stakeholders are identified, their interests have to be connected with the IOS. This means that part of the analysis consists of the assessment of the stakeholders' perception of the IOS. How do they interpret the IOS (Walsham, 1993) and to what extent do they believe that the IOS will fit their values and help them attain their objectives? In other words: what are their perceived interests in the IOS?

The degree to which parties are interested in an IOS can vary from low to high (Coltman, 2001). In case of a low interest level, the stakeholder may be inclined to believe that the IOS will lead to increasing operational costs as well as a decrease in efficiency due to incompatible internal and external technologies, and that it will offer insufficient support in the control of the primary process. On the other hand, a high degree of interest relates to the perception that an IOS contributes to the overall goals of the company.

Within the context of this study, it is not relevant whether perceptions are realistic. The perceived (dis)interest normally includes several elements and it is often based on strategic, organizational, financial and behavioral aspects (Chen, 2003; Coltman et al., 2001; Parker et al., 1988; Porter, 2001). These aspects are not of

equal relevance to all stakeholders: intended users have other kinds of interests than business managers. This means that the dimensions and the diagnostic questions should be prioritized in relation to the stakeholder in question. Questions that may help identify the degree of interest of a stakeholder in an IOS are:

Strategic Interests of Stakeholders
- Does the IOS affect the power, autonomy and independence within the value chain?
- Does the IOS lead to competitive advantage?
- Is the IOS instrumental in reaching new customers or does it lead to losing customers?

Operational/Organizational Interests of Stakeholders
- Is it easy or difficult to implement the IOS?
- Is it easy or difficult to link the IOS with internal business systems?
- Are the operational risks of the IOS high or low?

Financial Interests of Stakeholders
- Are the initial investments in the IOS high or low?
- Are the operational costs of the IOS high or low?
- Are the financial risks of the IOS high or low?

Behavioral Interests of Stakeholders
- Is the IOS compatible with the current culture, values and working procedures?
- Is the IOS easy to learn and use?
- Is the IOS useful for the intended users?

Power

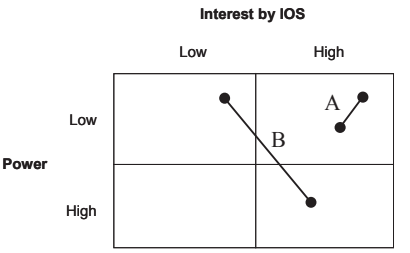
Another element of the framework is an analysis of the power relations among the parties involved. A powerful party with a clear interest in an IOS can apply its power to force less powerful parties to also start using the IOS, independent of their perceived interest in it (Standifera et al., 2003). At the same time, if certain parties only have little interest in an IOS it might be rather difficult for parties with a great deal of interest but a lack of power to implement an IOS successfully. In this paper, we will define power as the capacity to exert one's will over others in order to realize certain intended benefits. Since power is the capacity to exert one's will, it is possible to indicate the source of this capacity, or in the context of IOS: parties may possess different sources of power to urge others to use (or not to use) an IOS.

Processual
- Can the stakeholder force other stakeholders to comply with the implementation and use of the IOS?
- Can the stakeholder independently block the implementation and use of the IOS?
- Is the stakeholder (economically) dependent upon a party who can force another party to comply with or block the implementation and use of the IOS?

Institutional
- Does the stakeholder have the resources to develop and implement the IOS?
- Does the stakeholder have the size and/or resources to block the implementation or use of the IOS?
- Does the stakeholder has sufficient formal or legal authority to force others to use the IOS?

By linking the dimensions of power and interest, stakeholders involved in setting up and implementing an IOS can be categorized in a matrix. In this way, different IOS relationships can be distinguished. IOS relationship A for instance (figure 1), shows all characteristics of a balanced IOS. In this situation both parties believe that they can benefit from applying an IOS and they both possess an equal amount of power when it comes to its development and implementation. Relationship B on the other hand, can be categorized as an unbalanced IOS. In this case, one party benefits significantly more from the IOS than the other one does.

Figure 1. Example of a balanced and unbalanced IOS relationship



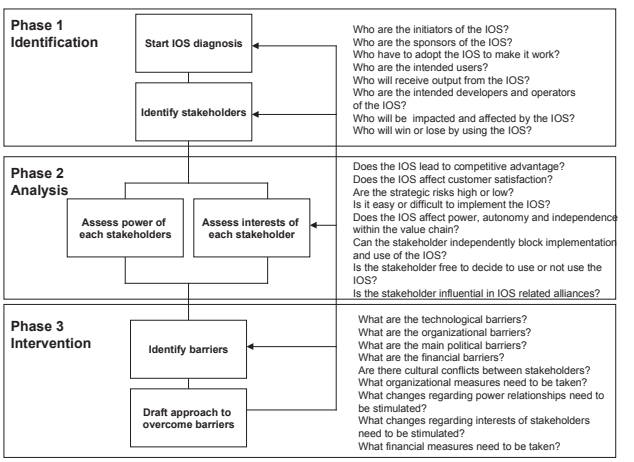
THE FRAMEWORK

The perspectives explained above can be combined in a diagnosing framework for the assessment of barriers to the development and implementation of an IOS. Figure 2 summarizes the main stages of diagnosis as well as the key issues to be addressed when applying the framework. The diagnosis starts with a formal agreement on the (proposed) IOS, its aim, the characteristics of the IOS and the planning of the development and implementation process. Then, the stakeholders involved are further identified (phase 1) in accordance with the guidelines as described above. In phase 2 the power and interests of each stakeholder are assessed by applying the dimensions and issues addressed in the previous section. Finally, the fourth phase concentrates on addressing the main barriers to the implementation of the IOS or, in case the IOS has already been developed, the operating-barriers. This phase obviously includes an action plan encompassing the issues of power relations as well as the interests in and alternatives to changing the IOS relationships.

RESEARCH METHODOLOGY

The empirical part of our study is founded on an in-depth study of an IOS project that took place during the period 1997-2004. The case study deals with the introduction as well as the operating phase of a dedicated and complex IOS in the retail sector. The initial research objective of the project was to study the potential benefits of and the barriers to the implementation of an IOS linking a cooperative wholesaler to its affiliate members. During the early stage of adoption however, it appeared that political processes played an important role and it was therefore generally expected that the success or failure of the IOS would be closely linked to the interests and power of the IOS parties involved in these processes. It was for this reason that the research objective of the project gradually shifted from a feasibility study to a monitoring study, aiming at exploring how power and interest relationships interact with each other and how the operation and modifications of the IOS are influenced by these two dimensions. However, this was clearly a 'how' question about a contemporary set of events over which the researcher has

Figure 2. Overview of the diagnosing framework



no control. It also had some open and explorative characteristics. Consequently, a case-study approach appeared to be the most appropriate choice (Yin, 1991) and we therefore conducted a longitudinal case study in order to compare the different strategies used by companies to implement and adopt an IOS.

WHOLESALER - MULTI-STORE CASE[1]

Episode 1: Backgrounds of the Project and Agenda Formation

At the end of the 1990s, after a long period of discussions and informal meetings, Wholesale Corp. decided to initiate a feasibility study on the design and implementation of an IOS. Wholesale Corp. is a purchasing organization representing independent retail formulas in the Netherlands. By means of joint purchasing, Wholesale Corp. is able to achieve substantial financial benefits for its members, e.g. supermarkets and retailers. Wholesale Corp. covers about 20% of the entire food market in the Netherlands and represents 23 affiliated members, including Multi-store Corp. Multi-store Corp. is a medium-sized chain of supermarkets consisting of three distribution centers and 26 stores. The company has a turnover of €200 million and employs about 2000 employees. Figure 3 summarizes the main good flows as well as the information flows among the stakeholders involved in the supply chain.

In 1999, Wholesale Corp. conducted a study on designing and implementing an IOS. Five driving forces triggered this study:

- the exchange of data between Wholesale Corp. and its affiliated members is characterized by high volumes;
- the food market is under high pressure to reduce costs;
- many supermarkets and retailers experience decreasing profit margins;
- supermarkets are confronted with a high competitive market forcing Wholesale Corp. to be more efficient;
- the aspect of 'time' is crucial in the ordering-process of food and retail products.

The feasibility study mainly focused on the technical aspects of the IOS and included issues, such as IOS-software, the protocols to be used, the necessary technological changes to be made and the costs associated with implementing an overall IOS standard to be applied by Wholesale Corp. and its members. Clearly, during the early stage of adopting the IOS many stakeholders were involved in the project. A project group of senior managers representing different business areas (sales, logistics, finance, IT) from Multi-store Corp., Wholesale Corp., and some other affiliated members worked closely together with external consultants. The group actively gathered information about the financial and technological benefits of the IOS and an assessment was made of the strategic risks to each of the stakeholders. With the aid of the diagnosing tool, also the issue of power was addressed by the group project. Especially representatives of Multi-store Corp. feared they would become dependent on Wholesaler Corp. So during several project meetings, this issue was explicitly addressed. Obviously, the discussions contained some political elements. The meetings, which were focused on the elements of power and dependence, were therefore chaired by an external consultant specialized in group processes. At the end of 1999, it was concluded that both Wholesaler Corp. and Multi-store Corp. would benefit from an IOS and an agreement was made upon the functionality requirements of the system. The project group also defined an action plan enabling the stakeholders to overcome potential barriers.

Episode 2: Development and implementation of the IOS

In 2001, Wholesale Corp. started with the development and implementation of an electronic procurement system that linked the ordering systems of the supermarkets and retailers to a central database. A substantial reduction in transaction costs, a further optimization of internal processes and increasing service delivery levels were expected to be the main benefits of the IOS. However, the implementation of the IOS within both Multi-store Corp. and Wholesale Corp. was confronted with numerous problems. Although some of these problems seemed to be of a technical nature, Wholesale Corp. also faced a number of organizational difficulties in its communication with Multi-store Corp. Project meetings were often canceled, information was not provided in time and pilot projects were often delayed severely. By the end of 2001, only a few functionalities of the IOS had been implemented, which were only partly used by Multi-store Corp. In 2002, both Multi-store Corp. and Wholesale Corp. concluded that the costs of implementing the IOS had largely outreached the benefits. It was therefore decided to reassess the functionalities of the IOS and to re-design the administrative procedures between Multi-store Corp. and Wholesale Corp. At the same time though, the implementation and usage of the IOS by Wholesale Corp. and some large supermarket chains appeared to be a great success. By means of a sophisticated IOS the leading three supermarkets were all successfully linked to Wholesale Corp.

Episode 3: Identifying Power and Interests

Starting from our model depicted in figure 1, the analysis showed that initially both parties possessed important sources of power. At the start of the project, the interdependence between Wholesale Corp. and Multi-store Corp. was strongly related to the company goals of Wholesale Corp. When buying products from suppliers, Wholesale Corp. was expected to represent the interests of its affiliated members, including those of Multi-store Corp. As a consequence, Wholesale Corp. strongly favored the development and implementation of an IOS, which was reinforced and stimulated by an informal strategic alliance between Wholesale Corp. and some large supermarket chains. The ability to develop and maintain a complex and sophisticated IOS as well as the control over an influential IOS alliance consisting of Wholesale Corp. and some large chains of supermarkets can be considered as the main sources of power of Wholesale Corp.

Regarding the (potential) interests in the IOS, at the start of the project both Wholesale Corp. and Multi-store Corp. were convinced of the benefits of implementing an IOS. It was expected that the IOS would be helpful in optimizing the internal processes of both companies and that it would significantly contribute to a reduction in the transaction costs. It was therefore concluded that the initial IOS situation for both parties could be categorized as one with high power and interest levels (see figure 4). In 2003, Multi-store Corp. was convinced that the benefits of the IOS did not outweigh the costs. Consequently, the IOS situation of Multi-store Corp. as it was initially assessed changed from a high power, high interest situation to a high power, low interest situation (see figure 4).

Figure 3. Overview of the relationships between the stakeholders involved in the supply chain

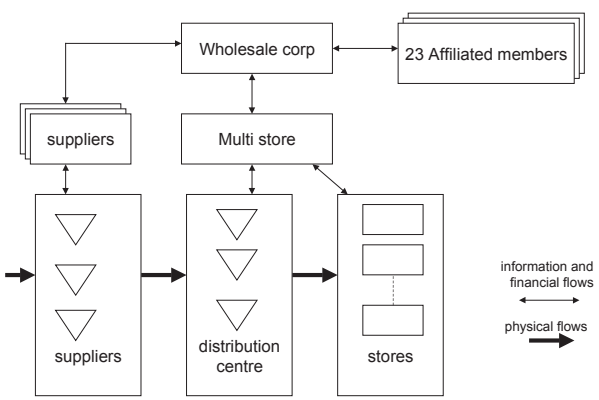
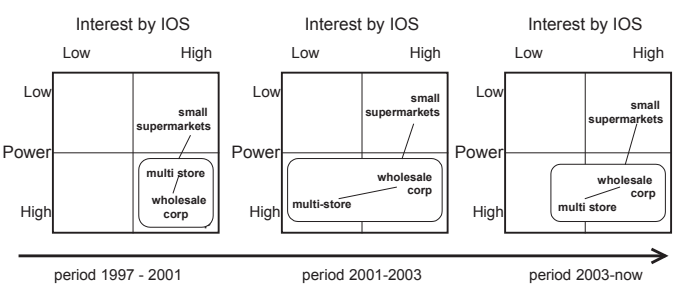


Figure 4. The dynamic character of the IOS-relationship



DISCUSSION

IOS are often presented as beneficial for all user organizations. The general assumption is that such systems may help to strengthen business relationships between participants. Stronger partnerships are normally associated with benefits such as clearer patterns of supply and demand, just-in-time, lower transaction costs, and closer vertical integration (Cavaye, 1995). However, closer partnerships can also have disadvantages. Partner organizations might feel overshadowed by powerful business partners and they may have to give up part of their independence. They may become dependent on their more powerful IOS partners, a dependency that may have existed before the IOS partnership, but that will become stronger and more explicit and tangible when the organization becomes electronically linked with the more powerful partner.

Stakeholders

The framework as presented in this article can be a helpful tool in identifying the most relevant stakeholders involved in an IOS proposal. The guiding questions as well as the other approaches mentioned in the backgrounds section are effective methods to identify this group. With respect to IOS projects, stakeholders can be divided in initiators, developers, implementers, and users and/or sponsors of the system. Identifying stakeholders is an important activity in relation to a broader goal, which is the management of stakeholders. Promoters of a certain IOS initiative have a clear interest in building an effective coalition of parties that may not have the same interests, but that may find each other through pursuing congruent goals that can be (partially) achieved by the successful implementation of an IOS.

Interests

The diagnostic framework acknowledges that IOS partners may have a variety of reasons to support or to resist an IOS initiative. These reasons can be divided in strategic, operational, financial, technological and behavioral motives. However, this categorization is only meant as a tool to identify all sorts of reasons that may influence the stakeholders' interpretations. These interpretations determine the attitude toward the IOS. In practice, the reasons are intertwined. In the case history, Wholesale faced numerous technological barriers when trying to introduce the IOS. However, these technological barriers appeared to be the result of miscommunication and the fact that parties were not prepared to exchange crucial information or change their organizational processes in favor of the IOS to be introduced. The technological problems were actually often used as an alibi and as a means to exert power and influence the other IOS party. It is the challenge of the analyst to talk to interest parties, to interpret their opinions and to gain insight into their real interests.

Dynamic Process

The presence of stakeholders as well as their interests and power are subject to change over time. This means that due to changing environments, the progressive nature of the system, and the shifting interpretations and perceptions of the parties involved, IOS development is not static but inherently dynamic. Sometimes these changes are the result of a well defined and explicit decision-making process. In the case history, Multi-store deliberately moved its position from a high interest, high power situation toward a low interest and high power situation. However, the dynamic character of IOS design and implementation is more often the result of implicit processes. Changing market circumstances, technological evolutions, or actions from other parties may influence the interpretations and actions of the different stakeholders.

CONCLUSIONS

In this paper we have offered a diagnostic method for identifying stakeholders and assessing their power and interests. The method's framework can be used before and during an IOS project, but also afterwards, to evaluate the project and to explain its degree of success as well as particular problems. This may improve an organization's learning capabilities during the process of starting new projects. Sufficient insight may also help executives of interested organizations to use their influence to move the project into the desired direction. McDonagh (2003) notes that IOS projects are frequently managed with a technical rather than an organizational focus, which reflects the relative isolation of the executive and user communities. "Executive communities view it as an economic imperative while IT specialists view it as a technical imperative. The coalescent nature of these two imperatives is such that human and organizational considerations are regularly marginalized and ignored". The framework as described in this paper may help business managers, executives and IT specialists become aware of the broad range of issues related to the development of inter organizational systems.

REFERENCES

Cavaye ALM (1995) The Sponsor-Adopter Gap- Differences between promoters and potential users of Information Systems that link organizations. International Journal of Information Management 15, 2, 85-96.

Chen S (2003) The real value of 'e-business models', Business Horizons 46, 6, 27-33.

Coltman T, Devenney TM, Latukefu A, Midgley DF (2001) E-business: Revolution, Evolution or Hype? California Management Review 44, 1, 57-85.

Cummings JL, Doh, JP (2000) Identifying who matters: Mapping key players in multiple environments, California Management Review, 42, 2, 83-105.

Freeman RE (1984) Strategic Management, a stakeholder approach, Pitman, Boston.

McDonagh J (2003) Not for the Faint Hearted: Social and Organizational Challenges in IT-enabled Change. Organization Development Journal 19, 1, 11-19.

Mintzberg H (1983) Power in and Around Organizations, Englewood Cliffs, Prentice Hall.

Mitchell RK , Agle B (1997)Toward a theory of stakeholder identification and salience. Academy of Management Review 22, 4, 853-887.

Pan G, Flynn D (2003) Information Systems Project Abandonment: A Case of Political Influence by the Stakeholders. Technology Analysis & Strategic Management.

Parker MM, Benson RJ, Trainor HE (1988) Information Economics. Linking business performance to information technology, Englewood Cliffs, Prentice Hall.

Porter ME (2001) Strategy and the Internet. Harvard Business Review 79, 3, 79-91.

Pouloudi A, Whitley EA (1997) Stakeholder identification in Inter Organisational Systems: Gaining Insights for Drug Use Management Systems. European Journal of Information Systems 6, 1, 1-14.

Standifera RL, Wall JA (2003) Managing Conflict in B2B e-commerce. Business Horizons 46, 2, 65-70.

Walsham G (1993) Interpreting Information Systems in Organizations, Wiley, Chichester.

Webster J (1995) Networks of collaboration or conflict? EDI and power in the supply chain. Journal of Strategic Information Systems, 4, 1, 31-42.

Yin, RK (1991) Case Study Research, Design and Methods, Sage, London.

ENDNOTE

[1] In order to maintain anonymity the names of the firms are not revealed in this paper.

Teaching Java™: Managing Instructional Tactics to Optimize Student Learning

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INTRODUCTION

Direct mastery of the core knowledge in a discipline is increasingly recognized as a fundamental requirement to applying and extending that knowledge to solve novel problems. That recognition implies an instructional design to overcome the empirically verified shortcomings of teaching tactics that provide minimal guidance during a student's learning experiences (Kirschner, Sweller, & Clark, 2006). In that regard, our previous work consistently confirmed the value of programmed instruction in teaching introductory Information Systems students a Java applet as a first technical training exercise in preparation for advanced learning (Emurian, 2004, 2005, 2006a,b). Similar value of programmed instruction is evident in its applications within other disciplines, such as chemistry (Kurbanoglu, Taskesenligil & Sozbilir, 2006). The objectives of our work are to apply programmed instruction and to assess its effectiveness as a tactic to promote a common level of mastery by all students for a designated learning objective in Java programming. An optimal level of mastery is taken to reflect a *true gain* in learning (Anderson, Corbett, Koedinger, & Pelletier, 1995).

Among several recommendations for effective learning principles to promote retention and transfer of knowledge, however, are repeated practice with different instructional modalities (Halpern & Hakel, 2003) and socially supported interactions (Fox & Hackerman, 2003). The modalities that have been adopted in our classroom applications include (1) programmed instruction, (2) lectures with hands-on learning, and (3) collaborative peer tutoring. Although these tactics are demonstrably effective in promoting programming skill, software self-efficacy, and generalizable knowledge, our most recent assessment of learning effectiveness showed room for improvement in the goal of achieving maximal learning in all students on tests of far transfer following the collaborative peer tutoring (Emurian, 2006b). To potentiate the effectiveness of the collaborative peer tutoring, then, the present evaluation was undertaken with a modification to the instructions and materials that were presented to students to prepare for peer tutoring and to use during the collaboration session. The procedure also allowed the collaborating students to view and discuss together the questions that constituted the tests of far transfer. Finally, the Java program to be learned by students as the first technical exercise was updated to Java swing, and it contained more items to be mastered in comparison to the previous work in this area of classroom applications and research.

METHOD

Subjects

Subjects were 13 graduate students, four females and nine males, taking IS 613 (*GUI Systems Using Java*) during a four-week summer session (Summer 2006). The class met three times each week, and each class lasted three hours. The course was designed for Information Systems students, and the prerequisite was one prior programming course.

The background characteristics of the students were as follows: age (median = 28 years, range = 23 to 33), number of prior programming courses taken (median = 3, range = 1 to 15), rated prior Java experience (median = 2, range = 1 to 5 on a 10-point scale presented below), and rated prior programming experience (median = 5, range = 2 to 8 on a 10-point scale presented below).

The research protocol was exempt from informed consent by the Institutional Review Board, and the course syllabus clearly indicated that questions both embedded in the Java tutor and administered during several assessment occasions in class were eligible to appear on a quiz. The course description and syllabus provided information about the Java tutor and the collaborative peer tutoring, and they presented the rationale for the repetition of initial learning using the several different instructional modalities under consideration.

Material

Java Program

The instructional tactics in this study were based upon teaching students a JApplet program that would display a JLabel object within a browser window. The program was arbitrarily organized into 11 lines of code (*e.g.*, ***JLabel myLabel;***) and 37 separate items of code (*e.g.*, ***getContentPane()***). The 11 lines of code are as follows:

```
(1) import javax.swing.JApplet;
(2) import javax.swing.JLabel;
(3) import java.awt.Color;
(4) public class MyProgram extends JApplet {
(5) JLabel myLabel;
(6) public void init() {
(7) myLabel = new JLabel("This is my first program.");
(8) getContentPane().setBackground(Color.yellow);
(9) getContentPane().add(myLabel);
(10)}
(11)}
```

Access to the web-based Java tutor, as presented below, will also show the complete program as part of the tutor's instructions to the student.

Questionnaires[1]

Java software self-efficacy was assessed by requesting a rating of confidence, for each of the 23 unique items of code (*e.g.*, ***import***) in the program, in being able to use the Java code to write a program that displays a text string, as a JLabel object, in a browser window. The scale anchors were ***1 = No confidence.*** to ***10 = Total confidence.*** Twelve multiple-choice questions were administered that required applying a general concept of Java object-oriented programming to solve. These questions did not appear within the Java tutor, and they were intended to assess far transfer or meaningful learning (Mayer, 2002). Each question had five choices, and for each question, a rating of confidence was made that the selected choice was the correct choice. The scale anchors were ***1 = Not at all confident.*** to ***10 = Totally confident.*** Ratings of classification and functionality learning for eight Java identifiers were also obtained, but they are beyond the scope of this paper.

The pre-tutor questionnaire also solicited demographic information, to include age, sex, and college major. The total number of prior programming courses taken was also requested. Two programming experience rating scales were presented, one for general programming experience and one for Java programming experience. For both scales, the anchors were ***1 = No experience. I am a novice.*** to ***10 = Extensive experience. I am an expert.***

The post-tutor questionnaire omitted the demographic information, and it assessed evaluations of the tutor for (1) overall effectiveness, (2) effectiveness in learning Java, and (3) usability. The anchors were ***1 = Lowest value.*** to ***10 = Highest value***.

Procedure

Java Tutor

At the first class meeting, students completed the pre-tutor questionnaire. Students next completed the web-based Java tutor[2]. The tutor taught a JApplet that

displays a text string, as a JLabel object, in a browser window on the web. The Java code and a brief description of the eight stages of the tutor are presented as part of the open source material[3]. When a student finished the tutor, he or she next completed a post-tutor questionnaire, which duplicated the software self-efficacy ratings and multiple-choice rules questions and confidence ratings. The student next accessed a set of questions and guidelines, which were posted on Blackboard, that were to be used to structure the collaborative peer tutoring session during a subsequent class. This material also presented a link to access the textual explanations of the items and lines of code that were presented in the Java tutor. The instructions with this material indicated that the questions presented were eligible to appear on a quiz.

Lecture

At the second class meeting, the author gave a lecture on the program taught in the Java tutor. The students wrote the code in a Unix™ text editor during the lecture, which repeated the information presented in the tutor. The students were also taught the HTML file, used to access the Java bytecode file, as a URL on the web. Support was provided so that all students successfully ran the JApplet program at the conclusion of this lecture-based exercise.

This lecture required approximately one hour to complete, and the remaining class time was spent on the next unit of material, which related to the life cycle of an Applet. Students were encouraged to help each other during the subsequent classes in the semester, which combined lectures and hands-on demonstrations, with the understanding that files were not to be copied without prior permission of the instructor.

Interteaching

At the third class meeting, a collaborative peer tutoring session occurred based upon the dyadic "interteaching" model (Boyce & Hineline, 2002). Students formed six groups of two and one group of three students for the session, which lasted one hour. The assignment was for the students to discuss the set of questions and guidelines made available at the conclusion of the Java tutor work undertaken at the first class meeting. Also presented was the questionnaire, and students were encouraged to discuss the items together prior to answering individually. This was the major innovation in the study, providing the opportunity for students to discuss the rules questions together. The interteaching questionnaire instructions stated that the 12 rules questions were eligible to appear on a quiz, but the remaining items were there only to assess instructional effectiveness of the interteaching session. The interteaching questionnaire also requested ratings of the effectiveness of the session for (1) learning the material and (2) readiness to be tested on the material, where ***1 = Not effective*** to ***10 = Totally effective***.

During the interteaching session, students posted questions on a Blackboard discussion board, and the instructor provided feedback. For the 12 rules questions, the correct selection was never given. Instead, the instructor responded in a way that made certain that students understood the general principle underlying the correct choice, and this process was occasionally iterative.

On the same day as the interteaching session, the instructor posted an announcement on Blackboard giving a rules question that was answered incorrectly by two of the students. The announcement was as follows: "Some students answered 'c' below for this question [also presented in the announcement]. The 'c' choice is not correct because JScrollPane is a class, not an object. An object name begins with a lowercase letter. If you have a question about this, please send me email." All student inquiries were answered privately in a way to promote understanding of the principle involved. The correct answer was not given.

Graded Quiz

At the fourth class meeting, a quiz was administered that included questions embedded within the Java tutor and the 12 rules questions as indicated above. The graded quiz did not include any rating assessments.

RESULTS

Figure 1 presents boxplots of correct answers on the rules test over the five assessment occasions. For each of the 12 questions answered during the Pre-Tutor assessment, one student did not select any answer, but instead indicated being unprepared to answer. The figure shows graphically that the median total correct answers increased over the first four occasions and reached the ceiling of 12 on the Interteaching occasion. A Friedman test (Conover, 1971, p. 264) was significant (Chi-Square = 42.259, df = 4, p = 0.000). The figure also shows that the greatest change occurred between the Pre-Tutor and Post-Tutor occasions, and both medians were 12 for the Interteaching and Quiz occasions. A Welch robust test (Maxwell & Delaney, 2004, p. 134), based on the differences, Di, in correct answers between successive pairs of occasions over the five occasions, was significant (W = 10.889, p = 0.000). Planned pairwise comparisons were significant[4] for D1 compared to D2 (W=10.145, p = 0.005), not significant for D2 compared to D3 (W = 1.513, p = 0.231), and significant for D3 compared to D4 (W = 12.295, p = 0.003).

Figure 1. Correct answers on rules test

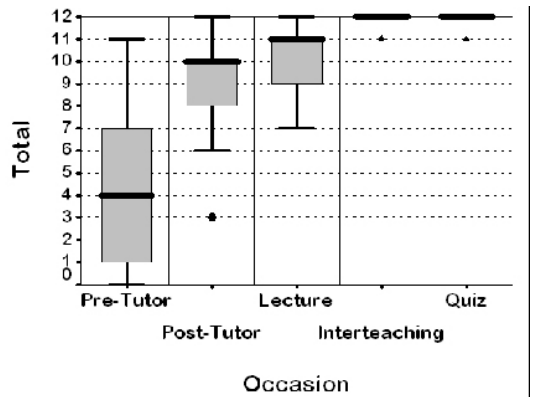


Figure 2 presents boxplots, over four successive occasions, of the ratings made by the students regarding confidence that the selected answer on the rules test was correct for answers that were Right and for answers that were Wrong. Ratings were not obtained during the graded quiz. The number below each boxplot reflects the number of students who answered Right and/or Wrong over the four assessment occasions, and that is the reason that the frequency for a boxplot is sometimes less than 13 (*e.g.*, number of students giving incorrect answers for the interteaching occasion). The Welch robust test, used because of unequal sample sizes, was significant for Right answers (W = 16.632, p = 0.000) and for Wrong answers (W = 40.864, p = 0.000). The latter test was based on the first three occasions because the variance for the Interteaching occasion was zero. For Right answers, planned pairwise comparisons were significant for Pre-Tutor and Post-Tutor (W = 27.398, p = 0.000), not significant for Post-Tutor and Lecture (W = 0.108, p = 0.745), and not significant for Lecture and Interteaching (W = 4.959, p = 0.044) occasions. For Wrong answers, planned pairwise comparisons were significant for Pre-Tutor and Post-Tutor (W = 55.646, p = 0.000) and not significant for Post-Tutor and Lecture (W = 1.220, p = 0.282) occasions. An overall comparison of confidence ratings between Right and Wrong answers was significant (W =

Figure 2. Confidence in accuracy of rules test answers

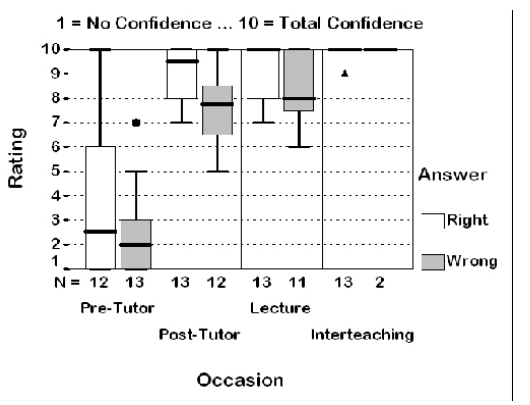


Figure 3. Interteaching evaluation

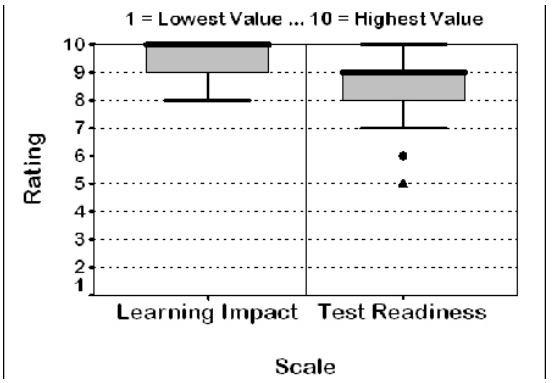
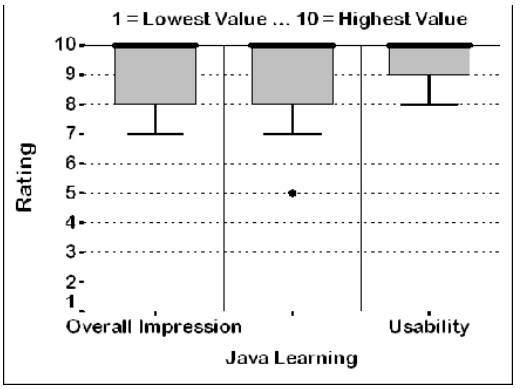


Figure 5. Evaluation of the tutor



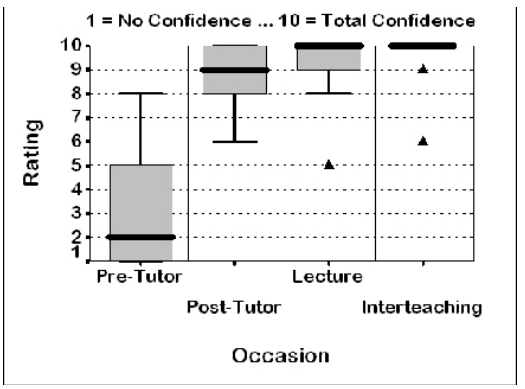
9.481, p = 0.003). Confidence generally increased over the assessment occasions, reaching the ceiling for correct answers after the lecture. However, confidence was seen to increase for both correct and incorrect answers, although an overall comparison favored the correct answer choices.

Figure 3 presents boxplots of ratings on the interteaching evaluation, which was administered at the conclusion of the interteaching session. The figure shows graphically the students' reported value in the interteaching session even when it occurred after using the Java tutor and after running the program on the web. The median rating of learning impact reached the scale's ceiling of ten, with eight being the lowest rating observed. The rating of test readiness was only slightly less, with a median of nine. A Friedman's test was significant (Chi-Square = 5.444, p = 0.020). Similar to our previous work, the ratings of test readiness were lower than corresponding ratings of learning impact. These show that the students reported value in the collaborative peer tutoring even when the session followed several other instructional experiences.

Figure 4 presents boxplots of software self-efficacy ratings across the first four assessment occasions. These ratings were not obtained during the graded quiz. Each boxplot is based upon the median rating over the 23 unique items of code in the program for the 13 students. Cronbach's alpha reliability of the ratings within each assessment exceeded 0.90, and all were significant ($p < .05$). A Friedman test was significant (Chi-Square = 32.614, df = 3, p = 000). A Welch test, based on the differences in correct answers between successive pairs of occasions, was significant (W = 30.222, p = 0.000). Planned pairwise comparisons of the differences, Di, were significant for D1 compared to D2 (W = 60.215, p = 0.000) and not significant for D2 compared to D3 (W = 1.330, p = 0.260). Software self-efficacy increased over the assessment occasions, and it reached the ceiling following the lecture.

Figure 5 presents boxplots of ratings of evaluation of the tutor taken during the Post-Tutor assessment. Medians for all three scales reached the scale ceiling of ten, with only a single outlier observed for Java Learning. These data show that students reported value in their use of the tutor.

Figure 4. Software self-efficacy



DISCUSSION

The results of this study show the value of applying several different instructional modalities in furtherance of having Information Systems students achieve a common level of skill and understanding in a simple Java applet, presented as a first technical exercise in a semester-long course. The data support the utility of this approach as reflected in students' rules test performance and software self-efficacy, which progressively improved over the successive assessment occasions. Rehearsal is an intuitively obvious and well-researched factor in knowledge and skill acquisition (*e.g.*, Salas & Cannon-Bowers, 2001), and the present study shows how structured rehearsal may be managed using the several modalities under consideration. Principles underlying such managed skill acquisition with different instructional modalities are presented elsewhere (Fox & Hackerman, 2003; Halpern & Hakel, 2003).

Having students discuss rules questions together enhanced understanding in the present context. Similar to our previous observations, however, students showed "overconfidence" in incorrect rules answers, and that issue requires exploration in the design of future work. Importantly, students reported value in the Java tutor and in the collaborative peer tutoring, and taken together with the lecture, these approaches to managing rehearsal in the classroom environment converge on what are increasingly recognized as vital ingredients to facilitate science education, in general (DeHaan, 2005).

This study constitutes a systematic replication (Sidman, 1960) of a set of teaching tactics that were revised with the expectation that student learning would be improved as a consequence. The methodology reflects design-based research, which is a type of formative evaluation (Collins, Joseph, & Bielaczyc, 2004) that is emerging as an alternative methodology in support of developing and assessing improvements in instructional design within the context of the classroom (Bell, Hoadley, & Linn, 2004; Design-Based Research Collective, 2003). In that regard, the order of presenting the several instructional tactics was determined by anecdotal observations of student performance over the several classroom evaluations that were previously undertaken in this stream of work. It was decided that a hands-on lecture would benefit from students' prior rehearsal with the Java code and that collaborative peer tutoring would benefit from the cumulative learning obtained from the programmed instruction and the lecture. Since the components in the current ordering are well received by students and since a desired learning outcome was achieved, we have the view that it is worthwhile now to direct our attention to developing advanced instructional material, rather than to "prove" the optimal ordering under conditions of a traditional "effect-size" experiment. Support for that view is implicit within designed-based research and has been discussed by educational scholars (*e.g.*, Mayer, 2004; Sackett & Mullen, 1993).

There are many approaches to teaching computer programming, ranging from an emphasis on mathematics and algorithms (Hu, 2006) to supportive programming environments such as BlueJ (Kolling, Quig, & Rosenberg, 2003), DrJava (Hsia, Simpson, Smith, & Cartwright, 2005), Problem-Based Learning (Tsang & Chan, 2004), PigWorld (Lister, 2004), and the Environment for Learning to Program

(Truong, Bancroft, & Roe, 2005).The instructional tactics adopted here in the classroom at the start of a semester's work are based initially upon *programmed instruction*, which is a form of structured and optionally automated instruction, as discussed by Emurian and Durham (2003) and Emurian, Wang, and Durham (2003) with respect to teaching computer programming. They also include *interteaching*, which is a form of collaborative peer tutoring (Boyce & Hineline, 2002). As implemented in the present context, these tactics originated from behavior analysis, and the Cambridge Center for Behavioral Studies[5] provides fundamental definitions and a wealth of information regarding the philosophical underpinnings and applications of this approach to science, in general, and to education, in particular. Finally, these tactics are to be understood as providing only an initial series of learning experiences to students in preparation for subsequent learning with other instructional and program development tools and techniques, to include the use of an integrated development environment (IDE) such as Eclipse.

Behavior analysis is one promising approach in identifying the ontogenetic instructional learn units (Greer & McDonough, 1999) whose mastery provides the textual tools essential for advanced understanding, thinking, and problem solving in the domain of computer programming and beyond (Skinner, 1957). Teachers facing the difficult challenge of providing effective instruction to the diversity of students who enroll in introductory computer programming courses need to be mindful of all approaches to helping their students succeed. The present study represents one set of instructional tactics that are demonstrably effective for Information Systems students.

REFERENCES

Anderson, J.R., Corbett, A.T., Koedinger, K.R., & Pelletier, R. (1995). Cognitive tutors: lessons learned. *Journal of the Learning Sciences*, *4*(2), 167-207.

Bell, P., Hoadley, C.M., & Linn, M.C. (2004). Design-based research in education. In M.C. Linn, E.A. Davis, & P. Bell (Eds.). *Internet Environments for Science Education* (pp. 73-88), Laurence Erlbaum Associates.

Boyce, T.E., & Hineline, P.N. (2002). Interteaching: a strategy for enhancing the user-friendliness of behavioral arrangements in the college classroom. *The Behavior Analyst*, *25*, 215-226.

Collins, A., Joseph, D., & Bielaczyc, K. (2004). Design research: theoretical and methodological issues. *Journal of the Learning Sciences*, *13*(1), 15-42.

Conover, W.J. (1971). *Practical Nonparametric Statistics.* New York, NY: John Wiley & Sons, Inc.

DeHaan, R.L. (2005). The impending revolution in undergraduate science education. *Journal of Science Education and Technology*, *14*(2), 253-269.

Design-Based Research Collective. (2003). *Educational Researcher*, *32*(1), 5-8.

Emurian, H.H. (2004). A programmed instruction tutoring system for Java: consideration of learning performance and software self-efficacy. *Computers in Human Behavior*, *20*(3), 423-459.

Emurian, H.H. (2005). Web-based programmed instruction: evidence of rule-governed learning. *Computers in Human Behavior*, *21*(6), 893-915.

Emurian, H.H. (2006a). A web-based tutor for Java™: evidence of meaningful learning. *Journal of Distance Education Technologies*, *4*(2), 10-30.

Emurian, H.H. (2006b). Assessing the effectiveness of programmed instruction and collaborative peer tutoring in teaching Java™. *International Journal of Information and Communication Technology Education*, *2*(2), 1-16.

Emurian, H.H., & Durham, A.G. (2003). Computer-based tutoring systems: a behavioral approach. In J.A. Jacko and A. Sears (Eds.), *Handbook of Human-Computer Interaction* (pp. 677-697). Mahwah, NJ: Lawrence Erlbaum & Associates.

Emurian, H.H., Wang, J., & Durham, A.G. (2003). Analysis of learner performance on a tutoring system for Java. In T. McGill (Ed.), *Current Issues in IT Education* (pp. 46-76). Hershey, PA: IRM Press.

Fox, M.A., & Hackerman, N. (2003). *Evaluating and improving undergraduate teaching in science, technology, engineering, and mathematics*. Washington, DC: The National Academies of Science Press.

Greer, R.D., & McDonough, S.H. (1999). Is the learn unit a fundamental measure of pedagogy? *The Behavior Analyst*, *22*, 5-16.

Halpern, D.F., & Hakel, M.F. (2003). Applying the science of learning to the university and beyond: teaching for long-term retention and transfer. *Change*, *35*(4), 37-41.

Hsia, J.I., Simpson, E., Smith, D., & Cartwright, R. (2005). Taming Java for the classroom. *SIGCSE'05,* February 23-27, St. Louis, MI, 327-331.

Hu, C. (2006). It's mathematical after all: the nature of learning computer programming. *Education and Information Technologies*, *11*(1), 83-92.

Kirschner, P.A., Sweller, J., & Clark, R.E. (2006). Why minimal guidance during instruction does not work: an analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist*, *41*(2), 75-86.

Kolling, M., Quig, B., Patterson, A., & Rosenberg, J. (2003). The BlueJ system and its pedagogy. *Journal of Computer Science Education*, *14*(Dec), 1-12.

Kurbanoglu, N.I., Taskesenligil, Y., & Sozbilir, M. (2006). Programmed instruction revisited: a study on teaching stereochemistry. *Chemistry Education Research and Practice*, *7*(1), 13-21.

Lister, R. (2004). Teaching Java first: experiments with a pigs-early pedagogy. *Proceedings of the Sixth Conference on Australian Computing Education* (pp. 177-183), Volume 30, Dunedin: Australian Computer Society, Inc.

Mayer, R.E. (2002). *The promise of educational psychology. Volume II. Teaching for meaningful learning*. Upper Saddle River, NJ: Pearson Education, Inc.

Mayer, R.E. (2004). Should there be a three-strikes rule against pure discovery learning? *American Psychologist*, *59*(1), 14-19.

Maxwell, S.E., & Delaney, H.D. (2004). *Designing Experiments and Analyzing Data: A Model Comparison Perspective. Second Edition*. Mahwah, NJ: Lawrence Erlbaum Associates.

Sackett, R.R., & Mullen, E.J. (1993). Beyond formal experimental design: towards an expanded view of the training evaluation process. *Personnel Psychology*, *46*, 613-627.

Salas, E., & Cannon-Bowers, J.A. (2001). The science of training: a decade of progress. *Annual Review of Psychology*, *52*, 471-499.

Sidman, M. (1960). *Tactics of Scientific Research*. New York: Basic Books.

Skinner, B.F. (1957). *Verbal Behavior*. New York: Appleton-Century-Crofts, Inc.

Truong, N., Bancroft, P., & Roe, P. (2005). Learning to program through the web. *Proceedings of the 10th annual SIGSCE conference on innovation and technology in computer science education*, ITiCSE'05, June 27–29, Monte de Caparica, Portugal. ACM Press.

Tsang, A.C.W., & Chan, N. (2004). An online problem-based model for the learning of Java. *Journal of Electronic Commerce in Organizations*, *2*(2), 55-64.

ENDNOTES

1. The Java tutor source code and all assessment instruments, to include the rules test and quiz, are freely available on the web: http://nasa1.ifsm.umbc.edu/irma/2007/
2. The Java tutor is freely accessible on web, and this report is based on version 2 of the tutor. The course material is also freely available: http://nasa1.ifsm.umbc.edu/IFSM413_613/
3. http://nasa1.ifsm.umbc.edu/learnJava/tutorLinks/TutorLinks.html
4. To control for the experimentwise error rate, the significant *p* value for each planned comparison must be less than 0.05/number-of-planned-comparisons.
5. http://www.behavior.org/index.cfm

Supporting Interorganizational Processes with Interaction Flows and Business Rules

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ABSTRACT

Framework contracts are the main instrument to regulate the cooperation of organizations but they are rarely sufficiently elaborated to actually support the daily routine of interaction. In order to provide this support we suggest the development of interaction flows, interorganizational workflows that describe routine behaviour on a detailed level (sunny-day scenario). They are complemented by business rules which cover exceptional behaviour.

1. INTRODUCTION

The principal mechanisms to coordinate economic activities are hierarchies (internal coordination) and markets (external coordination). Two major theories have been put forward to explain why a particular mechanism is preferred in a given situation: agency theory (Wilson, 1968) and transaction cost economics (Williamson, 1975). Based on these theories it is typically assumed that companies choose their organizational structure and network of trading partners in such a way that the sum of both costs is minimized. Regarding the impact information technology on governance structures, (Malone, Yates, & Benjamin, 1987) suggested that it will lower transaction costs and therefore, ceteris paribus, lead to an increase in market coordination. Empirical evidence (Holland & Lockett, 1997) shows that companies often operate in a "mixed mode" blending aspects from both markets and hierarchies.

In this situation organizations have to rely on contracts to regulate their cooperation. Such framework contracts should provide for sufficiently detailed rules to facilitate process design and IT support. But in reality we often find that the contract only covers few issues (prices, terms of delivery) and leaves it to the responsible managers on each side to work out the details between them. As a consequence the process organization is often ad-hoc and inefficient. Such a situation can be avoided if the framework contract also provided for a description of the necessary interorganizational workflows. The following chapters elaborate this idea.

We base our approach on Business Action Theory (Goldkuhl & Lind, 2004). It divides a process along two dimensions into phases and layers. The phases are: proposals, commitments, fulfilments and assessments, complemented by pre- and post-transactional activities. The layers are transaction group, business transaction, exchange, action pair and business act. We extend this classification scheme by a third dimension: regularity, which consists of regular and exceptional behaviour. This extension is driven by the need to balance complexity and level of detail in the process model. We therefore suggest to split it into regular and exceptional behaviour, where the former is covered by an interaction flow model and the latter by business rules. We show how we applied this approach to a case.

2. BUSINESS ACTION THEORY

Business Action Theory (BAT) is a framework for business interaction. Its origins are in Speech Act Theory (Searle, 1969) and the Theory of Communicative Action (Habermas, 1984) but considers also material (i.e. physical) aspects. According to BAT a business transaction is divided into four main phases: proposals, commitments, fulfilments and assessments. They are complemented by pre- and post-transactional activities. In addition to this BAT also defines layers of actions that represent levels of granularity (Lind & Goldkuhl, 2001). The layer dimension is orthogonal to that of the phases and on each layer a process is composed of elements of the next lower level.

The basic layer contains business acts which can be communicative and/or material. Communicative acts are speech acts in the sense of Speech Act Theory. They are performed in the social (or intersubjective) world. An example of a communicatice act is placing an order. Material acts are performed in the physical (or objective) world. An example of that is the delivery of a pallet. There is no strict demarcation between the two types of acts because business acts are often multi-functional. Delivery of a pallet constitutes, for example, both the material act of moving the physical object and the communicative act of fulfilling the commitment to deliver.

On the second layer business acts are arranged in pairs of action and reaction (or trigger and response). Some authors claim that only such combinations of speech acts should be considered as action pairs that lead to a deontic change, i.e. a commitment or accomplishment in the social world (Weigand & van den Heuvel, 1998; Weigand, van den Heuvel & Dignum, 1998; both papers use the term transaction instead of action pair). This claim is challenged by (Lind & Goldkuhl, 2001) who argue that there are relevant business action pairs that do not lead to deontic changes. When, for example, a customer places an order and the supplier refuses it, no commitment has been made nor has anything been accomplished. But this sequence still constitutes admissible and relevant business behaviour. The refusal might for example trigger the placement of a respective order with a different supplier.

On the third level one or more action pairs form an exchange. This is meant in the most general sense of something that is given in return for something else (e.g. a product in return for money). With respect to a particular exchange the things exchanged belong to the same category. The categories are: interests, proposals, commitments, values (products, services, money) and assessments. They are closely related to the phases so that a business transaction can also be defined as a sequence of exchanges (fourth level). The fifth layer, transaction group, groups consecutive transactions between the same partners.

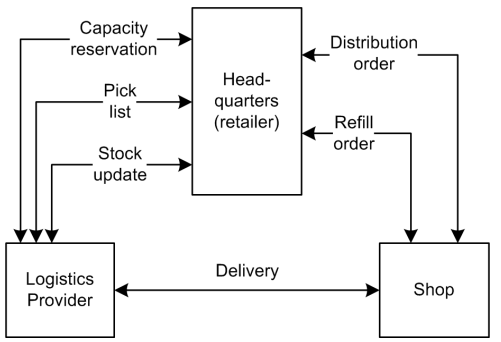
3. MODELING INTERACTIONS BETWEEN ORGANIZATIONS

Some business modeling methodologies provide their own modeling languages, e.g. Dynamic Essential Modeling of Organization (Dietz, 1999). In contrast to this BAT does not come with its own language. Instead its proponents suggest to use the language of SIMM (Situation adaptable work and Information systems Modelling Method) (Goldkuhl, 1996). The loose coupling between method and language might be seen as a disadvantage but (Lind & Goldkuhl, 1997) defend this approach. SIMM contains among other things a number of different diagram types for describing collaboration, interaction, process, action, problem, strength and goal. In our case the Interaction Diagram provided a suitable view. It describes interaction between actors within and between organizations. Its primary elements are actors (in roles) and actions. Actions can be initiated by some actor and directed towards another (single-headed arrows) or they can be mutual (double-headed arrows). Fig. 1 shows the interaction between the three organizations involved in our project.

The main actors are the Logistics Provider, the Headquarters of the retailer and the Shop. The figure shows the exchanges that are performed during order handling. It starts when Headquarters reserve capacity for handling a certain amount of ordered items in advance of the actual order. The Logisitics Provider (LogPro) allocates staff and space so that the reserved capacity can be provided at the time the respective order arrives. But the capacity required by the order might actually be higher or lower than the one that was reserved.

The product assortment of the retailer consists of basic-range products and seasonal products. The latter are distributed to the Shop according to turnover quota (distribution order). This is triggered by Headquarters. Orders for basic-range

Figure 1. The interaction diagram of the case (exchange level)



products are initiated by the Shop. This happens when the Shop is running low on certain products (refill order). Headquarters will forward both types of orders to LogPro in form of a pick list. The delivery to the Shop will then be performed by LogPro which includes picking items, packing them and handing them over to the carrier. The delivery consists of a material act (moving the goods to the Shop) complemented by a communicative act (confirmation of delivery). The material act also has a communicative function of its own: Through it LogPro states that they have performed the delivery and thereby fulfilled their obligation.

Periodically Headquarters will also ask for an update of the stock. This is necessary because they run their own warehouse management system which is not integrated with that of LogPro. The process described so far was part of the business analysis we performed in the project mentioned above. As a result we found out that the existing framework contract was vague which led to a series of problems including:

1. Broken patterns: One important characteristic of a business transaction is that each business act is related to another in a pattern of initiative and response. This means that the sequence of business acts needs to be followed in the sense that the pattern should not be broken. Going back to the empirical setting it can be identified that Headquarters supply estimates (as an initiative) without getting a response. There is thus a pattern of interaction when establishing the framework contract and another one when realizing the business transaction. The interaction pattern that glues framework contract and business process is thus broken. This has the effect that Headquarters cannot be sure of the capacity that will be available at the time of order and LogPro does not reserve the required capacity. The estimates made by Headquarters are therefore neither informative nor directive and hence do not imply mutual commitments. As a consequence, the contract should be specified in such a way that encourages the parties to keep the patterns intact.
2. Business rules: There are no rules that guide the interplay between the overall framework contract and the embedded business transactions. Such rules are necessary to regulate the details of interaction and to provide infrastructural support such as IT systems.
3. Indistinct communication structures: It is often unclear who communicates with whom regarding which issue.
4. Lack of trust: Different interpretations of the contract by the parties led to expectations that were not fulfilled. This led in turn to a lack of trust in succeeding transactions.
5. Excessive communication: A considerable amount of personal interorganizational communication was spent on handling everyday work. This was only necessary because of insufficient specification of routine procedures in the framework contract.
6. High transaction costs: Ad-hoc solutions to exceptional problems increased transaction costs.

In this situation it soon became clear that the solutions to these problems require a relatively detailed specification of the coordination process down to the level of business acts. Moreover, according to issues 1 and 2 this detailed process description has to be part of the framework contract itself to ensure that the internal workflows in each party to the contract are aligned with the overall interorganizational process. This poses a substantial problem because the resulting interaction model would be too large and complex to be included in a contract. As a consequence it would be difficult to achieve understanding on all sides of such a contract and the chances of reaching an agreement would be even smaller. The following section pursues a possible solution to this problem.

4. INTERACTION FLOW AND BUSINESS RULES

As mentioned in the previous section, an improved support for interorganizational processes requires the specification of the interaction on the level of business acts. Fig. 2 shows, as an example, the result of decomposing the pick list exchange of fig. 1 into its business acts assuming that the exchange requires only the minimum of two conversations (actagenic and factagenic) with one action pair each. These consecutive conversations aim at reaching an agreement about 1) the execution of an action, and 2) the result of that execution, respectively.

This scenario does not provide for exceptional behaviour. Headquarters send a pick list to LogPro which is confirmed. LogPro then picks the ordered items from the shelves and packs them onto pallets (which are subsequently picked up by a carrier). Thereafter the delivery is reported by LogPro and confirmed by Headquarters (after having received the corresponding confirmation from the Shop). If we make the same assumptions for the remaining exchanges of fig. 1 we arrive at the Interaction Diagram in fig. 3.

This diagram already exhibits a substantial complexity but it does still not cover cases where something goes wrong. We therefore decided to take a closer look at the process with respect to the frequency of each act. In the course of this analysis we discovered:

- Some business acts are rarely performed in reality. Putting them into the diagram would crowd it without improving understanding of the process. Such exceptional behaviour can better be treated separately in form of business rules. Business rules are listed in a table in the form of a textual description.

Figure 2. The interaction diagram of the pick list exchange (business-act level)

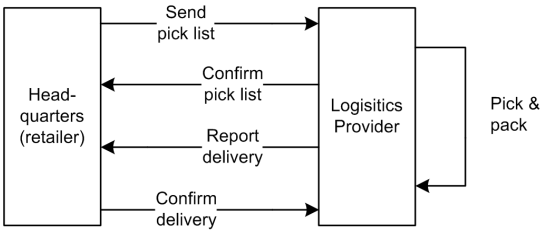
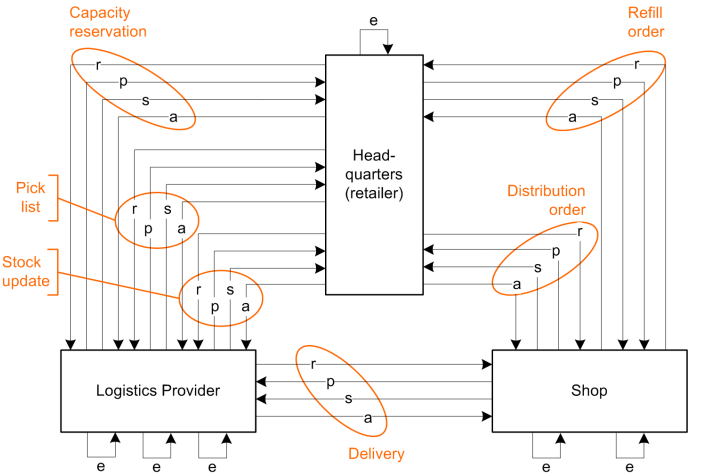


Figure 3. The interaction diagram of the case (business-act level): r = request, p = promise, s= state, a = accept, e = execute



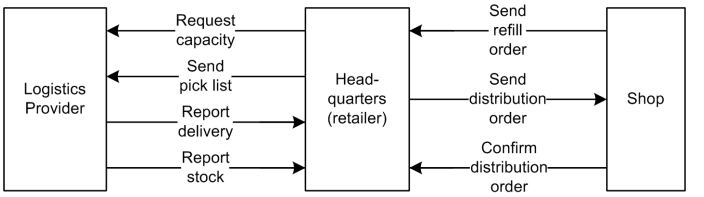
- Some business acts are often performed repeatedly with the same result or their result is usually not required. In such a situation it can be more appropriate to drop this act from the diagram (in the positive, regular case) and replace it with a business rule that covers the negative case instead (i.e. the exception). An example for this is the act "Confirm pick list". This confirmation is usually not needed because the act of sending the pick list is automated and hence quite reliable. So instead of having the confirmation act in the interaction diagram we will assume that the pick list was sent and specify a rule that provides for the case of a failure.

This means that we introduce a third dimension into Business Action Theory: regularity. It refers to the frequency with which a certain action is performed in relation to the overall business process. A regular action is one that is performed in (almost) every instance of the business process. An exceptional action is performed only in a fraction of the instances. Along this dimension the business action can be divided into a number of classes that depends on the application scenario. Each class is associated with a (possibly different) modeling language that fits this type of business action. In our case we found it useful to define two classes: regular and exceptional. The regular class is associated with the Interaction Diagram, the exceptional class with business rules. The borderline between the classes is usually not sharp and critical cases have to be assessed individually.

An Interaction Diagram on the business-act level that represents regular behaviour is called an Interaction Flow because its level of detail is such that it corresponds to a workflow of the interaction. Consequently it can be used not only for the framework contract but also as a basis for setting up the internal workflows in each participating organization. The latter could then be supported by workflow management systems.

Fig. 4 shows the Interaction Flow for our case. The flow starts when Headquarters send a request for capacity. Such a request is always granted provided that the limits specified in the framework contract are not exceeded. Hence no further interaction is triggered. At some later point in time Headquarters send a distribution order for seasonal products to the Shop. This distribution order has to be confirmed by the Shop because they often have to make corrections (i.e. this is a regular act). Independent of that the Shop can also send a refill order when the stock is running

Figure 4. The interaction flow of the case



low on certain products of the basic range. Such an order is, as a rule, not confirmed by Headquarters because a sufficient stock is assumed for these prodcuts. Only in the exceptional case of an out-of-stock situation they would send a respective notification. This is covered by a business rule (see table 1). Any kind of order is forwarded to LogPro in the form of a pick list. It contains detailed information on type and amount of products to be delivered to each Shop and it triggers a number of internal activities by LogPro such as picking the products from the shelves, packing them into boxes and stacking the boxes on pallets to be picked up by a carrier. Upon completion of this work LogPro will report the delivery. Again there is no confirmation and exceptions are handled by a business rule, such as complaints about missing items and returns of wrong items (see table 1). A daily stock report is sent automatically via file transfer without it being requested.

Regular and exceptional actions can be seen as complements of each other. A regular action is one that is performed in the majority of instances of a business process, i.e. it covers the "normal case" (so-called sunny-day scenario). The remaining instances represent "unusual cases" which are dealt with by a set of exceptional actions (rainy-day scenarios). Regular and exceptional actions together should cover all possible cases. It should be noted that there can be situations where all cases occur only occasionally and a regular case is hard to identify. In such a situation the decision regarding the regularity of the action should be guided by the suitability of the respective method (i.e. in our case Interaction Flow vs. business rule).

Table 1. The business rules of the case

Exchange	Business act	Performer	Adressee	Business Rule
Refill order	Accept order	Headquarters	Shop	A refill order is per default accepted and hence not confirmed. In case of out-of-stock a respective notification is sent.
	State/accept delivery	Covered by delivery		
Distribution order	State/accept delivery	Covered by delivery		
Delivery	Request/promise delivery	Covered by refill/distribution order		
	Accept delivery	Shop	LogPro	This is implied by the receipt of the delivery. If items are missing or wrong ones have been sent a respective complaint is sent to LogPro and wrong items are returned to LogPro.
Capacity reservation	Confirm reservation	LogPro	Head-quarters	A request for a capacity (forecast of required capacity) is always granted and hence not confirmed.
Pick list	Accept pick list	LogPro	Head-quarters	The pick list is accepted per default and no confirmation is sent. If the amount of items exceeds the limit specified in the general terms and conditions of the framework contract (in relation to the reserved capacity) a special arrangement is made (e.g. the warehouse staff is rescheduled, the unit price is raised).
	Confirm picking	Headquarters	LogPro	This is implied by the receipt of the delivery by the Shop and assumed by LogPro. The claims are handled directly between LogPro and Shop (return/resend).
Stock update	Request update	Headquarters	LogPro	Updating of the retailer's warehouse system is done via an automatic, daily file transmission containing a stock report. Request and promise are therefore obsolete.
	Promise update	LogPro	Head-quarters	
	Accept update	Headquarters	LogPro	The receipt of the stock report is assumed. If transmission fails, manual trouble-shooting is invoked.

5. RELATED AND FUTURE RESEARCH

The research we have performed so far shows the feasibility of the approach with respect to the case. An issue that we have barely touched is that of workflow management support. We already pointed out that Interaction Flows provide sufficient detail for the development of a workflow model. But conventional workflow technology is limited to deployment within an organization. A possible solution lies in the integration of decentralized workflow management systems. This is the object of current research (Jang, Choi, & Zhao, 2004; Shen & Liu, 2001).

The rigorous description of the interorganizational process could extended to the static part. e.g. the general terms and conditions. Simulation can facilitate both reengineering of the process itself and the derivation of static contract parameters from the simulation results (e.g. period of delivery based on the simulated time from order to delivery).

In the areas of electronic commerce and virtual organizations there is a growing interest in more formalized contracts (Artyshchev & Weigand, 2005; Milosevic, Linington, Gibson, Kulkarni, & Cole, 2004; Weigand & Xu, 2003). The existing approaches are often technology-driven and there is a need to complement them with rigorous approaches that have a strong business orientation. Our research takes a step in this direction. But formalized contracts (e.g. eContracts) are not only beneficial in electronic commerce or automated transactions. They can also make a substantial contribution towards the support of interorganizational business processes and workflows.

6. CONCLUSION

Business Action Theory offers a stable framework for the analysis of interorganizational processes and the SIMM language provides a suitable diagram, the Interaction Diagram, to model them from an interaction perspective. But this approach is fraught with a trade-off: In order to translate the contract into a workflow specification the Interaction Diagram has to be on a detailed, i.e. business-act level. But in order to reach an agreement on it all parties have to understand it. We balance these needs by splitting the interaction model into two parts, one for regular behavior and one for exceptions, thus introducing a third dimension into BAT. In our application the first part is modeled as an Interaction Flow, a special case of the Interaction Diagram, to facilitate the design of workflows. For the second part we have chosen business rules, an informal language that employs textual information in form of a table.

A case study involving a logistics provider and a retail chain was performed to prove the feasibility of the approach. To ensure the authenticity of the models we used seminar-based modeling sessions that involved participants from both organizations. A seminar leader elicited information from them to design a preliminary version of a model. This was then discussed and the feedback was used to adapt, extend or detail the model. This process was repeated until the required scope and level of detail were reached and no further improvements could be achieved.

REFERENCES

Artyshchev, S., & Weigand, H. (2005). Contract-Based Interoperability for E-Business Transactions. In D. Konstantas, J.-P. Bourrières, M. Léonard & N. Boudjlida (Eds.), *Interoperability of Enterprise Software and Applications*. Berlin: Springer.

Dietz, J. L. G. (1999). Understanding and modeling business processes with DEMO. In J. Akoka, M. Bouzeghoub, I. Comyn-Wattiau & E. Métais (Eds.), *Proceedings of the 18th International Conference on Conceptual Modeling ER '99* (pp. 188-202). Berlin: Springer.

Goldkuhl, G. (1996). Generic business frameworks and action modelling. In F. Dignum, J. Dietz, E. Verharen & H. Weigand (Eds.), *Communication Modeling - The Language/Action Perspective, Proceedings of the First International Workshop on Communication Modeling*. Berlin: Springer.

Goldkuhl, G., & Lind, M. (2004). *The generics of business interaction - emphasizing dynamic features through the BAT model.* Paper presented at the 9th International Working Conference on the Language-Action Perspective on Communication Modelling, Rutgers University.

Habermas, J. (1984). *The Theory of Communicative Action 1 - Reason and the Rationalization of Society*. Boston: Beacon Press.

Holland, C. P., & Lockett, A. G. (1997). Mixed Mode Network Structures: The Strategic Use of Electronic Communication by Organizations. *Organization Science 8*(5), 475-488.

Jang, J., Choi, Y., & Zhao, J. L. (2004). An Extensible Workflow Architecture through Web Services. *International Journal of Web Services Research, 1*(2), 1-15.

Lind, M., & Goldkuhl, G. (1997). *Reconstruction of different business processes - a theory and method driven analysis.* Paper presented at the 2nd International Workshop on Language/Action Perspective (LAP97), Eindhoven University of Technology, The Netherlands.

Lind, M., & Goldkuhl, G. (2001). *Generic Layered Patterns for Business Modelling.* Paper presented at the Sixth International Workshop on the Language-Action Perspective on Communication Modelling (LAP 2001), Montreal, Canada, July 21-22, 2001.

Malone, T. W., Yates, J., & Benjamin, R. I. (1987). Electronic Markets and Electronic Hierarchies. *Communications of the ACM 30*(6), 484-497.

Milosevic, Z., Linington, P. F., Gibson, S., Kulkarni, S., & Cole, J. (2004). *Inter-organisational collaborations supported by E-Contracts.* Paper presented at the IFIP 18th World Computer Congress "Building the E-Service Society: E-Commerce, E-Business, and E-Government", Toulouse, France, August 2004.

Searle, J. R. (1969). *Speech Acts - An Essay in the Philosophy of Language*. London: Cambridge University Press.

Shen, M., & Liu, D.-R. (2001). Coordinating Interorganizational Workflows based on Process-Views. In *Proceedings of the 12th International Conference on Database and Expert Systems Applications (DEXA'01)* (Vol. 2113, pp. 274-283). Berlin: Springer.

Weigand, H., & Xu, L. (2003). *Contracts in E-Commerce.* Paper presented at the Ninth IFIP TC2/WG2.6 Working Conference on Database Semantics "Semantic Issues in E-Commerce Systems", Hong Kong, April 25-28, 2001.

Williamson, O. E. (1975). *Markets and Hierarchies*. New York: Free Press.

Wilson, R. (1968). The theory of syndicates. *Econometrica, 36*, 119-132.

Transforming Procurement in the UK Immigration Directorate

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ABSTRACT

This paper discusses the Procurement Transformation Project of the UK Government's Immigration and Nationality Directorate. The project was designed to change the current procurement processes and to enable the frontline business units to undertake these activities. Through the use of Sveiby's (2001a) Ten Knowledge Strategy Issues a knowledge management strategy was devised and knowledge of the business requirements for goods and services procurement was successfully developed within the stakeholder community. Tangible benefits such as salary savings and improved organisational design were realised. Additionally, intangible benefits of increased staff knowledge, process understanding, and knowledge sharing within the improved social network were also achieved. This paper demonstrates that a practical implementation of knowledge management activities in the supply chain, devolving decision-making to the front-line staff, can make significant procurement savings and improve relationships within the stakeholder community.

Keywords: Knowledge strategy; procurement; supply chain management; innovation; business process transformation.

1.0 INTRODUCTION

This paper describes how knowledge management was established as one of the key elements of success for the Procurement Transformation Project of the UK Government's Immigration and Nationality Directorate (IND).

The Procurement Transformation Project (PTP) was designed to support and empower frontline business units to undertake routine local transactional and operational procurement. The PTP focussed on increasing knowledge and value within the procurement community and its stakeholders, through using Sveiby's (2001) Ten Knowledge Strategy Issues to support the business requirements.

This paper discusses the link between knowledge, innovation and business processes. It looks at Sveiby's work related to Knowledge Strategy and the Knowledge Based approach to organisations; and considers the use of knowledge management in procurement and business processes in the Public Sector and Government, illustrating this with the case of the Procurement Transformation Project.

1.1 Research (and Methods)

This was not a research project per se and so no questions were formulated prior to undertaking the work.

This was commercial consultancy project whereby the academic was presented with archival data by the consultant for analysis. Informal conversations were also conducted to clarify issues, timelines, and understandings.

Whilst an element of grounded theory was utilised in that no preconceptions as to what the data might reveal were formulated and no propositions developed, a full grounded data analysis was not performed. Rather a top level content analysis was performed to in order to classify and theme the data. This permitted the academic to apply different theory to different parts of the data for academic understanding of the process and to ensure that the data was partitioned appropriately. This high level open coding produced some interesting outcomes whereby the consultant commented "I hadn't thought of the project being like that", and additionally permitted sufficient segmentation so that more than one interpretation of the data could be taken and thus written up as academic papers (see Coakes and Young, 2006; Coakes and Young, 2007 forthcoming).

2.0 KNOWLEDGE, INNOVATION AND BUSINESS PROCESSES

In the section below we consider the link between innovation in business processes and knowledge. Whilst the IND is a public sector body, its role is to provide a service to other UK Government departments and thus, we would argue can be considered in the light of the literature that relates to the service sector.

Prajogo's (2006) article considered the link between innovation and business performance and discussed the existing literature assumptions relating to innovation in service firms. The literature suggests that such innovation is largely technological (Gallouj, 2002). Service firms it is argued are less radical than manufacturing and their emphasis is on continuity rather than newness (Voss et al, 1992). Innovation in such firms is mostly adopted and thus is concentrated on process rather than product (Gallouj, 2002) where such innovations are rapidly implemented but easily copied (Voss et al, 1992) - process innovation is thus a prime area of concern.

2.1 Process Innovation

In the case study discussed below relating to the IND, the major innovation was indeed related to a change in processes - in which a technological innovation was utilised to facilitate a process innovation. According to Popadiuk and Choo (2006) technological innovation relates to the 'knowledge of components, linkages between components, methods, processes and techniques that go into a product or service…(whereas) process innovation is concerned with introducing new elements into an organisation's operations such as input materials, task specifications, work and information flow mechanisms and equipment used to produce a product or render a service' (p303) (see also Afuah, 1998).

Stamm (2003) compares the major differences between incremental and radical innovation through 9 foci. These foci - time frame; development trajectory; idea generation; process; business case; players; development structure; resource requirements; and unit involvement, indicate who should be involved and how the project should be undertaken. In the case described below, the project falls very much into the incremental innovation category as indicated by Table 1.

Incremental innovation is appropriate for business processes in terms of continuous (quality) improvement, where radical organisational change is not required but rather improved support and greater efficiency (within the supply chain).

In addition, there are a number of models of innovation in the literature (for example Abernathy and Clark, 1985; Henderson and Clark, 1990; Tushman et al, 1997; Chandy and Tellis, 1998) which consider both technology and market perspectives in describing the type of innovation and its level of radicalism for the organisation. Technology is considered to impact on the market whereby new technology may produce new markets or market knowledge, or enhance penetration to the existing market and develop existing knowledge. The market of course can also be considered as the client and, in today's environment we can also consider that the market can be the supply-side value-chain. Technical innovation, whether it is radical, incremental, or indeed generational (Tushman et al, 1997), represents a change from existing firm practices and activities and thus requires project management and knowledge management of what is required, when, and

by whom. Innovation it is also argued (Popadiuk and Choo, 2006) depends on knowledge creation and in their paper they juxtapose a number of ideas relating to innovation and the types of knowledge creation that can produce them. In particular, they infer that sharing mental, emotional, and active knowledge can generate ideas to produce value for the organisation, suppliers and customers; and that knowledge based on the value chain produces innovation for both component and architectural elements of the firm. In addition, they pair procedural knowledge with market orientation and change in technology; and whole company knowledge with localised and functional area innovation.

The formal management of organisational knowledge in an organisation requires the organisation to formulate a knowledge strategy and to allocate resources to this end. Localised and functional area innovation, such as process innovation, can be guided through its development phases by answering Sveiby's Ten Strategy questions as discussed below.

2.2 Sveiby and Knowledge Strategy

In 2001(a), Sveiby identified ten issues or questions that should be asked to guide (knowledge) strategy formulation in the firm. These are:

1. How can we improve the transfer of competence between people in our organisation?
2. How can we transfer some of our competence to customers, suppliers and other stakeholders?
3. How can our people learn more from customers, suppliers and other stakeholders?
4. How can we support our customers' conversations with their customers, or host communities?
5. How can we use competence from customers and suppliers to add value to our systems, processes? Services, practices and products?
6. How can our customers and suppliers learn by accessing our systems, processes, services, practices and products?
7. How do we integrate systems, tools, processes and practices effectively internally?
8. How can we convert individually held competence to systems, tools and templates?
9. How can we improve individual's competence by using systems, tools and templates?
10. Strategic Purpose: how can the value of creation capacity of the whole system be maximised?

Sveiby emphasises three major aspects of the firm - customer relationships, internal structure, and employee competence. These elements make up what *Sveiby* calls 'knowledge capital'. The purpose of Knowledge Management for Sveiby (2001b) concerns how the organization best can nurture, leverage and motivate people to improve and share their Capacity to Act. Indeed, Sveiby says you should regard the organisation as consisting of knowledge, people, and the relationships between people. He proposes a knowledge-based approach to the organisation which recognises the fact that performance excellence does not exclusively mean financial performance. Under a knowledge-based approach the primary objective of actions is to enhance the value of all assets of the organisation by enhancing knowledge flows, generating intangible revenues, reducing intangible costs, and enabling knowledge creating processes (Sveiby 2001c).

If we consider Sveiby's three major aspects of the firm in the light of business processes, and in particular, the supply chain, we can see that process innovation needs to improve employee competence and knowledge, and that an organisational structure that empowers employees is likely to achieve this. It is also evident in the supply chain process that stakeholder relationships (both internal customer and external supplier) are of great importance and must be managed effectively and with understanding of their environments to formulate requirements. Formulating a strategy that develops competences and increases understanding is thus important in any organisation whether Public Sector or not.

3.0 KNOWLEDGE MANAGEMENT IN PROCUREMENT AND BUSINESS PROCESSES FOR GOVERNMENT ORGANISATIONS

Innovation in the public sector has not often been considered as being either radical or frequent. Additionally, it is often thought that innovation comes from the top and is not initiated by the front-line staff (Borins, 2000). However Borins' study showed this was not the case and many innovators in the public sector had the same entrepreneurial characteristics as those in the private sector and were prepared to be creative, to take risks and break rules and (even) not to be bureaucratic.

In the public sector, Borins' (2000) study showed that the most frequent reason for innovation was internal problems such as procurement (as cited below for our case organisation), but additionally, political initiatives were also high on the reason list for change and innovation with ICT (Information Communication Technology) frequently provided these opportunities.

Procurement in Government organisations is traditionally an area that has been looked at many times for ways to cut costs and to streamline the business processes and workflow to increase efficiency (Hsieh et al, 2002). To support business requirements procurement there needs to be a time-scheduled sequence comprised of the materials and components (Bowersox et al, 2002). ICT has long been involved in ways of stream-lining and numerous systems have been designed to improve the workflow. However, as with so many ICT systems, there has been a steady failure rate. Hsieh et al (2002) attribute these failures to diverse internal cultures (within the business units involved in the process); technical issues relating to the technology and systems; and human-computer interface issues.

Procurement is an essential component of an organisation's supply chain. It connects internal business units with external suppliers and is typically complex with, according to Hsieh et al (ibid) upwards of 15 different processes involved. Associated with these processes are numerous documents and activities and a variety of decision points for action along the supply chain. Many ICT systems pass the procurement decisions to the suppliers and thus organisations are reliant on their suppliers' knowledge and understanding of the business situation rather than using an internal understanding of the situation. This has caused significant problems for some organisations when the suppliers make the wrong decisions (see Solectron Corp as discussed in Engardio, 2001).

Procurement is about connecting up the diverse elements of the supply chain across unit and organisational boundaries and cultures and human understandings of the situation. Thus utilising and sharing knowledge across the procurement process will assist in helping with issues such as determining the optimal mix of order size and suppliers; controlling the timing of ordering and order delivery; managing product quality; and improving the management of cash-flows.

Best practices in utilising knowledge management (to assist in procurement) have been put forward by the APQC[1] (as described in Wimmer, 2005). These include creating a team approach; focusing efforts on business objectives and measuring tangible outcomes; and using a blend of knowledge-sharing approaches that incorporates people, processes, organisation and technology - the classical socio-technical approach. Wimmer also points out that learning cultures are not prevalent in governmental organisations and knowledge management has to be introduced in such a way that it can be seen to provide an immediate benefit. Knowledge management that preserve the organisation's Intellectual Capital she says, will not only cover the initial investment but will also add additional future value. Indeed, knowledge management is so difficult to introduce into public sector organisations that Sinclair (2006) argues it needs to be done by stealth… Sinclair also argues that this could be a result of senior managers' attitudes towards organisational structure and control which emphasises centrality over knowledge flows.

The intention of including knowledge in a procurement supply chain must be to lift the chain management from the 'ad hoc' level (Lockamy & McCormack, 2004) through to a higher level such as (initially) 'linked' but essentially up to 'integrated' and finally 'extended'. An integrated chain is where vendors and suppliers cooperate in the process and collaborative forecasting is performed. The extended chain has supply chain competition, and collaboration is through multi-firm teams with common processes, goals and a broad authority.

Seeley (2002) argues that effective knowledge management comes from connecting knowledge activities to processes that create value. Merely capturing, stockpiling, and transferring knowledge does not automatically lead to organisational performance enhancement (Swan, 2003). Successful processes indeed are (frequently) knowledge enabled (Smith & McKeen, 2004); yet to date this is not well developed in organisations. Successful processes will also link informal tacit knowledge into these activities and will be built within an organisational context and culture that supports (Marchand et al, 2000). An understanding of the context may also improve the process outcomes and execution (El Sawy & Josefek, 2003) and may elucidate the issues surrounding problems and uncertainties in the process.

The case study we describe below shows how the building of knowledge in the Procurement Transformation Project attempted to answer Sveiby's ten questions and also set out to link in this tacit knowledge that was held in the Immigration Service so that it was built into the processes and thus answered Smith and McKeen's current criticisms.

4.0 THE PROCUREMENT TRANSFORMATION PROJECT

Background

This project was carried out between January 2005 and April 2006 for the UK Immigration and Nationality Directorate (IND) within the Home Office.

The Immigration and Nationality Directorate (IND) is part of the Home Office. (Home Office, 2006a). The Home Office is the government department responsible for ensuring that the citizens of the UK " live in a safe, just and tolerant society by putting public protection at the heart" (Home Office, 2006b) of all they do. They are responsible for the police in England and Wales, national security, the justice system and immigration. The strategic objectives of the IND are to:

- Strengthen borders, use tougher checks abroad so that only those with permission can travel to the UK, and ensure that they know who leaves so that they can take action against those who break the rules.
- Make fast track asylum decisions, remove those whose claims fail and integrate those who need protection.
- Ensure and enforce compliance with UK immigration laws, removing the most harmful people first and denying the privileges of Britain to those who arrive illegally.
- Boost Britain's economy by bringing the right skills from around the world, and ensuring that the UK is easy to visit legally. (IND, 2006a)

The IND's work is underpinned by Home Office Aim 6: to manage immigration in the interests of Britain's security, economic growth and social stability. This means that their work includes the following areas:

- Immigration
  Considering applications from people who want to come to the UK to work, do business, visit relatives, take a holiday, or settle permanently.
- Nationality
  Deciding applications from people who want to become British citizens.
- Asylum
  Responsibility for processing all claims for asylum and asylum support made in the United Kingdom
- Border control and entry clearance
  Last year, the UK Immigration Officers facilitated the arrival of more than 12 million passengers who were subject to immigration control. British Diplomatic overseas visas staff decide applications from people who need to get permission to enter the UK before they travel.
- Law enforcement
  Enforcing and framing the immigration laws. It is their job to deter illegal workers and illegal entrants - Immigration Officers have legal powers to detain and remove them from the country.
- Appeals
  They share targets with the Department for Constitutional Affairs, the department with responsibility for the Asylum and Immigration Tribunal (IND, 2006b).

4.1 The PTP

The primary objective of the Procurement Transformation Project was to empower and support the frontline business units to undertake routine local transactional and operational procurement. The core PTP objective emanated from IND strategic business drivers which were to deliver the recommendations of the Government White Papers by Gershon (2004) and Lyons (2004) which related to the utilisation of assets, through releasing resources for the frontline units within the Home Office, and lowering the cost of resources needed to provide public services.

In particular the project set out to:

- Assist the organizational objectives by designing effective corporate governance to enable local procurement;
- Develop suitably trained staff;
- Increase the capacity of the central procurement unit to undertake and sustain local and operational buying at the frontline and high value strategic procurement at the centre;
- Enhance IND commercial activity by creating a procurement community of practice through knowledge sharing, utilizing the Procurement User Group (PUG) meeting format, commercial development workshops and a web based portal.

The Approach

The project was undertaken in a controlled environment based on a formal project management methodology (Prince II™). A Project Board was appointed to review progress at critical stages and reference to peer sounding boards was used throughout the project as and when needed.

Commencing with formal approval, the project completed a critical analysis of procurement activity and existing procurement skills through a gap analysis of skills, competences, information and technology. A formal Benefit Management tracking process was prepared at the commencement of the project and updated throughout the project. The analysis stage informed the proposed future structure of procurement within the hubs and the potential benefits arising. A review at the conclusion of this stage was undertaken to ensure buy-in of relevant key stakeholders, to consider the benefits and to confirm the continuance of the project.

A knowledge management strategy was developed from the "10 Knowledge Strategy Issues" and the "Knowledge based theory of the Firm" created by Karl-Erik Sveiby (2001).

The KM strategy for the project focused on increasing the knowledge and value within the procurement community and relevant stakeholders, and subsequently the 10 Sveiby strategies were developed to support the business requirements to effectively and efficiently procure goods and services.

As a result of the project analysis, minimal procurement competences and knowledge were identified in "frontline" business units and was identified that a recently implemented ERP system was not delivering its planned efficiencies. The ERP system was a powerful tool but the users were not fully aware of how it could be used and were unaware of its role in the supply chain and the totality of the system. As a result the first phase of the KM implementation focused on 5 of the Sveiby strategies and "individual competence" by:

- Improving the transfer of competence between people in the organization;
- Transferring competences to customers, suppliers and other stakeholders;
- Learning more from customers, suppliers and other stakeholders;
- Converting individually held competence to systems, tools and templates; and
- Improving individual's competence by using systems, tools and templates.

The PTP realities were that, through the use of the Prince II™ formal project management method, Stamm's innovations were all achieved.

5.0 OUTCOME AND BENEFITS

The project delivered both tangible and intangible benefits as the business units were receptive and open towards learning and a consensual style of organisation - these benefits were:

Table 1. Incremental innovation categorisation (as per Stamm)

Focus	Stamm's description	The PTP realities
Time frame	Short-term - 6-24 months	√
Development trajectory	Step by step. High levels of certainty.	√
Idea generation	Incremental. Critical events anticipated.	√
Process	Formal, staged.	√
Business case	Business case produced initially	√
Players	Cross-functional team. Clear roles.	√
Development structure	Cross-functional team within existing business unit.	√
Resources	Provided within team, standard process.	√
Operating unit	Involved from beginning.	√

Tangible

- Management reports for cross business procurement activity were derived from the ERP system;
- Procurement awareness workshops and material were developed and implemented;
- Procurement organizational design was undertaken;
- Buyer job specifications were developed and implemented;
- Salary savings were made as a result of the role scope changes;
- £700,000 plus savings were made through local training which enabled a wider usage of the GPC (Government Procurement Card i.e. a type of internal credit card), and the local decision-making and buying competences developed;
- A benefit tracking document was developed.

Intangible

- Local staff understanding of relationship between system activity and procurement practice was developed;
- An improved relationship with suppliers developed;
- Greater leverage in procurement negotiations occurred;
- An enlarged social network developed for informal sharing of procurement practices;
- There was knowledge sharing for system improvement;
- Enhanced system training was undertaken;
- Supply chain awareness was developed.

6.0 CONCLUSIONS

As John Ruskin said[2]:

It is unwise to pay too much, but it is worse to pay too little. When you pay too much, you lose a little money. When you pay too little, you sometimes lose everything.

Procurement is about providing the end users of the item procured with what they need, when they need it, and at the best value to the organisation. Procurement is a very complex task that is achieved through matching the multiple supplier offerings, through competition, with the multiple requirements of the purchasing organisation. Procurement has legal, ethical, specification, and supplier appraisal aspects. In all of these there are business processes that need to be undertaken and matched and integrated with each other. In each business process there will be found *sticky* knowledge (Coakes et al, 2004) which is related to tacit knowledge that will need to be considered and transferred. As argued above this sticky knowledge is often not transferred within the supply chain and procurement processes. As can be seen from the description of the work of the IND, their functions and connections within the UK Home Office are multiple and diverse. These multiple functions and activities can only complicate the procurement process. There is a requirement for a varied knowledge base and in-depth knowledge in a variety of fields of expertise.

In this paper therefore, we demonstrate through a case study of a UK project how knowledge within business processes and the supply chain for procurement can be identified, explicated, and made valuable through devolving decisions to those at the frontline of the decision-making process. Through utilising local knowledge, and developing competences and learning, with a change in organisational structure and management style, significant savings in procurement can be made.

REFERENCES

Abernathy W., & Clark, K.B., (1985) Mapping the winds of creative destruction *Research Policy* 14 pp3-22

Afuah, A., (1998) *Innovation management: Strategies, implementation, and profits* Oxford University Press: NY

Borins S., (2000) What border? Public management innovation in the Unites States and Canada *Journal of Policy Analysis and Management* 19 (1) pp46-74

Bowersox D.J., Closs D.J., & Cooper M.B., (2002) *Supply Chain Logistics Management* NY: McGraw-Hill

Chandy R.K., & Tellis, G.J., (1998) Organizing for radical product innovation: The overlooked role of willingness to cannibalize *Journal of Marketing Research* 35 (4) pp474-487

Coakes E., Bradburn A., & Sugden G., (2004) Managing and Leveraging Knowledge for Organisational Advantage *Knowledge Management Research and Practice* 2 2 pp118-128

Coakes E and Young N (2006) Procurement Transformation in the Immigration Directorate: the Money Tree Project.*BIOPom 2006* June Westminster

Coakes E and Young N (2007) "Transformation Procurement in the Immigration Directorate: applying Sveiby" Knowledge Management Challenges and Issues Special Edition *Journal of Knowledge Management Practice;* due Nov

El Sawy O., & Josefek R. Jr., (2003) Business Process as Nexus of Knowledge *Handbook on Knowledge Management* Vol 1 Berlin: Springer- Verlag pp425-38

Engardio P., (2001) Why the Supply Chain Broke Down *Business Week* p.41 03/19/2001

Gallouj F., (2002) Innovation in services and the attendant old and new myths, *Journal of Socio-Economics* 31 (2) pp137-154

Gershon Review, (2004), Releasing Resources for the Frontline: Independent Review of Public Sector Efficiency UK: *HM Treasury* July

Henderson R.M., & Clark, K.B., (1990) Architectural innovation: the reconfiguration of existing product technologies and the failure of established firms, *Administrative Science Quarterly* 35 (1) pp9-22

Home Office, (2006a) http://www.ind.homeoffice.gov.uk/aboutus/ accessed Sep 2006

Home Office, (2006b) (http://www.homeoffice.gov.uk/about-us/ accessed Sep 2006

Hsieh C-T., Yang H., & Lin B., (2002) Roles of knowledge management in online procurement systems *Industrial Management and Data Systems* 102 (7) pp365-70

IND, (2006a) (http://www.ind.homeoffice.gov.uk/aboutus/objectivesandvalues) accessed Sep 2006

IND, (2006b) http://www.ind.homeoffice.gov.uk/aboutus/whatinddoes accessed Sep 2006

Lockamy A., McCormack K., (2004) The Development of a Supply Chain Management Process Maturity Model Using the Concepts of Business Process Orientation *Supply Chain Management* 9 (4) pp272-278

Lyons Review, (2004), Independent Review of public sector relocation UK: *HM Treasury* July

Marchand D.W.,, Kettinger W., & Rollins J., (2000) Information Orientation: People, Technology and the Bottom Line *Sloan Management Review* 41 (4) Summer pp69-80

Popadiuk S., & Choo C.W., (2006) Innovation and knowledge creation: How are these concepts related? *International Journal of Information Management* 26 (4) Aug pp302-312

Prajogo D. I., (2006) The Relationship between Innovation and Business Performance - A Comparative Study between Manufacturing and Service Firms, *Knowledge and Process Management* 13 (3) pp218-225

Seeley C., (2002) Igniting knowledge in your Business Processes *K M Review* 5 (4) Sep/Oct pp12-15

Sinclair N., (2006) *Stealth KM: Winning knowledge management strategies for the Public Sector* Butterworth Heinemann: Oxford

Smith H.A., & McKeen J.D., (2004) Developments in Practice XII: Knowledge Enabling Business Processes *CAIS* 13 pp25-38

Stamm B von., (2003) *Managing innovation, design and creativity* Wiley: London

Swan J., (2003) Knowledge management in Action? *Handbook on Knowledge Management* Vol 1 Berlin: Springer- Verlag pp271-96

Sveiby K-E (2001a) A Knowledge Based Theory of the Firm to Guide Strategy Formulation *Journal of Intellectual Capital* 2 (4) retrieved from www.sveiby.com 21 May 2006

Sveiby (2001b) Knowledge Management – Lessons from the Pioneers http://www.sveiby.com/Portals/0/articles/KM-lessons.doc) accessed September 2006

Sveiby (2001c) A Knowledge-based Approach to Performance Excellence http://www.sveiby.com/Portals/0/articles/kbasedbaldrige.htm accessed Sep 2006

Tushman M.L., Anderson P.C., & O'Reilly C., (1997) Technological cycles, innovation streams, and ambidextrous organisations: organisational renewal through innovation streams and strategic change. In M.L., Tushman & P. Anderson (eds) *Managing strategic innovation and change: A collection of readings* Oxford University Press: NY

Voss C., Jonston R., Silvestro R., Fitzgerald L., Brignall T., (1992), Measurement of innovation and design performance in services, *Design Management Journal* 3 (1) pp40-46

Wimmer S.J., (2005) For Illinois Agency, Knowledge is Power - and Promise *Government Procurement* 13 (4) pp6-10 Aug

ENDNOTES

[1] APQC is the American Productivity & Quality Center

[2] 1888 is the approx year

Multi-Grounded Development of Enterprise Modeling Methods: The Case of SIMM

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ABSTRACT

Multi-Grounded Theory (MGT) extends Grounded Theory by further grounding processes, most notably theoretical grounding. As an example for applying MGT we use the enterprise modeling method SIMM, which is empirically grounded, and show that this method can profit from grounding it also in an external theory. We outline a procedure called communicative and material functions analysis that can be used for this purpose and apply it to Business Action Theory. With the help of the extended method we analyze a business situation in order to follow up the commitments that are made in the course of a business process with the ultimate aim of detecting flaws in that process.

1. INTRODUCTION

Grounded Theory (GT; Glaser, Strauss 1967; Glaser 1992; Glaser 1998; Strauss, Corbin 1998) was introduced to provide a systematic procedure for deriving categories and theoretical constructs from empirical data. GT is, strictly speaking, not a theory but rather a method for theory development. Its characteristics are the relatively short iteration cycles and a process of continual improvement. Starting with a small set of empirical data we develop an initial understanding of the problem field, which then can be used to gather further empirical data in a more controlled fashion, leading to an improved understanding and so on until we reach theoretical saturation.

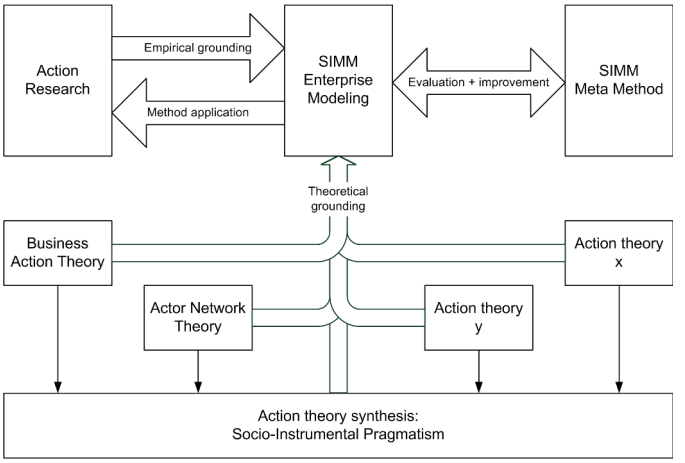
GT started out in sociology but has since been applied in a variety of fields including informatics. In the latter it has also been used to develop modeling methods, typically based on action research. An example of such a method is SIMM (Situation-adaptable work and Information systems Modeling Method; Goldkuhl 1996). SIMM has been empirically grounded in action research projects some of which are documented in (Lind, Goldkuhl 1997; Melin, Goldkuhl 1999; Axelsson et al. 2000; Goldkuhl, Melin 2001; Axelsson, Segerkvist 2001; Lind et al. 2003; Melin, Axelsson 2004; Johansson, Axelsson 2004; Johansson, Axelsson 2005; Haraldsson, Lind 2005). SIMM provides both a method for enterprise modeling and a meta-method for evaluating modeling methods.

Empirical grounding proceeds as follows: SIMM Enterprise Modeling is applied in an action research project. The experiences gained from the use of the method are evaluated with the SIMM Meta Method and corresponding changes to SIMM Enterprise Modeling are made. In a further round of action research these changes are consolidated and further improvements are made (see fig. 1).

GT has been criticized for being restricted to a purely inductive approach. It is argued that we cannot ignore the knowledge that established theories might contribute. Consequently, (Goldkuhl, Cronholm 2003) suggest that further grounding processes are required in addtion to the existing empirical grounding process, most of all a theoretical grounding process. They call this new approach Multi-Grounded Theory (MGT).

If we want to apply MGT in the context of enterprise modeling we must identify a suitable theory that can function as external theory for theoretical grounding. For the purpose of this paper we have chosen Business Action Theory (BAT; Goldkuhl 1996; Goldkuhl 1998; Goldkuhl, Lind 2004) because some preliminary work has already been done in that area. E.g. (Goldkuhl 1996) has extended SIMM to cover communicative actions, which are essential in BAT. Many other important concepts such as layers and phases have been disregarded, though. It is the purpose of this paper to complete the theoretical grounding of SIMM in BAT.

Figure 1. Multi-grounded development of an enterprise modeling method



This can be considered as a first step, as a grouding in other action theories might also be considered. But as the choice of external theory is contingent there are strong arguments to synthesize the relevant theories as Goldkuhl (2005) pointed out. The result, Socio-Instrumental Pragmatism (SIP; Goldkuhl 2002; Goldkuhl 2005), is a general ontology of social action. So far it is not sufficiently developed to provide a basis for theoretical grounding. We therefore restrict our approach to BAT for the purpose of this paper.

The remaining sections are structured as follows: We first introduce BAT and the generic layered patterns for business modeling. This framework is then refined by combining phases and layers. We proceed by applying communicative and material functions analysis to it, followed by a classification of the resulting functions, and finally leading to the extension of SIMM in terms of BAT concepts. We conclude by presenting an application of the extended method for the purpose of commitment analysis.

2. BUSINESS ACTION THEORY

The elementary unit of behavior in BAT is a business act. It comprises both a language act and a material act. A language act is an elementary communicative activity in spoken or written form directed from one actor to another with the aim of changing the mental state of the latter. A material act is an elementary physical activity directed from an actor to the material world with the aim of changing its state.

Strictly speaking, and as observed by Goldkuhl (1996), language and material acts are not so much distinct and separate acts but rather functions (or aspects) of one and the same business act. For example, the business act of delivering goods is, perhaps in the first place, a material act. i.e. transporting "stuff" from one place to another. But at the same time it has a communicative function, i.e. it implies the language act "We have fulfilled the commitment we entered by accepting the respective order."

This means that a deeper understanding of business action must be grounded in an analysis of these functions. We call this analysis 'communicative and material functions analysis' and use it as a basis for deriving concepts for modeling business actions. The objectives of such an analysis are

1. to find the communicative and material functions that are inherent in a generic or specific business act,
2. to classify the identified functions, and
3. to derive suitable concepts for business action modeling.

We apply the procedure to BAT itself to derive concepts for enterprise modeling that refine and extend an existing method: SIMM. A business process in BAT is divided into 6 phases:

1. Business prerequisites phase
2. Exposure and contact search phase
3. Contact establishment and proposal phase
4. Contractual or commitment phase
5. Fulfilment phase
6. Completion or assessment phase

BAT was introduced by Goldkuhl (1996) and was enhanced in (Goldkuhl 1998) and (Goldkuhl, Lind 2004). It is ontologically rooted in Socio-Instrumental Pragmatism (SIP; Goldkuhl 2002), which combines communicative (social) and material (instrumental) aspects of actions. The roots of BAT are Speech Act Theory (Austin 1962; Searle 1969) and the Theory of Communicative Action (Habermas 1984).

In BAT business interaction involves two principal players, supplier and customer (see fig. 2). The phases are constituted by generic business actions on each side of the transaction (see table 1).

The business actions follow a certain execution logic but the whole transaction is by no means linear. In the proposal phase, for example, the supplier can make any number of offers where each one will typically meet the customer's needs better than the preceding one. Likewise the customer can make a series of inquiries that usually become more and more "realistic". These loops terminate when offer and inquiry are sufficiently close to each other to reach an agreement whereupon we enter the contractual phase. In an ideal scenario this consists of the customer placing an order and the supplier confirming it. Both actions together constitute a contract the fulfilment of which is subject of the next phase. Here the supplier, again ideally, delivers the products/services and sends a corresponding invoice. The customer receives the delivery and makes the payment, which the supplier finally receives. In the completion phase each party decides whether they accept the delivery/money or make a claim, i.e. request the fulfilment of that part of the contract they consider unfulfilled.

Orthogonal to the phases (Lind, Goldkuhl 2001) introduced another dimension: layers. They extend and modify the layers originally suggested by Weigand and van den Heuvel (1998). Layers refer to the granularity of an action and they are, from fine grain to coarse grain: business act, action pair, exchange, business transaction and transaction group.

Figure 2. A business transaction in BAT (Lind, Goldkuhl 2005)

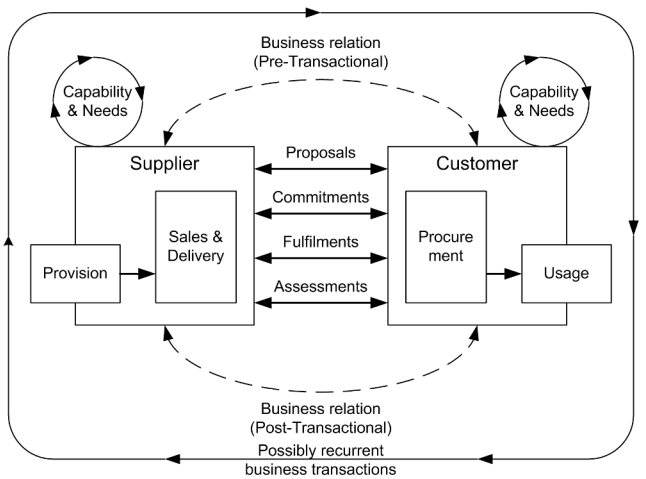


Table 1. Generic business actions

Phase	Supplier	Customer
Prerequisites phase	Product/offer development	Identification of problems/ needs
Exposure & contact search phase	Offer exposure	Contact search
Proposal phase	Offer	Inquiry
Commitment phase	Order confirmation	Order
Fulfilment phase	Delivery, Invoice, Receipt of payment	Receipt of delivery, Payment
Assessment phase	Acceptance, Claim	Acceptance, Claim

3. REFINING THE FRAMEWORK

A theoretical grounding in BAT has to take into account both dimensions, phases and layers. Strictly speaking, the phases are only a refinement of a particular layer, namely the transaction layer. To derive BAT concepts for SIMM we also need a refinement of the other layers. Such a refinement is suggested in figure 3.

On the fifth and final layer the same customer and supplier engage in a number of transactions over a longer period of time thus forming a stable business relation (Axelsson et al. 2000; Goldkuhl, Melin 2001). The transaction layer is divided into exchanges (they correspond to the phases). An exchange consists of two handover actions: One directed from supplier to customer and the other vice versa. These handovers usually happen one after the other where the second happens in return for the first but the order is not predefined, i.e. in some cases the supplier hands over first and in others the customer. An action pair is a pair of actions where the first one is a trigger (initiative) and the second a response. Actions can have a dual function so the response of one action pair can be the initiative of another. A business act is elementary and has a primary function which is always communicative but can also have a secondary function (communicative or material).

4. COMMUNICATIVE AND MATERIAL FUNCTIONS ANALYSIS

A business act consists of one or more functions. Goldkuhl (1996) gives the example of a (commercial) offer, which can be a single business act that has two communicative functions,

1. that of requesting the potential customer to buy (i.e. to place an order),
2. that of committing the potential supplier to sell (i.e. to deliver) under certain conditions.

Figure 3. Structure of the layers

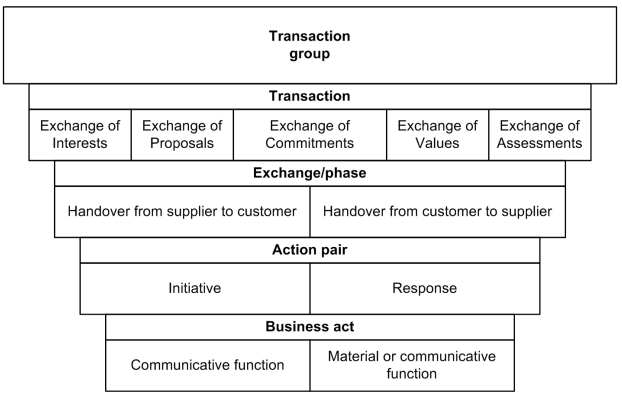


Table 2. Communicative & material functions of the generic business actions

Business Action	Communicative/material function	Business Action
Offer exposure	*State* general offer	Offer exposure
Contact search	*Express* interest	Contact search
Inquiry	*Request* commercial offer + *Express* interest	Inquiry
Commercial offer	*Offer* delivery + *Request* order	Commercial offer
Order	*Request* delivery + *Offer* payment	Order
Order confirmation	*Promise* delivery	Order confirmation
Delivery	*Transfer* merchandise/*Perform* service + *State* delivery	Delivery
Invoice	*Request* payment + *State* contract fulfilment [supplier]	Invoice
Receipt of delivery	*Accept* delivery + (*Accept* contract fulfilment [supplier])	Receipt of delivery
Payment	*Transfer* money + *State* contract fulfilment [customer]	Payment
Receipt of payment	*Accept* payment + (*Accept* contract fulfilment [customer])	Receipt of payment
Acceptance	*Accept* contract fulfilment [supplier or customer]	Acceptance
Claim	*Request* contract fulfilment [supplier or customer]	Claim

If we apply that kind of analysis, which we call communicative and material functions analysis, to the remaining generic business actions we get the results shown in table 2.

These results show that a business act typically has one or two functions. The communicative function is always present (even in the case of material acts) but there might be another function of either type. This is reflected in the model of figure 3.1. The generic business action "receipt of delivery or payment" can in some cases imply the acceptance of the contract fulfilment. In other cases the acceptance is stated explicitly (i.e. separately in the assessment phase) or a claim is made.

We are aware of the fact that such a list of generic actions and their functions can only serve as a recommendation that covers some typical or common situations. It is not meant to be a prescriptive template for all business interactions. Using that analysis in a different context might yield different actions and even different functions concerning the same actions. But the results can nevertheless be useful to find a set of recurring material and communicative functions that can be used as a pattern for a modeling language.

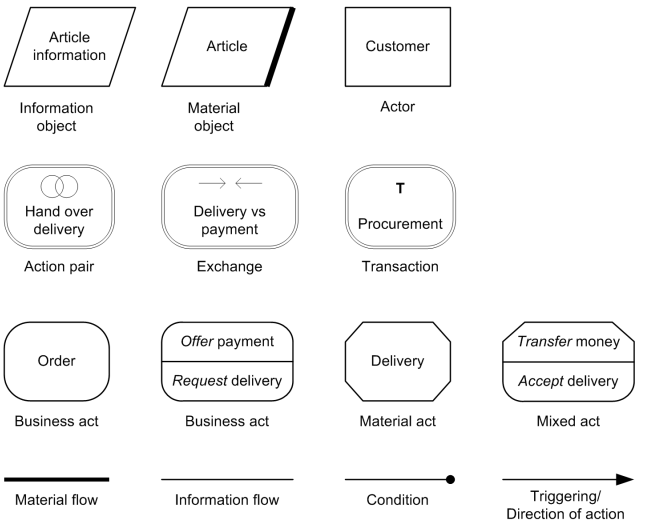
5. EXTENDING SIMM

The results from the communicative and material functions analysis are now used to enrich the SIMM method. This extension is part of theoretical grounding with the external theory being BAT. The techniques for such an extension are offered by (situational) method engineering (Ralyté et al. 2003). The idea behind method engineering is to design methods in such a way that they fit the specific modeling situation. This can be done in different ways. One way is to extend an existing method. Using this approach, we enrich and refine the language of SIMM with the concepts from the analysis.

SIMM provides three basic categories: actors, actions and (action) objects. The latter are divided in information and material objects. Examples of them are shown in fig. 6.1 but SIMM offers many additional types. For non-elementary actions the circumference is drawn as a double line and an inscribed symbol identifies the layer (see fig. 4). If a material function is involved we may use an octagon. The box is labelled with the business act or the respective function(s) where the function header is italicized.

Among the notational elements there are also four types of arcs. The condition arc allows us to show that one action is a condition for another action with the black dot being attached to the latter. The arrow serves two purposes. If it points from one action to another, the former triggers the latter. If it points from one actor to another, it represents an action that is directed from the first actor to the second. In this case the name of the action is written along the arrow. It can be accompanied by a symbol denoting the layer. For communicative or material functions we can also use a circle or a diamond, respectively. As an alternative to the arrow form of the action the boxed form of the action can be interlaced with the arrow.

Figure 4. Concepts for business action modeling and their notation



6. APPLYING THE EXTENDED METHOD: A CASE STUDY

Commitment analysis in terms of language action was introduced by Auramäki et al. (1988). We performed it in a project with two companies that have a very close business relationship. One of them is the headquarters of a retail chain, the other a third-party logistics provider (LogPro). Our goal was to detect and solve major problems in their relationship. For this we analyzed order processing and delivery. We intended to use SIMM Interaction Diagrams but required additional information on the type and level of an action so we enriched the diagram with the features introduced above. The result is shown in fig. 5.

The process starts when Headquarters send an estimate regarding the required capacity for future orders. There are three types of orders. A customer order is initiated by the Shop on behalf of a customer who wishes to buy an article that is not currently available. The refill order is triggered by Headquarters when the stock is running low. Both are on the action-pair level because they require confirmation from the partner. The third type is called distribution order. It is based on a negotiated budget and the Shop is obliged to accept it. This order is therefore only a single speech act with an informative character. The budget negotiation, however, is bilateral. It consists of an exchange of budget proposals initiated by Headquarters.

All orders are combined into one and forwarded to LogPro. LogPro will perform delivery to the Shop. Headquarters inform the Shop about an upcoming delivery and receive a confirmation when it arrives (delivery handshake). In regular intervals LogPro bill their services to Headquarters.

In the next step we developed detailed Interaction Diagrams. The one for LogPro and Headquarters is shown in fig. 6 on the business-act level. It shows that Headquarters send a capacity estimate first. On the day of delivery a pick file is

Figure 5. Enriched interaction diagram

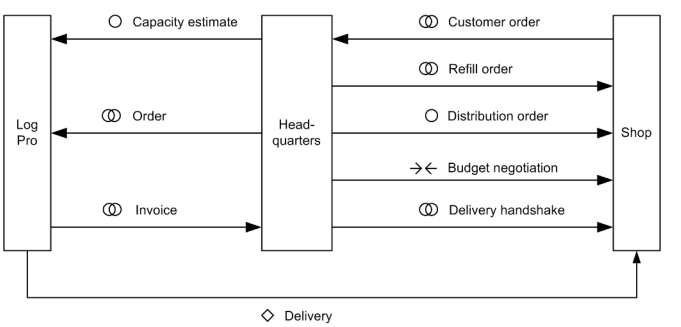
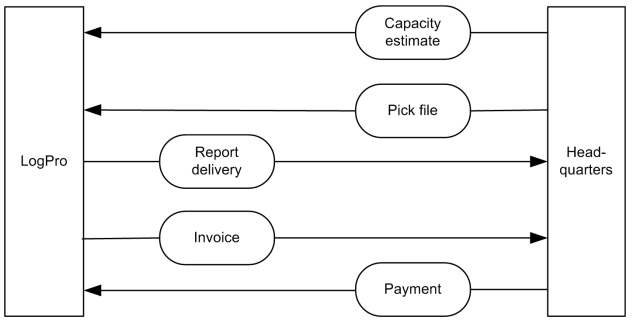


Figure 6. Detailed interaction diagram



transferred to LogPro that contains the order data. This is used to pick the articles from the shelves and to pack them. As soon as they are on their way, LogPro reports delivery to Headquarters. At the next billing occasion LogPro send an invoice and Headquarters make the respective payment.

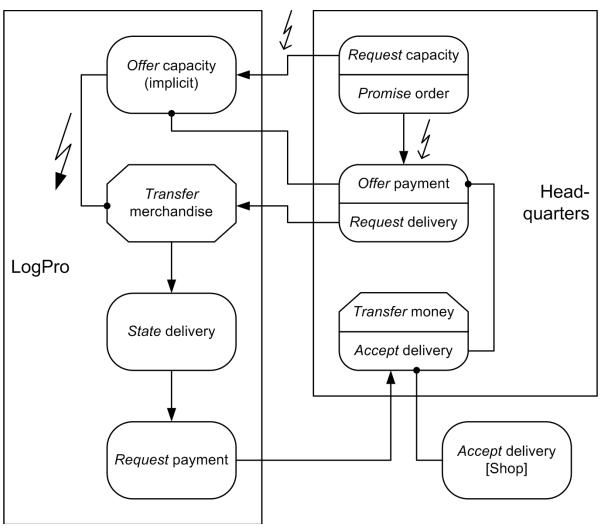
For commitment analysis we need more information about how actions are related to each other. This implies exhibiting their communicative and material functions that lead to the establishment or fulfilment of commitments and the conditional and causal relations between them. This helps us to uncover broken commitments. For this purpose we employ a Business Act Diagram (see fig. 7).

The capacity estimate implies a request to provide this capacity and a promise to place a respective order. LogPro offers to provide the capacity subject to the order and the implied offer of payment. The capacity offer is implicit (i.e. not communicated) because LogPro is required to provide it by virtue of the frame contract. The provision of capacity is a condition for performing the delivery that is triggered by the respective request from Headquarters (a function of the order). The other function, offer payment, is subject to an accepted delivery. The delivery triggers a respective report (state delivery) which in turn initiates the invoice (request payment). The latter triggers the payment (transfer money) but only if the Shop has confirmed the arrival of the delivery. Headquarters confirm acceptance of the delivery towards LogPro implicitly by paying the invoice. Therefore "Transfer money" and "Accept delivery" are functions of the same business act.

The Business Act Diagram has shown us that commitments are broken in three different places (see the flash symbols in fig. 7):

1. Headquarters promise that the order will require the requested capacity but in reality orders often deviate substantially from the estimates.
2. The request for capacity is not in a suitable format for LogPro so that capacity planning does not work but Headquarters rely on it.
3. Due to 1 and 2 the prerequisites for delivery are often not given leading to higher costs and occasional failures to meet delivery deadlines.

Figure 7. Business act diagram



We have used this approach for other parts of the business process where we also succeeded in identifying bad commitment management.

7. CONCLUSION

According to MGT a modeling method can be informed by grounding it in some theory or theories. We have chosen Business Action Theory to inform the existing enterprise modeling method of SIMM. Grounding is performed via a procedure called communicative and material functions analysis. The result is an extended method that reflects the properties of the theory. We have shown the usefulness of this approach in the context of a case study involving the analysis of commitments in an interorganizational business process. Future research might investigate the theoretical grounding of enterprise modeling in a more general theory or ontology.

8. REFERENCES

Auramäki, E., Lehtinen, E., Lyytinen, K. (1988). A Speech-Act-Based Office Modeling Approach. ACM Transactions on Office Information Systems 6(2), pp. 126-152.

Austin, J. L. (1962). How to Do Things with Words. Oxford University Press.

Axelsson K., Goldkuhl G., Melin U. (2000) Using Business Action Theory for dyadic Analysis. In Proceedings of the 10th Nordic Workshop on Interorganisational Research, Trondheim, August 18-20, 2000. CMTO Research Papers No. 2000:10

Axelsson K., Segerkvist P-A. (2001) Interaction between actors and information systems in web-based imaginary organisations – Experiences from two case studies. In Proceedings of the 1st Nordic Workshop on Electronic Commerce, Halmstad, Sweden, May 28-29, 2001

Glaser, B. (1992) Basics of Grounded Theory Analysis, Sociology Press, Mill Valley, Ca.

Glaser, B. (1998) Doing grounded theory: issues and discussions. Sociology Press, Mill Valley, Ca.

Glaser, B., Strauss, A. (1967) The discovery of grounded theory, Aldine, New York

Goldkuhl, G. (1996). Generic business frameworks and action modelling. In Dignum, F., Dietz, J., Verharen, E. and Weigand, H. (eds.): Communication Modeling – The Language/Action Perspective, Proceedings of the First International Workshop on Communication Modeling, Electronic Workshops in Computing, Berlin: Springer.

Goldkuhl G. (1998). The six phases of business processes - business communication and the exchange of value. 12th biennial ITS conference "Beyond convergence" (ITS´98), Stockholm.

Goldkuhl G. (2002). Anchoring scientific abstractions – ontological and linguistic determination following socio-instrumental pragmatism. European Conference on Research Methods in Business and Management (ECRM 2002), Reading, 29-30 April, 2002.

Goldkuhl, G. (2005) Socio-Instrumental Pragmatism: A Theoretical Synthesis for Pragmatic Conceptualisation in Information Systems, in Proceedings of the 3rd International Conference on Action in Language, Organisations and Information Systems (ALOIS), University of Limerick

Goldkuhl, G., Cronholm, S. (2003) Multi-grounded theory – adding theoretical grounding to grounded theory, 2nd European Conference on Research Methods in Business (ECRM), Reading

Goldkuhl G., Lind M. (2004). Developing e-interactions – A framework for business capabilities and exchanges. 12th European Conference on Information Systems, June 14-16, 2004, Turku, Finland

Goldkuhl, G., Melin, U. (2001). Relationship Management vs Business Transactions: Business Interaction as Design of Business Interaction. 10th International Annual IPSERA Conference, 9-11 April, 2001, Jönköping International Business School.

Habermas, J. (1984). The Theory of Communicative Action 1, Reason and the Rationalization of Society. Boston: Beacon Press.

Haraldson S., Lind M. (2005) Broken patterns. In Proceedings of the 10th International Conference on the Language Action Perspective, Kiruna, Sweden

Johansson B.-M., Axelsson K. (2004) Communication media in distance selling – Business Interactions in a B2C Setting. In Proceedings of the 12th European Conference in Information Systems (ECIS), Turku, Finland.

Johansson B.-M., Axelsson K. (2005) Analysing Communication Media and Actions – Extending and Evaluating the Business Action Matrix. In Proceedings of the 13th European Conference on Information Systems, Regensburg, Germany.

Lind M., Goldkuhl G. (1997) Reconstruction of different business processes - a theory and method driven analysis. In Proccedings of the 2nd Intl Workshop on language/action perspective (LAP97), Eindhoven University of Technology, The Netherlands.

Lind, M., Goldkuhl, G. (2001). Generic Layered Patterns for Business Modelling. In Proceedings of the Sixth International Workshop on the Language-Action Perspective on Communication Modelling (LAP 2001) Montreal, Canada, July 21-22, 2001.

Lind M., Goldkuhl, G. (2005). Designing business process variants. Business Process Design Workshop at the Third International Conference on Business Process Management, September 5-8 2005, Nancy, France.

Lind M., Hjalmarsson A., Olausson J. (2003) Modelling interaction and co-ordination as business communication in a mail order setting. In Proceedings of the 8th International Working Conference on the Language Action Perspective (LAP2003), Tilburg, The Netherlands.

Melin U., Axelsson K. (2004) Emphasising Symmetry Issues in Business Interaction Analysis and IOS. In Proceedings of the Sixth International Conference on Electronic Commerce, ICEC'04, Delft University of Technology, The Netherlands.

Melin U., Goldkuhl G. (1999) Information Systems and Process Orientation - evaluation and change using Business Action Theory. In Wojtkowski W (eds) Systems Development Methods for Databases, Enterprise Modeling, and Workflow Management, Kluwer Academic/Plenum Publishers, New York.

Ralyté, J., Deneckère, R., Rolland, C. (2003). Towards a Generic Model for Situational Method Engineering, In Proceedings of 15th International Conference on Advanced Information Systems Engineering (Caise 2003), Klagenfurt, Austria, June 16-18, 2003, (Eds, Eder J, et al.) Heidelberg, Germany: Springer-Verlag, pp. 95-110.

Reijswoud, V. E. van, Mulder, H. B. F., Dietz, J. L. G. (1999). Communicative action-based business process and information systems modelling with DEMO. Information Systems Journal 9(2), pp. 117-138.

Searle, J. R. (1969). Speech Acts, An Essay in the Philosophy of Language. London: Cambridge University Press.

Searle, J. R. (1979). Expression and meaning. Studies in the theory of speech acts, Cambridge University Press, London.

Strauss, A., Corbin, J. (1998) Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory, Sage Publications, Thousand Oaks, CA.

Verharen, E. (1997). A language-action perspective on the design of cooperative information agents. PhD thesis, KUB, Tilburg.

Weigand, H., van den Heuvel, W.J. (1998). Meta-Patterns for Electronic Commerce Transactions based on FLBC. Hawaii International Conference on System Sciences (HICSS '98), IEEE Press.

Evaluating Complexities in Software Configuration Management

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INTRODUCTION

In software engineering, software configuration management tools such as Apache Ant, CVS or ClearCase [1, 3, 5, 9] are often included as an integral part of constructing large information systems or managing changes in information systems [7, 8, 11]. It is often assumed that the organizations involved in the development and support of information systems have naturally embraced the concept of software configuration management. While enterprises engaged in medium to large size information systems development and support do subscribe to the concept of configuration management, many smaller establishments only pay lip services to this important activity. In this paper we will explore the reasons behind this through analysis of levels of complexity in software configuration management (SCM). First SCM will be discussed, categorized and divided into four different dimensional areas. Then a set of volume metrics related to these dimensional areas will be defined. Levels of complexities of SCM, in terms of volume metrics, will be explored. We will utilize a real case of a software application development to demonstrate the utility of these metrics and how the levels of complexity of SCM may be used to help the decision process of incorporating SCM and SCM tools. Ultimately, our goal is to provide a clear measure of the degrees of SCM and an ordering scheme of implementing SCM.

SOFTWARE CONFIGURATION MANAGEMENT

Configuration management initially started with the management of pieces and parts. In software systems this often meant the management of files. As software systems became more complex and larger in size, the number of files and the structure that needed to be placed on top of the files had to be managed. Also, software systems became more expensive, and the life span of a software system extended into multiple years after its initial release. The large number of changes to the software system and the lengthy period of maintenance cycles of a software system needed some form of change management. This precipitated the inclusion of change control as an essential component of software engineering. SCM, as a discipline of managing parts and managing changes, started to grow in scope. It is an integral part of the software processes described by Software Engineering Institute [10]; however, it continues to be a domain of software engineering that is understood by a relatively small number of information and software engineering experts.

A software configuration management system provides a wide range of functionality. Dart [6] first classified this range of concepts into fifteen areas as follows:

- Repository
- Distributed component
- Context management
- Contract
- Change request
- Life-cycle model
- Change set
- System modeling
- Subsystem
- Object pool
- Attribution
- Consistency maintenance
- Workspace
- Transparent view
- Transaction

Not all of these functionalities are implemented by any single SCM tool. These functional areas are inter-related in serving four critical dimensions of software configuration management [4,11].

- a mechanism that describes the artifacts that will be managed
- a mechanism to capture, access, and control the artifacts
- a mechanism to construct a specific product out of the artifacts
- a mechanism that describes the relationship among the artifacts

Artifact Identification

In order to manage a large number of pieces of software artifacts, we must be able to identify and specify those artifacts that are produced through the development and support activities. The decision of which artifacts need to be managed is based on the project and the process. If the deployed process of the software project states that only executable source code is of importance and that is the only artifact type that needs to be managed, then we only need to label code pieces and manage the changes to the code. On the other hand, if other artifacts from the requirements, design, and test phases are considered important, then the mechanism must include all of them. The mechanism must be able to identify and specify the artifacts within each artifact type. In addition, a specific piece of artifact, regardless of type, may experience several iterations of changes. In order to control changes, each version of the changes may need to be kept. Thus, the artifact identification mechanism must be able to allow different level of sophistication, which is in turn dependent on the over all software process employed.

Let A be the set of artifacts that the software project process has determined to manage. Then for a specific artifact x in A, there needs to be at least three attributes: name, version and type. Thus for x, the three attribute components formulate a unique identifier as follows.

artifact identifier = name **.** version **.** type

Name may be a string of characters of some predetermined length. Version may be an integer of some predetermined number of positions. Type may be a two position code to identify artifact types such as requirement, design, logic code, screen code, data base table, help text, test case, etc. The symbol, ".", separates the three components of the identifier.

Artifacts Capture and Control

After each piece of software artifact can be uniquely identified, it still needs to be managed. There are two components to this dimension. First, all the artifacts must be captured. This is a fundamental activity of configuration management. If there is no one place where all the pieces and parts are kept, then assembling and building a system would be left to a high degree of chance of failure. Something inevitably is lost at the worst time such as the night before the software product release. The larger is the number of individual pieces of artifacts, the greater is the opportunity to lose something.

The second part is the access and control of the artifacts. There is rarely a situation where nothing is changed. Practically every type of artifact in software development and support experiences some degree of change. These changes must be conducted under a controlled process or the software system will quickly degenerate into a non-manageable system. The degree of control required depends on several parameters:

- number of artifacts under configuration management
- the anticipated amount of changes
- the number of people involved in the project
- the geographical and time distribution of work efforts related to the changes

Check-in and Check-out [1,3,5,9] are the two most often mentioned functions related to the access and control of artifacts. Check-out is the retrieval function. Except for security reasons, all artifacts may be retrieved. If an artifact is retrieved for the purpose of viewing, then another function, such as View, may be used. However, if an artifact is retrieved with the intent of performing a change to it, then it must be retrieved with the Check-out function. This is so that any conflict from multiple changes to the same artifact can be controlled. An artifact which is Checked-out is balanced with a Check-in of that artifact. An artifact that is currently Checked-out may not be Checked-out by another party until it is formally returned through Checked-in. Once a Checked-out artifact is updated through a Check-in, then essentially a new version of that artifact is formed. Thus the Check-out and Check-in pair of mechanism, along with version update, not only controls multiple changes but also keeps a history of the changes. Beyond this pair of basic control function, there are many other functions, such as compare or version incrementing, that exist to support the control mechanism. The amount of capture, access and control functionality needed, again, depends on the project.

Construct or Build

It would be somewhat pointless to have all the pieces identified, collected and put under control unless we are able to build a final software system that executes correctly. The construction activity is sometimes known as the Build. The simplest Build is the compile and link of a single module. Most of software systems are composed of a number of artifacts that require a much more complicated, multiple statements direction which includes the following information.

- the files which contain the different sources for compilation
- the target files for the results of compilation
- the different files required for the activity of linking
- the target files for the results of linking

More formally, the Build process may be described as two levels of relations, R1 and R2.

R1 is the relation that describes where the identified artifacts are stored and can be accessed.

R1 = A x F where, A is the set of identified artifacts and F is the set of folders or libraries where these artifacts are stored

R2 is the relation that maps R1 into steps of compile and link activities. The specific numerical order is important here. Thus it is defined as follows.

R2 = R1 x N where, R1 is defined as above and N is the natural numbers, which serve as an ordering mechanism

Thus the relation, R2, may be viewed as a sequence of steps in the build.

Software code Build is composed of and dependent on how well the two relations, R1 and R2, are constructed.

The time for a code Build cycle is directly related to R2, which is the sequence of steps to copy, compile, and link the code. Often times the Build cycle for a large, software system requires several mid-way interruptions and attempts to correct errors due to complexity of R1 or R2.

A comprehensive Build for a complete software product that includes the construction of executable code and of non-executables, such as User Guide or Read Me First notes, today requires multiple tools and different methodology. There does not exist one Build tool that can construct multiple artifact types. In order to perform such a complex Build, the SCM system must include the capability to handle, not just multiple versions of artifacts, but also relationships among multiple artifact types.

Artifact Relationships

With very small software projects, there may not be a complicated relationship among the artifacts. However, even with managing just one type of artifact, such as code, we need to account for the pieces of source code and the pieces of executable code. The source code is the artifact developed by the "coders". The executable, on the hand, is the post-compiled code. In order for the developed software to execute, often it requires the use of many other existing components. The obvious ones are the underlying operating system, the data base system, and the network system. In addition, there may be executable code from system and private libraries that must be included for the developed source code to compile and execute properly. Thus even within the code artifact type there may need to be a further differentiation of sub-types of code.

For very large projects where the process dictates that multiple types of artifacts are needed, two types of relationship within the project need to be considered.

- Intra-artifact relationship and
- Inter-artifact relationship

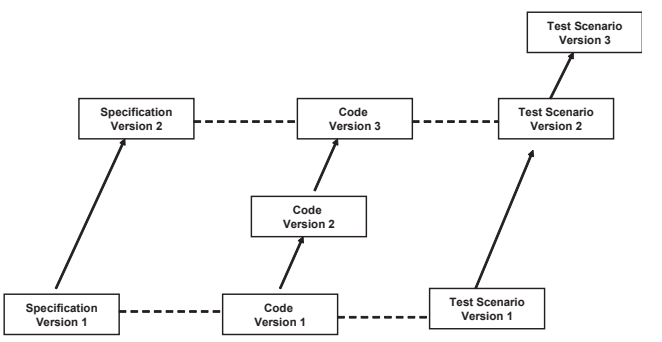
The intra-artifact relationship defines the relationship of the pieces within an artifact type. In the case of the executable software code artifact, the intra-relationship is stated in a set of statements related to the compilation and linking of the source code and reuse of other code in different libraries. This is a relatively simple software build process. If we require the use of other executable code such as a Tomcat [2] middleware or a specific database, then those executable code libraries must also be included in a larger build process where there is still a single artifact type but a large number of artifacts residing in different places.

The inter-artifact relationship defines the connections among different artifact types such as a requirement specification text, a source code which implemented that requirement, and a test scenario to test that implemented source code against the requirement specification. The relationship among these three types of artifacts may be further complicated when we introduce versions of the changes within each artifact type. See Figure 1.

Note that in Figure 1, the inter-artifact relationship among the specification, code, and test scenario artifacts are represented with dashed lines. The intra-artifact relationship is shown with solid arrows. There are two versions of specifications, three versions of code, and three versions of test scenarios. Associated with the first version of specification are version 1 and version 2 of code and version 1 of test scenario. The reason behind having two versions of code may be due to some error correction made to version 1 of code after conducting a test with version 1 of test scenario. Thus version 2 of code is the most updated version related to version 1 of specification and version 1 of test scenario. When the specification is updated to version 2, a code change is made and the related code is vesion3. The test scenario is updated to version 2 to reflect the corresponding changes made to version 1 test scenario. It is possible that the test scenario version 2 had an error and required a further update to create a version 3 test scenario. Thus specification version 2, code version 3 and test scenario version 3 form another inter-relationship among these three artifact types.

Keeping and maintaining a web of these relationships for a large software project can quickly turn into a nightmare. As the degree of complexity of inter and intra

Figure 1. Inter-relationship and intra-relationship



artifact relationships increases, an automated tool to help manage these relationships would definitely be a plus.

An ideal software product build would need to extend the current code Build. As such, the set of artifacts, A, in R1 would need to include all types of artifacts. R1 may be expanded to R1'. First define A_{tn} and $R1'_{tn}$.

A_{tn} = set of artifacts of type n

$R1'_{tn} = A_{tn} \times F$

Then, the extended R1, which includes more than one type of artifacts, is defined as:

$R1' = <R1'_{t1}, R1'_{t2}, - - -, R1'_{tn}>$

The activities of compile, link, merge, etc. depending on the artifact type, A_{tn}, for the second component of universal build would be defined as follows.

$$R2' = \{ R1'_{t1} \times N, \; R1'_{t2} \times N, \; \ldots \; R1'_{tn} \times N \}$$

Thus a general software product Build, which includes multiple artifact type relationships, is composed of R1' and R2'.

METRIC FOR SOFTWARE CONFIGURATION MANAGEMENT

In this section some basic metrics that applies to the four major dimensions of SCM will be introduced. The first metric gauges the volume of software artifacts that needs to be managed. Thus it impacts the dimensions of i) artifact identification and ii) artifact capture and control. SCM volume is an accumulation of all the uniquely identifiable artifacts. The SCM artifact volume, AV is defined in terms of the components of the artifact identifiers: name, version and type.

$$AV = \sum \text{unique artifact} = \sum \text{type} \sum \text{version} \sum \text{name}$$

Note that for each artifact name within an artifact type, there may be different number of versions. Pick the artifact name, across all the artifacts, which has the largest number of versions. Let that version number be version-max. Then the volume of the software product is bound by AVmax.

$$AV \leq AVmax = (\#\text{ of types}) * (\text{version-max}) * (\#\text{ of names})$$

The second metric is associated with SCM build. The normal code Build deals with just the single artifact type, code. Code build volume, CBV, may be measured in terms of R1 and R2. The ideal software product build may handle multiple artifact types. Thus SCM build volume for the ideal build, IBV, may be measured in terms of R1' and R2'.

First we define CBV as composed of two volumes, a) VR1, volume of R1 and b) VR2, volume of R2. Assume an element, a, to be an artifact of code type, and f to be an element of folders or libraries.

CBV = (VR1, VR2) where
VR1 = # of pairs in A x F $= \sum (a, f)$
VR2 = # of steps in the sequence {R1 x N}

Note that these two volumes, VR1 and VR2 can not just be arithmetically added together to give CBV a single number because they are two different units. VR1 is pairs in A x F, and VR2 is elements in a sequence. IBV is also defined in terms of its components, R1' and R2'.

IBV = (VR1', VR2') where
$VR1' = \sum R1'_{tn} = \sum (A_{tn} \times F) = \sum \text{type} \sum (a_{type}, f)$
$VR2' = \sum \text{type} \sum (R1'_{type} \times N)$

Thus IBV is a pair composed of a volume, VR1', and VR'2. VR1' is the sum of pairs of (artifact, folder) across all the artifact types that is to be built, and VR2' is composed of number of steps in a sequence of build activities for each artifact type summed across all artifact types included in the software product build. Thus both CBV for code and IBV for more general build may be used as metrics for the dimensionalities of iii) artifact build of SCN and iv) artifact relationships of SCM.

UTILITY OF SCM METRICS

In this section we will describe our experience with a small application software project and the utility of these metrics in the decision process of whether an SCM tool needs to be brought in.

The application software project was initiated in 2002 to automate the graduate admissions process for three graduate departments. There are three major functional areas in the application software. Initially, requirements were collected and documented. Several rounds of requirements modifications were incorporated and a final specification document was produced. The developers then took over and the product was constructed and tested. All the discovered defects were fixed and the product was released with a 2 weeks period of product support by the original developers. The project statistics are as follows.

- Duration: 4.5 months
- # of people: 14 (part-time)
- People effort: 1344 person hours
- Major Artifact Types: Requirements Specification, Code, Test Cases, Test Reports
- Build Artifacts: 20 Java code files, 27 JSP code files for screens, 19 relational tables
- System platform: Apache Tomcat, Microsoft Window, Access DB

The initial developers managed the requirement specification as one evolving artifact, using an excel spreadsheet to track the major functional requirements. The requirements were collected by multiple persons, but the actual authoring of the specification was performed by one person. The implementation team divided the work among 1) data base code, 2) screen code and logic code by functional areas and 3) a control logic flow code. Essentially, the design and coding efforts were carried out pretty much together by the implementers, and the unit tested versions of the code were all submitted to one person who replaced existing code with new submissions. Thus only one version of code was ever kept.

The Build activity included only one artifact type, code. Only one final version of the requirements was kept and that related to the entire set of code artifacts. Test cases were kept but not controlled. Thus, code version is 1, and there were a total of (20 + 27 + 19) or 66 unique code artifacts.

$$AV = \sum \text{type} \sum \text{version} \sum \text{names} = \sum \text{names} = 66$$

CBV = (VR1, VR2) = (18 , 44) where
VR1 = 18 pairs of (a, f)
VR2 = 44 steps in the sequence of instructions

The application software product was essentially composed of the requirement document and one final version of code artifacts. So there was no reason to consider artifact relationship. The software product build is the same as code build, and IBV = CBV. For this level of complexity, the SCM utilized was an accounting of a list of artifact names and a code build with Apache Ant tool [1].

The application software has gone through two more rounds of modifications. Although several code artifacts were modified, no new code artifact was added to

the software application system. Since the newest version just replaced the existing version, no change history was kept. After two years and two maintenance cycles, the SCM metrics remained the same, with AV = 66, and CBV = (18 , 44).

Now the software application is in its fourth year and there is a large set of new requirements. The new software project will involve more than just minor modifications. First the current running system must be kept running, and a duplicate but completely separate application system needs to be made. Thus there will be 2 versions of all the code artifacts. The new set of requirements will be associated with the second code version, and the old requirements of 4 years ago will be associated with the existing code version. The large set of new requirements is expected to add some new code artifacts and modify some old code artifacts. Thus the new AV is expected to be much larger than 66. The CBV for the new project may not increase much beyond the current CBV. However, because of the need to maintaining two versions, each associated with a different set of requirements document, we have to consider 2 IBVs. For IBV of the original application software system, the VR1' is the same as adding 1 requirements artifact in a separate library or one new pair (a, f) to the old VR1. Thus VR1' = 18 + 1 =19. Similarly, VR2' just include one more instruction step to build the requirements document. So VR2' = 44 +1 = 45. Since we do not expect too much change in the build instruction, the IBV for the second version may not differ much from the IBV of the first version. The big difference this time can be summarized as follows.

1. A large increase in AV is expected for the second version of application of software.
2. Since there will be two application versions, the original AV is still there.
3. There will be an association of requirements to code. Thus there will be two IBVs.

Even though the actual software project is still fairly small as the original version and no increase in development complexity is anticipated, we are now maintaining two versions of software products. This increased complexity of SCM is forcing us to consider the incorporation of additional SCM tools.

CONCLUDING REMARKS

We have introduced a set of volume metrics, AV, CBV, and IBV to gauge the SCM complexity. We have also found that when AV is small and only CBV is involved, the SCM complexity can be managed with minimal tool. But once we grow the AV and start to deal with multiple IBV metrics, it is an indication to start considering sophisticated SCM tools.

An area for future extension is to investigate the volume metric for managing the impact of changes and the impact of building non-code artifacts. This would take the IBV to another level of measurement.

REFERENCES

1. Apache Ant, http://ant.apache.org, 2006
2.Apache Tomcat, http://tomcat.apache.org, 2006
3. Atria Software, ClearCase User's Manual, Natick, MA, 1992.
4. M.E. Bayes, Software Release Methodology, Prentice Fall, 1999.
5. CVS, www.gnu.org/software/cvs, 2006.
6. S. Dart, "The Past, Present, and Future of Configuration Management, SEI Technical Technical Report, CMU/SEI-92-TR-8, 1992.
7. J. Estublier, et al, "Impact of Software Engineering Research on the Practice of Configuration Management," ACM Transactions on Software Engineering and Methodology, Vol. 14, No. 4 October 2005, pp 383-430.
8. A. van der Hoek, et al, "A Testbed for Configuration Management Policy Programming, IEEE Transactions on Software engineering, vol. 28, No 1, January, 2002, pp 79-99.
9. IBM Rational ClearCase, www-306.ibm.com/software/rational/offerings/scm.html, 2006.
10. SEI, www.sei.cmu.edu/legacy/scm, 2006.
11. F. Tsui and O. Karam, Essentials of Software Engineering, Jones and Bartlett Publishers, 2006.

Towards Augmenting Human Affordance in Evaluation of Agreement/Disagreement Phrases

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ABSTRACT

Our final goal is to utilize a cognition viewpoint for engineering of better design of human communication tools. In this paper, we extend the concept of affordance to cover human-to-human communication and propose the novel concept of ''human affordance,'' which is afforded from humans, not artifacts. As one possible utilization of the concept, we introduce the example of affordance in evaluating the strength of agreement / disagreement phrases. In text-based communication, it is important for mutual understanding to effectively afford information about how a person feels about the text itself. This paper presents experimental results on understanding the strength of agreement/disagreement and presents one simple example to augment human affordance in text-based communication.

INTRODUCTION

Human-to-human communication often fails due to a lack of appropriately afforded information. For example, text-based communication such as text chat or instant messenger sessions suffers from many weaknesses compared to face-to-face communication; these include a lack of facial expressions, gestures, and intonation. These are important for conveying how a person feels or what he/she is thinking about. In text-based communication, it is important for mutual understanding to effectively afford information about how a person feels about the text itself.

The term of affordance comes from the perceptual psychologist Gibson, who provided an ecological alternative to cognitive approaches (Gibson, 1966; 1979). His theory is that *the affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill*. Many studies in a psychology field focused on affordance in human communication (Acker & Valenti, 1989), however the concept of affordance is popular in the field of user interface design as it provides a means of enhancing usability (Norman, 1988).

In this paper, with regard to utilizing a cognition viewpoint for engineering, we extend the concept of affordance to cover human-to-human communication and propose the novel concept of ''human affordance,'' which is afforded from humans, not artifacts. A model of human affordance is defined as a set of perceptual information and human factors. One advantage of human affordance is the focus it places on human factors which yields user-centered designs.

Accordingly, we describe the significance of augmenting affordance in text-based human communication and illustrate the concept through examples although this work is explanatory in nature. We analyze the human affordance found in typical agreement/disagreement phrases in order to better augment human affordance in text-based communication. This paper presents the experimental results on evaluating the strength of agreement / disagreement and presents one simple example to augment human affordance in text-based communication by phrase replacement.

RELATED WORK

Text-based communication is getting popular as shown by examples such as text chat, instant messaging, and email. Several studies have examined text chat systems. Farnham et al. proposed a scripted chat system that uses Lead Line (Farnham et al., 2000) which allows users to add a layer of pre-authored structure to regular text chat. Vronay et al. identified the text chat problems related to the loss of timing-specific information (Vronay et al., 1999). Jozsef analyzed the impact of interactive graphics and text on social influence (Jozsef, 1994). DiMicco et al. introduced instant messaging with a skin conductivity channel (DiMicco et al., 2002).

Decision support is an important research field related to mutual understanding. Kenneth et al. reviewed group decision support for computer-supported cooperative work (Kenneth & John, 1988). Richard et al. explained the process of perspective taking and its roles in human communication, mutual trust, and organizational learning (Richard et al., 1992). John et al. described the significance of a common report space in addition to the messaging space (John et al., 1991). Mera et al. proposed a method to analyze users' affirmative/negative intentions from multiple utterances in spoken dialogs (Mera et al., 2001). Since these papers did not consider affordance in communication, they lack the ability to truly understand and thus support the user.

One example of research on affordance is the analysis of the concept of affordance to employ it for understanding human activity (Baerentsen & Trettvik, 2002). Most studies on affordance, however, lie in the field of engineering, particularly the design of user interfaces (Amant, 1999; Conn, 1995; Gaver, 1991; 92). Designing Computer-Mediated Communication (CMC) systems is also an important research field (Cassell et al., 2000; Bradner & Mark, 2001). (See the ''Human Affordance'' section describing ''awareness.'')

Authors have studied on typical responding phrases used in agreement/disagreement in communication (Ihara & Kobayashi, 2005). This paper discusses affordance for agreement / disagreement from the viewpoint of engineering in order to realize better system designs for text-based communication.

PROMOTING MUTUAL UNDERSTANDING IN TEXT-BASED COMMUNICATION

Table 1 shows the methods that can be used to promote mutual understanding in text-based communication. In this table, 1 and 2 enhance the presentation of the text. The remainder, 3, 4, and 5, alter the design of the statement (word) database.

Enhanced Presentation

In method 1, attributes are added to a text when it is presented to the partner such as a bigger font or red coloring. This method provides users with immediate understanding through visual comprehension. For example, Bodine et al. developed an instant messenger around kinetic Typography (Bodine & Pignol, 2003). Donath analyzed the effectiveness of graphics in online conversations (Donath, 2002). In method 2, a text is presented together with other media like voice. For example, synthesized speech with intonation may reinforce the expressive power of a text. Rothkrantz et al. added facial expressions to text balloons in cartoons (Rothkrantz & Wojdel, 2000). This is an example of combining text with graphics.

Statement Database Design

In method 3, a statement database is enlarged by addition of explicit statements. One of most typical examples is the ''smiley'' which presents an emotion by a sequence of a few letters like :-). Smileys are so symbolic and explicit that users can easily understand the partner's intention to express his/her emotion. On the other hand, method 4 restricts the statements available to prevent misunderstand-

Table 1. Methods to promote mutual understanding in text-based communication

	Method	Advantage	Examples	Approach
1	Add visual attributes to text	Immediate understanding through visual comprehension	Change size or color of fonts	Enhanced presentation
2	Use a text with other media	Reinforce text expressiveness	Play with synthesized speech	Enhanced presentation
3	Add explicit statements to database	Symbolic and explicit expressions	The ”smiley”	Statement database design
4	Restrict statements available in database	Simplified expressions	Textbook	Statement database design
5	Add attributes to statements in database	Familiar statements with higher expressiveness	Strength of agreement/disagreement	Statement database design

ing. A school textbook is an example of this approach in terms of using only easy words. Method 5 adds attributes to statements in a database. This method makes it possible to use familiar statements without adding or restricting the statements available. Our approach to setting the strength of agreement / disagreement of each statement is one example of this method.

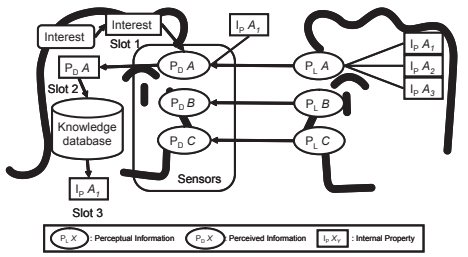
HUMAN AFFORDANCE

Definition

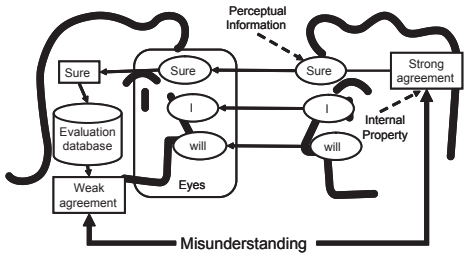
Affordance involves relationships or their properties. It is difficult to define affordance in precise analytical terms. One definition of general affordance is a set of perceptual information of an environment and an internal property of the environment such as a human's action capability. Similarly human affordance can be defined as a set of perceptual information of the human and the internal property of the human. For example, one internal property, the emotion of agreement, can be perceived from the facial expression of a smile as a piece of perceptual information. Note that human affordance focuses on an individual in human-to-human communication while social affordance (Acker & Valenti, 1989; Valenti & Good, 1991; Loveland, 1991; Kadar & Effken, 1994; Stoffregen, 2004), studied in a psychology field focuses on a relationship or interaction in a community.

Awareness has been discussed as one of the most important factors in a CMC system (Bradner, 2001; Dourish & Bly, 1992; Erickson et al., 1999). The term of awareness is related to existence or state. On the other hand, the focus of affordance is on a set of perceptual information and an internal property which is not necessarily limited to dynamic properties such as state, but includes static properties such as ability. For example, consider the user who knows important information but who hesitates to speak out. Awareness research does not discuss this kind of property.

Figure 1. Human affordance model



(a) A general human affordance model.



(b) A human affordance model of agreement.

Human Affordance Model

Figure 1-(a) shows the cognition model based on human affordance introduced in this paper. In this figure, (1) the giver offers three kinds of perceptual information, P_LA to P_LC, to the perceiver. Perceptual information P_LA is related to three internal properties, I_PA_1 to I_PA_3. The perceiver has sensors such as eyes or ears, which are used to gather the perceptual information from the giver. (2) Interest which exists in the perceiver's mind, establishes an entry in a sender slot in the perceiver; (3) the slot's content interacts with perceived information P_DA. (4) Based on the content of the sender slot, the corresponding perceived information P_DA is focused on which creates an entry in a receiver slot. (5) The receiver's knowledge (his/her database) which is referred to according to the content of the receiver slot makes an entry in a receiver's cognition slot. The perceiver's database has a lot of knowledge about the relationship between common perceptual information and internal properties. The result of this process is that the giver affords internal property I_PA_1 to the perceiver.

The above is a quite simple but highly applicable affordance model. This applicability is important to easily employ the model for engineering with a same metaphor. A set of perceptual information and internal property can be defined automatically or manually according to a situation or a person. In some cases user profiles or agent-based communication support techniques would be effective to identify the set of perceptual information and internal property.

Perceptual Information and Internal Properties

Perceptual information can be categorized into the kinds discerned by sensors; eyes, ears, nose and skin. A more detailed classification of perceptual information can be made based on components of the perceptual information and measurable parameters. For example, hairstyle is associated with ''look'' and utterance frequency in a chat is a measurable parameter. Moreover, changes in these parameters are also perceptual information. Internal properties can be divided into states and nature. A state is a dynamic factor as a facial expression or thought, which changes moment by moment. Nature covers static factors such as ability or priority.

Difficulties in Affordance Cognition

An everyday artifact does not have many affordances and its main affordance is clearly discernible. For example, most people understand that a mug is a tool for holding liquids to be drunk. A human, however, is capable of a wide variety of actions and has many internal properties. It is not easy to recognize human affordance due to this variety and the restriction that we are limited to perceptual information (appearance) in assessing an unknown person. This is true whether we are holding a face-to-face meeting or using a text chat system, although it is obvious that the problems are much stronger in the latter.

Human affordance cognition can fail in three ways:

1. No useful perceptual information is provided
2. Insufficient perceptual information is provided
3. Wrong perceptual information is provided.

In the first case, we say that the internal property is not expressed. For example, a participant knows something of value but makes no expression or utterance. In the second case, the perceptual information provided is insufficient. For example, the low image resolution provided by most videoconferencing systems hinders smooth interaction based on facial expressions. The most common solution is to improve transmission quality. In the third case, the perceptual information cannot be used to discern the internal property. An example is a participant who smiles while actually being unhappy about what is being discussed. In everyday life, we use a priori knowledge to prevent such misunderstandings. A lack of positive confirmation may be useful in understanding the participant's true feelings. In this case, the priori knowledge of ''he would say something if he were happy'' can be used to infer his true internal property. This paper discusses one example of the third case; wrong understanding of agreement/disagreement in text-based communication.

AFFORDANCE AUGMENTATION

The above problems in affordance cognition can be solved by an affordance augmentation system (AAS). Such a system can offset the lack of or incorrect perceptual information by creating the right affordance. It can also enhance affordance to make up for insufficient perceptual information.

People tend to believe that a quiet participant has no interesting or useful information. If the AAS could recognize the value of the participant, it could encourage him/her to speak forth. This means that the AAS would create the true and useful affordance. Consider a videoconference system that uses facial avatars based on computer graphics and can enhance the motion of facial parts such as the eyes. An emotion as an internal property may be conveyed by graphics enhancement instead of using a photorealistic video. In another case, one problem with text chat among people is cognition of the utterance requests by participants. The AAS can graphically enhance the utterance requests of key participants by actions such as framing their windows in red.

Affordance augmentation has two advantages. One is that it more fully utilizes computers for human communication. The other is to create a really effective communication style that is unavailable in the real world and differs from face-to-face communication in everyday life.

HUMAN AFFORDANCE IN AGREEMENT / DISAGREEMENT

People afford their agreement / disagreement to a partner in communication using several types of agreement / disagreement phrases. However, the strength of agreement / disagreement that a partner feels about each phrase is not necessarily same as that of agreement / disagreement that they put into their response. Some people overestimate and others underestimate. The overestimation type of user may misunderstand weak agreement as strong agreement. The underestimation type of user may not understand or accept the other's comment as praise. This failure of human affordance leads to inhibit mutual understanding.

Figure 1-(b) shows one example of human affordance model in the case of agreement. In this figure, a user responds to a partner by using a sentence of ''Sure, I will...'' This responding user employs ''Sure'' as a strong agreement word. In this case the implementation of human affordance model definition is that ''Sure'' as a visible letter sequence is perceptual information and that the user's evaluation of strong agreement is internal property. In this example, the partner understands ''Sure'' as a weak agreement, thus there is a misunderstanding between their evaluations for the agreement strength of the word ''Sure''.

To decrease such a misunderstanding, it is important to identify the human affordance in agreement / disagreement phrases and to design a better method for affordance augmentation which can be applied for engineering.

EXPERIMENTS

Experimental Design

We analyzed responding phrases of agreement / disagreement to identify the human affordance in agreement / disagreement phrases. We collected about 100 responding phrases and used questionnaires to rate the strength of agreement / disagreement. In these experiments, phrase type and user type were analyzed to explore better augmented human affordance in text-based communication.

Collecting Responding Phrases

We asked one hundred fluent English speaking subjects to list as many responding phrases that express agreement / disagreement as possible. The subjects were asked not to consider the situations in which the phrases could be used. The collected data included phrases used in both oral conversations and text-based conversations. We collected 67 phrases for agreement and 42 phrases for disagreement.

Rating the Collected Phrases

Questionnaires were used to rate the responses in terms of the strength of agreement / disagreement. The subjects were another one hundred fluent English speakers who were categorized into 10 groups by gender and age (teens to 50s). The strength of agreement / disagreement was assigned one of five levels from ''strong (5)'' to ''weak (1).'' In the questionnaires, radio buttons for each level were positioned at equal intervals on the screen.

RESULTS

It is important to identify phrase type in order to design better usage of agreement / disagreement. For mutual understanding, it is better that most users evaluate similarly the strength of agreement / disagreement. The success of the phrase usage depends on reliable metrics that can well represent the strength of agreement / disagreement.

Tables 2-(a) and 2-(b) list the top ten phrases of large and small standard deviation (shown as SD in the table) in rating by all subject groups in gender and age,

Table 2. A listing of the top ten phrases of large and small standard deviation in rating

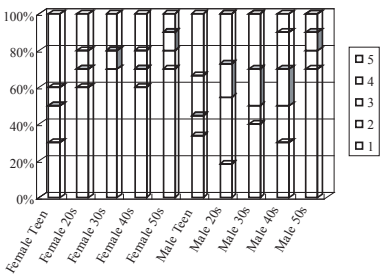
(a) Phrases: care needed.

Agreement (SD)	Disagreement (SD)
Whatever (1.55)	Whatever (1.49)
Yeah (1.53)	Nah (1.40)
Yea (1.47)	Well (1.35)
Yup (1.45)	Oppose (1.35)
Mm-hmm (1.44)	Uh uh (1.34)
I know (1.42)	Not (1.30)
Uh huh (1.38)	Nope (1.29)
Alright (1.37)	Not a chance (1.29)
Awesome (1.34)	I don't think so (1.28)
Totally (1.33)	No way (1.28)

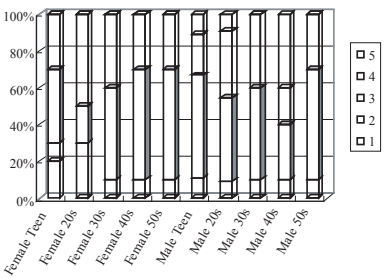
(b) Phrases: no care needed.

Agreement(SD)	Disagreement(SD)
That sounds good(0.83)	Of course not(0.94)
Absolutely (0.91)	No(1.03)
Excellent(0.93)	Can't(1.03)
That's right(0.93)	I don't know about that(1.03)
You're right(0.94)	Absolutely not(1.05)
Sounds good to me(0.96)	Stop(1.05)
That's true(0.97)	Not really (1.05)
I totally agree(0.98)	That's wrong(1.06)
Great(1.00)	Never(1.07)
Definitely (1.00)	Disagree(1.10)

Figure 2. Rating results for two types of phrase



(a) Rating results for "Whatever" (agreement).



(b) Rating results for "That sounds good".

respectively. The phrases shown in Table 2-(a) need to be handled with care while those in Table 2-(b) can be used relatively freely.

The most interesting phrase in Table 2-(a) is ''Whatever'' which ranked at the top of both agreement and disagreement columns. Figure 2-(a) is the rating result for ''Whatever'' in agreement. In this figure, the horizontal axis categories each subject group in gender and age and the vertical axis plots the ratio of each rated level in the evaluation. As shown in Figure 2-(a), subjects in each gender and age group assessed the expression ''Whatever'' quite differently. This is because ''Whatever'' can be used for either agreement or disagreement. A subject who rated ''Whatever'' as a 5 may have misunderstood weak agreement as strong agreement and someone who rated it 1 may not have understood other's praise.

On the other hand, as shown in Figure 2-(b), most subjects evaluated the expression ''That sounds good'' in the same way. ''That sounds good'' is a very safe phrase in terms of avoiding misunderstanding in communication.

DISCUSSIONS

One simple way of augmenting human affordance for an overestimating type of user is replacing the phrase that the partner used with another phrase of weaker agreement / disagreement. We compared two subjects in order to explore the potential of phrase replacement. The most overestimating user in our experiments overrated the strength of agreement phrases by 1.16 on average compared to the average user.

Figure 3 shows a comparison of the ratings produced by the normal user and the ''adjusted'' ratings by the overestimating user. In this figure, the vertical axis plots those ratings. The adjusted ratings were calculated by subtracting the factor of 1.16 from the original rating; subtraction was not performed on phrases that both users rated 5. As shown in Figure 3, this simple subtraction created 25 matched ratings by those two users (originally, there were 14 matches). Also, in Figure 3, a vertical line between o and x means a gap between the rating by the normal user and the adjusted rating by the overestimating user. As shown in the figure, the number of large gaps (more than 2) decreased from 14 to 7.

A lot of methods can be used for augmenting human affordance in agreement / disagreement. Here is one example for the overestimating user. Both phrases ''Excellent'' and ''Sounds good to me'' are phrases for which no care is needed in Table 2-(b). However, ''Excellent'' is a high rating phrase and may be overestimated by the overestimating user. Thus, using ''Sounds good to me'' instead of ''Excellent'' is better for the overestimating user. The fact is that the overestimating user rated ''Excellent'' as 5 but rated ''Sounds good to me'' as 3, while the normal user rated ''Excellent'' as 3.

CONCLUSION

In this paper, we proposed the novel concept of ''human affordance'' which is afforded from humans, not from artifacts and presented its definition and model with perceptual information and internal properties of humans. We also introduced experimental results on understanding the strength of agreement / disagreement in text-based communication. Analyses of those results in phrase type and user type provided findings towards better augmentation methods of human affordance in text-based communication.

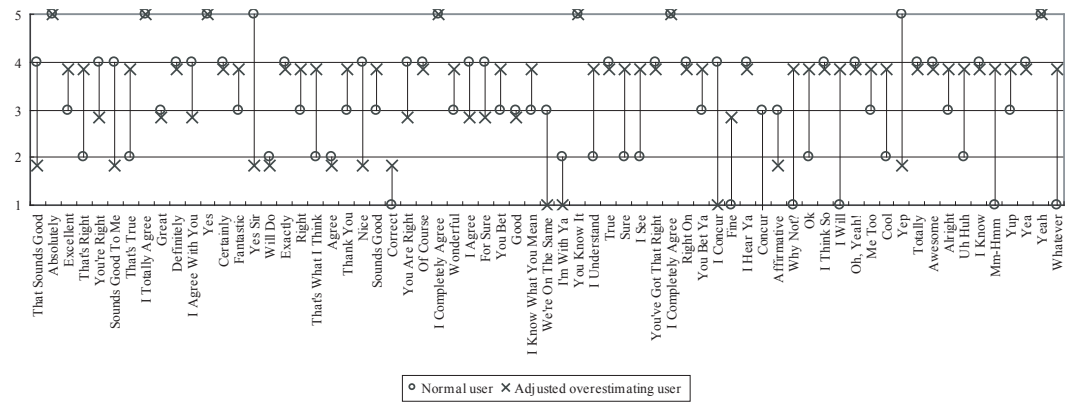
This work envisions that the new paradigm of human affordance will be a key design foundation for human-to-human communication systems in terms of user-centered design. Future work includes developing and evaluating affordance augmentation methods as a user support technology.

REFERENCES

Acker, R. V. & Valenti, S. S. (1989). "Perception of social affordances by children with mild handicapping conditions: implications for social skills research and training," Ecological Psychology, 1(4), 383-405.

Amant, R. S. (1999). "Planning and user interface affordances," In Proceedings of IUI 1999, ACM Press, 135-142.

Figure 3. Comparison between a normal user and an adjusted overestimating user



Baerentsen, K. B. & Trettvik, J. (2002). "An activity theory approach to affordance," In Proceedings of NordiCHI 2002, ACM Press, 51-60.

Bodine, K. & Pignol, M. (2003). "Kinetic typography-based instant messaging," In Extended Abstracts of CHI 2003, ACM Press, 914-915.

Bradner, E. (2001). "Social affordances of computer-mediated communication technology: understanding adoption," In Extended Abstracts of CHI 2001, ACM Press, 67-68.

Bradner, E. & Mark, G. (2001). "Social presence with video and application sharing," In Proceedings of GROUP 2001, ACM Press, 154-161.

Cassell, J., Bickmore, T., Vilhjalmsson, H., & Yan, H. (2000). "More than just a pretty face: affordances of embodiment," In Proceedings of IUI 2000, ACM Press, 52-59.

Conn, A. P. (1995). "Time affordances: the time factor in diagnostic usability heuristics," In Proceedings of CHI 1995, ACM Press, 186-193.

DiMicco, J. M., Lakshmipathy, V., & Fiore, A. T. (2002). "Conductive chat: Instant messaging with a skin conductivity channel," In Extended Abstracts of CSCW 2002, ACM Press, 193-194.

Donath, J. (2002). "A semantic approach to visualizing online conversations," Communications of the ACM, 45(4), 45-49.

Dourish, P. & Bly, S. (1992). "Portholes: Supporting awareness in a distributed workgroup," In Proceedings of CHI 1992, ACM Press, 541-547.

Erickson, T., Smith, D. N., Kellogg, W. A., Laff, M., Richards, J. T., & Bradner, E. (1999). "Socially translucent systems: social proxies, persistent conversation, and the design of ''bubble'','' In Proceedings of CHI 1999, ACM Press, 72-79.

Farnham, S., Chesley, H. R., McGhee, D. E., Kawal, R., & Landau, J. (2000). "Structured online interactions: improving the decision-making of small discussion groups," In Proceedings of CSCW 2000, ACM Press, 299-308.

Gaver, W. W. (1991). "Technology affordances," In Proceedings of CHI 1991, ACM Press, 79-84.

Gaver, W. W. (1992). "The affordances of media spaces for collaboration," In Proceedings of CHI 1992, ACM Press, 17-24.

Gibson, J. J. (1966). The senses considered as perceptual systems, Allen and Unwin, Ltd., London, 1966.

Gibson, J. J. (1979). The ecological approach to visual perception, Houghton Mifflin, New York, 1979.

Ihara, M. & Kobayashi, M. (2005). "Text-based communication enhanced by sharing human senses of values based on the agreement strength of responding phrases," In Proceedings of HCI International 2005 (CD-ROM).

John, C. M., Victoria, C. M., & Andrew, F. M. (1991). "An experimental study of common ground in text-based communication," In Proceedings of CHI 1991, ACM Press, 209-215.

Jozsef, A. T. (1994). "The effects of interactive graphics and text on social influence in computer-mediated small groups," In Proceedings of CSCW 1994, ACM Press, 299-310.

Kadar, E. & Effken, J. (1994). "Heideggerian meditations on an alternative ontology for ecological psychology: A response to Turvey's (1992) proposal," Ecological Psychology, 6(4), 297-341.

Kenneth, L. K. & John, L. K. (1988). "Computer-based systems for cooperative work and group decision making," ACM Computing Surveys (CSUR), 20(2), 115-146.

Loveland, K. A. (1991). "Social affordances and interaction II: Autism and the affordances of the human environment," Ecological Psychology, 3(2), 99-119.

Mera, K., Yoshie, M., Ichimura, T., Yamashita, T., Yoshida, K., & Aizawa, T. (2001). "Analyzing affirmative/negative intention from plural sentences," In Proceedings of KES 2001, 1222-1226.

Norman, D. A. (1988). The Psychology of Everyday Things, Basic Books, New York, 1988.

Richard, J. B., Anil, K. M., Dov, T., David, G. S., & Ramkrishnan, V. T. (1992). "Sharing perspectives in distributed decision making," In Proceedings of CSCW 1992, ACM Press, 306-313.

Rothkrantz, L. J. M. & Wojdel, A. (2000). "A text based talking face," Lecture Notes in Computer Science, 1902 (2000), 327-332.

Stoffregen, T. A. (2004). "Breadth and limits of the affordance concept," Ecological Psychology, 16(1), 79-85.

Valenti, S. S. & Good, J. M. M. (1991). "Social affordances and interaction I: Introduction," Ecological Psychology, 3(2), 77-98.

Vronay, D., Smith, M., & Drucker, S. (1999). "Alternative interfaces for chat," In Proceedings of UIST 1999, ACM Press, 19-26.

A Multi-Agent System for the Remote Control of Data Servers

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ABSTRACT

This work presents a computational tool for remotely monitoring data servers (Kipo System). To achieve this, the system contains a society of agents, where each agent performs a specific role within the process. Among the existing agents, two should be remarked: the Solver Agent, and the Supervisor Agent. The first one employs a case-based reasoning approach to interpreting and defining an action to be taken, given the detected fault. The latter one has an important role, as it constantly verifies the activation states of each agent. Through the Kipo System, a decrease in attendance times for faults on data servers could be experienced. This has corroborated our initial expectations on the adequacy of such agent's technology for this type of domain.

1. INTRODUCTION

Several software systems were developed for monitoring network behavior, as well as the operational conditions of its hardware and software components. Among the desired issues to be checked, we may include the memory available to the users, the working conditions of specific applications (such as databases), and many others. In these cases, information regarding the system's operational state, errors, and other collected data can be obtained through the analysis of log files, for example.

Many large, and even medium and small corporations have Information Technology (IT) departments, where specialized professionals are responsible for the preventive and corrective maintenance of the existing computational resources, besides other functions. They have to control the actions that identify undesired situations before they occur, avoiding unnecessary maintenance calls.

This way, the presence of identifying mechanisms, which can detect errors and undesired situations in the equipment, storage media, and data is of great importance. If the information could be retrieved remotely, without human presence, this system would be of major interest. Thus, the development of an identifying architecture which can, almost instantly, detect failures, undesired situations or potentially warning situations, is a very important issue for these corporations. As a consequence, the corporations may experience a reduction of the corrective maintenance calls, a reduction in there operational costs with personnel, and an improvement of their QoS (Quality of Service), assuring data and systems more trustable, among other gains.

This paper presents a monitoring system named Kipo[1], which uses intelligent mechanisms, designed to aid the monitoring work of geographically dispersed computers. Section 2 reviews some related works. Section 3 presents the application domain, and the next section presents the system architecture and functioning. Finally, Section 5 presents some concluding remarks.

2. APPROACHES

Since the objective was to obtain an "intelligent autonomy" regarding to the detection and sending of error information, intelligent agents characteristics were incorporated, because this technology aims at achieving some degree of "intelligence" in computer based systems [Wooldridge 95]. Solutions involving agents have been researched and applied in application areas such as air traffic control, data mining, and information retrieval, among many others [Kristensen 98].

Another research area in Artificial Intelligence (AI) is the Case-Based Reasoning (CBR), an AI paradigm mainly based on the idea that knowledge of past experiences may guide the human behavior [Kolodner 93]. This way, CBR means to use previous experiences to understand and to solve new problems.

There are some possible integrations between CBR and other approaches, such as [Marling 05, Rezende 06, Julio 06] The proposed architecture combines agents and CBR characteristics to provide intelligence with some degree of autonomy, and use of past experiences to help in the remote monitoring context.

Differently from most existing case based systems, in the proposed one, the data input will be based on parameters sent by the agents, when they detect failures. Moreover, the process of knowledge acquisition used was based on the actions that would be performed by local operators when noticing a failure.

The establishment of similarity metrics in CBR systems is one of the most important issues to achieve efficiency in such systems [Freitas 96]. Determining the similarity degree is an important component to identify the usefulness of a case. Another point to be considered is that the usefulness of a case also depends on its purposes, and which of its aspects were relevant in the past [Goel 05]. The similarity degree aims at attributing a numeric value to the similarity between two cases. All the cases stored are evaluated comparatively to the input problem (case). Usually, a similarity degree in the interval [0,1] is associated among the attributes of certain dimensions [Kolodner 93]. In the context of the architectural view presented, we used the syntactic similarity as the similarity measure. In this case, the greatest the number of coincident words between the problem description and the description of each case, the greatest the similarity degree achieved.

3. APPLICATION DOMAIN

In order to represent the use of intelligent agents and CBR in the remote corporative applications monitoring problem, it was chosen to apply them to geographically distant data servers, interconnected through a corporative network. This kind of servers usually has data servers used by several applications, and these applications need to work 24 hours a day, 7 days a week. Moreover, in the studied cases, there was only one administrator, who was responsible to guarantee the servers' operational state, as well as data integrity. Theses professionals use queries, which compute information to be compared with previously established tolerance thresholds for each monitored situation.

In the other hand, there are several professionals accessing computational resources stored in the data servers. Independently of the security policy adopted, the administrator is responsible to assure the integrity of both the data and the data structure, even if users with access rights try to modify them.

This way, if someone tries to erase a table or to modify a table's structure, this action has to be notified, so that another corrective action can be performed. Obviously, it is difficult to imagine a single person controlling all aspects of a database, without the aid of an automated system that identifies these kinds of situations, and reports them in time to avoid or minimize damage. Figure 1 depicts a general domain view of the system Kipo, exemplifying the studied situation.

Figure 1. General view of the application domain

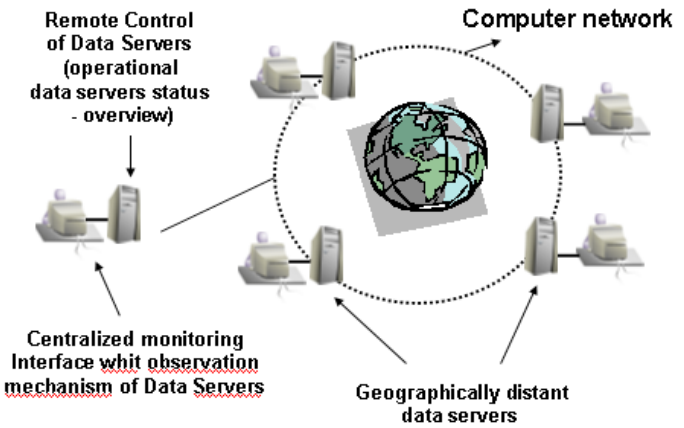
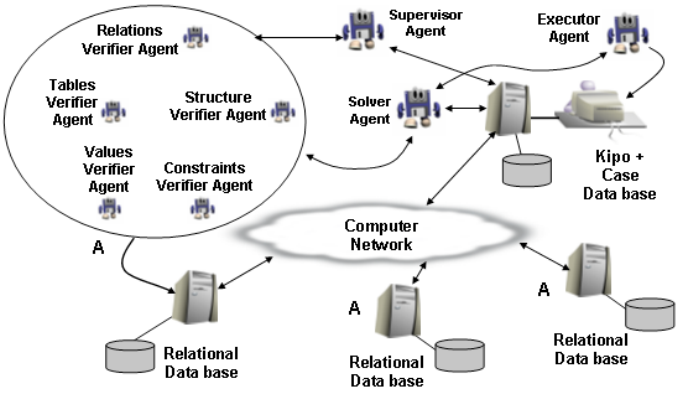


Figure 2. The main components of the Kipo architecture



Based on AI artifacts characteristics presented before, the system Kipo uses agents installed in the monitored servers, which, with a CBR agent, automatically detect and solve or inform failures and undesirable situations. An example of a failure situation could be an inactive service, the bad functioning of a specific port, the undesired change of a data base table, or even a server turned off. As examples of undesired situations, we could include a query returning an unexpected result, out of a tolerance interval, for instance. The normality standards are defined through a separated interface.

4. SYSTEM ARCHITECTURE

The motivation for the development of the system architecture included the use of agents and case-based applications for failure detection in computer networks. There are several similar works, including: Project P712 [Corley 98], SPIN [Hakima 98], PathFinder [Hart 01], SNMP [Puliafito 99], MAG [Gavalas 99], MCE [White 98], and EPSRC [Cruickshank 01], among others.

Based on these systems' behavior, the proposed model gives a new solution for the proposed domain. This way, the use of agents in the system Kipo implements alarm mechanisms, e-mail communication, and error correction, which are immediately performed after the error recognition or after a predetermined time period. These alarms can be observed through a centralized monitoring interface. This interface enables a quick and useful observation mechanism to the professional, and may be used to identify and anticipate possibly critical situations.

The Kipo architecture is composed by several intelligent agents' categories present in the data servers, each one with a specific purpose. The agents behavior and the comparing parameters they use are configured by the monitoring professional. Besides periodically perform their monitoring tasks, the agents also communicate with a supervisor agent. The detected errors are reported to a solver agent, which evaluates the situation by using CBR mechanisms. After this, it forwards the problem and its solution to an executor agent. Figure 2 depicts the main components of the proposed architecture.

The following agents' definitions detail how the system works, giving a better understanding of the architecture:

Solver Agent. This agent is responsible for the interpretation and execution of problems reported by other agents. It receives standard error situations as input, informing the sending agent, the computer identification, and the problem identified. Then, the solver agent checks for the best solution to be performed in a database, and sends a command to an executor agent. The solver agent uses CBR, checking for similarities between the reported problem and previous problems, using syntactic similarity. Figure 3 shows the agent's behavior. The arrow 1 represents the query performed by the solver agent. The arrow 2 indicates it sending an action solicitation to the executor agent, after consulting the database. The arrows with number 3 represent the possible actions to be performed by the executor agent, such as an alarm, e-mail, or error correction.

Executor Agent. This kind of agent receives information from solver agents, and they are responsible for correcting errors, sending e-mails informing about errors or updates in the database, which are related to monitoring the operational situation, among others.

Structure Verifier Agent. This agent is responsible for verifying unauthorized modifications in existing table structures. Initially, it consults the list of tables to be checked, as well as their expected structure. Then, it compares with the existing tables in the local database. Eventual discrepancies are communicated to the solver agent. Figure 4 shows this kind of agent's behavior. The correct structure of the database has to be stored and read previously, which is indicated by arrow 1. Auxiliary tables are created and used for future comparations (arrow 2). Then, periodical consults are performed in the reference database (arrow 3), and compared to the monitored tables (arrow 4). If there is any error, it is sent to the solver agent (arrow 5). The solver agent will forward the problem to the executor agent (arrow 6), which will decide if it will just report the error via e-mail, or if it will put in the monitoring interface, or if it will solve the problem (arrows 7).

Relations Verifier Agent. This agent is responsible for verifying unauthorized modifications in the predefined relations among the tables. They consult the relations of the reference database, and then, they compare them with the existing relations in the local database. Eventual differences are reported to the solver agent.

Values Verifier Agent. This kind of agent is responsible for verifying if the values get by specific queries are between predefined limits. The queries are edited using an ANSI SQL syntax interface, and unexpected results to the queries are reported to the solver agent.

Figure 3. Solver agent's behavior

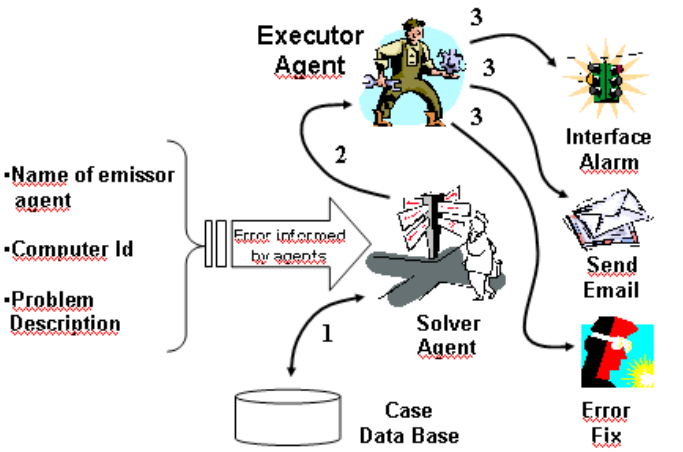
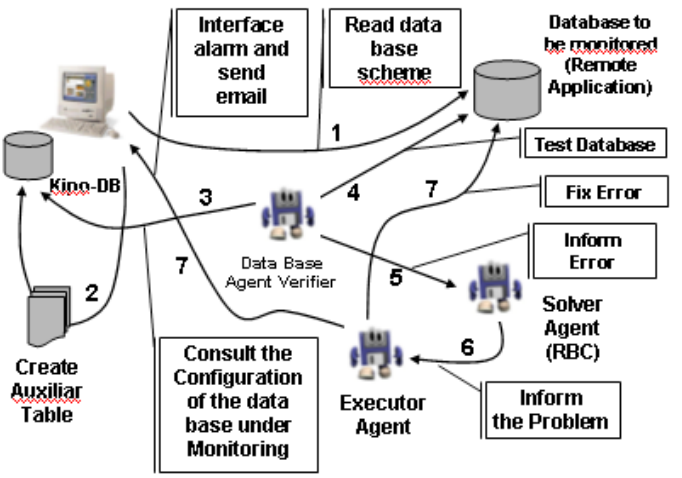


Figure 4. Structure verifier agent's standard behavior



Constraints Verifier Agent. This agent is responsible for verifying if unauthorized modifications in the predefined table constraints are performed. To do this, it consults the constraints descriptions in the reference database, and compare them with the constraints in the local database. Eventual discrepancies are reported to the solver agent.

Results Analyzer Agent. This agent compares the results got with the thresholds stored in the remote monitoring system database. Eventual discrepancies are reported to the solver agent.

Tables Verifier Agent. This kind of agent verifies if there is any table lacking in the database being monitored. To do this, it consults the list of tables in the reference database. If any table was wrongly deleted, it informs the solver agent.

Supervisor Agent. The Kipo system aims at assuring to the remote supervisor of the system a safe and trustable panorama of its software and data. Thus, safe mechanisms to verify the agents are needed. The supervisor agent supervises other agents, verifying, for example, if a server was turned off, or if it has hardware problems. The behavior of such agents is quite simple: when a remote monitoring interface is activated, its related agent is automatically activated. A signal (input parameter) identifying the sending agent is then waited. All agents, regardless of function, localization or characteristics, send periodically this type of information to the supervisor agent, assuring that they are active. A list of all agents can be consulted in the monitoring system database. Thus, if a signal is not received within a maximum amount of time, the supervisor agent updates its operational state to "without communication".

The developed architecture can be installed in any computed connected to a corporate network with databases. It uses a monitoring interface, which is responsible for the configuration of the various existing components, such as databases, information used by the agents to supervise the databases, monitoring screens, etc. An example is the interface used to check the general monitored events panorama (Figure 5), and the configuration interface, responsible for configuring the agents' behavior (Figure 6).

Figure 5a illustrates a monitored objects general state. It is based on color conventions, where the green color represents objects with normal behavior, the yellow objects means any abnormality, and red objects represents problems. Through this interface, it is possible to verify the geographical localization of the object (city, neighborhood, etc.), the description of the objects in a particular location (name, IP address, etc.), and the monitored objects list. For each object, it is possible to retrieve information about its behavior, as well as about its current operational state. The configuration interface presented in Figure 5b is used to establish each agent's behavior, regarding to their class, the periodicity of their communication with the verifier agents, their execution periodicity, and information about their function.

The agents were implemented using Java. All the agents have to consult the reference database computer (the node where the remote monitoring system is installed) to behave as established by the monitoring interface. This way, the agents need to send queries, to retrieve their syntax in the reference database, and to execute them. If necessary, they compare the query result with the values stored in the reference database. Depending on the result, they decide if they send a message to the remote monitoring system.

5. CONCLUDING REMARKS

An important contribution of this work was to explore the use of agents and CBR in the remote monitoring of computer networks domain, more specifically detecting errors and abnormal situations in distributed databases within the network. Usually, this task is performed with a human supervisor. The Kipo system auto-

Figure 5a. Remote monitoring interface

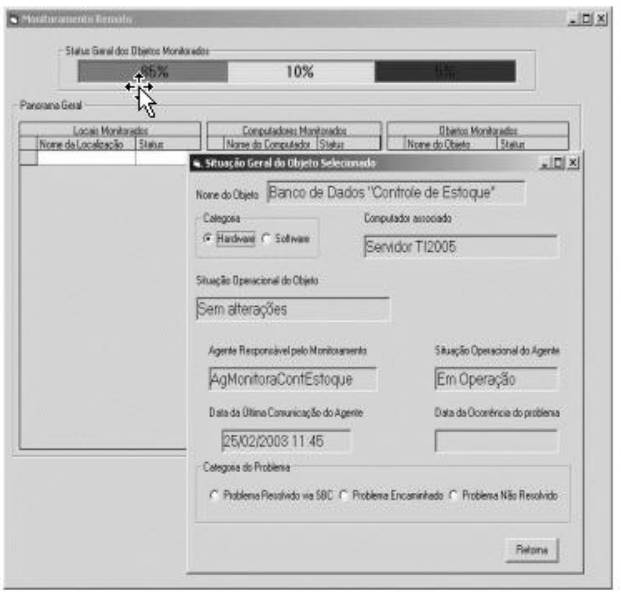
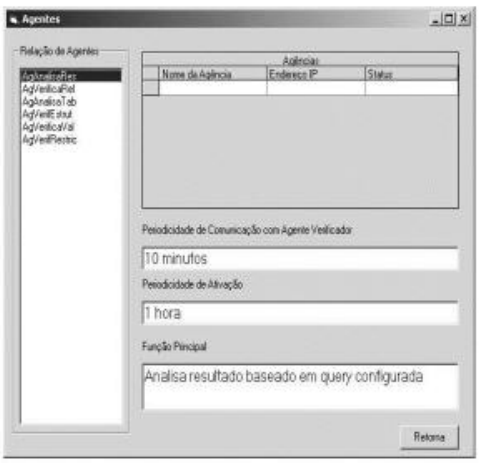


Figure 5b. Configuration interface



matically identifies and diagnoses failures, analyzes them through a case-based mechanism, signalizes the failure in an appropriate interface, automatically corrects the failure if this action is possible, and sends an e-mail describing the event occurred. Because the system tries to immediately identify failures and abnormal situations, it permits that these abnormalities to be rapidly resolved by the system agents or by another professional responsible by the monitoring system. In this context, the Kipo system is able to significantly aid to reduce the system maintenance time. Moreover, the rapid detection of failures and abnormal situations contributes to reduce the corrective system maintenance, which can be expensive to the corporations.

Currently, we are analyzing the system's first and promising results, and proposing new tests to obtain a wider set of comparative experiments. These results will be presented in a future paper.

6. REFERENCES

Corley, S., Tesselaar, M., Cooley, J., Meinköhn, J., Malabocchia, F. And Garijo, F. (1998) The Application of Intelligent and Mobile Agents to Network and Service Management. Proceedings of the Fifth International Conference on Intelligence in Services and Networks, Antwerp, Lecture Notes in Computer Science – v.1430, 127-138.

Cruickshank, D.Moreau, L.,Roure,D. (2001) Architectural design of a multi-agent system for handling metadata streams. Proceedings of the Fifth International Conference on Autonomous Agents, ACM Press, Montreal, Canada, 505-512.

Freitas, R. L., (1996) Um Sistema de Planejamento de Ações Baseado em Casos para uma célula Flexível de Manufatura, Tese de Doutorado, Escola Politécnica - USP, pp. 255, São Paulo.

Gavalas, D., Greenwood, D., Ghanbari, M., O´Mahony, M. (1999) Using Mobile Agents for Distributed Network Performance Management. Proceedings of the Third International Workshop on Intelligent Agents for Telecommunication, Stockholm, Lecture Notes in Artificial Intelligence – v.1699, 96-112.

Goel, A., Craw, S. (2005) Design, Innovation, and Case-Based Reasoning. The Knowledge Engineering Review, Cambridge University Press, UK.

Hakima, S.A., Impey, R., Liscano, R., Zeid, A. (1998) Multi-agent Testbed and an Agent Launch Tool for Diverse Seamless Personal Information Networking Applications. Proceedings of the Second International Workshop on Intelligent Agents for Telecommunication, Paris, Lecture Notes in Artificial Intelligence – v.1437, 171-189.

Hart, D., Tudoreanu, M., Kraemer, E. (2001) Mobile agents for monitoring distributed systems. Proceedings of the Fifth International Conference on Autonomous Agents, ACM Press, Montreal, Canada, 232-233.

Julio, M., Nakamiti, G., Freitas, R. (2006) A CBR Diagnostics System Applied in the Brazilian Public Health System, Proceedings of the 10th World Multi-Conference on Systemics, Cybernetics and Informatics, Orlando – FL, USA, pp. 184-189.

Kolodner, J. (1993) Case-Based Reasoning, 612 pages, Morgan Kaufman Publishers.

Kristensen, J. E. (1998) Agent Technology and Applications. Proceedings of the Fifth International Conference on Intelligence in Services and Networks, Antwerp, Lecture Notes in Computer Science – v.1430, 113-114.

Marling C., Rissland, E., AAmodt A,. (2005) Integrations with Case-Based Reasoning. The Knowledge Engineering Review, Cambridge University Press, UK.

Melchiors, C. (1999) Raciocínio Baseado em Casos Aplicado ao Gerenciamento de Falhas em Redes de Computadores, Dissertação de Mestrado, UFRGS, Porto Alegre.

Puliafito, A., Tomarchio, O. (1999) Advanced Network Management Functionalities through the Use of Mobile Software Agents. Proceedings of the Third International Workshop on Intelligent Agents for Telecommunication, Stockholm, Lecture Notes in Artificial Intelligence – v.1699, 33-45.

Rezende, M., Freitas, R., Nakamiti, G. (2006) HINT – A Hybrid Intelligent System for Telecommunication, Proceedings of the Sixth IEEE International Conference on Hybrid Intelligent Systems, Auckland, Australia.

White T., Bieszczad A., Pagurek B. (1998) Intelligent Agents for Telecommunication Applications. Proceedings of the Second International Workshop on Intelligent Agents for Telecommunication, Paris-France, Lecture Notes in Artificial Intelligence – v.1437, 130-141.

Wooldridge, M., Jennings, N. R. (1995) Intelligent Agents: Theory and Practice. The Knowledge Engineering Review, vol. 10, n° 2, 115-152.

ENDNOTE

[1] Kipo is related to a peculiar Inca communication system, which used colorful woolen cords, where knots correspond to letters and numbers. These cords were transported by messengers through the Inca Empire.

The Effect of Hidden Units in Neural Networks on Identifying Data Duplication Records

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ABSTRACT

Learning algorithms have been widely used to solve different problems in the field of Artificial Intelligence. Presently there are many learning algorithms; each is used depending on specifics of the problem to be solved. Examples of learning algorithms can be found in the field of Artificial Neural Networks (Neural Nets) where these algorithms are used to train the neural nets (as an example, Backpropagation algorithm). Neural nets have been used in data quality problems where a complex database has a lot of duplicate data (dirty data). By using neural nets, it was demonstrated that they can be a very useful tool to identify duplicate and non-duplicate records in the database. In this paper, we show the impact of internal architecture of neural network (hidden units) on the accuracy of results.

INTRODUCTION

Neural Networks are one of the most popular advanced modeling techniques (Barth, 1997). A neural network is an information processing system that can be used to store and recall data or patterns and classify them. It has the capability to learn by examples. Neural networks have proven to be quite effective for a broad range of problems, and are especially useful for predicting events when there is a large pool of data during the learning process. Neural Networks are of interest to both academics and practitioners in many areas like signal processing, medicine, pattern recognition, speech recognition, and even in business (Harston, 1990). Chiang, Urban and Baldridge (1996) developed a neural network to forecast the net asset value of mutual funds, and found the model to perform well in forecasting processes. Another example of using neural nets in business was to predict daily stock prices for three German stocks (Schoneburg, 1990). In 1995, Jain and Nag applied a neural net to the problem of pricing initial public offerings (Jain and Nag, 1995).

Lately, neural networks have been used in the field of Computer Science to address data quality during the software maintenance process (Al-Namlah and Becker,2003). Neural nets also have been used in the data quality field where a complex database has a lot of duplicate data (dirty data), and showed that they can be a very useful tool to identify duplicate and non-duplicate records in a database (Al-Namlah, Becker and Koksal,2002) and (Al-Namlah,2003).

DATA DUPLICATION PROBLEM

Data duplication means the database has stored duplicate data about an object. Conversely, non-duplication is defined by English (1999), as "The degree to which there is a one-to-one correlation between records and the real-world object or events being represented" (English, 1999, p. 142).

There are many processes that lead to having duplicate data in a database. Common processes that lead to this situation (Milrud, 2001) are:

1. Merging two or more databases as in the case of creating a data warehouse.
2. Using the system to generate a unique number for each row and assign it as a primary key.

Data duplication adds costs in at least two ways: First, it leads the organization to have more data than it needs. Brauer (2001) reports that an acquiring company learned long after the deal was closed that their new consumer business only had 50% of the customers as they thought because of the large amount of duplicate data in their customer database (Brauer, 2001). Second, data duplication affects the correctness of all the processes that depend upon this data, such as business reports.

Sending duplicate mail to customers leads to additional costs that can be alleviated if the company cleans their customer database. Here are some of the costs involved in having duplicate data:

- The cost of duplicate faxes, mailing and other forms of communication
- The cost of printing and production of additional mail services
- The cost of inaccurate results from analysis of data and subsequent reports
- The cost of inaccurate forecasting due to the misleading number of records
- The negative impact presented to potential clients receiving duplicate mail
- Time consumed by salespeople to contact the same customer

To prevent these additional costs, business organizations should consider eliminating duplicate records before they start using their data warehouses.

DATA DUPLICATION METRICS

Before highlighting the past efforts and the results of our work, we introduce metrics that are used to evaluate the data duplication solution. Researchers in the area of solving data duplication problems have used the following metrics:

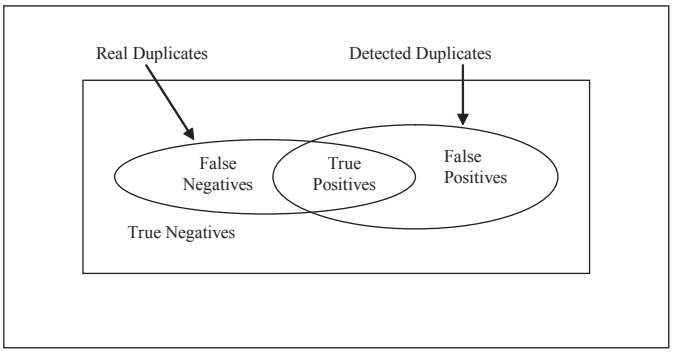
1. ***False negatives*** are also called *missed matches* (Winkler, 1995) and some researchers call them *misses*- which are those duplicate records where the approach fails to identify them as duplicates (see Figure 2).
2. ***False positives*** are also known as *false matches* (Winkler, 1995), which include those records that are not duplicates but the approach wrongly identifies them as duplicates (see Figure 2).
3. ***True positives*** *are* those records that are duplicates and the approach correctly identifies them as duplicates (see Figure 2).
4. ***True negatives*** are those records that are not duplicates and the approach correctly identifies them as not duplicates (see Figure 2).
5. ***Recall*** is also known as *percentage hits* (Lee et al., 2000), and is defined as the percentage of duplicate records being correctly identified. Higher recall is achieved by accepting records with low degrees of similarity as duplicates. Recall is computed as follows:

$$Recall = \frac{|True\ Positives|}{|Misses| + |True\ Positives|}$$

6. ***Precision*** is contrasted with recall; the percentage of correct predictions among all pairs of records that have been identified as duplicates (McCallum, Nigam and Ungar, 2000). Higher precision is achieved by accepting records with a higher degree of similarity as duplicates (Monge & Elkan, 1996; Lee et al., 2000; Do et al. 2002). Precision is computed as follows:

$$Precision = \frac{|True\ Positives|}{|True\ Positives| + |False Positives|}$$

Figure 1. Data duplication metrics (from Do et al. (2002), pg. 224)



PREVIOUS EFFORTS TO SOLVE DATA DUPLICATION PROBLEM

Record duplication is a complex problem that many researchers have tried to solve, using a variety of approaches. One of the most effective approaches is (Hernandez & Stolfo, 1995), and almost all subsequent researches have referenced this approach as a unique and effective way of solving the data duplication problem. Since the process of identifying data duplicates in databases involves matching the corresponding attributes in two different records, some efforts have focused on the field matching algorithms used to find the degree of similarity between two corresponding database fields. Monge and Elkan (1996) describe three record matching algorithms and evaluate their performance on real-world datasets. These are the basic field matching algorithm, recursive field matching algorithm and Smith-Waterman algorithm. Monge and Elkan (1996) found that recursive field matching and Smith-Waterman algorithms could achieve 100% recall while the basic algorithm could only achieve 90% recall. One fact to consider is that the Smith-Waterman algorithm has lower precision than the other two algorithms. A main contribution of the Monge and Elkan (1997) study is that it gives a relatively domain-independent algorithm to detect approximate duplicate records. It also shows how to compute transitive closure of the "is duplicate of" relationship by incrementally using a union-find data structure.

Lee et al. (2000) presents a knowledge-based framework for intelligent data cleaning. The framework consists of three stages: pre-processing, processing, and (validation and verification) stages. In the preprocessing stage, data records are first conditioned and scrubbed of any anomalies, and then data type and format are standardized. In the second stage, conditioned records are fed into an expert system engine together with a set of rules. The rules are fired in an opportunistic manner when conditioned records are fed into the expert system engine. These rules are responsible for identifying duplicate records, updating records that have missing data, and raising certain alert rules when some constraints are violated. The third and last stage is to generate a log report, which is used as an audit trail for all actions that have been done to the database records.

McCallum et al. (2000) used a technique for clustering, called canopies, to solve the problem of grouping large, high-dimensional data sets such as clustering textual bibliographic references. A canopy is a subset of the data elements to be clustered, and each data item that appears in a canopy is within some distance threshold from the center of the canopy (which is another data item).

Cohen and Richman (2002) have used the canopy approach, and presented an adaptive scheme for entity-name matching and clustering. What is meant by adaptive in this paper is that accuracy can be improved by training, like the nature of most learning methods. The entity-name matching means matching names for two different sources to identify those names that belong to the same object. The main use of the canopy approach in their scheme is to compute the set of candidate pairs to be compared in a subsequent stage. This way, the canopy approach restrains the number of items in each canopy and then another expensive edit distance is used to compare the items under each canopy. By doing this, overall time complexity is reduced since not all data items in the two resources are compared against each other using an expensive edit distance.

In (Al-Namlah, 2003) we showed that combining neural nets with other methods such as the one used by (Hernandez & Stolfo, 1995), was a powerful mechanism in uncovering data duplication. Our results showed that this approach reduced time complexity, uncovered duplicate records, and reduced the number of false positives and misses when uncovering duplicate records. However, there were some variables related to the neural net that were not studied in detail in this effort. One of them is the effect of the internal architecture (hidden layer) of the neural net on accuracy of the results. This paper details the effect of the number of hidden units in the hidden layer on overall results for resolving the data duplication problem.

NEURAL NETWORK ARCHITECTURE

Artificial neural nets are mathematical models that have been developed to imitate the biological neural net and they share common properties. The following assumptions are made to generalize artificial neural nets so that they are similar to human neural biology (Fausett, 1994):

- The information is processed in multiple central processing units called neurons (units).
- Neurons interchange signals through a highly connected net.
- Each connection between two neurons has an associated weight.
- Each neuron computes the output by summing all incoming signals (net input) and applies an activation function to the net input

The internal architecture of the neural net consists of nodes that are highly connected. Each connection has a weight, and as the neural network is trained, the weights are adjusted. When these weights no longer need to be adjusted during the training phase, the neural net has learned from provided examples. Then, it should be able to recognize (memorize) exact and (generalize) similar (generalize) patterns when it sees them in future applications (Fausett, 1994).

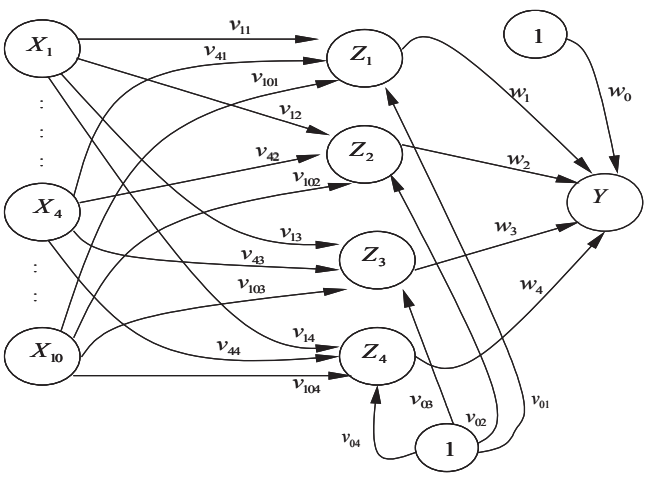
Neural nets are usually characterized by their internal architectures and methods that are used to train them. Training a neural net involves changing the weights to reflect current understanding to the behavior of the problem under investigation. In general, there are two methods of training: *supervised* and *unsupervised*. *Supervised training* is accomplished when the provided training examples (also can be referred to as training vectors or training patterns) consist of two parts: input example and output target.

In order to have a reasonable number of training pairs, we use the following formula (Baum and Haussler, 1989)

$$\frac{W}{P} = e$$

where W is the number of weights in the net, P is the number of training pairs, and e is the accuracy of classification expected. In our study, we start the algorithm

Figure 2. Neural net architecture



by assuming e=0.01 and the total weights W= 44, which suggests 4,400 training pairs. We train the net using a back propagation algorithm with Nguyen-Widrow (1990) initial weights. After the net is trained, we capture the final weights and use them in performing ten separate tests for different sets of data. The net has a ten-unit input layer (X_i), variable of units in the hidden layer (Z_i), and a single unit output layer (Y). As an example, Figure 2 shows the neural net architecture with four hidden units.

To test the effect of the hidden layer on accuracy of the end result of the net, number of the hidden units in the hidden layer will vary. Each time we change the number of hidden units, we train the net until it reaches the stability phase and then weights are captured to be used in the test phase. In this work we tested the results when the hidden layer had 2, 3, 4, 5, 6, 8, 10 and 12 units. Results of these tests are detailed in the Experimental Results Section of this paper.

EXPERIMENTAL RESULTS

The database used to test our proposed method was generated by the same database generator used by Hernandez (1996). This database generator allowed us to generate data with prior knowledge about duplicate data records. Furthermore, the database generator as described in (Hernandez, 1996) provided a large number of parameters that helped us perform controlled studies. These parameters include size of the database, percentage of duplicates in the database, and amount and type of error in any attribute to be introduced**.**

The layout of generated records consists of the following fields: social security number, first name, middle initial, last name, street number, street address, apartment #, city, state, and zip code. Some of these fields can contain null values as a simulation of errors that can happen in real life databases. The names were chosen randomly from a list of 63,000 real names. The cities, states and zip codes are all from the U.S.A.

In order to test effect of the hidden layer on accuracy of the neural net in identifying duplicate records, we built 8 neural nets with 10 input units, one hidden layer and one output unit. The difference between these neural nets is the number of units in the hidden layer. The 8 neural nets have 2, 3, 4, 5, 6, 8, 10 and 12 units respectively. After building each one of these neural nets we trained it using the 4,400 training examples. After the training we tested the neural net by feeding it with 501,360 records. Among these 501,360 there were 295,689 duplicate records, and 205,671 non-duplicate records. Table 1 shows the results of these tests.

Table 1 shows that when the neural net has only 2 units in the hidden layer, 294,842 out of 295,689 duplicate records were correctly identified by the neural net as duplicates (true positives), where 847 duplicate records were misses, i.e. the neural net failed to identify them as duplicates (false negatives). Furthermore, 205,639 out of 205,671 non- duplicate records were correctly identified by the neural net as non-duplicates (true negatives), where only 32 non-duplicate records were wrongly identified as duplicates (false positives). As a result of the above identification, recall was computed as follows:

$$Recall = \frac{|True\ Positives|}{|Misses| + |True\ Positives|} = \frac{294{,}842}{847 + 294{,}842} = 0.997$$

Table 1. The result of identifying duplicate records with different number of hidden units

Metric	Number of Hidden Units							
	2	3	4	5	6	8	10	12
True Positives	294,842	294,607	295,037	295,037	294,927	294,644	294,932	294,867
False Negatives	847	1082	652	652	762	1045	757	822
True Negatives	205,639	205,651	205,621	205,637	205,649	205,386	205,534	205,393
False Positives	32	20	50	34	22	285	137	278
Recall (%)	99.7	99.6	99.8	99.8	99.7	99.6	99.7	99.7
Precision (%)	100	100	100	100	100	99.9	99.9	99.9

and the precision was computed as follows:

$$Precision = \frac{|True\ Positives|}{|True\ Positives| + |False\ Positives|} = \frac{294{,}842}{294{,}842 + 3} \approx 1$$

We should take notice that the best overall results were obtained when the neural net had 3, 4 and 5 hidden units. The net with 3 hidden units was the best in identifying non-duplicate records, while the net with 4 and 5 hidden units was the best in identifying duplicate records. By reviewing the overall results, all 8 neural nets were excellent in their recall and precision. This is almost complies with (Rumelhart, McClelland, & PDP Research Group, 1986) that a set of N orthogonal input patterns can be mapped onto $\log_2 N$ hidden units to form a binary code with distinct patterns for each of the *N* input patterns.

It should be noticed that in our proposed solution we are always trying to obtain the maximum value of both precision and recall metrics together by doing a balance between them. It might be observed as an example, Monge and Elkan (1996) found that recursive field matching and Smith-Waterman algorithms could achieve 100% recall whereas our proposed method the best achieved 99.8%, however, we should consider the other metric (precision) in both solutions as well as other advantages such as the ability to improve the results through learning among others, that are not the subject of this paper. Detailed advantages of our solution can be found at Al-Namlah.(2003).

SUMMARY AND FUTURE WORK

In this study we found that internal architecture has an effect on the results of a neural net in identifying duplicate records. What we mean by internal architecture involves number of hidden units in the hidden layer. It was also observed that it is not necessarily the increase of hidden units that makes a neural net more capable of identifying duplicate records as noticed when the neural net had 8, 10, and 12 hidden units.

Theoretical results show that one hidden layer is sufficient for a backpropagation net to approximate any continuous mapping from the input patterns to the output patterns, to an arbitrary degree of accuracy (Fausett, 1994). Future work will include a practical study regarding the effect of number of hidden layers on the accuracy of a neural net in identifying duplicate records.

REFERENCES

Al-Namlah A., Becker S., and Koksal S., (2002). "Eliminating Data Duplication Using A Back propagation Neural Net," Proceedings of the 2nd International Conference on Neural, Parallel, and Scientific Computations, Vol. 2, pages 37-41, Atlanta, GA, August 07-10, 2002.

Al-Namlah, A.(2003). "Solving the Data Duplication Problem for Complex Databases Using Neural Networks." Ph. D. dissertation, Florida Institute of Technology, December, 2003.

Al-Namlah, A., and & Becker S. (2003). "Using Neural Networks for Addressing Data Quality During the Software Maintenance Process Proceedings of the 2003 IRMA Conference, Vol. 1, pages 1-4, Philadelphia, Pennsylvania, USA, May 18-21, 2003.

Baum, E. and Haussler (1989). "What Size Net Gives Valid Generalization?" Neural Computation, Vol. 1, No.1, Pages 151-160.

Barth P., (1997). Mining for Profits in the Data Warehouse. In Barquin R. & Edelstein H. (Eds.), Building, Using, and Managing The Data Warehouse, Prentice-Hall, Inc., Upper Saddle River, NJ.

Brauer Bob (2001). "Data quality, Spinning Straw Into Gold", Data Flux Corporation. http://www.dataflux.com/data/spinning.pdf

Chiang, W., Urban T., and Baldridge G. (1996). A neural network approach to mutual net asset value forecasting. Omega 24: 205-215.

Cohen W. and Richman J. (2002). "Learning to Match and Cluster Large High-Dimensional Data Sets for Data Integration". In Proceedings of 8th ACM SIGKDD International Conference on Knowledge Discovery and Data Mining, KDD 2002, Edmonton, Alberta, Canada, July 23-26, 2002.

Do H., Melnik S., Rahm E. (2002). "Comparison of Schema Matching Evaluation." In Proceedings of the 2nd Int. Workshop on Web Databases (German Informatics Society), Pages 221-237, 2002.

English Larry P. (1999). Improving Data Warehouse and Business Information Quality, Methods for Reducing Costs and Increasing Profits, John Wiley & Sons, Inc., New York, NY.

Fausett L. (1994). Fundamentals of Neural Networks, Architectures, Algorithms, and Applications, Prentice-Hall, Inc., Upper Saddle River, NJ.

Harston, C. T. (1990). "Business with Neural Networks" In A. J. Maren, C. T. Harston, & R. M. Pap, eds., Handbook of Neural Computing Applications. San Diego: Academic Press, pp. 391-400.

Hernandez M. and Stolfo S., (1995). "Merge/Purge Problem for large databases", Proceedings of the ACM SIGMOD International Conference on Management of Data, pages 127-138, May 1995.

Hernandez M. (1996). "A Generalization of Band Joins and the Merge/Purge Problem", Ph.D. thesis, Columbia University, 1996.

Jain, B. and Nag, B. (1995). Artificial neural network models for pricing initial public offerings. Decision Sciences 26: 283-302.

Lee M.L., Ling T. W. and Low W.L. (2000). "IntelliClean: A Knowledge-Based Intelligent Data Cleaner ", Proceedings of the 6th ACM SIGMOD International Conference on Knowledge discovery and Data Mining, pages 290-294, August 2000.

McCallum A., Nigam K., and Ungar L. (2000). "Efficient Clustering of High-Dimensional Data Sets with Application to Reference Matching". In Proceedings of the Sixth International Conference on Knowledge Discovery and Data Mining, pages 169-178, 2000.

Milrud B. (2001). "Finding and Eliminating Duplicate Data." Retrieved November 13, 2001 on World Wide Web. http://gethelp.devx.com/techtips/oracle_pro/10min/10min0501/10min0501.asp

Monge A. E., and Elkan C. P. (1996). "The field matching problem: Algorithms and applications", Proceedings of the 2nd International Conference on Knowledge Discovery and Data Mining, pages 267-270, AAAI Press, August 1996.

Monge A. E., and Elkan C. P. (1997). "An efficient domain-independent algorithm for detecting approximately duplicate database records", Proceedings of the ACM-SIGMOD workshop on Research Issues on Knowledge Discovery and Data Mining, Tucson, AZ, 1997.

Nguyen, D., and B. Widrow. (1990). "Improving the Learning Speed of Two-Layer Neural Networks by Choosing Initial Values of the Adaptive Weights." International Joint Conference on Neural Networks, San Diego, CA, III: 21-26, 1990.

Rumelhart, D.E., J. L. McClelland, & PDP Research Group. (1986). Parallel Distributed Processing, Explorations in the Microstructure of Cognition; Vol. 1: Foundations. Cambridge, MA : MIT Press.

Schoneburg, E. (1990). Stock price prediction using neural networks: A project report. Neurocomputing 2: 17-27.

Winkler, W. E. (1995). "Matching and Record Linkage," in B.G. Cox et al. (ed.) Business Survey Methods, New York: J. Wiley, 335-384.

Perceived Service Quality, Relationship Quality, and IT Outsourcing Success in Malaysian Organizations

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ABSTRACT

The objective of this research was to examine the outsourcing of IT functions in Malaysian organizations; in particular how variables like perceived service quality of outsourcer and relationship quality affect outsourcing success. The research adopted a cross-sectional approach and employed both self-administered and mailed survey procedure. The unit of analysis is organizational level. In order to achieve the research objective, data was analyzed using structural equation modeling. The measures seem to demonstrate internal consistency for Malaysian organizations. The study confirms that perceived service quality of outsourcer determines both relationship quality and IT outsourcing success. However, there was no link between relationship quality and IT outsourcing success for Malaysian organizations. Lastly, the finding indicates that the proposed research model is good fit to the observed data.

Keywords: Service quality, relationship quality, information technology outsourcing, structural equation modeling

1. INTRODUCTION

Information technology (IT) outsourcing is neither a new nor an emerging trend. In recent years, the growth of IT outsourcing has been phenomenal. In year 2001, the worldwide spending on IT outsourcing services already reached over USD60 billion and the figure was expected to grow by a 5 year compound average growth rate (CAGR) of 12 per cent[1].

In Malaysia, the International Data Corporation (IDC) expected the IT outsourcing market to grow at 34.2% over the next five years since year 2004. The nature of services being provided and the type of contracts that are being signed, according to IDC, would largely determine the IT outsourcing market size[2]. IDC also forecasted that the Malaysian IT outsourcing market would hit the US$164 million mark by 2005 (Manecksha, 2003).

The IT outsourcing market for the financial sector in Malaysia has been largely shaped by the Financial Master Plan of the Malaysian Central Bank revealed in year 2001. One notable key principle of the plan was the encouragement for banks to outsource non-core back office and IT processes towards enhancing internal efficiency and enabling focus on selling and marketing financial services products. Several blue chip Malaysian banking firms answered this call. Malaysia's anchor banks such as, Maybank and Bumiputra Commerce Berhad notably and recently announced the signing of major IT outsourcing agreements. In year 2003, Maybank signed an outsourcing agreement estimated at RM1.3 billion over a 10-year period with the CSC Group to outsource IT infrastructure services in Malaysia and Singapore[3]. The Bumiputra Commerce Berhad, signed a USD250 million outsourcing contract for a period of over 10 years with EDS Malaysia. Malaysia also sees the trend of outsourcing IT functions in government-linked companies[4]. In year 2003, Permodalan Nasional Berhad (PNB), Malaysia's leading fund manager signed a major IT outsourcing agreement for a period of three years with HeiTech Padu Berhad a local home-grown IT service provider[5]. In Malaysia, the outsourcing of IT functions does not limit itself within the financial industry. In the transportation industry, the Malaysian Airlines Systems in year 2003 awarded a US$116 million outsourcing contract to IBM Global Services[6].

While the IT outsourcing trend in Malaysia has been encouraging, empirical studies on the contributions of perceived service quality of outsourcer and relationship quality between client and outsourcer to IT outsourcing success seem to lack. Hence, this paper aims to determine whether perceived service quality of outsourcer and relationship quality between client and outsourcer predict IT outsourcing success in Malaysian organizations. In this research, the client evaluates the service quality of outsourcer and the quality of relationship between the client and outsourcer. In other words, the research assumes the perspective of client in an outsourcing arrangement.

This paper is organized into six sections. This section has introduced the research area. A review of literature is in section two. Section three depicts the hypotheses and research model. Section four presents the methodology. The findings and discussions are available in section five. The last section provides the conclusions of this study.

2. REVIEW OF LITERATURE

This section reviews the literature on IT outsourcing success, perceived service quality of outsourcer and relationship quality between client and outsourcer.

2.1 IT Outsourcing Success

In the past, researchers attempted to provide several definitions of IT outsourcing success. Grover *et a*l., (1996) defined outsourcing success as the benefits derived from the practice of turning over part or all of an organization's IT functions to be administered by one or several external service providers. The outcome of IT sourcing decisions meeting expectations was referred to as outsourcing success (Lacity and Willcocks, 2001). Lee and Kim (2003) defined outsourcing success as the level of fitness between service receiver requirements and outsourcing outcomes delivered by the service provider. More recently, IT outsourcing researchers seem to focus on client's experience of integrated outsourcing success (Grover *et al.,* 1996, Lee and Kim, 1999; Lee, 2001; Lee and Kim, 2003). Clients derive three main benefits of outsourcing success, namely:

- *strategic benefit*: the ability of a firm to focus on its core business by outsourcing routine IT activities' (Lacity and Willcocks, 1998; Williams, 1998)
- *economic benefit:* the ability of a firm to use expertise and economies of scale in human and technological resources of the service provider and to manage its cost structure through unambiguous contractual arrangement (Smith *et al.,* 1998; Klepper and Jones, 1998; Bryson and Ngwenyama, 2000).
- *technological benefit*: the ability of a firm to gain access to leading-edge IT and to avoid the risk of technological obsolescence that results from dynamic changes in IT' (Lacity and Willcocks, 1998, Aubert *et al*., 1999, Lee *et al*., 2000).

2.2 Perceived Service Quality of Outsourcer

The quality of service is thought to be the core criterion for overall customer service (Parasuraman *et al.,* 1991). Service quality is defined as the overall support delivered by the service provider, regardless whether such support is handled by the IT department, a new organizational unit or outsourced to an Internet service provider (DeLone and McLean, 2003). From the service receiver perspective, the service quality delivered by service provider may contribute to outsourcing success (Grover *et al*., 1996; Jiang *et al*., 2003).

IS researchers have been assessing service quality using the SERVQUAL instrument. Based on Parasuraman *et al.,* (1988), the service quality dimensions in the SERVQUAL instrument comprise the following elements namely:-

- *Tangibles:* appearance of outsourcer's physical facilities, equipment, personnel and communication materials;
- *Reliability:* outsourcer's ability to perform the promised service dependably and accurately;
- *Responsiveness:* outsourcer's willingness to help customers and provide prompt service;
- *Assurance:* knowledge and courtesy of outsourcer's employees and their ability to convey trust and confidence;
- *Empathy:* caring, individualized attention which the outsourcer provides to its customers.

Grover *et al.,* (1996) found that service quality had a direct effect on IT outsourcing success in 188 firms in the United States. They concluded that improved service quality and fostering relationship between outsourcer and client had a significant and positive impact on the success of application development and maintenance outsourcing functions. However, only reliability and tangibles constructs were considered in the assessment of service quality in their research. In an empirical research among 168 users and 168 IS professionals, Jiang *et al*,. (2002) concluded that the SERVQUAL was a valuable analytical tool for IT managers.

2.3 Relationship Quality

A working relationship, according to Henderson (1990), is reflected by a long-term commitment, a sense of mutual cooperation, shared risks and benefits, and other qualities consistent with concepts and theories of participatory decision making. In recent years, managing relationship has been regarded as an important role in the effective acquisition and management of emerging information technologies (Grover *et al.,* 1996, Koh *et al.,* 1999, Lee and Kim, 1999, Lee *et al.,* 2004). Consistent with these arguments, researchers suggested that IT outsourcing relationship quality encompasses:-

- *Benefit and risk sharing*: this refers to the degree of articulation and agreement on benefits and risks between partners (McFarlan and Nolan, 1995). Lee and Kim (1999) concluded that benefit and risk share had a positive effect on outsourcing success. Sun *et al*., (2002) found mutual benefit had the greatest impact on outsourcing success.
- *Trust*: the degree of confidence and willingness between IT outsourcing partners (Lee and Kim, 1999; Sabherwal, 1999; Mohr and Spekman, 1994). Sabherwal (1999) found that trust as a key factor in outsourcing of information system development projects. Lee and Kim (1999) found trust had a significant effect on outsourcing success. Wietz *et al.* (2004) found support for the relationship between trust and multiple service channel cooperation
- *Commitment:* cooperative behaviors that provide the context in which both partners could achieve joint goals without raising opportunistic behavior (Mohr and Spekman, 1994). Lee and Kim (1999) indicated that commitment was significantly associated with outsourcing success. Sun *et al.* (2002) found that there was a positive relationship between commitment and IT outsourcing satisfaction.
- *Knowledge sharing:* the extent to which critical or propriety information is communicated between partners (Lee and Kim, 2003). Lee (2001) found knowledge sharing was significantly associated with the degree of attainment of outsourcing benefits.
- *Business understanding:* the degree of understanding in behaviors, goals and policies between partners (Lee and Kim, 1999). Lee and Kim (1999) found business understanding had a significant effect on outsourcing success from both business and user perspectives. Rai *et al.,* (1996) identified congruity in relationship affected strategic alliances between organizations in IT industry.

Crosby *et al.,* (1990) suggested that service quality could influence relationship quality. On the contrary, Gwinner *et al.,* (1998), in a qualitative research, suggested that customers in service industries might remain in a relationship even if they perceived the core service attributes to be less than superior service quality provided that they received important relational benefits. Similarly, Zeithaml *et al.,* (1996) found that service quality directly influenced relational quality. In Australia, Wong and Sohal (2002) indicated that there was a positive and direct relationship between service quality and relationship quality for shoppers in a retail chain department store. More recently, Roberts *et al.,* (2003) research showed that managers needed to consider not only the quality of the service provided but also the quality of consumers' relationship with the organization. However, the context of the research was not in IT outsourcing but consumer purchases.

2.4 Gap in the Literature

To the best of the researchers' knowledge, empirical research on perceived service quality of outsourcer and relationship quality in the context of IT outsourcing continues to remain an under-investigated research area especially in developing nations like Malaysia.

3. RESEARCH HYPOTHESES & RESEARCH MODEL

The objective of this research was to examine the outsourcing of IT functions in Malaysian organizations; in particular how variables like perceived service quality and relationship quality affect outsourcing success. Based on the literature review, the hypotheses of this research are listed as follows:

H_1: *Perceived service quality of outsourcer is associated with IT outsourcing success in Malaysian organizations.*

H_2: *The relationship quality between outsourcer and client is associated with IT outsourcing success in Malaysian organizations.*

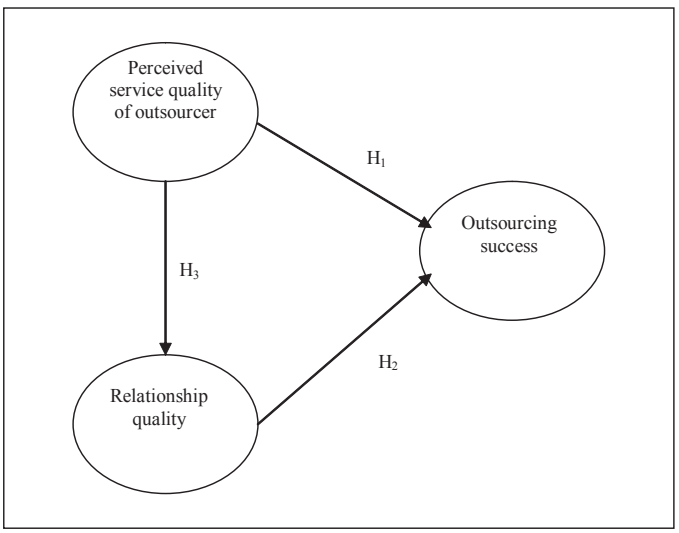
H_3: *Perceived service quality of outsourcer contributes to relationship quality between outsourcer and client in Malaysian organizations.*

Figure 1 shows the research model, depicting the various hypotheses.

4. METHODOLOGY

The research adopted a cross-sectional approach and employed both self-administered and mailed survey procedure. Measures of IT outsourcing benefits were adapted from Lee *et al*. (2004). Respondents were required to evaluate agreement to statements that used a seven-point Likert scale. A seven-point represents "strongly agree" while a one-point represents "strongly disagree". Measures of perceived service quality IT outsourcer were adapted from Jiang *et al*., (2002). Respondents were required to evaluate agreement to statements that used a seven-point Likert

Figure 1. Research model



scale. A seven-point represents "strongly agree" while a one-point represents "strongly disagree". Measures of relationship quality were adapted from Lee and Kim (1999). Respondents were required to evaluate agreement to statements that used a seven-point Likert scale. A seven-point represents "strongly agree" while a one-point represents "strongly disagree".

The unit of analysis in this research is organizational level. According to IT outsourcing literature, many empirical studies set out the measurement of organizational characteristics using the 'key informant' approach. IT managers or the equivalent level to such position holders were selected as key informant to provide information on an aggregated unit of analysis of their outsourced IT functions. Target responding organizations broadly consisted of government and private sectors situated in Putrajaya and the Klang Valley. A sampling frame was formulated based on listing in the Malaysian government official website, Federation of Malaysian Manufacturers (FMM), Small and Medium Industries Development Corporation (SMIDEC) and Bursa Malaysia (the Malaysian Stock Exchange). The estimated number of population was 2475.

We conducted a pre-test among academics as well as practitioners in government and private sectors. Consequently, we incorporated their feedback in ensuring the quality of the questionnaire. We then distributed 50 questionnaires to both government and private organizations in a pilot study. Out of 50, we only received 23 or a response rate of 46%. The questionnaire was revised based on suggestions made. Using stratified systematic sampling method, a total of 960 questionnaires were distributed and e-mail alerts were generated. Data were collected through paper-based questionnaire and web site from April 2005 until July 2005.

5. FINDINGS AND DISCUSSION

In total, we received 162 questionnaires (approximately 18% response rate). Only 143 were found usable for analysis. Unusable questionnaires included those that were returned completely unanswered, incomplete responses on key variables, and organizations that did not practice outsourcing. Data was cleaned and coded accordingly in SPSS Version 13.0. Data was then analyzed using both SPSS Version 13.0 and AMOS Version 5.0. An analysis on non-response bias was conducted by employing post hoc strategy. The early and late respondents were compared on key constructs. There was no significant difference on major variables.

Table 1. Profile of responding organizations

Characteristics	Frequency	Percent
By Industry		
Government	60	42.0
Other services	36	25.1
Manufacturing	22	15.4
Banking and finance	12	8.4
Education	7	4.9
Telecommunication	6	4.2
By total number of employees		
Less than or 50 *(small size organizations)*	13	9.1
51 – 149 *(medium sized organizations)*	18	12.6
Over 150 *(large organizations)*	112	78.3
By the availability of IT department		
Available	118	82.5
Unavailable	25	17.5
By degree of integration		
Minimal outsourcing (below 20% of IT budget)	47	32.9
Selective outsourcing (between 21%-80% of IT budget)	62	43.4
Comprehensive outsourcing (more than 80% of IT budget)	34	23.7
Types of IT functions outsourced		
Application development	112	78.3
Hardware maintenance	110	76.9
Telecommunication/network	91	63.6
Application maintenance	82	57.3
IT consulting	55	38.5
Data center	32	22.4
Help desk	26	18.2
End user support	27	18.9
Others	8	5.6

5.1 Profile of Responding Organizations

Table 1 shows the profile of responding organizations.

The majority of the responding organizations belonged to the government sector (42%). The remainder organizations were in the private sector. A *t*-test was performed to determine if there could be a significant difference. The finding shows that there was no significant difference. Hence, the sample consisting of 143 organizations was treated as one sample and subsequently used in further analysis.

The majority (82.5%) of the responding organizations indicated that they had IT departments. Only a small proportion (17.5%) did not have IT departments.

In terms of degree of integration for outsourcing, the majority of responding organizations indicated that they conducted selective outsourcing (43.4%). Only 23.7% conducted comprehensive outsourcing.

The majority of the organizations (78.3%) outsourced application development. This was followed closely by hardware maintenance (76.9%). Telecommunication/network was ranked third (63.6%). Slightly more than half (57.3%) of the sample indicated that application maintenance were outsourced. Over a third of the organizations (38.5%) outsourced IT consulting to third parties. Slightly over a fifth (22.4%) outsourced their data center. The remaining organizations outsourced help desk, end-user support and others.

5.2 Reliability and Internal Consistency Check

Table 2 shows the Cronbach's coefficient α that was used to assess the reliability of all multi-item scales.

All scales showed reasonable reliability ranging from .866 to .959. They were well above Norusis (2002) generally accepted alpha level .80, indicating good scales.

5.3 Evaluation of the Structural Model

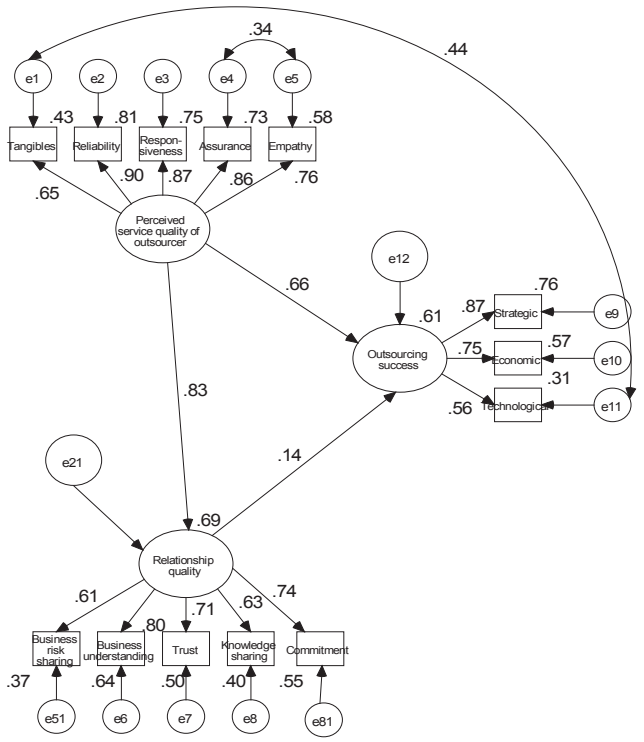
Multi-item constructs were measured using a summated scale derived as the average value of all items pertaining to the constructs. AMOS 5.0 was used to test the structural model. Figure 2 shows the standardized parameter estimates.

Perceived service quality of outsourcer predicted IT outsourcing success (β=.66, $p<.01$) and relationship quality (β=.83, $p<.01$). Higher levels of perceived service quality of outsourcer resulted in greater IT outsourcing success in Malaysian organizations while greater levels of perceived service quality of outsourcer resulted in clients' experiencing higher levels of relationship quality with outsourcer. The model explained substantial item variance: 61% of the variance in IT outsourcing success and 69% in relationship quality, suggesting that perceived service quality is important in explaining outsourcing success and relationship quality. This finding is consistent with Grover *et al.,* (1996) and Jiang *et al.* (2002). The finding that perceived service quality is linked to relationship quality in IT outsourcing success supports Crosby *et al.* (1990) and Roberts *et al*., (2003) work. Against expectation, the hypothesized significant relationship between relationship quality and IT outsourcing success in Malaysian organizations was not supported (β=.14, $p>.05$). This finding appears to be inconsistent with many previous studies (Mohr and Spekman, 1994; Sabherwal, 1999; Lee and Kim, 1999; 2002; Lee, 2001; Sun *et al*., 2002). One possible explanation for the nonsignificant relationship might be a mediating effect for the relationship between relationship quality and IT outsourcing success; culture could be a possible mediating variable. Beulen and Ribbers (2003) suggested cultural issues played an important role in managing IT outsourcing relationships in Asia. Besides, cultural similarity was considered important to create convergent values to help lead to outsourcing success (Henderson, 1990; Fitzgerald and Willcocks, 1994). This is left for investigation in future studies.

Table 2. Cronbach's coefficient for constructs

Factors	α
Outsourcing success (9 items)	.866
Perceived service quality of outsourcer (21 items)	.959
Relationship quality between client and outsourcer (17 items)	.923

Figure 2. Structural model



The confirmation of the overall proposed model was important in providing empirical evidence on predictors of IT outsourcing success (see Table 3).

The χ^2=97.405, df=60, p=.002. According to Raykov (2000), χ^2 and p-value are not the only indicators for model fit. The indicators GFI, NFI, IFI, TLI and CFI for the research model are greater than .90; which indicate good fit to data. The RMSEA=.06 which is approaching .05 indicates a reasonable fit to data (Diamantopoulos and Siguaw, 2000). Overall, the finding indicates that the fit for the structural model for IT outsourcing success was good. In conclusion, there is evidence to support the notion that the model explains a substantial percentage of the variance of the construct.

Table 3. Goodness of fit measures

Fit measure	Value for the research model
χ^2	97.405
Degrees of freedom	60
p-value	.002
GFI	.902
Adjusted GFI	.852
Normed fit index (NFI)	.917
Relative fit index (RFI)	.892
Incremental fit index (IFI)	.966
Tucker Lewis index (TLI)	.956
Comparative fit index (CFI)	.966
RMSEA	.06

6. CONCLUSIONS

The objective of the research was to determine whether perceived service quality of outsourcer and the relationship quality between client and outsourcer predict IT outsourcing success in Malaysian organizations. The research affirms that perceived service quality of outsourcer determines both relationship quality and IT outsourcing success. This phenomenon is consistent with findings of organizations in other countries. In contrast with previous studies, the research did not find a link between relationship quality and IT outsourcing success for Malaysian organizations. Culture might be a mediating variable between relationship quality and IT outsourcing success. Hence, the research enhances our understanding in the role of perceived service quality of outsourcer and relationship quality on IT outsourcing success especially in Malaysian organizations. Overall, the findings call for outsourcers in Malaysia to focus on and enhance the quality of IT services in sustaining relationship quality and attaining benefits from outsourcing.

Some limitations exist and should be acknowledged. Firstly, the research used cross-sectional approach and was static in nature. Therefore, the research did not directly examine the temporal aspects. Future research may consider longitudinal approach. Secondly, the research used single respondent. The perspective was IT managers. Future research may employ actual observations or interviews with different actors conducted at different managerial levels in selected organizations or industries to obtain the benefits of triangulation in understanding the outsourcing phenomenon. Third, this research examined the proposed research model only from the service receiver's perspective. Analysis of the relationship that includes service provider's perspective would be crucial in developing and sustaining high-quality relationship over time. Fourthly, future studies should investigate the mediating effect of culture on the relationship between relationship quality and IT outsourcing success. Finally, results of this research may not be completely generalized and may have to be carefully interpreted since the setting was restricted to Malaysia. The practice of outsourcing in Malaysia and its socioeconomic environment may have played a distinct role to the findings of this research.

REFERENCES

1. Aubert, B.A., Dussault, S., Patry, M., and Rivard, S. (1999). Managing the risk of IT outsourcing. *Proceedings of the 32nd Hawaii International Conference on System Sciences*.
2. Beulen, E., and Ribbers, P. (2003). International examples of large-scale systems-theory and practice II: A Case study of managing IT outsourcing partnerships in Asia. *Communications of the Association for Information Systems*, 11, 357-376.
3. Bryson, N. & Ngwenyama, O.K. (2000). Structuring IS Outsourcing contracts for Mutual Gain: An approach to analyzing performance incentive schemes. *Journal of the Association for Information Systems*, 1(9).
4. Crosby, L. A., Evans, K. R. and Cowles, D. (1990). Relationship quality in services selling: an interpersonal influence perspective. *Journal of Marketing*, 54, 68-81.
5. DeLone W. H. and McLean E. R. (2003). The DeLone and McLean Model of Information System Success: A Ten-Year Update. *Journal of Management Information Systems*, 19(4), 9-30.
6. Diamantopoulos, A. and Siguaw, J. A. (2000). I*ntroducing LISREL A Guide for the Uninitiated.* London: Sage Publications.
7. Fitzgerald, G. and Willcocks, L. (1994). Contract and partnerships in the outsourcing of IT. *Proceedings of the Fifteenth International Conference on Information Systems*, 91-98.
8. Grover, V., Cheon, M.J., and Teng, J.T.C. (1996). The effect of service quality and partnership on the outsourcing of information systems functions. *Journal of Management Information Systems*, 12(4), 89-116.
9. Gwinner, K. P, Gemler, D. D., Bitner, M. J. (1998) Relational benefits in services industries: the customer's perspective. *Journal of the Academy of Marketing Science*, 26(2) 101-114.
10. Henderson, J.C. (1990). *Plugging into Strategic Partnerships: The Critical IS Connection.* MIT Sloan School of Management.
11. Jiang, J.J., Klein, G. and Carr, C.L. (2002). Measuring information systems service quality: SERVQUAL from the other side. *MIS Quarterly*, 26(2),145-166.
12. Klepper R., & Jones W.O. (1998). *Outsourcing information technology, systems, and services.* Prentice Hall, NJ: Upper Saddle River.

13. Koh, C., Tay, C., and Soon Ang. (1999). Managing Vendor-Client Expectations in IT Outsourcing: A Psychological Contract Perspective. *Proceedings of the 20th International Conference on Information System*, 512-517.
14. Lacity, M.C. and Willcocks L. (1998). An Empirical Investigation of Information Technology Sourcing Practices: Lessons from Experience. *MIS Quarterly*, 363-408.
15. Lacity, M. C. and Willcocks L. (2001). *Global Information Technology Outsourcing. In search of business advantage*. Chichester: John Wiley & Sons
16. Lee, J. (2001). The impact of knowledge sharing organizational capability and partnership quality on IS outsourcing success. *Information and Management*, 38(5), 323-335.
17. Lee, J., Huynh, M. Q., Kwok, C. and Pi, S. (2000). The evolution of outsourcing research: What is the Next Issue? *Proceedings of the 33rd Hawaii International Conference on System Science*.
18. Lee, J. and Kim, Y. (1999). The effect of partnership quality on IS outsourcing success: Conceptual framework and empirical validation. *Journal of Management Information Systems*, 15(4), 29-61.
19. Lee, J. and Kim, Y. (2003). Exploring a Casual Model for the Understanding of Outsourcing Partnership. *Proceedings of the 36rd Hawaii International Conference on System Science*.
20. Lee, J., Miranda, S. M. and Kim, Y. (2004). IT outsourcing strategies: universalistic, contingency, and configurational explanations of success. *Information Systems Research*, 15(2), 110-131.
21. Manecksha, F. (2003). Outsourcing sector to keep growing. *Computimes, New Straits Times*, 6.
22. McFarlan, F. an Nolan, R. L. (1995). How to manage an IT Outsourcing Alliance. *Sloan Management Review*, 36, 9-22.
23. Mohr, J. and Spekman, R. (1994). Characteristics of partnership success: Partnership attributes, communication behavior, and conflict resolution techniques. *Strategic Management Journal*, 15, 135-152.
24. Norusis, M. J. (2003). *SPSS 12.0, Statistical Procedures Companion*. NJ: Prentice-Hall. Inc.
25. Parasuraman, A., Berry, L. L. and Zeithaml, V. A. (1991). Refinement and reassessment of the SERVQUAL scale. *Journal of Retailing*, 67(4), 420-450.
26. Parasuraman A., Zeithmal, V. A. and Berry, L. L. (1988). SERVQUAL: A Multiple-Item Scale for Measuring Consumer Perceptions of Service Quality. *Journal of Retailing*, 64(1), 12-40.
27. Roberts, K., Varki, S. and Brodie, R. (2003). Measuring the quality of relationships in consumer services: an empirical study. *European Journal of Marketing*, 37(1/2), 169-196.
28. Rai, A, Borah, S. and Ramaprasad, A. (1996). Critical success factors for strategic alliances in the information technology industry: an empirical study. *Decision Science,* 27 (1), 141-155.
29. Raykov, T. (2000) *A First Course in Structural Equation Modeling*. NJ: Lawrence Erlbaum Associates.
30. Sabherwahl, R. (1999). The Role of Trust in IS Outsourcing Development Projects, *Communications of ACM*, 42(2), 80-86.
31. Smith, M.A., Sabyasachi, M. and Sridhar, N. (1998). Information Systems Outsourcing: A Study of pre-event firm characteristics. *Journal of Management Information Systems*, 15(2), 61-93.
32. Sun, S.Y., Lin, T.C., and Sun, P.C. (2002). The factors influencing information systems outsourcing partnership – A study integrating case study and survey research methods. *Proceedings of the 35th Hawaii International Conference on System Sciences*, 235.
33. Wietz, C., de Ruyter, K., Keen C., and Streukens, S. (2004). Cooperating for service excellence in multichannel service systems: An empirical assessment. *Journal of Business Research*, 57, 424-436.
34. Williams, O. (1998*). Outsourcing: A CIO's Perspective*. St. Lucie Press.
35. Wong, A. and Sohal, A. (2002). Customers' perspectives on service quality and relationship quality in retail encounters. *Managing Service Quality*, 12(6), 424-433.
36. Zeithaml, V., Berry, L.L., and Parasuraman, A. (1996). The behavioural consequences of service quality. *Journal of Marketing*, 60, 31-46.
37. Zeithaml, V., Parasuraman, A., and Berry, L. L. (1990). *Delivering Quality Service: Balancing Customers Perceptions and Expectations*. NY: The Free Press.

ENDNOTES

1 http://www.idc.com(accessed on 7.11.2004)
2 http://www.idc.com.my/Press/releases/PR_IT%20Services_2004.htm (accessed on 7.11.2004)
3 http://my.country.csc.com/en/ne/na/1614.shtml (accessed on 7.11.2004)
4 http://www.fastrackasia.com/page.cfm?name=operational (accessed on 7.11.2004)
5 http://www.heitech.com.my/news/2004/nst200804.html (accessed on 7.11.2004)
6 http://www.fastrackasia.com/page.cfm?name=operational (accessed on 7.11.2004)

Time for Reflection: Going Back to Autopoiesis to Understand Knowledge Management

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ABSTRACT

The field of Knowledge Management has lots of ideas and models, but the problem lies in that the discipline has no solid foundations on which to build new ideas and developments. A lot of the theory in knowledge management is scientifically unfounded and unproven, possibly a result of the difficulty in testing ideas resulting in numerous debates and leaving little time for new developments in the field. The paper introduces the concept of applying Autopoiesis to the Knowledge Management field in order to provide the discipline with a foundation from which to build.

1. KNOWLEDGE MANAGEMENT

1.1 What can we learn from revisiting the Building Blocks of Knowledge Management?

Knowledge management is a relatively young discipline, and is rapidly evolving with new ideas. Whilst knowledge management can be defined as using knowledge as the key asset to drive organisational survival and success (Jashapara, 2004), numerous methods and perspectives exist for implementing knowledge management systems.

There is general agreement among the academic community that definitions of knowledge have their foundations in the work carried out by Ryle and Polanyi (Ryle, 1949; Polanyi, 1967), providing a logical behaviourist perspective. Polanyi suggests that knowledge exists on a continuum between tacit knowledge and explicit knowledge. Tacit knowledge is explained by Ryle as 'knowing how' whilst explicit knowledge is described as 'knowing that'. Ryle provided the example of a person riding a bike. The person has tacit knowledge in that they know how to stay upright, but often they can not explain what keeps them upright. The main idea behind tacit and explicit knowledge appears to be that 'we can know more than we can tell' (Jashapara, 2004).

Davenport and Prusak (1998) extended the work of Ryle and Polanyi to create a continuum with experience (tacit knowledge) and information (explicit knowledge) at each end. 'Insight', 'values' and 'data' were also added as recognition that 'there is no knowledge which is totally tacit and none without at least some tacit aspect' (Eraut et al., 1998). This approach recognises that whilst a person may not have experience of something, they can still have an insight or information about an experience.

Nonaka (1994), whose work was based on that of Ryle and Polanyi, attempts to show that knowledge can be converted between tacit and explicit form, and vice versa, and be transferred between different people. Whilst recognising this takes place, Nonaka does not provide any framework as to how this might happen or what processes are involved. Nonaka's work is almost holistic in its approach.

Whilst most authors have different views on what knowledge is, an agreement that the ideas are based on the work of Ryle and Polanyi means that regardless of what the finer points of the definition are, there is a common understanding that knowledge can exist on a continuum between tacit and explicit knowledge. An understanding of what knowledge is, allows an analysis of what knowledge management is and how knowledge management has developed.

1.2 The History of Knowledge Management

Metaxiotis et al. (2005) split the history of knowledge management into three generations. The first generation was concerned with defining knowledge management, investigating possible systems and looking at the benefits of such systems. Advances in artificial intelligence also prompted study into how knowledge could be represented and stored. The second generation recognised the influence knowledge management could have in management information systems, for example creating frameworks and instigating organisational change.

The third, and current, generation is based on new insights and practices developed from the second generation. According to Wiig (2002), the third generation is more 'integrated with an enterprise's philosophy, strategy, goals, practices, systems and procedures'. This is in recognition that knowledge management has links wider than information management. The third generation reflects the work of Ryle and Polanyi by emphasising the link between knowing and action (Paraponaris, 2003).

The three generations of knowledge management have given rise to numerous definitions, although two authors have tried to create a definition that encompasses current views. Jashapara (2004) defines knowledge management as:

'the effective learning processes associated with exploration, exploitation and sharing of human knowledge (tacit and explicit) that use appropriate technology and cultural environments to enhance an organisation's intellectual capital and performance'

and Davenport and Prusak (1998) define knowledge management as:

'concerned with the exploitation and development of the knowledge assets of an organisation with a view to furthering the organisations objectives. The knowledge to be managed includes both explicit, documented knowledge, and tacit, subjective knowledge'

Both of these definitions consider exploiting knowledge, but then deviate to focus on separate things. Jashapara (2004) is more concerned with sharing knowledge and different methods for sharing, whilst Davenport and Prusak (1998) are more concerned with developing and managing knowledge. Whilst both definitions are different, they are complementary and necessary, since without the ability to develop and manage an organisation's knowledge, it is impossible to exploit and share it.

As this paper has shown, knowledge management theory has lots of ideas and different routes for research. However, the problem is that the research is very conceptual, with high level ideas, and needs to be grounded in science to become sufficient for new and necessary improvements in knowledge management.

1.3 People Focused KM

As knowledge management is concerned with people, substantial work was done to develop the idea of knowledge networks, as introduced by Seufert et al. (1999). Based on the idea of networks and social interactions, knowledge networks were defined as 'a number of people, resources and relationships among them, who are assembled in order to accumulate and use knowledge primarily by means of knowledge creation'. This definition implies that people are working together to share knowledge with the common aim of knowledge creation. Seufert et al. (1999) suggest a framework for knowledge networks, but they neglect to suggest a mode

of implementation. This is probably because 'an integrated approach is required which includes both tacit and explicit knowledge' (Seufert et al., 1999)

Schőnstrőm (2005) has since focused on creating knowledge networks because 'the intentional creation of knowledge networks has only, to a limited degree been treated by KM researchers' (Schőnstrőm, 2005). Seufert et al. (1999) identified two types of knowledge networks, intentional and emergent. The work by Schőnstrőm (2005) focuses on intentional networks, because emergent networks cannot be created. Schőnstrőm (2005) identifies three key learning points from the experiment. First, that knowledge activist must exist in the organisation and be willing to act as network coordinators. Second, that knowledge networks must form part of a company's strategy. Top management support is vital in the implementation of any new mode of operating. Third, that knowledge networks are not immune to organisation restructuring. This is simply because the very basis on which the networks are created can be removed or changed.

2. IS THERE A CONSENSUS TO THE FOUNDATIONS OF KM?

Metaxiotis et al. (2005) have reviewed all of the main agreements and disagreements in the field of knowledge management. The authors suggest that there are agreements with regards to the definition of knowledge management, the benefits of knowledge management, the factors influencing knowledge management and how learning is associated with knowledge management. However, the review so far has shown that there is general disagreement among academics about what constitutes a definition of knowledge management, but it could be that Metaxiotis et al. (2005) are commenting about the complexity and ambiguity surrounding the field.

Among disagreements, Metaxiotis et al. (2005) list frameworks for implementation, whether Information Technology (IT) is a central interest to knowledge management and if knowledge can actually be managed. These are important disagreements. For example, if no framework can be agreed upon, then no system can ever be developed and implemented. With regards to IT, whilst it may not be central to a knowledge management system, it should be essential to implementing a system, especially in firms of considerable size. It is generally accepted that IT will play some part in knowledge management because many authors (Holsapple, 2005; Junnarkar and Brown, 1997) have written about the application of software in knowledge management. The last disagreement Metaxiotis et al. (2005) mention is perhaps the most important; if knowledge can never be managed, then all that can be done is to create systems that can facilitate knowledge sharing among employees.

Despite knowledge management being a relatively young field, organisational learning is a more mature area which has been integrated into knowledge management (Jashapara, 2004). Organisational learning is defined by Senge (1990) as:

'Organizations where people continually expand their capacity to create the results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free, and where people are continually learning to learn together'

The principle of this definition is that employees must be continually learning so that an organisation can learn. Whilst this is true, employee learning does not happen in isolation. This definition also recognises that there must be an interaction and sharing of knowledge between employees for learning to make a difference organisationally.

3. ORGANISATIONAL LEARNING

The learning organisation is a new concept. Yeo (2005) defines a learning organisation as an organisation that "embraces the importance of collective learning as it draws on a larger dimension of internal and external environments." The difference between organisational learning and a learning organisation is that organisational learning is a process an organisation goes through to learn, whereas a learning organisation is a type of organisation (Yeo, 2005). The implication is that whilst all organisations can learn, only learning organisations are continually learning and improving. There is an assumption that learning organisations will be better able to manage knowledge.

Organisational learning is categorised by three stages (Yeo, 2005). The first stage is concerned with individual learning, the second stage with people solving problems by using other team members. The third stage is concerned with the external environment, and how people try to solve problems with respect to external resources. The only criticism is that Yeo does not provide any detail on how the three stages occur or the processes in them.

One important concept in organisational learning is single and double loop learning, originally developed by Argyris and Schon (1978). Single loop learning occurs when an entity modifies their behaviour when there is a difference between expected and actual outcomes. In comparison, double loop learning, occurs when an entity revisits the assumptions and values that led to the behaviour in the first place (Smith, 2001). It is important to consider single and double loop learning because these theories provide the foundations which explain how people learn, and ultimately how organisations learn.

Kim (1993) created a model of organisational learning based on Argyris and Schon's (1978) theory of single and double loop learning. Kim's (1993) integrated model shows the link between individual and organisational learning and all the factors important in the transfer of knowledge.

4. BIOLOGICAL APPROACHES TO KNOWLEDGE MANAGEMENT

Maula (2000) and Hall (2005) have taken a biological approach to knowledge management and organisational learning. Maula (2000) suggests that since organisations are 'living systems that reproduce themselves' the theory of autopoiesis can be applied to them. Maula considers the organisation as a whole with a corporate memory and one boundary, and says that as organisations portray certain characteristics, they are autopoietic. However, Maula (2000) does not provide any detailed analysis to validate his work, or the claim that organisations are living systems.

Hall (2005) gives a more detailed application of autopoiesis to organisations, by explaining how organisations meet the six criteria necessary to be autopoietic, as identified by Varela et al. (1974). Although Hall (2005), like Maula (2000), still only considers the organisation as a whole, and does not consider processes within the organisation.

5. CURRENT KNOWLEDGE MANAGEMENT GAPS

Given the current literature there seems to be several gaps that have been identified and these are:

1. No accepted definition of knowledge or knowledge management
2. No explanation of whether knowledge can actually be managed
3. Disagreements on role and use of IT in knowledge management (Metaxiotis et al., 2005)
4. No commonly accepted framework/toolkit
5. The lack of actual implementations (Schőnstrőm, 2005)
6. Superficial biological approaches (Hall, 2005; Maula, 2000)

There may be numerous reasons why no or very little literature has been found on these topics. First, the lack of agreement on areas such as how knowledge is composed means no consensus can be gained to enable further research. Further research in other disciplines may be needed, for example human cognition. Human cognition is an important area because if it is possible to understand how people learn and generate knowledge, it will be easier to create a system based on that knowledge. There are also difficulties regarding the nature of organisations. Unless an organisation's exact structure can be recorded, it will be impossible to prescribe a knowledge management tool. A third problem occurs with autopoiesis itself. As autopoiesis is such a complex theory, many authors have either applied it to knowledge management at the conceptually very high level, or indicated that it is too complicated, and needs to be significantly simplified to be applied to organisations. However, this could be due to a lack of understanding about autopoiesis.

6. WHAT IS AUTOPOIESIS?

Autopoiesis is a theory which shows what it means to be living. Previously, living entities had been defined by listing their characteristics. However, the counter argument against this approach is that if a machine could mimic these characteristics then it should be considered living. This is evidently wrong, and autopoiesis provides the new approach needed. Instead of defining entities by

their characteristics, Maturana and Varela (1980) define entities by the relationship between the components in the entity. There is also an assumption that living systems are discrete, autonomous entities.

Combining these two ideas, Maturana and Varela (1980) propose that it is the relationship between the processes in living system that realises the entity's ability to be discrete, autonomous and self producing. Autopoiesis could then be defined as the maintenance of an entity's organisation, or relationships between its processes. Maturana and Varela (1980) go onto explain that the network of processes is self producing, in other words the network of processes realises its own existence.

In defining autopoiesis, Maturana and Varela are careful to distinguish between organisation and structure (Maturana and Varela, 1998). Organisation refers to the relationship between the processes that realise the entity, whereas structure refers to the actual components within the entity. For example, when considering living entities, they all have the same organisation, which is autopoietic, but they have different structures, enabling observers to see them as different animals/birds/insects.

When developing the theory of autopoiesis, it was also necessary to define how such entities would interact with each other, in relation to their organisation and structure. The theory of how autopoietic entities interact was developed in structural coupling. This states that any entity, autopoietic or not, can only trigger change in an autopoietic entity. In other words, the autopoietic entity can only change according to its structure.

7. CAN AUTOPOIESIS SOLVE THE PROBLEMS WITH KM?

Preliminary research by Parboteeah and Jackson (2006) shows how autopoiesis can be applied to knowledge management, namely models of organisational learning. The authors are instrumental in breaking down autopoiesis to be useful in knowledge management. After successfully creating a model of autopoietic organisational learning, they propose areas of research that could yield useful results. These areas include creating systems based on their proposed model and other areas of knowledge management to which autopoiesis can be applied.

Several other attempts have been made to apply autopoiesis to organisations (Hall, 2005; Limone and Bastias, 2006), but they have been superficial and avoided actual implementation issues.

In applying autopoiesis to knowledge management, it is hoped the phenomenology normally associated with living systems: self reproduction, the spontaneous creation/destruction of new entities and self specification, can be applied to knowledge management. The self reproduction aspects of living systems could give new insights into knowledge creation, and how a knowledge management system could aid this. Alternatively, this aspect could foster a knowledge management system that will aid or promote innovation and the appropriate culture.

There is also an aspect of autopoiesis that looks at the interactions between two or more entities, called structural coupling. Structural coupling could also be used to enhance a knowledge management systems ability to create knowledge. However, structural coupling could be more suited to applications looking at the issue of collaboration, and the sharing of knowledge among employees.

With an increasing number of organisations going global in their operations, a knowledge management system that can resolve cultural issues will be increasingly important. Culture, should not be an issue with an autopoietic knowledge management system because the system will be self-specifying, meaning that any knowledge stored will include any assumptions/cultural aspects.

Autopoiesis could also be used as a validation tool for knowledge management models. This could prove useful in determining if some models are better than others, if models can be improved after applying autopoiesis, or simply by reducing the number of potential models in circulation.

This research aims to further the work of Parboteeah and Jackson (2006) and will aim to determine the usefulness and practicality of applying autopoiesis to knowledge management. The research will be carried in five stages. The first stage will attempt to formally specify autopoiesis, and hence make it more accessible, and stage two will create tools to model organisations and knowledge management systems. Stage two sets the ground work for stage three which will look at creating an autopoietic knowledge management system at an organisation which already has a knowledge management system. Stage four will attempt to create a knowledge management for an organisation that has no formal knowledge management system. The final stage will aim to create a framework or toolkit to enable future organisations to create an autopoietic knowledge management system.

8. CONCLUSION

Following a review of current knowledge management literature, numerous problems were identified, which included a lack of reported implementations, a lack of a common framework and a lot of unfounded ideas. The field of knowledge management would benefit from unifying all of the current ideas into one model. This unifying model would help to create a foundation for knowledge management from which new ideas can be developed and so helping the field of knowledge management to move forward.

As has been identified by this paper, the current work on autopoiesis is too abstract and conceptual to be of substantial use in knowledge management. Formalising autopoiesis will help to make autopoiesis and its associated theories more accessible and more easily applied to other disciplines. It is hoped that using autopoiesis in knowledge management will help to create a deeper understanding of issues in knowledge management, such as what constitutes knowledge and how it can be mapped. These are all ideas which the authors hope will be addressed by the ongoing research that is taking place.

REFERENCES

Argyris, C., & Schön, D. (1978) 'Organizational learning: A theory of action perspective', Reading, Mass: Addison Wesley.

Davenport, T., and Prusak, L. (1998) 'Working Knowledge: Managing What Your Organisation Knows', Harvard Business School Press, Boston, MA.

Eraut, M., Alderton, J., Cole, G. and Seneker, P. (1998) 'Development of Knowledge and Skills in Employment', Research Report Number 5, USIE.

Hall, W.P. (2005) 'Biological nature of knowledge in the learning organisation', The Learning Organization, Vol. 12 No. 2 pp. 169-188.

Holsapple, C.W. (2005) 'The inseparability of modern knowledge management and computer based technology', Journal of Knowledge Management, Vol. 9 No. 1 pp. 42-52.

Jashapara, A. (2004) 'Knowledge Management: An Integrated Approach', FT Prentice Hall, Essex.

Junnarkar, B. and Brown, C.V. (1997) 'Re-assessing the enabling role of Information Technology in KM', Journal of Knowledge Management, Vol. 1 No. 2 pp.142-148.

Kim, D.H. (1993) 'The Link between Individual and Organizational Learning', Sloan Management Review, Fall 1993 pp.37-50.

Limone, A. and Bastias, L.E. (2006) 'Autopoiesis and Knowledge in the Organization: Conceptual Foundation for Authentic Knowledge Management'.

Maturana, H.R., Varela, F.J. (1998) 'The Tree of Knowledge: Biological Roots of Human Understanding', Revised Edition, Shambhala, Boston and London.

Maturana, H. R. and Varela, F.J. (1980) 'Autopoiesis and Cognition: The Realization of the Living' D Reidel Publishing Company, Holland and The USA.

Maula, M. (2000) 'The senses and memory of a firm – implications of autopoiesis theory for knowledge Management', Journal of Knowledge Management, Vol. 4 No. 2 pp. 157 – 161.

Metaxiotis, K., Ergazakis, K., and Psarras, J. (2005) 'Exploring the world of knowledge management: agreements and disagreements in the academic/practitioner community', Journal of Knowledge Management, Vol. 9 No.2, pp 6-18.

Nonaka, I. (1994) 'A dynamic theory of organizational knowledge creation', Organization Science, Vol. 5 No.1 pp. 14-37.

Paraponaris, C. (2003) 'Third Generation R&D and strategies for knowledge management', Journal of Knowledge Management, Vol. 7 No. 5 pp. 96-106.

Parboteeah, P. and Jackson, T.W., 'Building a Scientific Foundation for Organisational Learning Within the KM Paradigm', The Knowledge Management Aston Conference, Edwards, J (ed), Operational Research Society, The Knowledge Management Aston Conference, Aston, UK, July 2006, pp 76-91.

Polanyi, M. (1967) 'The Tacit Dimension', Doubleday, New York.

Ryle, G. (1949) 'The Concept of Mind', Hutcheson, London.

Schőnstrőm, M. (2005) 'Creating knowledge networks: lessons from practice', Journal of Knowledge Management, Vol. 9 No. 6 pp. 17-29.

Senge, P. M., Roberts, C., Ross, R. B., and Smith, B. J. (1994) 'The Fifth Discipline Fieldbook: Strategies and Tools for Building a Learning Organization', Bantam Doubleday Dell Publishing Group.

Seufert, A., von Krogh, G., and Bach, A. (1999) 'Towards knowledge networking', Journal of Knowledge Management, Vol. 3 No. 3 pp. 180-190.

Smith, M. K. (2001) 'Chris Argyris: theories of action, double-loop learning and organizational learning', the encyclopedia of informal education, www.infed.org/thinkers/argyris.htm, Accessed 12 April

Varela, F.G., Maturana, H.R., and Uribe, R. (1974) 'Autopoiesis: The Organization of Living Systems, its Characterization and a Model', Biosystems, Vol. 5 pp187-196.

Wiig, K. (2002) 'New Generation Knowledge Management: What May We Expect?', Knowledge Research Institute, Arlington, Texas.

Yeo, R.K. (2005) 'Revisiting the roots of learning organization: A synthesis of the learning organization literature', The Learning Organization, Vol. 12 No. 4 pp. 368-382.

Knowledge Losses in the Capturing Process

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ABSTRACT

To be competitive organizations need to manage the knowledge resource. One aspect of doing this is to build IT-supported knowledge repositories. Successful knowledge repositories require that stored information is updated and relevant. The importance of the capturing process is obvious. To run the capturing process efficiently requires identifying "all" knowledge, evaluating it and sorting out knowledge which should not be stored, i.e. managing knowledge losses. Based on theoretical and empirical studies, this paper complements the capturing process in an existing framework with knowledge losses in order to take a first step to make the framework implementation-oriented. Furthermore, in order to show the potential usefulness of this approach, we present some initial guidelines for how to manage the identified knowledge losses.

Keywords: Knowledge repositories, the capturing process, knowledge losses, guidelines

1. INTRODUCTION

To be competitive organizations must reuse knowledge from earlier experiences and learn how to not do the same mistake over and over again. "*If failure is ignored, denied or repressed, the opportunity to learn from past mistakes is lost.*" (Chua and Lam, 2005, p. 7). One way to enhance knowledge reusing is to develop IT-supported knowledge repositories. A large number of Knowledge Management (KM) projects fail (e.g. Storey and Barnett, 2000; Senge, 1999), and the question is *how* organizations can implement and manage KM (e.g. Sena and Shani, 1999; Wong and Aspinwall, 2004). Aggestam (2006) proposes a framework for IT-supported KM (FIT-KM) from the perspective of knowledge repositories (Figure 1). FIT-KM shows *what* this is about, but lacks support for *how* to do it. This paper *aims* to take a first step to extend this framework to an implementation one.

One dimension of KM success is user satisfaction (Jennex and Olfman, 2006). This requires high quality in stored information, which in turn prerequisites capturing "all" knowledge, evaluating it and sorting out knowledge which not should be stored, i.e. reducing unwanted knowledge losses as well as increasing wanted ones. The *goal* for this paper is to complement *"Capture New Knowledge"* in FIT-KM with knowledge losses, and present some *initial* thoughts about how to manage them. These thoughts make no claims to be complete; but to show the potential usefulness of the approach. Little research exists that relates knowledge losses to knowledge processes, and to the best of our knowledge, this approach when developing a KM implementation support has not earlier been used. The *research method* is a qualitative analysis based on a literature study, and a case study performed through participation in a KM implementation project. One case study can be justified if it is purposeful and provides a large amount of information (Gummesson, 2001). While unwanted losses results from not running this process efficient, and wanted losses the opposite, we in both studies focused on success factors.

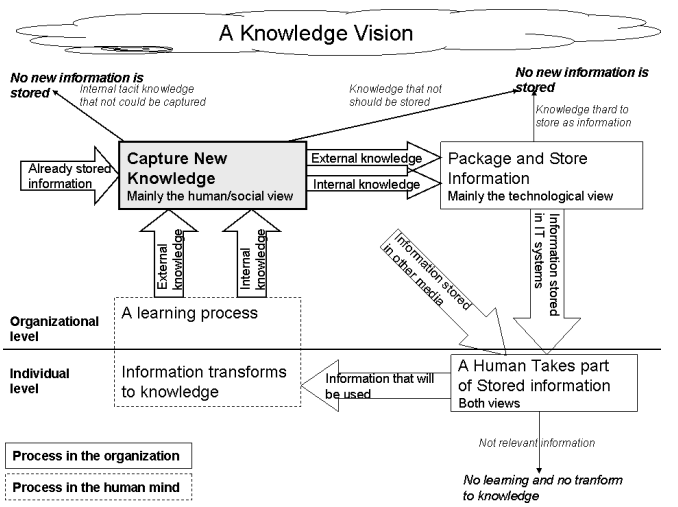
2. BACKGROUND

Focusing on the capturing process, 2.1 gives an introduction to FIT-KM, while 2.2 describes the case.

2.1 FIT-KM

FIT-KM, Figure 1, describes what IT-supported KM is from the perspective of knowledge repositories (Aggestam, 2006).

Figure 1. FIT-KM and the focus of this paper (from Aggestam, 2006)



The remainder of this chapter discusses the focused process, *Capture New Knowledge*.

Capture New Knowledge aims to capture already stored information, and different types of knowledge which has potential for being stored in the repository. Knowledge can not exist outside the human mind, thus the repository can only hold information that supports knowledge transformation. The capturing process includes an identification activity as well as a selection element. FIT-KM separates between internal and external knowledge. Internal knowledge is knowledge that people hold in their minds (Wiig, 1993), and knowledge that is held, e.g., in books and IT systems, is external knowledge, information (our remark). Information can be processed by IT, but knowledge requires humans (Swan et al, 1999). Another common distinction is between tacit and explicit knowledge (e.g. Gore and Gore, 1999). FIT-KM lacks this separation. Tacit knowledge is rooted in individual actions, experiences, ideals etc. (Gore and Gore, 1999; Nonaka and Takeuchi, 1995), and not easy to identify and express (e.g. Blodgood and Salisbury, 2001). Explicit knowledge is easier to express and can, in contrast to tacit knowledge, also easily be processed by a computer (Nonaka and Takeuchi, 1995). Table 1 summarizes this.

New in Capture New Knowledge refers to knowledge which supporting information not is stored in the repository, and/or not is conscious for employees. FIT-KM identifies here two potential losses, one wanted and one unwanted.

Table 1. Different types of knowledge

	Internal knowledge	External knowledge
Tacit knowledge	e.g. "know-how"	-
Explicit knowledge	e.g. Stockholm is the capital of Sweden	e.g. documented, "information"

2.2 Case Study

The project EKLär is in the area of health care, more precisely focusing on the treatment of leg ulcers. EKLär aims to develop an IT-supported knowledge repository for learning and sharing of best practices with respect to treatment and prevention methods for leg ulcers[1]. The approach used in EKLär, Enterprise Knowledge Patterns (EKP), combines Enterprise Modelling (EM) with organisational patterns (Stirna, Persson and Aggestam 2002). It is characterized by a strong emphasis on stakeholder participation and the use of Organizational Patterns in order to identify possible knowledge chunks and their content.

The project is carried out in three main phases: preparation, implementation, and evaluation, where the evaluation phase is in its initial stages. **The preparation phase** continued for approximately six months, and aimed to collect knowledge about the domain, and gain approval for the main purpose of the project. Data were collected during 19 interviews and 2 observations. **The implementation phase** continued for approximately fifteen months. It included daily works to develop the repository and hands-on-learning to teach the stakeholders how to manage knowledge. Data were mainly collected during project meetings. An average of one meeting a month lasted a half to a whole day. The meetings were documented through models and patterns developed, and also by detailed notes. The notes for each meeting were summarized and sent to the participants. Further collected data include relevant documents as well as similar projects from other hospitals. The aim of the initial meetings was to identify which knowledge area to focus on. The result was a compromise between the identified needs in the preparation phase and what the hospital staff regarded to be the most important knowledge to be taught. On this basis, the work proceeded to capture relevant knowledge, and package and store it. As work proceeded the nurses became increasingly autonomous and carried out more and more work between our meetings. One important issue was to decide which technical tool to use. The project decided to use an existing technical solution, which the hospital had already decided to invest in. A critical step is making the result survive after the project is finished. In EKLär this requires that the repository it is kept up-to-date. This work is still progressing, parallel with the evaluation phase. **The evaluation phase** has been going on for 4 months. So far, we have made 8 observations using "think aloud" protocols. The observations were taped and transcribed. In relation to the observation we asked questions based on Jennex and Olfman (2006) KM success model in order to identify the potential for the repository to being successful.

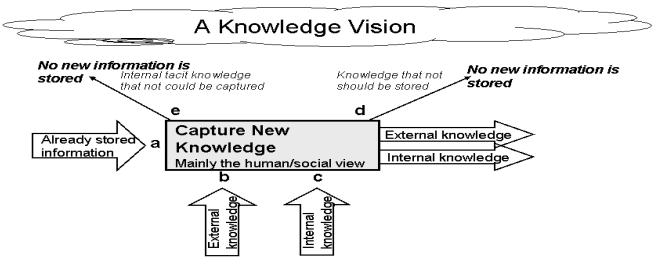
3. ANALYSIS

We have compared data with data, with existing theories, and previous results. This is a key to qualitative research analysis (Gummesson, 2005). In order to enable traceability we throughout the analysis kept empirical and theoretical data separated. We summarize what we have done, but not *how* our minds were thinking. Intuition is like a brother or sister to common sense (Gummesson, 2001), and not easy to describe. It is not possible to include all data that has been input to the analysis[2], but in order to clarify we give examples from both EKLär and literature.

1. *Analyzing data from the perspective of Capture New Knowledge.* This results in two lists of success factors; one list originates from theoretical data, and one from empirical. This step also shows factors, not specific for capturing, but important to manage from the beginning of the project, and throughout the whole. Some of these concern things that must be done *before* the project start. For example, the project must convince the users (e.g. Chua and Lam, 2005), and the needed participation from employees require teaching (e.g. Davenport and Prusak, 1998). With regard to the focus of this paper we decided to exclude these factors. Other general factors concern passing knowledge to "Package and Store Information". In EKLär we discussed who are responsible for this, and how would it be done. From a maintenance perspective this is crucial if the repository will be successful in the long run. These factors we placed in an own group called "Other factors". For clarity reasons, they are described in the next step.
2. *Grouping success factors in accordance with FIT-KM* (**a–e** in Figure 2)
   - ***a.*** *Already stored information:* We must separate between information already stored *in* the organization, and information stored *outside*. In the literature this is to our knowledge not explicitly mentioned, but in EKLär this was obvious. Examples of information stored outside are a Danish net based knowledge repository, and films distributed from the material suppliers. EKLär also high lightened legal aspects, what information are we allowed to reuse? This legal aspect impacts if knowledge could be stored or not, and we concern them to influence the already identified wanted loss in FIT-KM. Furthermore, in EKLär there was information as different types of programs and recommendations that no one in the beginning relates to EKLär. The used EKP approach enhances the work to identify this information. It is a good idea to start with a review of existing external knowledge (Gore and Gore, 1999), which lightens that there could be information no one knows about. To scan potentially relevant information is time-consuming. Asymmetry of knowledge is a problem (Davenport and Prusak, 1998), and managing knowledge only within silo-oriented communities represent great risks that business-critical knowledge is neglected (Chua and Lam, 2005).
   - ***b.*** *External knowledge:* There is external knowledge which the knowledge knower does not want to share with others. Political processes between different stakeholders, e.g. IT and media affairs, must be managed (Chua and Lam, 2005), and individuals must overcome imperatives as wanting to be where they are (e.g. Sun and Scott, 2005). There must be a knowledge sharing attitude (e.g. Busch and Richards, 2004). The quickest and easiest ways to affect the culture are changes in the reward and punishment system (Schein, 2004). The willingness to share knowledge was not a problem in EKLär, possible with regard to the fact that they are use to share knowledge. External knowledge is the same as information, and we argue that this process is included in the former one. Both are about willingness to contribute, and prerequisites that the information is known.
   - ***c.*** *Internal knowledge:* The analysis clears the need to differentiate between internal *tacit* and internal *explicit* knowledge. KM should include both because if it only concerns explicit then it could be difficult to distinguish it from *information* management (Loermans, 2002). Comparing to tacit knowledge, explicit knowledge is easy to capture *if* the knowledge owner wants to share it. Success factors for capturing explicit knowledge concern the same thing as discussed in the former groups. A key in KM is the degree to which tacit knowledge can be captured and transformed into explicit knowledge (Gore and Gore, 1999). Nonaka and Takeuchi (1995) identify four knowledge conversion modes. With regard to the strong emphasis on participatory design, to our experience the EKP approach enables these:
     - Socialization (from tacit to tacit): In accordance with EKP we have develop the repository together in the project group. In this group we have share experiences, mental models etc. which enhance socialization.
     - Externalization (from tacit to explicit): Using patterns we have in the project group had successive rounds of meaningful dialogue in order to reveal hidden tacit knowledge.
     - Combination (from explicit to explicit): In the project group concepts have been combined with existing data and knowledge, both in the hospital and outside, in order to create more shareable specifications.

     The EKP approach also assists internalization (from explicit to tacit). Internalization is about *using* knowledge and outside the scope of this paper. Visiting each others working places is another way mentioned in EKLär aiming to identify tacit knowledge.
   - ***d.*** *Knowledge that not should be stored:* This is a wanted loss already identified in FIT-KM. The analysis strengthens its importance, and clari-

Figure 2. Analyze step 2



fies the critical role the vision plays here (e.g. Blodgood and Salisbury, 2001; Wong and Aspinwall, 2004). The analysis reveals the importance to differ between the knowledge vision and knowledge goal. The vision is strategic, but in line with this, for each KM project, there must be a goal to evaluate against. The importance of both becomes more and more obvious in EKLär as it proceeds. Should further knowledge areas be incorporated or not? What knowledge vision does the top management has for the whole hospital? Top management has responsibility for the vision. (Gore and Gore, 1999; Davenport and Prusak, 1998), and senior management support is critical. (e.g. Chua and Lam, 2005; Davenport and Prusak, 1998). Factors here also include the importance of updating. It is not only a question about putting in new information, it is also necessary to take away information. This concerns mainly the next process, "Package and Store Information", but often brings to the fore in the capturing process.

e. *Reducing internal tacit knowledge loss:* The key here is to convert tacit knowledge to explicit knowledge, and the discussion in point c is applicable.

Other factors: KM has to be adapted to business and knowledge processes (Remus and Schub, 2003). A lack of effective mechanism to distil knowledge from debriefs and discussions results in valuable knowledge remained obscured (Chua and Lam, 2005). In EKLär this work is in its initial phase, but we plan a lot of effort to identify capturing points, i.e. to find the link between new generated knowledge and the capturing process. For this the content, its structure and relevance, is important (e.g. Chua and Lam, 2005; Davenport and Prusak, 1998), and the method used to develop it. We argue that the EKP approach enhances this work by its structure of knowledge chunks.

3. *Analyzing each group from the perspective of knowledge loss*

The analysis reveals four new losses and embeds knowledge for how to manage them.

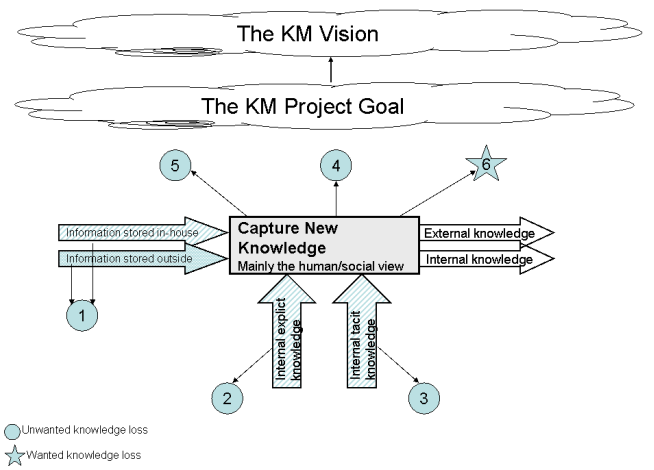
4. RESULTS

The analysis results in four unwanted knowledge losses and some further aspects to already identified losses in FIT-KM. It also reveals some lacks in FIT-KM as no

- separation between internal tacit and explicit knowledge
- knowledge goal
- separation between information stored in and outside the organization.

Furthermore, the input "External knowledge", is both wrong and overflow. It emerges from the individual level and concerns *internal* knowledge an individual has created when using information, and it is the same thing as information which is already covered in FIT-KM. Figure 3 shows the extended and updated version of Capture New Knowledge.

Figure 3. Knowledge losses in the capturing processes



Numbers 1-6 in Figure 3 refer to knowledge losses, where losses 1-4 result from the work presented in this paper. Number 1-5 concern unwanted losses, and number 6 a wanted one. Number 1-3 refer to losses meaning that knowledge does not even reach the capturing process, and the need of a structured approach to identify *when* new knowledge has been created is obvious. It is not enough that knowledge is known, and the knowledge owner is willing to share it, the KM process must also be integrated in organizational processes, and supported of the technical tool. With regard to the goal for this paper, the remainder of this section will elaborate the 6 losses.

1. There is information stored in other media as documents, books, protocols etc. This information can be found inside the organization, in the actual department or in another one, or outside. If no one knows about this information, or thinks about it from the perspective of the actual KM work, it will never reach the capturing process. Furthermore, there is also information which is known, but the knowledge knower does not want to disseminate it. This information is already stored somewhere else, but if it is not integrated and related with other organizational knowledge it will probably be hard to find and reuse.
2. This is about willingness. The knowledge knower is the knowledge owner. With regard to the fact that actual knowledge is explicit it must be known. However, one further problem can be that the knowledge owner does not think about it as relevant for the repository.
3. Like number 2 the knowledge knower is always the knowledge owner, but it varies if the knowledge owner is conscious about the knowledge or not. If the knowledge is known, reasons for losses are willingness or unconscious about the knowledge.
4. An important part is to pass captured relevant knowledge to the next process. If this not is integrated in daily processes, or supported by IT-tool, there is a great risk that the knowledge never is stored.

Table 2. Supporting knowledge losses

Initial Guidelines	**Knowledge loss**
G1. Use an approach, e.g. EKP, that forces employees studying information from other perspectives comparing to how it is stored and structured. This also enhances combination.	1
G2. Increase employee's reserved time for searching and evaluating information.	1
G3. Introduce reward system that encourage willingness to share knowledge	1,2
G4. Disseminate early successes as success stories (Chua and Lam, 2005).	1,2,3
G5. Stimulate networks, both formal and informal, to create relationships. Relationships increase the flow of information (Sun and Scott, 2005).	1,2,3
G6. Try to identify points in organizational processes which indicate that knowledge has been created.	1,2,3
G7. Visit each others working places and learn by sitting on in a class.	1,2,3
G8. Base discussions on a tool, e.g. EKP, to force thinking from another perspective in order to enhance externalization.	3,5
G9. Structure the content in such way that it enhances updating, e.g. knowledge chunks.	4
G10. Pay attention to the employees who should maintain the repository when choosing technical support.	4
G11. Store information about knowledge owners	5
G12. Describe the goal in adaptive ways so employees understand what it is about.	6
G13. Relate knowledge that is identified as relevant to the knowledge goal.	6
G14. Study captured relevant knowledge from the perspective of legal aspects.	6

5. There is internal tacit knowledge that not could be captured. Comparing to number 3, the knowledge owner is conscious about it and wants to share it, but there is a lack of methods, processes etc. to capture it. An alternative could be to store information about the owner.
6. There is knowledge that not should be stored. Reasons for this are for example that it does not contribute to the knowledge goal, or that it is illegal to store it.

The analysis embeds knowledge for how to attack these losses. In Table 2 we present some initial thoughts concerning this. The leftmost column presents the thoughts in form of guidelines, and the rightmost its corresponding knowledge loss/es.

Some unwanted losses depend primary on organizational culture, e.g. if a member in the organization wants to share knowledge or not, while some would get concrete benefit from tool support, e.g. to reveal already stored information in the organization. Work aiming to influence the culture is a long time work. However, even losses caused primarily of culture will get benefits from more directly activities as for examples reward systems (G3) and reserved time in regular tasks (G2). Even different types of tool and method support have the same effect, e.g. EKP (G1, G9) and how the repository is build and structured (G10, G11). If it is easy to share knowledge the willingness to do it will increase and this will have positive effects on the knowledge sharing culture.

5. CONCLUSION AND FUTURE WORK

In this paper we have complemented the process *"Capture New Knowledge"* in FIT-KM with four knowledge losses, and presented some initial thoughts for how to manage knowledge losses. Furthermore, the results show the potential usefulness of this approach when developing a KM support. This is in accordance with the goal for the paper, and a first step to extend FIT-KM to an implementation one has been taken.

Presented guidelines are initial thoughts which must be refined and complemented. This future work must pay attention to demands as

- if the capturing process is a start one in a new KM project or if it is a process in ongoing KM
- strategic and operative levels
- different roles in KM work

Systematic effort to track and measure success of KM projects is needed (Chua and Lam, 2005). From the perspective of the KM success model presented in Jennex and Olfman (2006) the capturing process mainly influences the Knowledge Quality dimension. We argue that this dimension is valuable when evaluating the further developed guidelines.

6. REFERENCES

Aggestam, L. (2006). *Wanted: A Framework for IT-supported KM* Proceedings of the 17:th Information Resources Management Association (IRMA), 21-24 May 2006, Washington, USA, pp.46-49.

Blodgood, J.M. and Salisbury, W.D. (2001) *Understanding the influence of organizational change strategies on information technology and knowledge management strategies* Decision Support Systems 31, pp. 55-69.

Busch, P and Richards, D (2004) *Tacit knowledge and culture* The Proceedings of the First International Conference on Knowledge Management (ICKM'04), 13-15 December 2004, Singapore.

Chua, A. and Lam, W. (2005) *Why KM projects fail: a multi-case analysis* Journal of Knowledge Management, Vol. 9, No. 3, 2005, pp. 6-17.

Davenport, T.H. & Prusak, L. (1998) *Working Knowledge* Harvard Business School Press Boston.

Gore, C. and Gore, E. (1999) *Knowledge management: The way forward* Total Quality Management 10 (4,5), pp. 554-56.

Gummesson, E (2001) *Are Current Research Approaches in Marketing Leading us Astray?* Marketing Theory, Vol. 1, No.1, pp.27-48.

Gummesson, (2005) *Qualitative research marketing Road-map for a wilderness of complexity and unpredictability* Euorepean Journal of Marketing Vol. 39, No ¾, 2005, pp.309-327.

Jennex, M. E. and Olfman, L (2006) *A model of Knowledge Management Success* International Journal of Knowledge Management, 2 (3), 51-68, July-September, 2006.

Loermans J. (2002) *Synergizing the learning organization* Journal of Knowledge Management, Vol. 6, No. 3, pp. 285-294.

Nonaka I. and Takeuchi, H (1995) *The Knowledge-creating Company* Oxford University Press 1995.

Remus, U. and Schub, S. (2003) *A blueprint for the Implementation of Process-oriented Knowledge Management* Knowledge and Process Management, Vol. 10, No. 4, pp. 237-253.

Schein, E.H. (2004) *Organizational culture and Leadership (3rd edition)* John Wiley & Sons, Inc. (2004) ISBN: 0-7879-6845-5.

Sena, J. A. and Shani, A. B. (1999) *Intellectual Capital and Knowledge Creation: Towards an Alternative Framework* In Liebowitz, J. (Eds) (1999) *Knowledge Management handbook*, Boca Raton, FL: CRC Press.

Senge, P. (1999) *The Dance of Change* ISBN 0-385-493223.

Stirna, J. Persson, A. and Aggestam, L. (2006) *Building knowledge repositories with enterprise modelling and patterns – from theory to practice* in the Proceedings of the 14:th Conference on Information Systems, 2006, Gothenburg, Sweden, June 12-14, 2006.

Storey, J. and Bernett, E. (2000) *Knowledge management initiatives: learning from failures* Journal of Knowledge Management, Vol. 4, No. 2, pp. 145-156.

Sun Yih-Tong, P. and Scot, J. L. (2005) *An investigation of barriers to knowledge transfer* Journal of Management Vol. 9, No 2, 2005, pp. 75-90.

Swan, J. Scarborough, H. and Preston, J. (1999): *Knowledge management – the next fad to forget people* Proceedings of the 7th European Conference on Information Systems: Copenhagen Business School Copenhagen, Denmark, pp. 668-678.

Wiig, K.M. (1993) *Knowledge Management Foundations – Thinking About Thinking – How People and Organizations Create, Represent, and use Knowledge* Schema Press LTD.

Wong, K.Y. and Aspinwall, E. (2004) *Knowledge Management Implementation Frameworks: A Review* Knowledge and Process Management, Vol. 11, No. 2, pp. 93-104.

ENDNOTES

[1] The link to the developed repository is www. vgregion.se/skassarwebben

[2] For further information about the data, contact the author.

Towards Measuring the Complexity of Information Systems: A Language-Critique Approach

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ABSTRACT

Organizations increasingly depend on information technology for their operation. Consequently, complexity of information systems becomes an important issue for management. This paper shows how the combination of conceptual modeling with the concept of variety from cybernetics contributes to the measurement of complexity for the analysis and diagnosis of information systems. Building on language critique, we propose that conceptual models are marks of the shared understanding of a language community. Consequently, conceptual models are a means to make the variety of an information system visible. Within an information technology controlling setting, we apply our approach for the diagnosis of a controlling and reporting system used in the German subsidiary of a large European bank. We show how conceptual models can significantly contribute to organizational analysis if used in combination with an established cybernetic theory.

Keywords: Complexity, Variety, Language Critique, Conceptual Modeling.

1. INTRODUCTION

Organizations invest greatly in information technology (IT) and information systems (IS) in order to improve their operational and strategic position (Laudon & Laudon 2005, p. 7). But not all organizations are successful in this (Brynjolfsson 1993). The interaction between IT and organization is complex and influenced by many mediating factors, including the organization's structure, standard operating procedures, politics, culture, environment and management decisions (Laudon & Laudon 2005, p. 77). As a consequence, complexity of IS becomes a subject for IS research.

Complexity is a multi-facetted term which has many possible meanings (Flood & Carson 1993). Since complexity is something subjective (Ashby 1973, p. 1), perceived by an observer, the complexity of the system being observed can be described as a measure of the perceived effort that is required to understand and cope with the system (Backlund 2002, p. 31). This makes the analysis and design of complexity of IS more difficult. Since unnecessarily complex IS seem undesirable, we should find methods to reduce complexity. However, we cannot address this problem unless we have a shared meaning of what comprises the complexity of an IS. Furthermore, it would be desirable to compare several organizations or IS regarding their complexity (Backlund 2002, p. 40). Then, how can we measure the complexity of an IS? Can we categorize the factors for complexity in IS and organizations if complexity depends on the subjective understanding of an observer? Or are we able to deduct a general and intersubjective measurement for complexity?

In this paper, we propose to combine concepts from cybernetics with a language-based approach for conceptual modeling in order to measure the complexity of an IS. In the remainder of the paper we proceed as follows. First, we introduce variety as a measure for complexity. Then, we present our understanding of conceptual models based on language critique. Afterwards, we propose that conceptual models are a means to make variety visible. We apply and test our approach in an action case study.

2. VARIETY AS A MEASURE FOR COMPLEXITY

The cybernetic concept of variety is a measure for complexity, and defines the number of manifestations or patterns of behavior, the possible states of a system (Ashby 1964, p. 126). Variety, in relation to a set of distinguishable elements of a system, means either 1) the number of distinct elements, or 2) the logarithm to the base 2 of this number. Measured in logarithmic form, the unit of variety is the bit. If a situation has a variety of 32, or 5 bits, it will take five "yes/no" decisions to eliminate the uncertainty implicit in that variety – because $32 = 2^5$ (Beer 1981, p. 45). In theory, it is possible to count all possible states. If this is not directly possible, we can make comparisons ("something has more or less variety than another thing") or apply ordinal scaling ("This product has a rank of five"). Consequently, we are able to compare things that are different in nature.

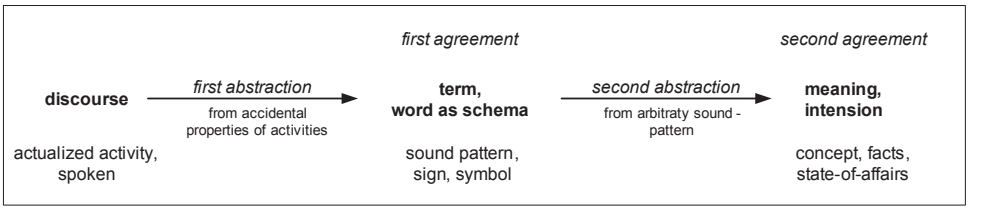
Ashby's *Law of Requisite Variety* is one important driver for the design of complexity reduction: "Only variety can destroy variety" (Ashby 1964, p. 207). This forms a problem because in order to make a system responsive to change, we need to possess as much variety as the system itself exhibits. With systems that exhibit massive variety, such as organizations and IS, only reducing the environmental variety or increasing the manager's own internal variety enables us to cope with this problem (Jackson 2000, p. 73).

In this paper, we follow Backlund's call to explore the usefulness of variety as a measure when applied to organizations and IS (Backlund 2002, p. 40). But several charges have been put forward against the use of variety (Jackson 2000, pp. 172-177, 207). Most severe seems to be Ulrich's attack (Ulrich 1981). Ulrich argues that variety operates only at the syntactic level, which is solely concerned with whether a message is well formed or not, in the sense of readability. Consequently, according to Ulrich, variety ignores the meaning and significance of messages for the receiver (semantics and pragmatics). This argument falls short considering our approach based on language critique.

Language critique, a branch of constructive philosophy known as the "Erlangen School" of Kamlah and Lorenzen (Kamlah & Lorenzen 1984, Lorenzen 1987), provides useful insights and backup for our understanding. By separating *language* (as a schema which one knows how to speak) and *discourse* (as linguistic action and activities), Kamlah and Lorenzen separate concepts from their linguistic usage (Kamlah & Lorenzen 1984, p. 41). Discourse means the repeatedly actualized usage of concepts in changing combination and variation. Thus, discourse is an actualized activity, whereas language comprises potential activities, or activity-schema (Kamlah & Lorenzen 1984, p. 45). The transition from an actualized activity to its activity-schema is called an *abstraction*. Terms are syntactical representations used in discourse with fixed conventions (*first abstraction*), whereas in order to get concepts, we abstract from the phonetic form of terms (*second abstraction*), see Figure 1 (Lorenzen 1987, pp. 115-118).

The question of how the conventions that align syntax, semantics and pragmatics of symbols are formed can be answered using the construct of a *language community*. Kamlah and Lorenzen argue that language as a system of signs promotes mutual understanding as "a 'know-how' held in common, the possession of a 'language community'." (Kamlah & Lorenzen 1984, p. 47). A new term is introduced by *explicit agreement* between language users with respect to its usage (*first agreement*) and meaning (*second agreement*) (Kamlah & Lorenzen 1984, p. 57). This agreement leads to a relation of concept and term, and is shared by a language

Figure 1. Agreements and abstractions in language critique (Holten 2003a, Holten et al. 2005)



community as the knowledge of using this term. Accordingly, if members of a group of people communicate, and each has an aligned semantic and pragmatic dimension of a symbol (or term) in mind, then this group of people forms a language community. The implications for our work are that the semantic and pragmatic dimensions of symbols need to be introduced together. If a language community has been created, based on a language (re)construction of a domain, the members of this language community share the pragmatic dimension of a symbol.

Usually, conceptual models are understood as part of a method, a planned and systematic approach (Braun et al. 2005). Conceptual modeling deals with the process of building or interpreting a conceptual model whereby the stakeholders reason and communicate about a domain in order to improve their common understanding of it (Gemino & Wand 2004, p. 80). According to our understanding, conceptual models play a significant role in making language communities explicit: conceptual models are designed through linguistic actions of a language community. Therefore, they are an expression of a shared language understanding, so-called *marks* (Kamlah & Lorenzen 1984, p. 46, Holten 2003a, pp. 33-91). Marks are written-down or printed writing-signs (Kamlah & Lorenzen 1984, p. 51). They are actualized as activities by the one who produces the marks in *writing* them, and again actualized by the one who *reads* them (Kamlah & Lorenzen 1984, p. 46). Models as marks create persistent things. Like road signs or written words, models are solidified activities which stay put and can be read.

Following this, conceptual models can be used as a formalized way of stating the intersubjective consensus of a language community. Then, truth or correctness of statements depends on the consensus of the group of people that constructed the conceptual models (Kamlah & Lorenzen 1984, pp. 101-111). For example, in IS development, mere understanding of the syntax or even the specific semantics of a specialized modeling language or grammar is not the most crucial factor. Of far greater significance are the pragmatics, the unstated assumptions that reflect the shared (common sense) knowledge of people familiar with the social, business and technical contexts within which the proposed system will operate (Ryan 1993, p. 240). Therefore, conceptual models are intensively used in requirements engineering to facilitate the process of creating a language community.

Although variety – like complexity – is an inherently subjective concept, it becomes intersubjective for the members of a language community as soon as the language community is created. A member of the language community is able to distinguish between data (syntax and semantics, term) and information (pragmatics, meaning) and to relate the two. Once a language community has been created, variety as a measure of complexity for the used terms considers pragmatics and semantics respectively. As a result, Ulrich's argument falls short considering language critique. Language restricts the possibilities to communicate the possible states of a system (Daft & Wiginton 1979). Variety is a measure of the number of possible states of a system. Based on the conceptual models as marks of the shared understanding of a language community, we are able to measure this variety. In the next section, we use an action case to show how the variety of an IS can be made visible by conceptual models.

3. VARIETY IN IT CONTROLLING: AN ACTION CASE

3.1 Research Methodology & Action Case Description

Every research approach is based on fundamental philosophical assumptions (Myers 1997, Lee 2004). We believe that a *constructive philosophy* (Lorenzen 1987) which integrates interpretive and positivist approaches is required. Consequently, we assume that an objective world exists (*ontological realism*), but that our cognition of this world is subjective or private (*epistemological subjectivism*) (Holten et al. 2005, p. 177). We argue that due to this subjectivity, cognition relies upon the (re)construction of reality through linguistic action. After having created a subjective understanding of everyday meanings within the observed organization, which provides the basis for the interpretive understanding, we create a positivist understanding in order to explain the empirical reality – the explanation being a scientific theory which can be tested against the subjective meaning as recorded in the interpretive understanding (Lee 1991, pp. 351-354). Following this, we apply our understanding of variety and conceptual models within an action case study (Hughes & Wood-Harper 1999).

The action case domain concerns IT controlling at FSB AG, a German subsidiary company of the FSB banking group[1]. The FSB Group is among the leading asset managers and financial service providers throughout Europe (as measured by managed capital). Within the FSB Group all operative tasks concerning IT are delegated to FSB IT, a wholly owned subsidiary of FSB Group. For example, this includes the development and maintenance of networks, mainframes, host systems, databases, servers and user support (e. g. helpdesk). FSB IT Development (FSB ITD) is a department of FSB AG that conducts development and controlling of IS for the German business units. FSB ITD develops and supports IS (*development functions*). Additionally, FSB ITD plans and controls both self-developed IS as well as IS developed by FSB IT in order to make the IT usage transparent for the German business units and divisional management (*controlling functions*). A management IS (based on a data warehouse solution using an Oracle database) is used for reporting and controlling in general. The management of FSB ITD approached our research group, voicing difficulties in their IT controlling processes. Especially the reporting was mentioned as an area of concern, creating frustration amongst the business units.

3.2 Data Collection & Interpretation

The action case study lasted from November 2004 to August 2005. We conducted a series of initial semi-structured interviews with different stakeholders. The interviews focused on the IT controlling process and on the roles within it. They were of variable length, ranging from 30 minutes to 90 minutes. The stakeholders selected for the interviews were head of IT controlling at FSB ITD, IT controlling staff, system developers, head of business unit and service staff (from business units). Additionally, we had full access to the MIS and to the created reports. The transcripts and notes from our interviews, administrative documents and printouts of the generated reports were collected in a project diary. The diary served as the main source of data for the following interpretation.

We used conceptual models for the interpretation of the reports, choosing MetaMIS as a modelling language. MetaMIS has been originally developed for the specification of management views on business processes (Holten 2003b, Holten et al. 2005). The approach has been previously applied in similar contexts (e. g. Holten et al. 2002, Holten & Laumann 2004).

Initially, we constructed conceptual models based on our understanding of the reports, which were refined by insights gained from the interviews and observation of controller activities. Afterwards, all project participants at FSB AG were made familiar with the MetaMIS approach, which resulted in a common language to discuss the conceptual models. Repeatedly, the models were refined together with all participants. This resulted in a common presentation of facts about the IT controlling and reporting system in such way that all participants could understand it and relate it to their objectives. Additionally, the conceptual models ensured that we as researchers understood what is really happening in IT controlling at FSB AG. Consequently, we engaged into a language (re)construction, using the

conceptual models as marks of the pragmatic dimension of the domain in focus in order to create a mutual understanding and a language community.

3.3 IT Controlling at FSB AG

FSB ITD in its controlling function creates detailed reports of IT usage. An in-depth analysis of the constructed models revealed that the reporting is purely cost-based. The costs for the IT supplied by FSB IT are based on internal transfer prices for IT items which usually are used for the chargeback of IT costs. These prices are negotiated between the divisional management of the German business units and FSB IT's management. The chargeback structure is initially applied for the resource bargaining during periodical budgeting negotiations between FSB IT and the business units. As a result, the charged items are extremely resource-oriented (e. g. measured as "costs per CPU second"). The created models are extremely large and intricate, mirroring this phenomenon (see Figure 2).

The models show that the variety of this item catalogue is very high: it lists over 550 single items, grouped according to 85 services. Each of these items is used in several IS, for which both price negotiation and controlling are undertaken. Usually, a management decision is the selection of one possible state from all the others. In our case, there are approximately 550 items in total – each with a price accuracy down to Euro and cent. The average IS includes about 150 items. FSB AG has approximately 150 IS in total for which IT chargeback and reporting are conducted. Additional complexity arises because even these items are not constant over time, but change between and during budget periods. In the example of a document management system, the models revealed that nearly two-thirds of the charged items for this system changed between two budgeting periods.

The *potential* variety of the IT controlling and reporting system, as revealed by the conceptual models, and reflected in the item catalogue, appears as approximately

$$V \approx \text{number of IS} \times \text{set of possible combinations using 150 items} = 150 \times 2^{150} \approx 157 \text{ bits}$$

Note that we did not consider the additional variety that results from the changing item structure. In order to identify a particular item – an item for an IS – we need to select one out of that total variety. Even with grouping, constraints and categorization of items, which leads to a reduction of numbers (and which is a rather fruitless task since the item structure is constantly changing), a decision for an IS is a matter of selecting "yes/no" answers for more than 150 items on an average. Consequently, the numbers involved in calculating variety for IT controlling are enormous.

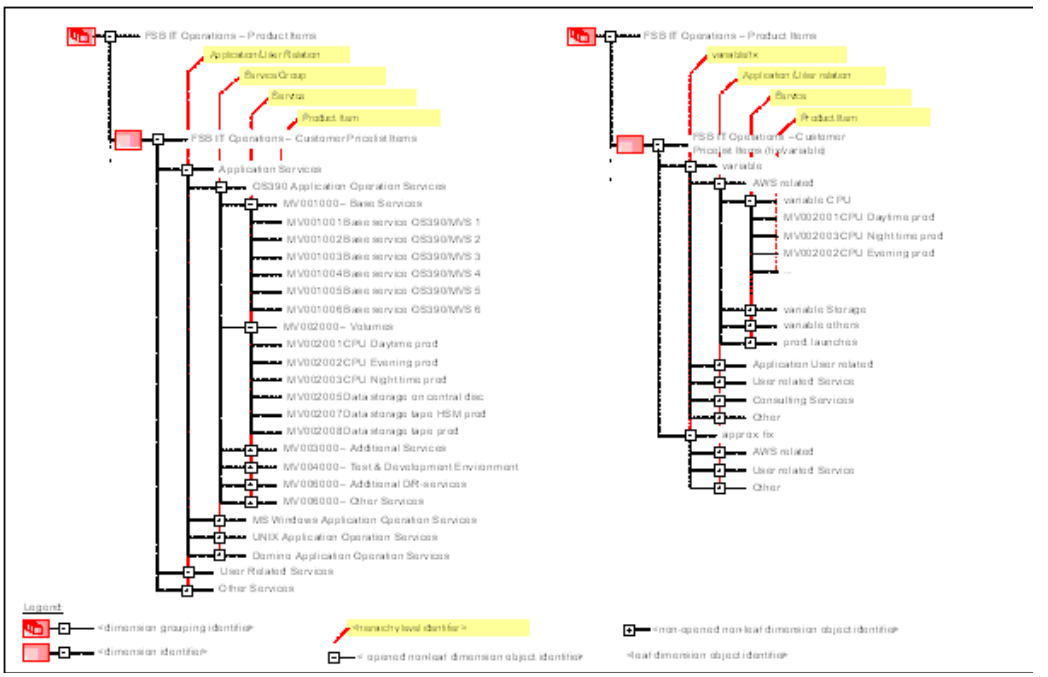
The models point to a high variety within the coordinatory function of FSB ITD: the item structure used for IT controlling 1) has many items, and 2) is changing often. The change of the item structure during and between budgeting periods even makes things more complex.

4.4 Matching with Theory: Hypothesizing on the Establishment of Requisite Variety

The IT controlling and reporting system exhibits a proliferating variety. We gained this insight by analyzing the conceptual models as marks of the language community in focus. The conceptual models enabled us to make that variety visible. According to Ashby's Law, varieties tend to equate naturally (only variety absorbs variety). Consequently, the proliferating variety will be compensated by other means. The *actual* variety must be less enormous than the potential variety. As a result, we hypothesized that in order to establish requisite variety, either 1) *attenuation* on the side of the business units reduces the external variety, or 2) *amplification* on the side of the business units increases the internal variety (Beer 1979, pp. 89-93). Both types of adjustment establish requisite variety and should be detectable accordingly. In order to corroborate or falsify this hypothesis about the establishment of requisite variety, we subsequently conducted a second set of unstructured interviews. The questions for these informal interviews were derived from our application of Ashby's Law. In addition, we used the conceptual models as a starting point for discussions.

Following our analysis, it is not surprising that our hypothesis about the establishment of requisite variety was corroborated. To summarize our results, people from FSB AG's business units have difficulties to understand the IT controlling reports. They are not "written in business language" and "not related to the daily affairs". In addition, the pure number of the provided information generates a feeling of information flooding. In order to cope with these problems, the business units have developed various strategies. For example, one business unit appointed two people with a background in IT that are responsible for the analysis of the IT reports and for the understanding of the item catalogue. Accordingly, this business

Figure 2. Excerpt of MetaMIS model (item catalogue)



unit establishes the missing internal variety by amplification. In addition, other amplifiers and attenuators have been identified, e. g. most prominent the complete disregard of the reports delivered by the IT controlling and reporting system.

4. DISCUSSION & CONCLUSION

According to our findings, the implemented IT controlling and reporting system at FSB AG is not designed with regard to requisite variety. It is quite clear by the different strategies employed by different business units that the existing IT controlling system fails to deliver meaningful information, i. e. information that makes the usage of IT transparent to the business units. For example, this leads to the need of people with expert knowledge in order to establish requisite variety for divisional management, and consequently to a misuse of resources (time, people and/or money). As a practical recommendation, the system should be redesigned in order to fulfill its cybernetic role as a regulator. We propose that this problem could be solved by a reduced item catalogue, made up of terms that are understandable by both business units and IT departments (Zarnekow & Brenner 2003, Nolan 1977).

In this paper, we showed how conceptual modeling and cybernetics can be combined in order to measure complexity. By using language critique as a means to understand conceptual models as marks of a language community, we were able to construct models in order to generate an interpretive understanding of the IS in focus, and to use variety as a measure for the complexity of this IS. Next, we confronted Ashby's Law as a theory with our interpreted observations. Based on Ashby's Law, we generated the hypothesis that due to the failed design of the IT controlling and reporting system, requisite variety asserts itself in other ways. Consequently, we generalized from the interpreted observations to a theory. Using the concept of variety and Ashby's Law as a theory in order to test our hypotheses, we make certain that our research approach is both rigorous and relevant. Our understanding based on language critique shows how conceptual modeling can be applied as a tool for diagnosis.

REFERENCES

Ashby, W. R. (1964) *An Introduction to Cybernetics.* University Paperbacks, London, UK.

Ashby, W. R. (1973) Some peculiarities of complex systems. *Cybernetic Medicine* 9 (2), 1-7.

Backlund, A. (2002) The concept of complexity in organisations and information systems. *Kybernetes* 31 (1), 30-43.

Beer, S. (1979) *The Heart of Enterprise.* John Wiley & Sons, Chichester, UK et al.

Beer, S. (1981) *Brain of the Firm.* John Wiley & Sons, Chichester, UK et al.

Braun, C., Wortmann, F., Hafner, M. and Winter, R. (2005) Method Construction - A Core Approach to Organizational Engineering. In *20th ACM Symposium on Applied Computing (SAC 2005)*, pp 1295-1299, Santa Fe, New Mexico, USA.

Brynjolfsson, E. (1993) The Productivity Paradox of Information Technology. *Communications of the ACM* 36 (12), 67-77.

Daft, R. L. and Wiginton, J. C. (1979) Language and Organization. *The Academy of Management Review* 4 (2), 179-191.

Flood, R. L. and Carson, E. R. (1993) *Dealing with Complexity. An Introduction to the Theory and Application of Systems Science.* Plenum Press, New York, NY, USA.

Gemino, A. and Wand, Y. (2004) A framework for empirical evaluation of conceptual modeling techniques. *Requirements Engineering* 9 (4), 248-260.

Holten, R. (2003a) Integration von Informationssystemen. Theorie und Anwendung im Supply Chain Management. Universität Münster.

Holten, R. (2003b) Specification of Management Views in Information Warehouse Projects. *Information Systems* 28 (7), 709-751.

Holten, R., Dreiling, A. and Becker, J. (2005) Ontology-Driven Method Engineering for Information Systems Development. In *Business Systems Analysis with Ontologies* (Green, P. and Rosemann, M., Eds), pp 174-215, IDEA Group, Hershey, PA, USA et al.

Holten, R., Dreiling, A. and Schmid, B. (2002) Management Report Engineering. A Swiss Re Business Case. In *Vom Data Warehouse zum Corporate Knowledge Center. Proceedings der Data Warehousing 2002* (Von Maur, E. and Winter, R., Eds), pp 421-437, Heidelberg, Germany.

Holten, R. and Laumann, M. (2004) Integrating Management Views in Supply Chain Environments - An arvato (Bertelsmann) Business Case. In *Auf dem Weg zur Integration Factory. Proceedings der Data Warehousing 2004* (Schelp, J. and Winter, R., Eds), pp 329-351, Heidelberg, Germany.

Hughes, J. and Wood-Harper, A. T. (1999) Systems development as a research act. *Journal of Information Technology* 14 (1), 83-94.

Jackson, M. C. (2000) *Systems Approaches to Management.* Kluwer Academic/ Plenum Publishers, New York, NY, USA.

Kamlah, W. and Lorenzen, P. (1984) *Logical Propaedeutic. Pre-School of Reasonable Discourse.* University Press of America, Lanham, MD, USA.

Laudon, K. C. and Laudon, J. P. (2005) *Essentials of Management Information Systems. Managing the Digital Firm.* Pearson Prentice Hall, Upper Saddle River, NJ, USA.

Lee, A. S. (1991) Integrating Positivist and Interpretive Approaches to Organizational Research. *Organization Science* 2 (4), 342-365.

Lee, A. S. (2004) Thinking about Social Theory and Philosophy for Information Systems. In *Social Theory and Philosophy for Information Systems* (Willcocks, L. and Mingers, J., Eds), pp 1-26, John Wiley & Sons, Chichester, UK et al.

Lorenzen, P. (1987) *Constructive Philosophy.* The University of Massachusetts Press, Amherst, MD, USA.

Myers, M. D. (1997) Qualitative Research in Information Systems. *MIS Quarterly* 21 (2), 241-242.

Nolan, R. L. (1977) Effects of Chargeout on User/Manager Attitudes. *Communications of the ACM* 20 (3), 177-185.

Ryan, K. (1993) The Role of Natural Language in Requirements Engineering. In *IEEE International Symposium on Requirements Engineering 1993*, pp 240-242, San Diego, CA, USA.

Ulrich, W. (1981) A critique of pure cybernetic reason: the Chilenian experience with cybernetics. *Journal of Applied Systems Analysis* 8, 33-59.

Zarnekow, R. and Brenner, W. (2003) A product-based information management approach. In *11th European Conference on Information Systems (ECIS 2003)* (Ciborra, C. U. and Mercurio, R. and De Marco, M. and Martinez, M. and Carignani, A., Eds), Naples, Italy.

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A Research-Driven View of Conceptual Models as Instruments for Information Systems Research

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ABSTRACT
Conceptual modelling deals with the process of building or interpreting a conceptual model whereby the stakeholders reason and communicate about a domain in order to improve their common understanding of it. In this paper, we argue that the common engineering-driven view on conceptual models is only one possible perspective. Based on language critique, we show how conceptual models can be used as an important instrument for information systems research. We argue that researchers need to take on three roles in order to integrate interpretive and positivist approaches, and we combine our view with an existing framework for research based on (Lee 1991).

Keywords: Information Systems Research, Language Critique, Conceptual Modelling, Methodology.

1. INTRODUCTION

The traditional understanding of conceptual modelling focuses on what we call the *engineering-driven view of conceptual models*. From this perspective, conceptual models are part of a method, a planned and systematic (engineering) approach (Braun et al. 2005) which deals with the process of building or interpreting a conceptual model whereby the stakeholders reason and communicate about a domain in order to improve their common understanding of it (Gemino & Wand 2003, p. 80). The engineering-driven view has a long tradition in the information systems (IS) research community, especially regarding the construction and application of conceptual modelling languages and grammars for the specification of business requirements. Conceptual modelling and reference modelling are considered to be important instruments for analyzing and solving several technical and organizational design issues on an application level, enterprise level or industry level (Moody 2005, p. 244). Although conceptual modelling and the construction of modelling languages tailored to specific problem domains are well understood, open questions remain, e. g. regarding the construction of conceptual models (Wand & Weber 2002, Weber 2003), the evaluation of conceptual models (Shanks et al. 2003, Gemino & Wand 2004) or the quality of conceptual models (Moody 2005). From this perspective, conceptual modelling and conceptual models are *subjects* of research.

In contrast, we propose a *research-driven view of conceptual models*. As Silverman argues, IS researchers would do well to think a long time before rushing into yet another interview-based study (Silverman 1998, p. 19). Instead of focusing on how people 'see things', we have to focus on how people 'do things' (Silverman 1998, p. 3). In this regard, conceptual models are a means for forming an interpretive understanding. In practice, they are often used for several purposes, e. g. to support the development, acquisition, adoption, standardisation and integration of IS (Maier 1999). Every organization usually has a large collection of various conceptual models. For example, UML or ERM diagrams are used for software and architecture design, flow chart diagrams or event-driven process chains for ISO or Sarbanes-Oxley Act certification, and BPML/N for workflow specification. Incidentally, conceptual models are a means for the researcher to develop a common understanding of a problem domain with experts and practitioners (Ribbert et al. 2004). This results in a presentation of facts about the system in focus in such way that all stakeholders can understand it and relate it to their objectives.

Clearly, there is a need to address relevant problems for organizations. If a rigorous theory provides backup, why not leverage conceptual models as a useful source of knowledge? The issues that arrive from this understanding of conceptual models are fundamentally different in nature to the engineering-driven view. How can conceptual models contribute to the testing of theories? What are the consequences for research methodologies?

2. AN ARGUMENT: A LANGUAGE-BASED UNDERSTANDING OF CONCEPTUAL MODELS

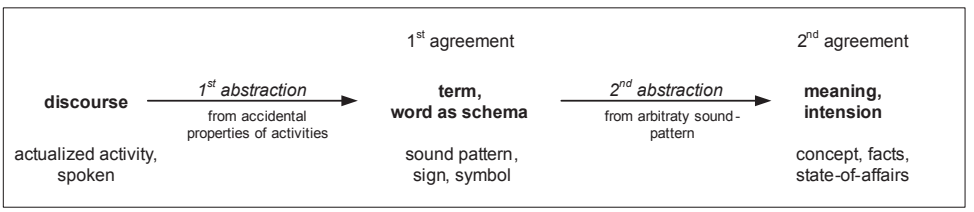
Several fields like linguistics, philosophy, psychology or neurology inquire about the nature of language. Following this, Lyytinen adequately demonstrated the importance of language for IS research (Lyytinen 1985). Nevertheless, there is no consensual answer to the question as to how meaning is given to language. Wittgenstein argued that every perception of the world is language-bound, so that language becomes the 'mediator' between reality and an individual (Wittgenstein 1922, 5.6). Nothing is an object "inherently"; it only becomes an object as we talk about it. For this reason we use language to represent some meaning that we conceive (Bühler 1934, p. 254).

In linguistics, de Saussure's seminal work conceptualized a linguistic sign as a union of a *concept* – the signified (signifié) – and a *sound image* – the signifier (significant) (de Saussure 1974, p. 66). According to de Saussure, the combination of concept and sound image is arbitrary. Therefore, a language consisting of linguistic signs is based on conventions (de Saussure 1974, p. 67). Following de Saussure, Morris proposed that a language consists of a set of interrelated signs, or *symbols* (Morris 1971, p. 24). Both de Saussure's and Morris' approaches are based on conventions as a precondition for meaningful language-based communication, and both separate a concept from its representation. By symbols, Morris addresses only what de Saussure termed the signifier. As the "lore of symbols", semiotics consists of three subordinate branches: syntactics, semantics, and pragmatics (Morris 1971, pp. 22-43). Syntactics (or syntax) deals with relations of symbols to one-another. People who want to communicate by language need syntactical conventions in order to create a common understanding of interrelated symbols. Semantics deals with the relation of symbols to concepts. These conventions are necessary for language-based communication in order to address one object with the same symbol. Pragmatics deals with the relation of symbols to their interpreters, and addresses the understanding of symbols to language users.

In accordance with Ågerfalk and Eriksson, we argue that traditional conceptual modelling research has focused too much on the syntactic and semantic aspects of language and too little on the pragmatics (Ågerfalk & Eriksson 2004). But where Ågerfalk and Eriksson use speech act theory as a theoretical foundation for conceptual modelling, we focus on language critique in order to explain the role of conceptual models for IS research.

Language critique, a branch of constructive philosophy known as the "Erlangen School" (Kamlah & Lorenzen 1984, Lorenzen 1987) provides useful insights and support for the research-driven view of conceptual modelling. By separating *language* (as a schema which one knows how to speak) and *discourse* (as linguistic action and activities), Kamlah and Lorenzen separate concepts from their linguistic usage (Kamlah & Lorenzen 1984, p. 41). Discourse means the repeatedly actualized usage of concepts in changing combination and variation.

Figure 1. Agreements and abstractions in language critique (Holten 2003, Holten et al. 2005)



Thus, discourse is an actualized activity, whereas language comprises potential activities (activity-schema) (Kamlah & Lorenzen 1984, p. 45). The transition from an actualized activity to its schema is called an *abstraction* (Figure 1). Terms are syntactical representations used in discourse with fixed conventions (1st abstraction), whereas in order to get concepts, we abstract from the phonetic form of terms (2nd abstraction) (Lorenzen 1987, pp. 115-118).

The question of how the conventions that align syntax, semantics, and pragmatics of symbols are formed can be answered using the construct of a *language community*. Kamlah and Lorenzen argue that language as a system of signs promotes mutual understanding as "a 'know-how' held in common, the possession of a 'language community'." (Kamlah & Lorenzen 1984, p. 47). A new term is introduced by *explicit agreement* between language users with respect to its usage (1st agreement) and meaning (2nd agreement) (Kamlah & Lorenzen 1984, p. 57). This agreement leads to a relation of concept and term, and is shared by a language community as the knowledge of using this term. Accordingly, if members of a group of people communicate, and each has an aligned semantic and pragmatic dimension of a symbol (or term) in mind, then this group of people forms a language community. The implications for our work are that the semantic and pragmatic dimensions of symbols need to be introduced together. If a language community has been created, based on a language (re)construction of a domain, the members of this language community share the pragmatic dimension of a symbol. All members have the same concept in mind if they are confronted with a symbol of the language and vice versa.

According to this understanding, conceptual models play a significant role in making language communities explicit: conceptual models are designed through linguistic actions of a language community, and therefore are an expression of a shared language understanding, so-called *marks* (Kamlah & Lorenzen 1984, p. 91, Holten 2003). Marks are written-down or printed writing-signs (Kamlah & Lorenzen 1984, p. 51). They are actualized as activities by the one who produces the marks in *writing* them, and again actualized by the one who *reads* them (Kamlah & Lorenzen 1984, p. 46, Gemino & Wand 2003). Models as marks create persistent things: solidified activities which stay put, are produced and can be read. By this means, conceptual models can be used as a formalized way of stating the intersubjective consensus of a language community (Ribbert et al. 2004). Conceptual models provide a starting point for communication as the written expression of the shared understanding of the language community that is part of every IS as a socio-technical system (e. g. business users, experts, managers, IT experts, programmers et cetera). New concepts and problems that every changing organization constantly encounters need to be introduced and explicitly agreed upon by this language community.

At the moment, it is of no interest for us how a consensus has been achieved, e. g. by enforcing a dominant power position, or by engaging into a reasonable discourse. All that matters is that a mutual understanding of concepts and terms has been created. Then, in accordance with (Ribbert et al. 2004), truth or correctness of statements depends on the consensus of the group of people that constructed the conceptual models (Kamlah & Lorenzen 1984, pp. 101-111).

3. THE IDEA: IMPLICATIONS FOR IS RESEARCH

Every research approach is based on fundamental philosophical assumptions (Myers 1997, Lee 2004). Based on these assumptions, IS researchers have debated competing philosophical paradigms for research, mostly represented by the two labels positivism (Jenkins 1985) and interpretivism (Walsham 1995a). Although the differences and boundaries between research positions have ever been a cause for discussion and argument among IS researchers, recent contributions argue for a conciliation and the acceptance of each others key assumptions and arguments as ontological and epistemological paradigms (Weber 2004).

Different positions not withstanding, given the richness and complexity of the real world, a research approach best suited to the problem under consideration, as well as the objectives of the researcher, should be chosen. The over-riding concern of our research approach is that the research we undertake should be both relevant to the research questions in focus and rigorous in its operationalization. Due to our understanding of language, we believe that a *constructive philosophy* (Lorenzen 1987) which integrates interpretive and positivist approaches is required for this purpose. Consequently, we assume that an objective world exists (ontological realism), but that our cognition of this world is subjective or private (epistemological subjectivism) (Holten et al. 2005, p. 177). We argue that due to this subjectivity, cognition relies upon the (re)construction of reality through (linguistic) action.

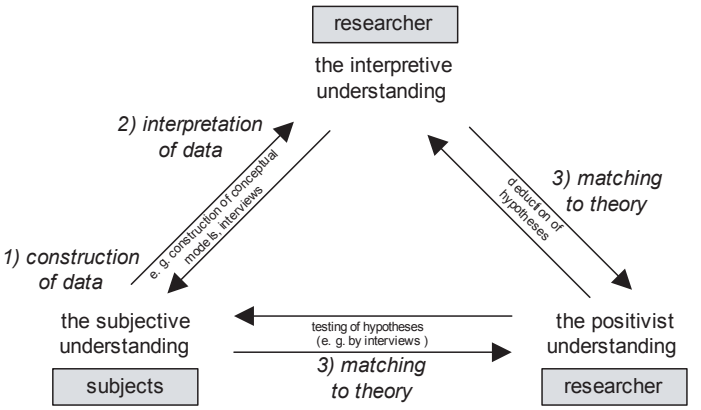
Following our language-based understanding of conceptual modelling and our philosophical assumptions, our research approach is characterized by three roles that the researcher adopts during her or his investigation. By anchoring our approach in language critique, we provide a new and alternative rationale from the philosophy of science. Our approach fits with a framework for the development of scientific theories as proposed by Lee (Lee 1991, Lee 2004). After having created a subjective understanding of everyday meanings and common sense within the observed organization, which provides the basis for the interpretive understanding, the researcher creates a positivist understanding in order to explain the empirical reality – the explanation being a scientific theory which can be tested against the subjective meaning as recorded in the interpretive understanding (Lee 1991, pp. 351-354). The result is an integrated framework for an interpretive and positivist understanding (see Figure 2). By taking up the three roles, the researcher acts in character with the processes described by Lee. Furthermore, she or he is conscious of the boundaries for research which are defined by these roles. The three roles can be applied and embodied during known research methods, e. g. action research (Baskerville & Wood-Harper 1996, Baskerville & Myers 2004), case study research (Yin 2003, Walsham 1995b, Barrett & Walsham 1999) or action case studies (Hughes & Wood-Harper 1999). We argue that engaging into the three roles allows the researcher to collect rich and meaningful data for answering his research questions.

1) Construction of Data

The first role refers to the *construction of data*, wherein the researcher acts as a participant and engages in practical work within an organization as a partner in active problem solving. We exist "all along" within a subjective understanding of the world which is linguistically articulated (Kamlah & Lorenzen 1984, p. 5). Participating in a language community thus becomes a prerequisite for any observation. In order to generate a mutual understanding, researchers and other participants actively create a language community, aligning their language constructs during projects. Thus, an inter-subjective understanding of the research domain is created. In doing so, the researcher gains access to observations in this research domain. Based on the observations, she or he is enabled to collect and construct data. This includes the collection of *existing* conceptual models.

Adopting a strategy akin to Langley, the researcher chooses to plunge deeply into the processes themselves, collecting fine grained qualitative data (Langley 1999, p. 691). This is a common characteristic of field studies which take place in the natural environment of the phenomenon, and where the researcher uses systematic techniques for the collection and recording of data (Cavaye 1996). Like an ethnographer, the researcher should begin by using and participating in

Figure 2. Framework for research (adapted from (Lee 1991))



everyday interactions and focus on "How do participants do things?" (Maynard 1989, p. 144).

2) Interpretation of Data

The second role concerns the *interpretation of data*. The extracted data and observations need to be analyzed and interpreted. The researcher makes statements about the research domain, which are based on common agreement and are understandable for the language community. This is in line with Lee's and Baskerville's generalizing from empirical statements to other empirical statements (Type EE generalizability) (Lee & Baskerville 2003). A researcher must thus repeatedly go from his own interpretive understanding to the subjective understanding and then back again to his own interpretive understanding (Klein & Myers 1999, p. 71).

Following our argument in section 2, the mutual construction of new conceptual models of the IS or organization under examination is a suitable tool for this interpretation. The conceptual models as marks ensure that the researchers actually understand what is happening in the research domain, if these descriptions are created and discussed by the language community consisting of all project participants. Conceptual models based on participatory action in operational processes are actualized activities of how people do things. The jointly discussion and refinement of these conceptual models serves to test the interpretive understanding recorded in the models against the subjective understanding.

3) Matching to Theory

In the third role, a *matching to theory* takes place. The researcher confronts a theory with her or his interpreted observations in order to deduct meaningful hypotheses. Generally, we understand theory as a means for describing, explaining and predicting as for design and action as well (Gregor 2006, pp. 626-630). Consequently, the researcher generalizes from the interpreted observations to a theory (Type ET generalizability) (Lee & Baskerville 2003). From this generalizability concept stems the idea that one case may yield as many information as many cases, since science operates with conjectures and jumps to conclusions, even after one single observation (Popper 1965). In IS research, this means the deduction of hypotheses about the organization and the IS in focus in order to match the findings with a theory.

It is an important accomplishment to construct correct conceptual models (correct in the sense of a correct interpretive understanding of a domain in focus, as in the engineering-driven view). But for science, the interpretation is but one link in the chain. Science interprets a domain, relates this interpretation to theories and subsequently tests these theories. As Lee shows, there is no discrepancy between interpretive and positivist positions. Therefore, we ask for an empirical checking of hypotheses. Consequently, we need to confront the interpretive understanding, and hence the conceptual models, with theories.

An example for an application of our research approach is a recent action case study carried out at a logistics service provider which was acquired by a bigger corporation (Laumann et al. 2007). The new management decided to analyse the reporting within the organization, since reporting consumed a lot of time. A conceptual modelling language was used to model the actual reporting, to get an overview of the company-wide reporting and to establish a fit between the information channels and the new functions after the integration into the corporation. Based on Ashby's Law of Requisite Variety (Ashby 1964) and the Viable System Model (Beer 1985) as underlying theories, hypotheses were proposed for the causes of the identified problems and were subsequently tested. To sum it up, the reporting was not any more appropriate for the new structure and strategy of the organization and had to be reorganized. The reporting information system was redesigned with respect to requisite variety.

4. CONCLUSION

By applying language critique in order to qualify conceptual models as marks, and hence as a formalized way to describe the consensus of a language community, we are able to leverage conceptual models as a source of knowledge and as an instrument for creating and testing an interpretive understanding for IS research.

Based on this, we described how conceptual models and the creation of a language community are important steps in participatory research in order to create an interpretive understanding of a subject matter. In this regard, both existing conceptual models and models mutually created by researchers and participants are useful – the first as collected data, the second as an instrument for interpretation.

As a next step, we plan to apply and refine this framework in different research domains, and to conduct a survey in order to qualify existing research as matching to our approach. Furthermore, other interesting questions for research arise from our approach, e. g. how consensus is actually achieved within a language community. We encourage other research to use this framework, and to criticize it for refinement.

REFERENCES

Ågerfalk, P. J. and Eriksson, O. (2004) Action-oriented conceptual modelling. *European Journal of Information Systems* 13 (1), 80-92.

Ashby, W. R. (1964) *An Introduction to Cybernetics*. University Paperbacks, London, UK.

Barrett, M. and Walsham, G. (1999) Electronic trading and work transformation in the London Insurance Market. *Information Systems Research* 10 (1), 1-22.

Baskerville, R. L. and Myers, M. D. (2004) Special Issue on Action research in Information Systems: Making IS Research Relevant to Practice-Foreword. *MIS Quarterly* 28 (3), 329-335.

Baskerville, R. L. and Wood-Harper, A. T. (1996) A critical perspective on action research as a method for information systems research. *Journal of Information Technology* 11 (3), 235-246.

Beer, S. (1985) *Diagnosing the System for Organizations*. John Wiley & Sons, Chichester, UK et al.

Braun, C., Wortmann, F., Hafner, M. and Winter, R. (2005) Method Construction - A Core Approach to Organizational Engineering. In *20th ACM Symposium on Applied Computing (SAC 2005)*, pp 1295-1299, Santa Fe, New Mexico, USA.

Bühler, K. (1934) *Sprachtheorie. Die Darstellungsfunktion der Sprache*. G. Fischer, Jena, Germany.

Cavaye, A. L. M. (1996) Case study research: a multi-facetted research approach for IS. *Information Systems Journal* 6 (3), 227-242.

De Saussure, F. (1974) *Course in General Linguistics*. Peter Owen Ltd., London, UK.

Gemino, A. and Wand, Y. (2003) Evaluating Modeling Techniques based on Modles of Learning. *Communications of the ACM* 46 (10), 79-84.

Gemino, A. and Wand, Y. (2004) A framework for empirical evaluation of conceptual modeling techniques. *Requirements Engineering* 9 (4), 248-260.

Gregor, S. (2006) The Nature of Theory in Information Systems. *MIS Quarterly* 30 (3), 611-642.

Holten, R. (2003) Integration von Informationssystemen. Theorie und Anwendung im Supply Chain Management. Universität Münster, Münster.

Holten, R., Dreiling, A. and Becker, J. (2005) Ontology-Driven Method Engineering for Information Systems Development. In *Business Systems Analysis with Ontologies* (Green, P. and Rosemann, M., Eds), pp 174-215, IDEA Group, Hershey, PA, USA et al.

Hughes, J. and Wood-Harper, A. T. (1999) Systems development as a research act. *Journal of Information Technology* 14 (1), 83-94.

Jenkins, A. M. (1985) Research Methodologies and MIS Research. In *Research Methods in Information Systems* (Mumford, E. and Hirschheim, R. and Fitzgerald, G. and Wood-Harper, A. T., Eds), pp 103-117, North-Holland Publishing Co, Amsterdam, The Netherlands.

Kamlah, W. and Lorenzen, P. (1984) *Logical Propaedeutic. Pre-School of Reasonable Discourse.* University Press of America, Lanham, MD, USA.

Klein, H. K. and Myers, M. D. (1999) A Set of Principles for Conducting and Evaluating Interpretive Field Studies in Information Systems. *MIS Quarterly* 23 (1), 67-94.

Langley, A. (1999) Strategies for Theorizing from Process Data. *Academy of Management Review* 24 (4), 691-710.

Laumann, M., Rosenkranz, C. and Kolbe, H. (2007) Diagnosing and Redesigning a Health(y) Organization - An avarto (Bertelsmann) Action Research Study. Under review.

Lee, A. S. (1991) Integrating Positivist and Interpretive Approaches to Organizational Research. *Organization Science* 2 (4), 342-365.

Lee, A. S. (2004) Thinking about Social Theory and Philosophy for Information Systems. In *Social Theory and Philosophy for Information Systems* (Willcocks, L. and Mingers, J., Eds), pp 1-26, John Wiley & Sons, Chichester, UK et al.

Lee, A. S. and Baskerville, R. L. (2003) Gerneralizing Generalizability in Information Systems Research. *Information Systems Research* 14 (3), 221-243.

Lorenzen, P. (1987) *Constructive Philosophy.* The University of Massachusetts Press, Amherst, MD, USA.

Lyytinen, K. J. (1985) Implications of Theories of Language for Information Systems. *MIS Quarterly* 9 (1), 61-76.

Maier, R. (1999) Evaluation of Data Modeling. In *Advances in Databases and Information Systems: Third East European Conference, ADBIS'99, Maribor, Slovenia, September 1999* (Eder, J. and Rozman, I. and Welzer, T., Eds), pp 232-246, Springer Verlag, Heidelberg, Germany.

Maynard, D. W. (1989) On the ethnography and analysis of discourse in institutional settings. In *Perspectives on Social Problems* (Holstein, J. A. and Miller, G., Eds), pp 127-146, JAI Press, Greenwich, Connecticut, USA.

Moody, D. L. (2005) Theoretical and practical issues in evaluating the quality of conceptual models: current state and future directions. *Data & Knowledge Engineering* 55, 243-276.

Morris, C. (1971) *Writings on the general theory of signs.* Mouton, The Hague, Netherlands.

Myers, M. D. (1997) Qualitative Research in Information Systems. *MIS Quarterly* 21 (2), 241-242.

Popper, K. R. (1965) *Conjectures and Refutations: The Growth of Scientific Knowledge.* Harper, New York, NY, USA.

Ribbert, M., Niehaves, B., Dreiling, A. and Holten, R. (2004) An Epistemological Foundation of Conceptual Modeling. In *12th European Conference on Information Systems (ECIS 2004)* (Leino, T. and Saarinen, T. and Klein, S., Eds), Turku School of Economics and Business Administration, Turku, Finland.

Shanks, G., Tansley, E. and Weber, R. (2003) Using Ontology to validate Conceptual Models. *Communications of the ACM* 46 (10), 85-89.

Silverman, D. (1998) Qualitative research: meanings or practices. *Information Systems Journal* 8 (1), 3-20.

Walsham, G. (1995a) The Emergence of Interpretivism in IS Research. *Information Systems Research* 6 (4), 376-394.

Walsham, G. (1995b) Interpretive case studies in IS research: nature and method. *European Journal of Information Systems* 4 (1), 74-81.

Wand, Y. and Weber, R. (2002) Research Commentary: Information Systems and Conceptual Modeling - A Research Agenda. *Information Systems Research* 13 (4), 363-376.

Weber, R. (2003) Conceptual Modelling and Ontology: Possibilities and Pitfalls. *Journal of Database Management* 14 (3), 1-20.

Weber, R. (2004) Editor's Comments. The Rhetoric of Positivism Versus Interpretivism: A Personal View. *MIS Quarterly* 28 (1), iii-xii.

Wittgenstein, L. (1922) *Tractatus Logico-Philosophicus.* London, UK.

Yin, R. K. (2003) *Case Study Research: Design and Methods.* SAGE Publications, Thousand Oaks, CA, USA et al.

Enterprise Architecture Using the Zachman Framework: A Model Driven Approach

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ABSTRACT

Many organizations are interested in building their enterprise architectures using the Zachman framework. They hope to solve the problems of misalignment between business processes and information systems along with gaining a desired level of interoperability and flexibility in their IT environment. However, in most cases the Zachman framework remains as a conceptual framework more than a pragmatic one. This causes a serious doubt as to whether the enterprise could satisfy the motivations of employing the Zachman framework. Model driven architecture (MDA) is addressed in this paper as a framework, which is in a very high synch with the Zachman framework. MDA provides a means of flexible reusable model-driven development environment that is being applied in more and more situations everyday. It is also based on commonplace technologies, which makes it popular amongst software engineers and IT specialists. In this paper, we show that MDA could be the key that opens the world of reality to the Zachman framework. Not only does MDA have everything the Zachman framework needs to be practical, but it also follows the same logical structure and very similar metadata language as the Zachman framework.

Keywords: MDA, Zachman, Architecture, MOF, Conceptual Graphs.

1. INTRODUCTION

The Zachman framework (as firstly introduced Zachman (1987)) is considered as of the major origins of Enterprise Architecture (EA) (Wilton, 2001). According to Schekkerman (2005), 25% of current EA-related activities are being done using the Zachman framework, which is the highest rate amongst all the other frameworks.

The Zachman framework aims at reducing the problems of building information systems without strategic and/or business-related considerations. It categorizes different stakeholders' viewpoints into a fixed set of perspectives through which, everybody could find the exact information he/she is interested in. The framework also captures the knowledge of enterprise via abstracting it into a collection of integrated features.

A key factor of the Zachman framework is that it promises the alignment between business and technology because it provides all stakeholders with the same pattern of information. However, this promise could not be realized without having a mechanism to ensure that different viewpoints have correctly been transformed to each other.

Another important issue is the ability of the Zachman framework to capture the enterprise knowledge in an integrated scheme. In practice, it is very hard to track this ability because modelers use different sets of models with no common background. These problems alongside with other ones (Fatolahi & Shams, 2006) mandate the use of the Zachman framework as a conceptual tool. This means that enterprises could not benefit from all of the advantages of the Zachman framework in practice.

Model driven architecture (MDA) is the OMG's solution to increase model reusability and design-time interoperability. MDA deals with model as an asset rather than a cost. A very important feature of MDA is the facility to transform models among different areas. Not only is it easier to build automatic model mappings in the MDA context, but MDA could also be beneficiary when the model transformation is done manually. MDA provides a collection of popular standards beneath a common philosophy to facilitate the process of quality software design and implementation.

We believe that MDA can be used as a source to supply all the modeling needs of the Zachman framework. This is because MDA:

1. provides a strong approach for model transformation. This means that using MDA, it is possible to build models, which are true transformations of each other or at least very close mappings. This capability makes MDA a good choice to solve the challenge of perspective transforming and tracking within the Zachman framework.
2. provides a broad collection of flexible modeling standards based on a single simple basic notation. Therefore, one can apply MDA-based modeling notations all over the Zachman framework with a high chance to preserve the integrity of the enterprise's knowledge.
3. separates modeling concerns just as the Zachman framework does.
4. levels metamodeling in the same way the Zachman framework does.
5. uses a metamodeling language that could be easily translated to the one used by the Zachman framework.

In this paper we try to address some of the problems regarding the Zachman framework using MDA. Employing the two frameworks with each other, we hope for enterprise architectures that would be well defined and understood by all the stakeholders because of the Zachman framework; ones that would be easily developed and maintained because of the popularity of the MDA framework and its supporting tools.

The rest of this paper is organized as follows. In Sections 2, we introduce the Zachman framework and MDA. In Section 3, we mention related work and discuss the similarities and differences of the current research with the previous ones. Section 4 addresses the adaptability of MDA and the Zachman framework with an emphasis on metamodeling languages and levels. In Section 5, some issues regarding the current research are discussed. At last, we provide a summary along with a plan for future work in Section 6.

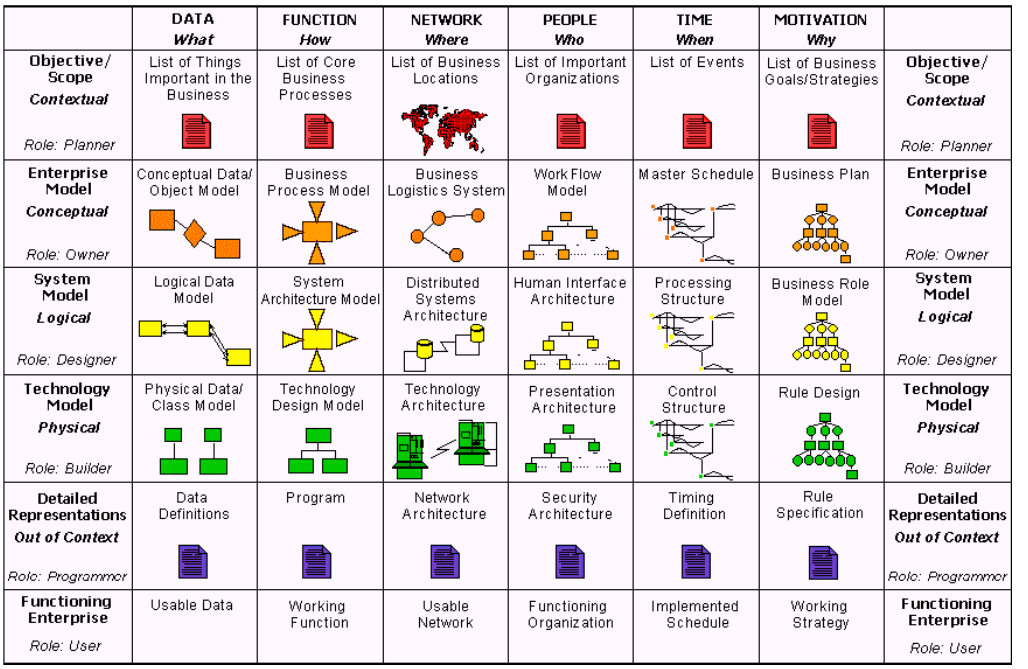
2. BACKGROUND

2.1. The Zachman Framework

Figure 1 is a depiction of the Zachman framework. The Zachman framework consists of six rows and six columns. Rows represent different stakeholders' perspective in building enterprise architecture. Columns are different ways in which, we describe the same product for different purposes. Crossing each row by each column, results in a cell, which contains a unique model.

As it can be seen in Figure 1, the first row is a definition of the context for the enterprise. In the second row, the enterprise is modeled using business modeling techniques. within the third row, the IT environment is conceptually modeled. These design models are mapped onto technology dependent design models in the fourth row. The fifth row contains implementation models. Since systems

Figure 1. The Zachman framework



development is often an outsourced task, which is not performed by the organization itself, this row is supposed to be out of context for the EA. The last row corresponds to the real working enterprise.

Columns of the framework facilitate abstraction of the enterprise's knowledge in a way that is suitable for modeling purposes. Each column is supposed to answer a single question regarding the enterprise. "What are important things for the enterprise?" is answered by the *Data* column. "How does it run?" is answered using the *Function* column. "Where is it located?" is answered in the *Network* column. "Who are acting within the enterprise?" is answered by the *People* column. "When does it perform its businesses?" is answered using the *Time* column and "Why the enterprise does the businesses?" is answered in the *Motivation* column.

2.2. Model Driven Architecture (www.omg.org/mda)

MDA proposes four different layers of modeling. The most top layer is the layer of *Computation-Independent Models* (CIM). CIM represents models, which are valid in spite of the computational options. Business models reside in this layer. Then we have the layer of *Platform-Independent Models* (PIM). PIM acts as a standpoint of systems/software design and architecture. However, it does not contain any information about specific platforms. The third layer, *Platform-Specific Models* (PSM) deals with the technological details of platforms. Here, logical design models are expressed in terms of certain platforms. At the lowest level, there are *Implementation-Specific Models* (ISM[1]). These are real-world objects and components, which act as a running version of the system.

The Meta-Object Facility (MOF) (www.omg.org/mda) is the heart of MDA. MOF provides a means of building new modeling languages and/or transforming different languages each to the other. The MOF is composed of very simple but strong enough elements to describe any other modeling language. Although MOF does not provide any specific notation, it is possible (and convenient) to use basic UML Class modeling notations (with few considerations) to depict MOF models.

MDA admits two levels of MOF-based languages. The first level addresses languages, which are rooted in the MOF itself. In fact, some of these languages such as CWM and UML are even older than MOF, but eventually OMG has refactored them to comply with the MOF. The second level deals with the UML profiles. This level involves different UML extensions. In order to facilitate model exchange amongst different tools and standards, XMI Metadata Interchange (XMI) is also a part of MDA.

3. RELATED WORK

The work closest to ours is reported by (Frankel, et al., 2003). This article shows how different perspectives of the Zachman framework maps to the MDA ones. This is shown in table 1. It also contains a valuable classification of MOF-based models, which can be used to fill in the different cells of the Zachman framework. For example, they propose CWM for the entire *Data* column or *UML Scheduling Profile* for a fraction of the *Time* column. Although we accept this approach, our paper extends the solution with bridging the metadata behind the two frameworks and mapping their hierarchy of metamodeling.

Another interesting work is provided by (B´ezivin & Gerb´, 2001), where the author discusses a precise definition for the MDA framework using CGs. It is worth-mentioning that the paper is published when MOF was not commonplace. The other work is published by (Fatolahi & Shams, 2006), which investigates the capability and popularity of UML models, when applying to the Zachman framework.

In summary, it can be concluded that the related-work has been generally focused on recognizing appropriate models for different parts of the Zachman framework and in the case of (Frankel, et al., 2003) a mapping between the perspectives of Zachman framework and the stages of MDA. Although the work of (B´ezivin & Gerb´, 2001) tries to define MDA using CGs, we do not see an explicit mapping between CGs and MOF in it. Our research is focused on mapping MOF and CGs alongside with discussing the similarity of the approach of the two frameworks towards metamodeling in practice.

Table 1. MDA layers vs. perspectives of the Zachman framework

Perspectives of the Zachman Framework	Layers of MDA
Planner	N/A
Owner	CIM
Designer	PIM
Builder	PSM
Sub-Contractor	ISM
User	N/A

4. ALIGNMENT

4.1. Separation of Concerns

Each row of the Zachman framework could be supplied with models from a certain MDA layer. Our discussion excludes the first row of the Zachman framework. This row represents the planners' viewpoint, which is supposed to be full of textual discriptions of different aspects of enterprise architecture planning, such as constraints, important features, limitations, geographical distribution, etc. We also do not mention the last row that is assigned to the real-working enterprise, which is not related to modeling.

The second row is the owners' perspective. This is the row, which describes different features of the business. This row is the area of different business modeling techniques. Since the models of this row are non-computational, we can use CIM to build the models of this row.

The third row represents the designers' viewpoint. Information systems are designed in this row. However, this design is a platform-independent modeling activity. Models to fill in this row come from PIM.

The standpoint of technology is indicated in the fourth row. In this row, design is simply transformed into technology-dependent modelings. For example, if we chose J2EE as the platform, design *Entities* would become *Entity Beans* here. This is why, we select MDA's PSM as our source for filling this row of the Zachman framework.

Programmers' role is compromised within the fifth row, where the building blocks of the architecture are made up. Because this row deals wholely with the implementation issues, we can feed it using ISM.

4.2. Model Assignment

Although there could be several valid approaches to assign a collection of models to each column of the Zachman framework, the important point is that both (Frankel, et al., 2003) and (Fatolahi & Shams, 2006) show that the family of MDA standards or some subsets of it could cover the Zachman framework. In fact, based on one of the rules of the Zachman framework (Sowa & Zachman, 1992) *there must be a simple, basic and unique model for each column*. Elements of such a model for different columns are provided in table 2. As long as a language can satisfy this rule it could be considered as a valid option. However, there is no guarantee that the chosen language reaches an acceptable level of popularity. Fortunately, this is the main advantage of the MDA, which deals with a family of popular languages.

4.3. MOF vs. CG

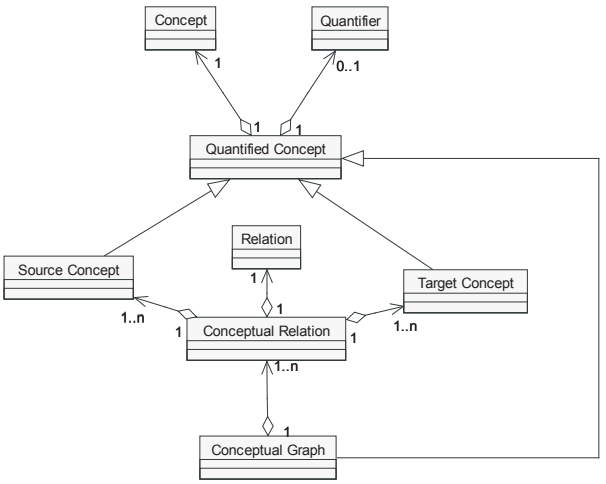
A very important factor to guarantee the quality of final enterprise architecture using the Zachman framework is its integrity. Integrity is gained through applying a set of rules. A question is to know if MDA could facilitate the usage of the Zachman framework. If MDA wanted to facilitate the usage of the Zachman framework, it should support the integrity mechanism of the Zachman framework, which is specified using the metadata language Conceptual Graph (CG) (Sowa, 2000). We address this challenge by providing metamodels showing that the language used to describe each framework could be formally defined using the language of the other framework.

The metadata language of the Zachman framework is CG (Sowa & Zachman, 1992). There is a simple and interesting relationship between CG and MOF. Figure 2 shows how MOF could describe CGs. A *conceptual graph* is composed of some *concept*s and *relation*s. For example, *a cat is on a mat*, is a CG of two concepts, *cat* and *mat*, and a relation, *on*. Usually a concept is being preceded by a quantifier, which is *a* (or more formally *exists*) in this case. Figure 3 is a representation of this CG. Quantifier *a* is not shown because it is the default quantifier. Figure 4 shows how this CG is synthesized using our metamodel. This is a very simple CG but our metamodel is also capable to describe more subtle CGs, including nested CGs. This is done through the generalization association between *Conceptual Graph* and *Quantified Concept* in Figure 2.

Table 2. Essential modeling elements for columns of the Zachman framework

What?	How?	Where?	Who?	When?	Why?
Entity	Function	Node	Agent	Time	Ends
Relation	Argument	Link	Work	Cycle	Means

Figure 2. MOF metamodel for conceptual graphs



We can see that each *Concept* plus an optional *Quantifier* results in a Quantified Concept like "a cat". This could be a target or a source concept. For example, as it can be seen in Figure 4, "a cat" is recognized as a *Source Concept* and "a mat" is realized as a *Target Concept*. A number of source and target concepts then aggregate to a *Conceptual Relation* through a *Relation*, which is "on" in the case of Figure 3 (and Figure 4). Finally, a *Conceptual Graph* is composed of some *Conceptual Relations*.

On the other hand, consider Figure 5 as an essential part of MOF imported from UML metamodel (OMG, 2005). Figure 6, presents a valid CG to express this metamodel. Symbol, *T*, is used as a means of repeating a concept. As it can be seen, multiplicity of MOF associations is shown using quantifier *{*}*, which means a set of concepts. In Figure 6, a "meta" relation represents the generalization from the general type toward the specific type. An "own" relation is used to show the aggregation association among two types.

Figure 3. A cat is on a mat CG

Figure 4. Synthesizing the CG of Figure 3 using the metamodel in Figure 2

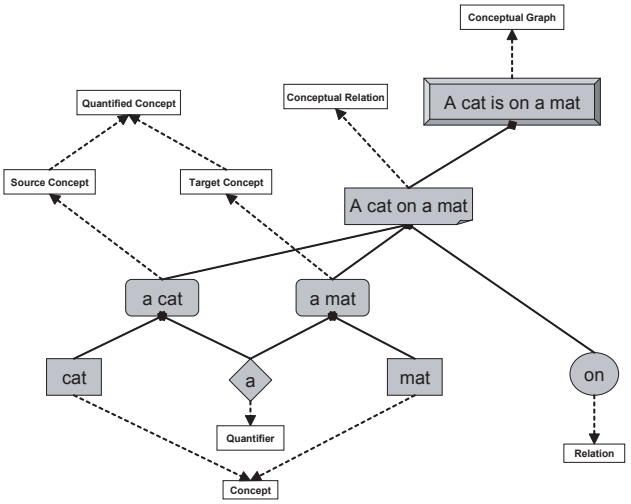


Figure 5. A part of a UML metamodel expressed using MOF

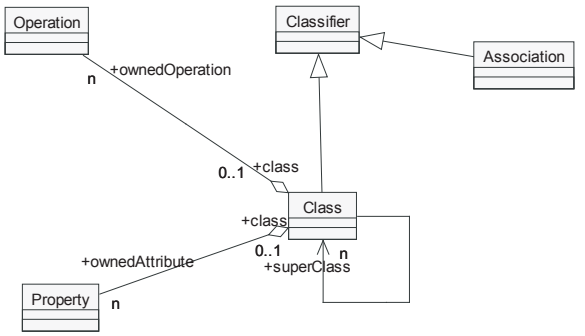


Figure 6. The conceptual graph describing the UML metamodel of Figure 5

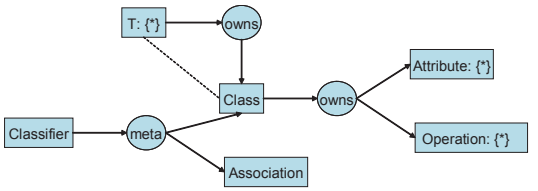
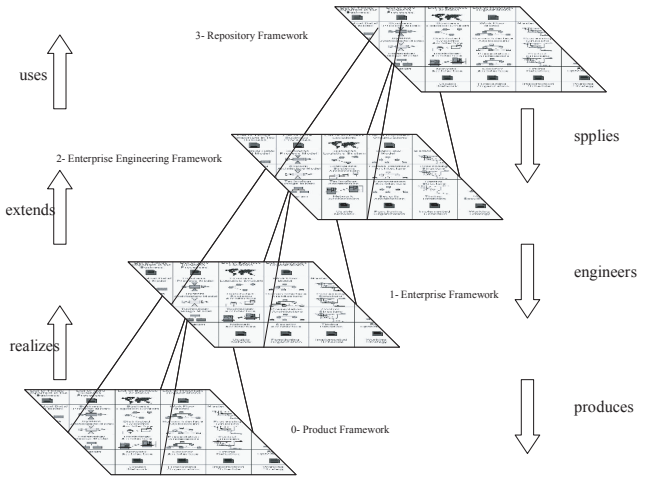


Figure 7. The stack of the Zachman framework



4.4. Metamodeling

An important question would be the ability of MDA to match with the hierarchical structure the Zachman framework provides to maintain reusable and scalable enterprise architectures. We provide general guidelines and ideas to apply MDA at different abstraction levels.

The Zachman framework is not just a pattern to build enterprise architectures; it also provides a mechanism for maintaining the enterprise knowledge. This mechanism guarantees the ability and scalability of the enterprise architecture. This means that the framework makes it possible to change the enterprise at any time using the stack of architectures Figure 7, shows the stack of the Zachman frameworks (Inmon, et al, 1997). MDA has the same mechanism to supply the framework with the models required for each level of this stack. This mechanism is defined within table 3.

According to Figure 7:

1. The framework at level 0 represents the architecture framework for the products of the enterprise. This product could be a software package or an airplane. A product is composed of real working objects, i.e. objects with certain serial numbers. This level could be equivalent to MDA's M0.
2. Architecture for the enterprise itself is modeled within the level 1. The enterprise architecture at level 1 defines the resources and methods through which, the enterprise generates its products. Thus, this level is a supplier for level 0. Since this is the specific enterprise that produces certain products of level 0, architects have to elaborate it using domain-specific models. Therefore, level 1 grabs its modeling essentials from MDA's M1.
3. Level 2 deals with planning, modeling, building and maintaining the enterprise. Enterprise engineers reside at this level. The enterprise engineering framework consists of tools and methods required to define different enterprises. Metamodels are critical for such an activity. Enterprise engineers need metamodels to extend them for the specific aspects of certain enterprises. Using MDA, they can select metamodels from M2. They may extend *UML Activity Model*s to describe the enterprise's workflow or create profiles of *CWM* to define the enterprise's warehousing mechanism (both will then appear at level 1).
4. Finally, there is the Repository Framework at level 3. This is the most abstract framework, which is used to manage enterprise engineering tasks. In fact, enterprise engineers refer to this framework as a general source for all the materials they need in order to develop or maintain an enterprise. Because metamodels are used as a means of enterprise engineering, the repository framework as the supplier of the enterprise engineering framework must also provide a mechanism of handling metamodels. This is why we assign MDA's M3 to this level. MOF is used as the metametamodeling language for all the languages and standards of level 2. It also assures the interoperability of the enterprise models, resulting in everything the Zachman framework promises for: interoperability, flexibility and maintainability.

Table 3. MDA metamodeling mechanism

M3 (MOF)	Metametamodeling layer, including the most abstract materials required to build new languages and interoperability standards.
M2 (UML, CWM, …)	Metamodeling layer, providing the notation and formalism that can be used to model specific domains and systems. This layer is fed by M3.
M1 (User Model)	Projections of M2 in terms of certain user requirements. This includes different extensions of M2 to model the specifications of a certain subject. Examples are UMP profiles.
M0 (Runtime Model)	Runtime objects. Running versions of M1.

Table 4. Mapping the metamodeling mechanism of the Zachman framework and MDA

MDA Metamodeling layer	The Zachman Framework
M3 (MOF)	Repository Framework
M2 (UML, CWM, …)	Enterprise Engineering Framework
M1 (User Model)	Enterprise Framework
M0 (Runtime Model)	Product Framework

Table 4 summarizes the mapping of metamodeling layers of both frameworks.

5. DISCUSSION

Despite of all the similarities, there are some differences between the Zachman framework and MDA. The concept of platform in MDA is different from the similar notion within the Zachman framework. From the viewpoint of the Zachman framework all technological platforms are considered the same and are addressed within the fourth row. For example, Oracle DBMS and .Net framework both belong to a unique category. The case is not the same with MDA, where the architect has to define his/her purpose of the platform explicitly. As a result, a platform-independent model is not necessarily a pure logical model. For example,

a PIM may be independent from .Net but not from the Oracle DBMS; that is the platform means just .Net.

The Zachman framework has a recursive nature. This means that each subset of the framework could be a new framework by itself. For example, as we discussed, the enterprise framework is a product of the Function column of the enterprise engineering framework. MDA does not support this recursiveness explicitly. The mapping of table 4 seems to resolve this problem, but yet the Zachman framework support of the recursive frameworks could be different than the structure of Figure 6.

A possible solution to this conflict is to consider different technologies and standards as members of different columns in the fourth row. For example, we have DB2 in the first column and DCOM in the second column. Since the logic of the Zachman framework is recursive, it is possible to think about each cell independently (Sowa & Zachman, 1992). We could isolate the cell at the fourth row and first column; then restrict the concept of platform to DB2, resulting in *DB2 Specific Model*. We iterate this process within other columns. (e.g. considering DCOM as the platform results in DCOM *Specific Model* for Function column)

6. CONCLUSION AND FUTURE WORK

So far, we have shown that MDA could fit with the Zachman framework very well. Since MDA supports a large collection of standard modeling languages, there is a good chance to assign a subset of MDA to each cell of the Zachman framework. Further, there are many tools and methodologies in use or under development in accordance with MDA.

One of the main benefits of MDA is that it facilitates the process of model transformation. On the other hand, model transformation is one of the major threats against the Zachman framework. MDA makes model transformation easier, more accurate and automated. Here, we find a big set of open problems, which are different MDA mapping functions and transformation paths throughout the Zachman framework.

This research is not just about a conceptual mapping between the Zachman framework and MDA. We believe that these two frameworks could collaborate with each other to build EAs in practice. The purpose of Sections 4.3 and 4.4 was to dismiss the gap between conceptual frameworks and practical applications. According to 4.3, MOF could be translated to CG; so, every model described with MDA is capable to fit within the Zachman framework. The discussion of the Section 4.4 promotes the ability of architects to support all levels of the Zachman framework using MDA.

As our future research, we will mainly focus on different MDA transformation functions to convert and/or track models through adjacent rows of the Zachman framework. Besides, we will be declaring the application of the notion of platform in MDA using the recursive logic of the Zachman framework. Clearly, we will need more and more tools and techniques to support our research. Therefore, this would be an indispensable track of our future research too.

REFERENCES

B´ezivin, J., Gerb´, O. (2001). *Towards a precise definition of the OMG/MDA Framework.* Proceedings of Automated Software Engineering 2001.

Fatolahi, A., Shams, F. (2006). *An Investigation into Applying UML to the Zachman Framework*. Journal of Information Systems Frontiers, Special Issue on Enterprise Architecture, Volume: 8, Issue: 2, 133 – 143.

Frankel, David S., et al. (2003, September). *The Zachman Framework and the OMG's Model Driven Architecture*. Business Process Trends, from Object Management Group database.

Inmon, W., Zachman, J. A., Geiger, J. G.(1997). *Data stores, data warehousing and the Zachman framework, Managing enterprise knowledge*. McGraw-Hill.

OMG. (2005). *Unified Modeling Language Superstructure.* Website: http://www.omg.org/docs/formal/05-07-04.pdf

Schekkerman, J. (2005). *EA Survey Trends 2005 Results.* Website: http://www.enterprise-architecture.info/Images/EA Survey/Enterprise Architecture Survey 2005 IFEAD v10.pdf

Sowa, J. F. (2000). *Knowledge Representation, Logical, Philosphical and Computational Foundations*. Brooks/Cole.

Sowa, J. F., Zachman, J.A. (1992). *Extending and formalizing the framework for information systems architecture.* IBM Systems Journal 31, No. 3, 590-616.

Wilton, David R. (2001). *The Relationship between IT Strategic Planning and Enterprise Architecture Practice*. Journal of BattleField Technology, Vol 4, No. 1, 18-22.

Zachman, John A. (1987). *A framework for information systems architecture.* IBM Systems Journal 26, No. 3, 276-292.

ENDNOTE

[1] This is not an official term from OMG.

The Impact of Australian Legislation Upon an IT Degree: Considerations and Response

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ABSTRACT

In Australia, all recent higher education reforms have been driven by new legislation detailed in The Higher Education Support Act (HESA) 2003 that mandates and regulates the conditions under which tertiary institutions are able to be run and funded. In anticipation of the HESA enactment, Victoria University in Melbourne, Australia, conducted an institutional wide assessment of the University's position regarding HESA compliance and found that the University needed to rationalise course structures and progression rules, including standardization of subject sizes (Lister Review, 2003). This paper reports upon the adoption of a uniform system of subject size and associated credit points has necessitated a major course review of our Information Technology undergraduate program. This review, which posed a number of challenges at both School and inter-faculty levels, was informed by the needs of the stakeholders: the University, academics, the Australian Computer Society, industry and students. An insight into issues of importance on the IT curriculum is discussed before arrival at a HESA compliance program for our degree.

INTRODUCTION

In Australia, all recent higher education reforms have been driven by new legislation detailed in The Higher Education Support Act (HESA) 2003 that mandates and regulates the conditions under which tertiary institutions are able to be run and funded. In anticipation of the HESA enactment on 1 January 2005, Victoria University in Melbourne, Australia commissioned a taskforce to conduct an institutional wide assessment of the University's position regarding HESA compliance or otherwise. After an examination of all university course offerings, a major recommendation of the review obligated that *"the University rationalise course structures and progression rules, including the standardisation of subject sizes"* (Lister Review, 2003, Recommendation 17).

In 2004, an audit undertaken on the range of subject sizes and their credit point allocations in operation at the University highlighted disturbing anomalies. The investigation found a broad spectrum of unit sizes with differing credit point values ranging from 2 to 20 points and it exposed inequalities for different student majors in that the same unit of study could be awarded different credit point values dependent upon the program where the unit was undertaken. This audit underlined the need for the creation of a fair and equitable credit point system that would be accurate and consistent for all undergraduate and postgraduate courses. In addition, such a structure would ensure equitable course fee arrangements across the University's offerings and it would provide a transparency intelligible to students, staff and the community (Lister Taskforce, 2004a).

Through its Academic Board, the University instructed a working party to describe a uniform structure and a framework for a more suitable credit point system. The working party was also tasked with drafting a policy, entitled "The Credit Point System" for implementation by faculties. Subsequently, the Academic Board, at its June 2004 meeting, approved the introduction of the proposed new credit point system and the adoption policy that needed to be fully operational and HESA compliant by January 2006 (Lister Taskforce, 2004b).

Charged with implementing the new policy, individual faculties needed to align their existing courses with the new credit point arrangements. The Faculty of Health, Engineering and Science devolved the responsibility for the revision of the undergraduate Information Technology (IT) degree program to the School of Computer Science and Mathematics, where it underwent an extensive academic review. This paper describes the new credit point system and the impact of its implementation upon the IT degree program offering at Victoria University. By examining the needs and considerations of the respective stakeholders, the paper offers an insight into the process of arriving at a HESA compliant program which meets the statutory requirements and has academic and educational merits.

HISTORICAL BACKGROUND

Prior to 2006, the undergraduate Information Technology (IT) degree was a three year full time program, comprised of six study semesters. In the first year, students were introduced to core subjects in IT that laid a foundation of computing technology and these units included hardware, software, mathematics and statistics. The second and third year curriculum comprised both core and electives, which allowed student flexibility to pursue their particular strengths and interests. A

Table 1. IT program structure at Victoria University prior to HESA

Unit of study		Year	Semester	
Year 1				
SCM1311	Programming 1	1	1	15
SCM1312	Programming 2	1	2	15
SCM1114	Introduction to Computing & the Internet	1	1	15
SCM1115	Computer Systems and Architecture	1	2	15
SCM1613	Applied Statistics 1	1	1	15
ACE1141	English Language & Communication 1	1	1	7
ACE1142	English Language & Communication 2	1	2	8
OR SCM1614	(For those not doing ACE1141 and ACE1142): Applied Statistics 2	1	2	15
SCM1711	Mathematical Foundations 1	1	1	15
SCM1712	Mathematical Foundations 2	1	2	15
Year 2				
SCM2211	Database Systems 1	2	1	12
SCM2311	Object Oriented Programming 1	2	1	12
SCM2312	Software Engineering	2	1	12
	Two electives	2	1	24
SCM2111	Data Communications and Networks 1	2	2	12
SCM2112	Operating Systems	2	2	12
SCM2218	Database Systems 2	2	2	12
SCM2313	Software Development	2	2	12
	One elective	2	2	12
Year 3				
SCM3001	Project 1	3	1	12
ACE3143	English Language & Communication 3	3	1	12
SCM3112	User Interface Design	3	1	12
SCM3314	Object Oriented Analysis and Design	3	1	12
	One elective	3	1	12
SCM3002	Project 2	3	2	12
ACE3144	English Language & Communication 4	3	2	12
SCM3312	Intelligent Systems	3	2	12
SCM3313	Software Engineering 2	3	2	12
	One elective	3	2	12

significant part of the degree was an industry based project spanning two semesters in the final year of study; regarded as a 'dress rehearsal' for IT students about to graduate and face the needs of the commercial world. To develop the necessary advanced written and oral communication skills for successful completion of the Project, students must undertake two mandatory co-requisite units in English Language and Communication. A detailed pre-HESA compliant course structure is shown in Table 1.

A quick inspection of Table 1 illustrates that the pre-HESA IT degree program was comprised of units of varying credit points. However a less obvious anomaly is that dependent upon their English language proficiency, students needed to complete either 28 or 29 units of study for their degree program. Those lacking in English language skills were required to undertake two enabling English language subjects valued at 8 and 7 credit points each, whilst proficient language students were enrolled in a single 15 point elective instead. All first year students enrolled in the remaining core units, which carried 15 credit points each. In the second and third year of the program all units to be undertaken were valued at 12 credit points each. So a typical fulltime student carried 4 units of study per semester in the first year and 5 units in each subsequent semester, which summed to 360 credit points over their undergraduate degree.

THE NEW CREDIT POINT MODEL AND POLICY

To be HESA compliant, all University programs were expected to adopt a 48 credit points per semester model for fulltime study; typically comprised of 4 units of study, each assigned a 12 credit points (cp) value. This standard model is known as the 4 * 12 model. The model further stipulated that 1 cp represented an average student workload of approximately 1 hour per week over a standard 12 week semester. It was hoped that the adoption of a standard system of credit points throughout the University would remove the anomalies identified by the audit process and ensure equitable course fee arrangements across the University's offerings. In addition, the model allowed for a more systematic approach to course planning in relation to student workloads. It was deemed that a full-time student would accrue 96 credit points (2 * 4 * 12 cp) yearly over two semesters and that 96 cp equated to 1.0 equivalent fulltime student load for measurement of funding by the Australian government. As such, the model provided a transparency intelligible to the government and the University and at the same time, the model enabled students to make more realistic planning in their studies (Lister Taskforce, 2004a).

The policy document entitled "The Credit Point System" outlined the framework for converting all existing programs in the University to the 4 * 12 model in two sequenced steps. Step 1 required that each respective course of study be identified as one of three types of amendments and Step 2 involved carrying out the amendment by revision of the entire course structure under the new model.

For Step 1, all existing programs were classified as one of the following three types of amendment: Type 1- Arithmetic Amendment that related to courses of study which involved no structural change (a mere arithmetic change to the standard 12 cp for each unit of study); Type 2- Minimal Structural Amendment that related to courses of study which required a minimal structural amendment (no more than 20% change); Type 3- Major Structural Amendment that related to courses of study which required a major reconfiguration (more than 20% change). Following which, Step 2 involved the preparation and submission of the full course credit point conversion document to be subsequently approved by the Faculty Course Approvals Committee, Faculty Board of Studies and the University's Academic Board.

CONSIDERATIONS FOR IMPLEMENTATION

So how could the 'decree' of the new (4 * 12 cp) program model be implemented in the undergraduate IT degree by the School of Computer Science and Mathematics? Examination of the pre-HESA IT program described above, revealed inconsistencies in the number of units for different year levels within the degree. As well, there was no uniformity in the unit values within and across year levels. In fact, the total number of units for the awarding of the degree was dependent upon a student's language proficiency!

For the School of Computer Science and Mathematics, the imposition of HESA compliance dictated an interruption to the timing of regular four yearly course reviews. However, in line with the prescribed steps, several course review meetings were held during late 2004 to nominate the category of amendment for revision of the IT program. These meetings identified that a Type 2 amendment would be the most appropriate since a fulltime second and third year load comprised of 5 units of study per semester (5 * 12 cp), thereby simplifying the retrofitting of the existing degree structure to the new standard 4 * 12 model. Further the first year could, with some readjustment, be aligned with the model.

For the course review committee, this identification of amendment type was a relatively simple task. However, implementing the amendment for Step 2 was a lengthy and complicated process. Retrofitting the existing course structure to incorporate the new 4 * 12 model credit point system posed a number of challenges at both School and inter-faculty levels. Some issues considered in this conversion exercise included questions like:

- How would the proposed changes maintain or enhance the educational outcomes of the course?
- Would the modification impact on the taught load of another School or Faculty?
- What would be the validity and relevance of the new course mapping to the various stakeholders (the University, academics, professional bodies, industry and students)?
- And how could the needs of the key stakeholders in the process be taken into consideration?

STAKEHOLDERS' NEEDS

a) The University

HESA compliance meant that all higher education units of study in Australia are assigned a credit point value, being a measure of the proportion of the year's workload that the subject represents to a student. Additionally, within a university, a unit must carry the same credit point value irrespective of the program in which the unit is undertaken. An important aspect of the Act's implementation was the introduction of an electronic information and communication system, the Higher Education Information Management System (HEIMS), to inform the community at large. HEIMS has two portals: a public portal where potential students would be able to access information such as higher education courses, units of study, unit costs and admission requirements, and a private portal – a personal site for students to access their enrolment and other details (HEIMS, 2006). Thus, as a step toward compliance, Victoria University needed to supply information for the public through HEIMS.

One of the aims of the "The Credit Point System" policy was to achieve no nett loss of taught load, including service teaching across and between faculties. Another consideration in the implementation of Step 2 was the completion of a standard proforma for effecting program conversion. This was particularly pertinent to English language teaching staff from the School of Communication, Culture and Languages in another faculty who serviced the language and communication teaching of the pre-HESA IT program.

Independent of HESA, Victoria University's "Core Graduate Attributes (CGA) Policy" embodied the broad aim of preparing students for lifelong learning in the four scholarship categories of discovery, application, integration and learning. To this end, the policy was developed with the stated objective of improving employment outcomes for its graduates and the policy mandates that a necessary condition for fulfilment of all undergraduate programs is for students to complete an assessment that encapsulates the four scholarships (Miliszewska & Tan, 2004a). Thus, this capstone assessment must be embedded within a core unit of study at final year level of the IT degree.

b) Academics

Hurst et al. (2001) concur with us that the primary driving force for academics involved in the teaching of the IT degree program is the validity and value of curriculum for students, both current and prospective. Moving to 4 * 12 cp per semester, as it appeared on paper, would result in fewer units being taught and thus implied that the breadth and depth of syllabus might not be covered. To effect the review would require the re-identification of core content within the curriculum. So despite a reduction in the number of units, it would be important to ensure that there would be no overall loss of teaching content.

Guided by the requirements of the accreditation body, the Australian Computer Society (ACS), staff identified the core body of knowledge to include programming, software engineering, conceptual modelling, databases, data communications, security, computer organization & architecture, and mathematics. A fundamental

inclusion in the course was a capstone task to provide students with an opportunity to work on a real-life software development through two Project units where they synthesized and consolidated their knowledge (Miliszewska & Tan, 2004b). These units would be the final and all-encompassing subjects in the degree program. It would be expected that students would also acquire non-technical skills like project management and awareness of business practices (Fairchild & Taylor, 2000; Novitzki, 1998). These important units would be supported by the English language lecturers who, although not familiar with the computing side of the projects, could play a vital role in helping students realize the importance of good communication and presentation skills.

c) ACS & Industry

The ACS, as the accreditation body, is responsible for the standards of knowledge in IT degree programs throughout Australia. This organization examines the quality of a program through an assessment of the content and structure of syllabi against the Society's core body of knowledge. A set of ACS mandatory skills including project management, interpersonal communication, and professional practice must be incorporated within a program before it can be accredited.

A research on employer satisfaction with graduate skills found that Computer Science graduates lacked problem solving and communication skills (AC Nielsen Research Services, 2000). Relatively low ratings were given by employers assessing new graduates in their written and oral business communication skills, initiative, leadership qualities, personal presentation, and problem solving skills. Employers wanted graduates with all of those skills together with knowledge, intellect and a willingness to learn (Harvey et al., 1997).

d) Students

In Australia, political weight is attached to student evaluations, where they used as a performance indicator by the independent auditing body Australian Universities Quality Agency (AQUA) to assess the quality of a university. It would be a foolhardy department that chose to ignore their students' desires and interests since it is the second most important driver for curriculum change in Australian computing departments (Gruba et al., 2004).

In their research of what students want from their IT programs, Venables et al. (2006) found that students were very pragmatic. Student priorities included transparency of unit worth for planning, admission requirements and the value to employers of the degree program. Students expected that their program would be professionally accredited and incorporate cutting edge technologies.

THE RESPONSE

The Course Review Committee saw the extra ordinary revision imposed by HESA as an opportunity to restructure and enhance the educational outcomes of the course so that it better addressed the core body of knowledge in ICT programs as required by the ACS. However the implementation of the new 4 * 12 cp program necessitated a reordering of material to reduce the number of study units from 28/29 to 24. To consider the needs of all stakeholders and weigh possible alternatives became a very time consuming 3 months process, relying upon the collegial goodwill amongst the more than 30 staff representing programming, information systems, internet technologies and networking, security, mathematics and English streams.

To accommodate the new 3 year program, an increase was made in the number of face-to-face contact hours with students from 3 to 4 hours a week for all second and third year units and a minimal change was needed to revamp first year units. In deciding upon core components, the response was guided by both the ACS framework documents and the CGA policy of the University, the two final year Project and two English units were included as mandatory in the degree. However, due to the increase in face-to-face contact hours, the original 4 units were reorganized into 3 units. Note that no loss of taught load for the School of Communication, Culture and Languages staff occurred as some study material was incorporated into the second Project unit. In addition, the two semesters first year enabling English subjects were consolidated into a single subject resulting in an identical number of hours to be taught at the first and third year level. Also the restructure of the IT program allowed the introduction of new topics and subjects, for example, the shifting of a unit in Database Systems 1 from second year to first year had facilitated the introduction of an additional elective in the second year. To strengthen our program in the area of data structures and algorithms, a formal elective in Discrete Mathematics was introduced as a core unit in the first year instead. The resulting program HESA compliant structure is shown in Table 2 below.

Table 2. HESA compliant IT program structure at Victoria University

Unit of study		Year	Semester
Year 1			
RCM1311	Programming 1	1	1
RCM1115	Computer Systems & Architecture	1	1
RCM1711	Mathematical Foundations 1	1	1
RCM1613	Applied Statistics 1	1	1
RCM1312	Programming 2	1	2
RCM1114 OR RCM1614	Introduction to Computing & the Internet Applied Statistics 2	1	2
RCM1713	Discrete Mathematics	1	2
RCM1211	Database Systems 1	1	2
Year 2			
RCM2112	Operating Systems	2	1
RCM2311	Object Oriented Programming 1	2	1
RCM2312	Software Engineering	2	1
	One elective	2	1
RCM2111	Data Communications and Networks	2	2
RCM2218	Database Systems 2	2	2
RCM2313	Software Development	2	2
	One elective	2	2
Year 3			
RCM3001	Project 1	3	1
ACE 3145	Professional Communication	3	1
RCM3314	Object Oriented Analysis and Design	3	1
	One elective	3	1
RCM3002	Project 2	3	2
RCM3312	Intelligent Systems	3	2
RCM3313	Software Engineering 2	3	2
	One elective	3	2

At the end of an exhausting review process, the Course Review Committee delivered what they believed to be an enhanced and academically sound IT degree program situated on top of a HESA compliant structure. Whilst being sensitive to the needs of all stakeholders, the new structure achieved no reduction in taught load of academics whilst improving the fit with the ACS mandatory body of knowledge for the discipline and complying with the University's CGA policy. Overall, the IT program has achieved a tighter structure with fewer electives spanning the core body of knowledge. With the addition of extra face to face contact time per elective, it is now possible to cover more advanced level topics which added extra breadth and depth in information technology that had not been previously possible.

CONCLUSIONS

Satisfying the needs and expectation for all stakeholders in a normal cycle of academic review for any program is challenging enough. It is particularly more difficult when the impetus for change is driven by an external force, such as national legislation. Typically, in these instances the timing can be problematic, especially where political machinations for funding can come into play; academics charged with the responsibility for implementation do not necessarily have the same goals in mind as their financial masters! Rather academics concern themselves more with the learning outcomes and the core body of knowledge within their discipline (Toleman et al., 2004).

For continuing students migrating to the new structure, the sudden artificial transition to the 4 * 12 model caused many problems. Dependent on which set of previously completed units a student possessed, the new structure progressed some students and retarded others within the same cohort. To nullify this erratic effect and ensure fairness to all members in the student body, a specific individual mapping was created for every single student in the program. This created an enormous administrative burden for the academic advisor. The first implementation of the new HESA compliant program took effect for the academic year commencing in

March 2006. With only one semester completion, at the time of writing, anecdotal evidence from students and staff has indicated that the new system does allow for more in-depth coverage of materials particularly with the additional face-to-face contact within specific courses. However, a more systematic analysis is planned for the future, along with consideration of the implications on existing study pathways for students articulating into the program through recognition of prior learning or credits transfer.

In this paper we offer an insight into the process of arriving at HESA compliancy; in this instance the local implementation involved taking a more lateral view of the degree versus the longitudinal view of the institution. The issues under consideration are not unique to this degree program or this University. In a 2003 survey of 19 different Australasian higher education institutions covering 75 different cases of curriculum change, Gruba et al. (2004) concluded that "there needs to be a balance between institutional objectives and that of academic staff." Overall the study found that most academics, like us, remained confident that their programs were academically sound despite being under considerable institutional pressures to implement changes for financial concerns. It does however raise the overriding and most important question of

Who SHOULD drive the changes in the IT curriculum – government, institution, professional bodies, industry, employers or students?

REFERENCES

AC Nielsen Research Services (2000). Employer Satisfaction with Graduate Skills. Research Report 99/7. Department of Education, Training and Youth Affairs (DETYA).

Fairchild, G.F., & Taylor, T.G. (2000). Business Simulations and Issue Debates to Facilitate Synthesis in Agribusiness Capstone Courses. Retrieved September 2002, from http://bear.cba.ufl.edu/centers/ciber/workingpapers/capstone.pdf

Gruba, P., Moffat, A., Sondergaard, H., & Zobel, J. (2004) What Drives Cirriculum Change? *Proceedings of Sixth Australasian Computing Education Conference (ACE2004)*, Dunedin, New Zealand. Conferences in Research and Practice in Information Technology, Vol. 30.

Harvey, L., Moon, S., Geall, V. & Bower, R (1997). Graduates' Work: Organisation change and students' attributes. Birmingham, Centre for Research into Quality (CRQ) and Association of Graduate Recruiter (AGR).

HEIMS – Higher Education Information Management Systems (2006). Retrieved 15 September, 2006 from http://www.goingtouni.gov.au

Hurst, J., Carbone, A., Eley, M., Ellis, A., Hagan, D., Markham, S., Sheard, J & Tuovinen, J. (2001). Teaching ICT: The report on learning outcomes and curriculum development in major university disciplines in Information and Communication Technology. Higher Education Division, Department of Education, Training and Youth Affairs.

Lister Review (2003). A report prepared for Victoria University.

Lister Taskforce (2004a). A Proposed Credit Point System for Higher Education – Victoria University , an internal University report .

Lister Taskforce (2004b). Implementing the Credit Point Conversion for a Course of Study. Victoria University Memorandum.

Miliszewska, I., & Tan, G (2004a). "Realising Core Graduate Attributes in Computer Science through a CPR (Collaboration-Participation-Relevance) Approach to Teaching", *Proceedings of the HERDSA Conference, Miri, Malaysia.*

Miliszewska, I., & Tan, G (2004b). "Web ACE - A Study in Reciprocal Informing", *International Journal of Issues in Informing Science and Information Technology,* Vol. 1, pp 31-40.

Novitzki, J.E. (1998). The MIS Capstone: Development of an Integrating Group Applied Project Course. *In Proceedings of the International Academy for Information Management (IAIM) 13th Annual Conference* (pp.100-109). Helsinki, Finland.

Toleman, M., Roberts, D. and Ryan, C. (2004). Retrofitting Generic Graduate Attributes: A Case-Study of Information Systems Undergraduate Programs. *International Journal of Issues in Informing Science and Information Technology,* Vol. 1, pp 625-635.

Venables, A., Tan, G., Devi Nagappan, S. & Ghous, A (2006). "Everything we wanted to know about our course, but were afraid to ask?" Views from a students' perspective. *Proceedings of 2006 Information Resources Management Association International Conference.* May 21-24, 2006. Washington. D.C. USA, 595-598.

Improving Class Participation by Asian Students

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ABSTRACT

Encouraging Asian students, particularly those with poor English proficiency, to participate fully in university classes has long been recognized as a major challenge. This paper reports on a study into addressing this issue within the discipline Information Technology. The researchers interviewed 20 academics from a Faculty of Information Technology at an Australian University as well as conducting focus groups of 36 local and Asian students. A number of cultural and language factors were identified and several strategies for improving class participation by Asian students were suggested.

INTRODUCTION

Participation in class is a valuable teaching method to encourage a more active involvement in learning. However, our experience shows that class participation represents a major problem for many students, especially Asian students, undergraduates more so than postgraduates. Academics in our Faculty often complain about Asian student passivity but to date there has been little research into the promotion of Asian student class participation within the discipline of Information Technology (IT). IT has its own particular challenges:

- a different subject matter
- students who are more focused on technology rather than activities requiring oral or written expression
- larger classes than in the humanities (e.g., 30 in tutorials and labs at the authors' university, with lectures often in the hundreds)
- and high numbers of international students, especially Asian students.

This paper presents the initial findings of an investigation to determine strategies for improving Asian international students' class participation in face-to-face tutorials and small lectures within the IT Faculty at an Australian University. The research focuses on Asian students since they are usually the most under-represented group in class discussion and also because they comprise the majority of international students in the Faculty. The top five source countries for international students at our university are China, India, Indonesia, Vietnam and Thailand (F. Guo 2006, e-mail communication, 15 Sep.). Therefore the contribution of this paper will be useful in shaping our knowledge of why Asian students are under-represented in class participation, how Asian students view class participation, what barriers these students put forward for not participating and how we as instructors can overcome these barriers and ensure that participation is worthwhile to all concerned, particularly in cross-cultural settings.

The paper is organized in the following manner: the first sections provide an overview of the literature exploring cultural factors in class participation. Details of the research project and methodology are then stated. The preliminary results of the research are presented. Finally the key points are summarized and conclusions drawn.

BACKGROUND: EXPLORING CULTURAL FACTORS IN CLASS PARTICIPATION

Erickson (2004, pp 31-32) indicates that:

" ...everything in education relates to culture ... Culture shapes and is shaped by the learning and teaching that happen during practical conduct of daily life within all the educational settings we encounter as learning environments throughout the human life span – in families, in school classrooms, in community settings ..."

Culturally learned norms, rules and beliefs affect the way people communicate as well as predict the effect of their communication on others. Consequently, both students and instructors will bring their own culture and this will affect their expectation of instructor behaviour, their perception of what is proper classroom conduct, and what they view as appropriate learning methods and goals (Lee & Carrasquillo 2006; Winbush 1995; Kato 2001; and Chu & Kim 1999).

Tierney (1992) states that university reflects the culture of mainstream or dominant society. Accordingly, in Western universities it is believed that class participation is important since it will help to reinforce the curriculum, as well as improve presentation and social skills. These universities are full of their own social conventions, such as rules for class presentations, student attitudes to hierarchy and the subtleties of English usage, which may be unclear or unknown to overseas students (Dunphy 1998).

Asian Students

Sheehan and Pearson (quoted in Liu 2001) found that Asian students in Western classrooms expect instructors to tell them what to do and they believe that what the lecturer said is the truth. They are taught to follow it to the letter and memorise it, not to question, disagree or speak in the class. They believe that asking questions or speaking up in class is disrespectful. They often feel frustrated when they try to memorise the extensive readings given by the instructor and consequently are reluctant to participate in class.

Asian students prefer to rely on discussions in their own native language with their co-nationals in order to share their opinions or solve problems. They usually do the required pre-reading or activities before class and believe that any questions arising from pre-reading can be answered by a second reading or listening to the lectures attentively, not by asking questions. They experience language difficulties and are uncomfortable speaking up in class (Liu 2001).

When Asian students have questions, they prefer to ask their co-national or other classmates after class rather than asking their lecturer during class. If they have to ask the lecturer, they will try to do it after class (Liu 2001). This preference is affected by their previous experience in their home country. Most Asian countries have large class sizes: if the students ask questions in class, the lecture would not finish on time, and therefore the instructor prefers students to discuss any issues that they have after class.

Asian students also have a different concept of class participation than other students. They believe that class participation is responding to questions, as opposed to actively interacting with peers and asking their *own* questions. Furthermore, they are hesitant to comment on other students' presentations and prefer direct feedback from the instructor, compared to whole class critiques. Consequently, Asian students have become stereotyped as passive and unresponsive in class participation. (Chu & Kim 1999).

Sifianou (1997) states that there is a big difference in how silence is interpreted in Anglo and Asian cultures. Asian people consider that silence is the norm and talk is only desirable if there is something that needs to be conveyed, whereas English-speaking people deem that talk is desirable and is a way to show affection and social interaction.

A pilot survey on Asian students' participation in US universities by Liu (2001) revealed that the main barriers to class participation for Asian students are their belief that being quiet in the class shows respect for instructors. It is also connected to the Confucian concept of face saving by avoiding making mistakes in class and the need to preserve harmony. They believe that silence is an indication that the student is listening attentively and thinking actively. When they do not understand, they expect that other students will speak up and ask similar questions and consequently their issues will be addressed.

Further research by Liu (2001) in US universities found that, even if Asian students understand the importance of participation and want to participate, they often have to wait to get an opening to speak and then they are sometimes interrupted by their American classmates which subsequently silences them. Some American students speak up to fill in the silence because they misinterpret Asian students' silence as meaning they have nothing to say. Other American students interrupt because they want to help and inadvertently take over the conversation.

Asian students, regardless of whether they participate or not in class, agree that class participation is important to engage new ideas and gain knowledge (Liu 2001). However they believe that they can benefit from class participation without actively participating. They learn by listening attentively to other people's interactions. Preparation, knowledge and prior experience affect their participation mode.

These results support research by Tsui (1996) which identified five barriers to class participation:

1. Insufficient English proficiency
2. Fear of making mistakes and being ridiculed by classmates
3. Insufficient time to think (instructors' intolerance of silence)
4. Unequal opportunity to participate
5. Complex language usage by the instructor.

RESEARCH METHODOLOGY

To investigate strategies for improving class participation, particularly with Asian students, we explored:

- Student perceptions and expectations in relation to learning, in particular their attitudes to discussing, speaking and presenting in class;
- Cross-cultural issues and barriers with regard to participation; and
- Teacher experiences and strategies to foster effective participation.

The research followed a qualitative approach: focus groups and semi-structured interviews (McGovern 2003; Morse & Richards 2002).

Staff Interviews

Twenty academics from the Faculty were interviewed. Staff members were chosen partly on the basis of their availability and willingness to be interviewed, and partly in order to represent a broad cross-section of the various subject areas of IT. Interviewees were also selected to cover the full spectrum of academic levels from part-time tutor and associate lecturer to professor. The interviews were audio recorded and a partial transcription of each interview was undertaken. Interviews were semi-structured and based on a number of questions covering general class participation issues as well as cultural factors.

Student Focus Groups

Five focus groups were conducted, two for local undergraduates, two for Asian undergraduates, and 1 for postgraduates (combined local and Asian due to insufficient applicants), with a total of 36 participants. Students volunteered to participate by responding to advertisements on the intranet. In each focus group students were asked about their preferred learning style and about what factors affected their participation. Comments by students were organized and typed up during the focus groups.

RESULTS

Staff Interview

The Challenges of Asian Student Participation in the IT Classroom

On the challenge of trying to get all students to actively participate, there was general agreement that a very few people will do all the talking if allowed. With few exceptions, interviewees agreed that the biggest challenge was getting Asian students to participate because they are:

a lot quieter and not able to communicate as well – it could be because English isn't their first language; that's obviously going to inhibit them – but there is also the cultural part where they don't think it is appropriate to question the lecturer.

Several academics believed that Asian students have got an extra hurdle to overcome before they start participating because English is not their first language. The students also have problems understanding the lecturers, especially if the lecturer speaks too softly or uses colloquialisms. On the other hand, the lecturer might also have problems in understanding the Asian student. It has been suggested that one needed to speak slowly and clearly to accommodate Asian students.

Two interviewees believed that lack of English proficiency was not the only factor that hinders Asian students from participating since even using online discussion boards to help them overcome the language issue, as well as being given encouragement, still failed to make them participate.

Several interviewees described Asian students as "culturally shy", very reserved, not used to speaking up and afraid of losing face if they made a mistake. Asian students' upbringing taught them to respect their teacher: therefore, unless the teacher called their name and asked questions, they will not say anything. It is considered disrespectful to question the teacher. In this case, they are very different from Australians students who are much more interactive, dare to get involved and present their opinions.

Several interviewees said that Asian students have different expectations about teaching and learning methods based on their experience in their home countries. They were used to a "more didactic learning space" and unaware of educational practices in Australia. Some academics saw the Asian women students as the most timid about participating: in addition to the reasons already cited, the overwhelming predominance of men in IT classes was thought to be intimidating and create a very masculine atmosphere.

Strategies to Promote Class Participation by Asian Students

There was general agreement that it was "quite a challenge" finding ways of promoting class participation in multicultural classes with mixed race, gender, ethnicity and culture, especially with the increasing number of Asian students. However, there was no clear consensus about the best way of tackling this problem except that one needed to be very proactive. Various approaches were used by different staff members with more or less success. A couple of lecturers talked about the need to clearly convey one's expectations to the students at the beginning of semester so that they knew what was expected of them. For example, when awarding marks for class participation as a method of encouraging the students, they must be made aware of the difference between mere attendance and real participation.

Several staff members noted the importance of openly encouraging students to speak out, and also creating a comfortable atmosphere in the classroom. A number of academics regularly asked students to introduce themselves to the class or to the student sitting next to them as a way of creating activity and getting students over the first hurdle. Other academics recommended asking non-intrusive questions first, not asking them to express their opinions but more to say things that they know. These activities formed an icebreaker and also, because they talked about something they knew better than anyone else, it gave confidence to the Asian students and at the same time provided an insight to others.

Nominating the students by name was also one of the most popular strategies since a lot of Asian students would not participate unless they were directly called upon. Giving Asian students more time to discuss issues with their group first before they have to give their opinions was also mentioned. It gave more confidence and gave them time to formulate the answers in the English language.

Academics used a variety of participatory classroom activities but by far the greatest number recommended small-group discussions, with a representative of each group reporting back to the class afterwards:

First they have to be in small groups so that they know what they can tell and they can hide behind the group. Specially I think some cultures, they don't dare to express their opinion, but if they have to speak for a group they would do and indirectly give their own opinion.

Several interviewees mixed students from a variety of cultures through the groups and changed the groups as needed. This spread the good English speakers around, got people to be more aware of other people's cultures and activities as well as got them to learn from each other and made the Asian students feel welcome.

One interviewee suggested a group activity called "Interviewing an expert" in which the student has to be the expert from another country (the country which they originated from). At the end the students who have posed the questions have to present the expertise they have learned to the class.

It was also suggested that group presentations were better than individual presentations, because they provided a shorter amount of time for the audience if the presenter was an Asian student with poor English.

Another suggestion was formative assessment. Early in the semester (weeks 3-5), the lecturer should ask for some written feedback from everyone about how they are finding the class, their comfort level in asking and answering questions, asking for help, etc. This created an inclusive learning space for all students.

Student Focus Groups

Preferred Learning Style of Asian Students

There were several commonalities in preferred learning style. While most local students favoured interaction with their instructors and liked to talk and discuss issues, most Asian students said that they preferred Question and Answer at the end of the lecture, they liked to ask questions one on one with the instructor, mostly after class, and they were inclined to study or research individually.

As long as discussion was conducted in small groups, several Asian students liked subjects that required participation because it provided interactions, made the tutorial more lively, helped them to absorb the knowledge and gain other information, forced them to think more widely than the lecture or books, as well as provided opportunities to ask questions and clear any doubts. Getting the correct answer, if there was one, from the tutor after the discussion was seen as important. Some students also mentioned that it depended on the subject and also depended on the work given. One student said that he liked participation if he could ask for help in relation with the assignments, another if it provided workshop support and yet another student preferred practical work in the laboratory.

All Asian students and local students agreed class participation in tutorials was worthwhile. They also agreed that participation helped to clarify their understanding, gave opportunity to learn from each other and get better understanding. It helped to build public speaking skills, assisted in solving problems and answering questions, as well as making it more interesting and enjoyable. Asian students also put forward additional reasons such as: it gave them the opportunity to practice English and improved proficiency, helped them to learn how to interact with the instructor and the class, eliminated the fear of asking, improved the quality of participation skills and helped them to get to know more people. They also emphasized that the participation should be held in tutorials, not in lectures where it would become an interruption.

While they agreed that participation was worthwhile, only one Asian student said that participation was enjoyable. Several students forced themselves to participate because they realized that it was a good training and they will need it in the workplace. They also tried participating because they understood that they will learn more from discussion. Several students also said that they are a bit shy to participate.

Factors that Affect Participation of Asian Students

Both Asians and Locals said that fear of saying something stupid was one of the factors that prevented them from participating. It also depended on whether they had knowledge about the subject, whether they had prepared for the class, and their own individual mood and personality. If they participated and couldn't be understood, most Asian students said they would feel bad and may not participate again, compared to most Local students who would find other ways of getting their message across. Only three Asian students said that they would probably try other ways such as discussing the matter after class one on one with the teacher. One suggested using email or online discussion boards. Another would try to improve their English and IT knowledge. A third student would try to clarify what they meant, getting some help either from the tutor or other students, or would rephrase the sentences or give examples.

A big factor that Asian students commented on was that they liked to know ahead what information would be dealt with in class and therefore preferred to have the opportunity to prepare by reading. They had additional factors related to lack of proficiency in the English language, which led to lack of understanding, and inability to translate or clarify their answers. Another issue was the dominating player, where class participation was taken over by certain people, consequently providing no opportunity or time for Asian students to participate.

Tutor style, attitude and control of the class were essential as was the timing of the class and the class environment. Some students said that it depended on the quality of the questions, the level of the tutor's preparation and knowledge of the subject, and also whether the subject was interesting. Asian students believed that the instructor should ask questions equally to all students and give feedback and clarification of the material as well as give a summary to enhance student understanding. Asian students also hoped that the instructor would use simple vocabulary and give them more time to take notes. In addition, students wanted their effort in the tutorial to be recognized, for example by being a component of the subject's overall assessment.

CONCLUSION

This study of Asian students in the field of Information Technology confirms many of the findings that a number of researchers have found in other discipline areas (Lee & Carasquillo 2006, Chu & Kim 1999, Egan 1996). The major findings include that full participation of international students, particularly those from Asia, is hindered by a lack of English language proficiency as well as fear of making mistakes and losing face. Students voiced a strong preference for being given an opportunity to prepare properly for the class so that they could participate more.

An important finding was that all the Asian students involved in the study believed that class participation was worthwhile. This highlights the need for teachers to develop better strategies for including Asian students. The fact that only one of these students actually liked participation also points to the necessity for participatory activities to be enjoyable and less stressful. In addition, teachers should take into account Asian students' preferred methods of participation, for example, having a Question-and-Answer session at the end of class.

Moreover, the research provided a number of interesting strategies to improve class participation with Asian students. A key issue is to match the student and teacher expectations of learning in the class: teachers must clearly establish how the class will be organized and what sorts of activities students will engage in. An effective way to stimulate discussion is to divide the class into small groups: this is less intimidating for students whose English is poor. Spreading the good English speakers around the groups also helps. Some of the academics considered that the cultural backgrounds of the Asian students could be used to enhance the learning of the class rather than being viewed always as a deficit: for example, students can learn about other cultures.

The researchers acknowledge that the grouping together of all Asian students, regardless of their culture or English-language proficiency, tended to generalize the issues in this study and create a monolithic view. The researchers are also aware that there is a possibility that the really shy Asian students might not have volunteered to join the focus groups, thus affecting the results. Future research needs to be conducted to overcome these limitations. Focus groups will need to separate different nationalities and take account of different levels of English ability, for example Indian versus Chinese students.

REFERENCES

Chu, S. & Kim, J.H. 1999, "Comparison of the Perceptions of Classroom Participation among Asian and Non-Asian Design Students", *Multicultural Education*, Vol. 7, No. 2, pp 21-24.

Dunphy, J. 1998, "Special Considerations for Teaching in the Multicultural Classroom", *Teacher Talk Articles in the Faculty Newsletter*, Vol. 10, No. 6. Retrieved on November 1, 2004 from http://web.mit.edu/tll/published/multicultural.htm.

Egan, M. L. 1996, "Condoms and Culture: An exercise to foster classroom participation of international students", *Journal of Management Education*, Vol. 20, No. 1, pp. 98-103.

Erickson, F. 2004, "Culture in Society and in Educational practices", in J Banks and C. Banks (eds), *Multicultural Education: issues and perspectives*, 5th ed, John Wiley & Sons, USA, pp.31-60.

Kato, Kumi 2001, "Exploring 'Culture of Learning': a Case of Japanese and Australian classrooms", *Journal of Intercultural Studies*, Vol. 23, No. 1, pp. 51-67.

Lee, K.S. and Carrasquillo, A. 2006, "Korean College Students in United States: Perceptions of Professors and Students", *College Student Journal*, Vol. 40, Issue 2, pp. 442-456.

Liu, Jun 2001, *Asian Students' Classroom Communication Patterns in U.S. Universities: An Emic Perspective*, Greenwood Publishing Group, USA.

McGovern, Y 2003, *The Practice of Market and Social Research*, Pearson Education FT Prentice Hall, Harlow, England.

Morse, J.M. and Richards, L. 2002, *Readme First for a User's Guide to Qualitative Methods,* Sage Publications, Thousand Oaks, California.

Sifianou, M. 1997, "Silence and Politeness", in A. Jaworski (ed.), *Silence: Interdisciplinary perspective*, Mouton de Gruyter, Germany.

Tierney, W. 1992, "An anthropological analysis of student participation in college", *Journal of Higher Education*, Vol. 63, Issue 6, pp.603-618.

Tsui, A.B.M. 1996, "Reticence and anxiety in second language learning", in K.M Bailey & D. Nunan (eds.), *Voices from language classroom*, Cambridge University Press, USA, pp. 145-167.

Winbush, D.E. 1995, "Building Bridges: Healthy Multicultural Relationships Highlighted at Conference on Diversity", *Black Issues in Higher Education*, Vol. 12, No. 4, pp. 20-23

Learning Objects and Semantic Web in Education: From Students' Analysis to New Perspectives for Their Use

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ABSTRACT

The work aims at giving a new perspective in ICT use in education by integrating web technologies in traditional teaching-learning processes. First it proposes the analysis of the difficulties students meet while attending both traditional and on line courses, then the factors influencing students' performances are discussed and alternative assessment instruments based on ICT use are reported. At last recent hypotheses on the introduction of learning objects and semantic Web in education are analyzed and e-learning strategies and instruments are compared with the results from traditional teaching contexts. As a consequence an adaptive e-learning strategy is suggested.

Keywords: Learning difficulties, Learning Object, Meaningful learning, Semantic Web, Teaching planning, Unit of Learning.

INTRODUCTION

Didactics and the disciplines interested in teaching planning and carrying out, always devoted their attention to three different elements in the teaching-learning process:

a) topics to be learned from students and their order and organization,
b) teaching process and its phases,
c) subjects (usually students) the teaching action was planned for.

During last decades (mostly in the second half of twentieth century) cognitive, sense-motor and affective taxonomies were developed (Bloom 1956, Mialaret 1999) to better define the strategies didactical process had to be based on (i.e., analysis of pre-requisites, planning and carrying out of teaching, evaluation, assessment and feedback). The process was in fact hypothesized to be cyclic, due to the feed back from students which could induce the planning of recovering actions when the expected results were not attained (Nicholls & Nicholls, 1983).

Recently different elements, including the introduction of ICT instruments and strategies, intervened to modify the well settled teaching-learning processes in education; two among them are analyzed in a greater detail in what follows:

a) students' learning features and assessment when e-learning environments are used,
b) the development of new instruments, like learning objects (LO) and semantic Web, to support continuous education and lifelong learning and to improve high and advanced education.

ICT AND STUDENTS' LEARNING

During last decades educational research evidenced the presence of many problems and difficulties in students' learning and especially:

1) preconceptions, misconceptions, and mental schemes, leading students to wrong interpretation of phenomena (for a survey of the work produced in this field the site of the Meaningful Learning Research Group http://www.mlrg.org/ can be seen),
2) the possible dependence of students' performances from their learning styles,
3) the importance of alternative instruments (i.e. portfolios) in students' assessment due to the value that people's performances and competences have in knowledge society.

The increase in the amount of the information to be managed, the frequent use of ICT in teaching and education and the need for the monitoring of the teaching process induced many scholars to experiment special information systems for facing the above problems (Cartelli, 2005).

Preconceptions, Misconceptions, Mental Schemes, and ICT

Literature shows that wrong ideas can be interpreted in at least two different ways (Driver & Erickson, 1983): a) mental schemes, if only the coherence of people's ideas in the analysis of phenomena is considered (with no reference to scientific paradigms); b) preconceptions or misconceptions, when people's ideas are compared and evaluated with respect to right scientific paradigms.

Many studies (Cartelli, 2002) carried out all over the world with differently aged people (from students to workers, from professionals to teachers etc.) show that:

- wrong ideas can be found in almost all scientific disciplinary fields;
- a lot of strategies and instruments have been proposed to overcome the problems people meet, based or not on IT and ICT strategies, and adopting or not constructivist strategies (supported or not by ICT). Nevertheless the good results of those experiences rarely were compared with traditional teaching and never were systematically used in education or adopted on a large scale (nationally or internationally wide spread);
- some experiments report that wrong ideas can persist in students (also if they attended the special courses described above) when they are forced to face special situations.

As an example the author's experience in basic computer science (CS) courses is reported here. First of all some wrong ideas were detected while analyzing students' learning on: computer input/output, human-computer interaction (when a GUI was used), data storing and retrieving, basic operations with a mouse etc.; it was then hypothesized that an e-learning platform based on traditional teaching elements and continuously monitoring the didactic process could help students in overcoming the difficulties reported above, while being a powerful instrument for the management of teaching. The information system the author planned and carried out (Cartelli, 2003), very similar to an e-learning platform, had CMS and CSCLS features. Notably:

- a well structured knowledge tree for the topics to be taught/learned was used for the course,
- special auto-evaluation surveys, integrated with the course's pages were available to students (i.e., many questions easily accessible for students were planned, on the basis of the wrong ideas formerly detected),
- various communication areas implementing virtual environments for teachers/professors, tutors, and students were used (to improve communication),
- a system for the management of students' evaluation and assessment tests was made available to teachers,
- two functions for the analysis of the students' access to course materials and the use they made of the communication services were continuously accessible.

The system was experimented with two different sets of students and had positive results as regards the number of students passing ending examinations; there was in fact only 20% student loss, while more than 65% of the students

had positive, if not excellent scores. At the end of the courses a deeper analysis of students' data showed unexpected results and some limits for the system: 1) many students still evidenced the presence of misconceptions (more than 43% of the universe); 2) the great amount of data generated by the second set of students (more than 300 subjects) made very difficult the continuous monitoring of the didactical process by means of the functions described above and could be analyzed only at the end of the course.

Meaningful Learning, Learning Styles, and ICT

It has to be noted that a unique definition of meaningful learning has not jet been found and at least two definitions are available. The former one, credited to Ausubel (1990), is based on the following statements: a) the logical meaningfulness of the topic to be learned; b) the presence in the topic to be studied of special knowledge elements making easier the insertion of new knowledge into previous knowledge; and c) motivation to learn. The latter definition credits Jonassen (1995) with the following statement: knowledge construction (internal and external negotiation), context (meaningful and authentic environment), and cooperation (among students and teachers) are the basic elements for the definition of an environment leading to meaningful learning (which is active, constructive, cooperative, intentional, conversational, and reflexive).

Also under the hypothesis of both the above definitions, little or no dependence has been shown between the students' meaningful learning of topics and their performances at ending examinations, neither in traditional contexts nor in virtual environments and online courses.

Recently some studies have been carried out on the possible dependence of students' success on their learning styles (in distance education and e-learning courses).

First Kovacic and Green (2004) report of significant differences in the performances they registered in different learners' types in a computer concepts class. The authors identified the students requiring additional learning support for passing examinations and used the Felder-Silverman model for the detection of their learning styles. After the evaluation and classification of the students' learning styles according to the model they found statistically significant differences in their performances – that is, students with reflective, sensing, verbal, and global learning preferences had the best performances both in in-course assessment and in final examination. The authors explained this result with the vantage the learners received from current teaching styles and from the learning environment (course material and online students' support).

Other scholars (Kumar, Kumar & Smart, 2004) used pre- and post-tests based on the Grasha-Riechman Student Learning Styles Scale (another model for the analysis of students' learning styles) on a sample of 65 students (both graduate and undergraduate). They compared the number and types of learning styles at the beginning and at the end of the course and found relevant changes in the their distribution. For the authors the observed changes were due to the instructional strategies and to the technologies they adopted in the class (i.e., the use of collaborative projects and course management software increased the number of collaborative, participant, and independent learning styles among students).

Students' Assessment and ICT

Knowledge society and lifelong learning require a more efficient evaluation of the knowledge and skill people develop both while attending courses and while integrating out-school experiences into formal education. The portfolio of competences, one of the instruments recently developed, has had a great success in certifying students' success in educational activities (i.e., people acquisition of good skills and competences). There has also been a significant increase in the number of online portfolios at different levels of education; they tend in fact to combine the benefits of traditional portfolio-based assessment with the paper-saving and other benefits of online environments.

Love and Cooper (2004), while investigating the key factors for the design of information systems for online portfolio-based assessment identified four weaknesses: 1) design mostly omit key educational and administrative issues while focusing on technical aspects; 2) "online portfolios" are often made only of a single essay, a project report or presented as a Web-based electronic facsimile of a conventional document; 3) many designs for online portfolio are based on an over-narrow view of value distribution and do not take all stakeholders into account; and 4) designing of online portfolio assessment systems are often not well integrated with overall course design processes.

As a conclusion online portfolio systems feel significantly short of their potential, and in many cases are inferior to conventional portfolio assessment and other more traditional assessment approaches.

TEACHING, LEARNING OBJECTS AND SEMANTIC WEB

Learning Objects (LOs) were firstly introduced for their adaptation and reuse features and are nowadays experimenting new interest for their possible insertion in traditional teaching; new didactical proposals introduce teaching strategies in LOs' structure (i.e., a learner centered teaching activity is hypothesized). In such a way LOs can be used in schools and university and not only in contexts of lifelong learning (Fini & Vanni, 2005).

The new hypotheses for LOs' structure and use neither cancel nor modify the problems until now evidenced for them: a) the lack of a clear and shared definition of LO and the different models and standards until now proposed for them, b) the doubts on the pedagogical neutrality of LOs and on their reusability (depending for some authors on the pedagogical aims of didactical actions and for others on the educational contexts they are referred to).

Furthermore Semantic Web is even more seen as a valid instrument supporting teachers' work and reducing everyday workload.

From LOs to UOLs

Some scholars recently hypothesized the application of learning theory ideas to the planning and using of LOs in constructivist and collaborative teaching-learning contexts; in other words the construction of learner-centered or community-centered environments strongly based on the use of LOs was hypothesized (Fini & Vanni, 2005).

The hitting of the above target was performed with the inclusion into the LO model of the planning strategies guiding its choice and use (Alvino & Sarti, 2004). As a consequence LO structure was extended to contain the tacit knowledge and the meta-cognition depending on the adopted materials and reusability laid no more on the adopted materials but on the ways they were used for (i.e., LO becomes very similar to a "best practice" rather than a "piece of content" to be recombined with other content elements).

The theoretical change emerging from the above hypotheses induced R. Koper (2001) to propose a new language, called EML (Educational Modeling Language) and very similar to UML and XML, for the definition and description of teaching/learning environments. The EML language doesn't manage LOs, its basic elements are called UOLs (Units of Learning), each UOL describing learning activities and all elements involved in the teaching/ learning process (i.e., the actors such as teachers, students, tutors etc. and materials, learning environments etc.).

Koper's work aimed at the construction of conceptual models for teaching/learning activities, letting people completely describe them in a formal way, adapt them to any pedagogical model, use them for supporting collaborative work and personalize them on the basis of students' prerequisites; the same conceptual models could also manage the collection of students' data and portfolios while respecting usual defined standards.

EML has been accepted from the Global Learning Consortium IMS and is know called IMS Learning Design (LD). It aims at the reusability of teaching/learning activities (i.e. templates to adapt to different situations or teaching experiences to re-produce).

Role and Function of the Semantic Web in Education

The basic idea of the semantic web, as stated from Tim Berners-Lee, is relatively straightforward: to create a layer on the existing web enabling advanced automatic processing of the web content, so that data can be shared and processed both by humans and software.

This declared result is obtained through the use of Resource Description Framework (RDF)-related technologies but there are also many other technologies for the creation of semantics. Some among them are reported below (Koper, 2004):

1. Unified Modeling Language (UML), providing a collection of models and graphs for the description of the structural and behavioral semantics of complex information systems,

2. XML and XML Schemas, to structure data and documents according to personal or community defined vocabularies (within which semantics can be implemented),
3. RDF and RDF-Schema, the metadata approach from the W3C, defining semantic meaning for data on the web (i.e., multiple semantic perspectives of the same data are possible),
4. Topic Maps, defining arbitrarily complex semantic knowledge structures and allowing the exchange of information for collaboratively building and maintaining of indexes of knowledge,
5. OWL – Ontology Web Language, implementing the semantic description of a domain by means of the specification of its concepts and relationships,
6. Latent Semantic Analysis, based on the use of programs for the understanding of natural language,
7. Software Agents, rather ill-defined, but commonly identified as pieces of software acting proactively (they are adaptive and (semi-) autonomous and can communicate with other agents and human creators).

An important question, strictly related to the educational semantic web, is concerned with the representation of a course in a formal, semantic way, so that it can be interpreted and manipulated by computers as well as humans. R. Koper (2001) refers to this process in terms of 'Educational Modeling'. He also states that Educational Modeling can be useful to solve (all or parts of) the following problems: development of flexible web-based courses (adaptable to learner features), preservation and sharing of knowledge on effective learning design, instantiation of e-learning courses in Learning Management Systems (LMSs), development of software agents supporting learners and staff in managing the workflow of activities, adaptation of didactical materials to individual learner's features (automatically driven by the descriptions of the conditions for adaptation), sharing and re-use of (all or parts of) e-learning courses, creation of more advanced and complex (but consistent) learning design and, at last, performing research into more effective and efficient learning design.

CONCLUSION AND FUTURE TRENDS

LOs and Semantic Web have had useful and interesting applications in continuous education, adult education and lifelong learning so that many authors suggested their application in traditional education, i.e. school and university.

The use of UOLs and EML by R. Koper can be seen as an example for the introduction of social-constructivist pedagogical approaches and different teaching models (active, learner-centered and community-centered) in educational practices supported by ICT.

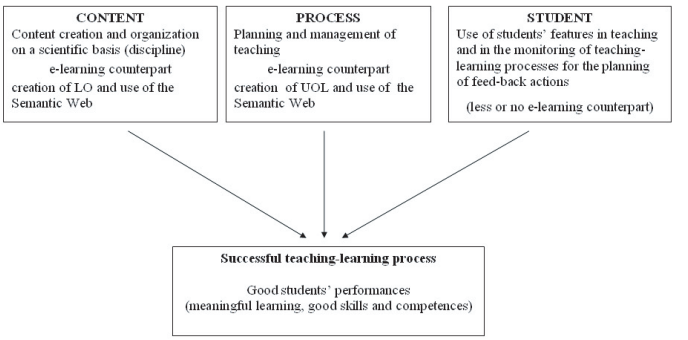
If everything seems to sound good there is, in the author opinion, an obstacle for the hitting of the target of a successful teaching by means of ICT in the above projects: it is the underlying presence of positivistic and deterministic ideas in all hypotheses formerly reported. In the projects involving ICT use in education the determinism is implicitly included in the optimistic idea that the right management of topics and discipline contents and the right control of teaching-learning processes can guarantee an efficient and meaningful learning in students. Otherwise stated the planning of special and well defined LOs, also made under the consideration of the right dependencies from other topics (which can be other LOs or more complex structures like the ones in the semantic Web) and when inserted in the processes of knowledge construction performed by one or more ULO (which can be individually or socially planned), do not guarantee, in the author's opinion, the students' acquisition of the right knowledge, skills and competences.

If e-learning aims at exiting from the important but limited field of lifelong learning and adult education, to become an essential element of school education (also in the limited hypothesis of integration of ICT into traditional educational processes), it cannot ignore the results of traditional teaching. Two key phenomena must be especially managed:

a) the introduction of feed-back and recovery actions in teaching processes governed by ICT,
b) the support to strategies helping students to overcome their difficulties and to acquire a meaningful learning.

A comparison between traditional teaching activities and their possible implementations by means of ICT can be useful to better understand the problems described above.

Figure 1. Elements affecting teaching-learning process and their e-learning counterparts



In figure 1 it is reported a comparison between traditional teaching and e-learning and in the last box it clearly appears the lack of adequate instruments and strategies in e-learning contexts.

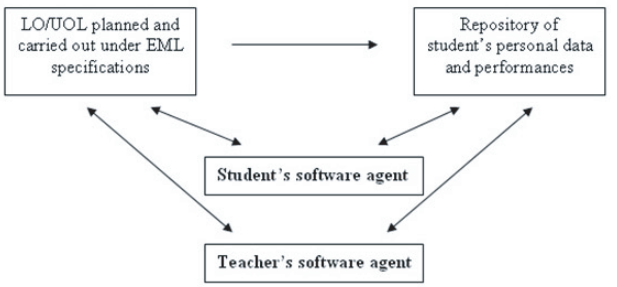
The lack of contact points between traditional teaching and e-learning in the last box is neither synonymous of the ICT exclusion from the corresponding processes, nor means that there is no experience or research involving its use. As reported in the first section of the paper there are many examples of studies collecting data on:

a) students' features and their modifications during the interaction with discipline topics in real and virtual environments;
b) students' messages, opinions and answers in forums, surveys and e-discussion instruments,
c) impact of e-learning strategies on students' learning and performances.

As a consequence it can be hypothesized the presence of the following scenarios for the integration of ICT in teaching:

- for the purists of learning objects theory and/or semantic Web there are at least two solutions (both depending or not on teachers' support to students' work and strongly based on a careful analysis of teaching-learning process): a) the need for special LOs and/or UOLs the student must interact with, when he/she does not succeed in hitting the target of a teaching action based on former different LOs/UOLs, b) a more complex structure for usual LOs and/or UOLs, which must have within them the functions for the analysis of students' learning styles (and other features), the functions to evaluate teaching action, the planning of recovering and support actions (when the right targets are not attained) and further learning materials and actions to be used for the recovering work,
- for artificial intelligent scientists the proposal of special systems, very similar for their structure to the well known ITS (Intelligent Tutoring Systems) or ICAIS (Intelligent Computer Assisted Instruction Systems), could better answer to the need of controlling the teaching-learning action and in helping students to improve their performances (main problem with this hypothesis is the presence of the same mechanistic hypotheses supporting the first solutions),
- at last an intermediate and adaptive solution can be proposed. It is based on the following three elements: LOs and/or UOLs and their semantic representations, repositories of students' data and software agents (respectively for students and teachers). It has the main advantage, in the author's opinion, that it doesn't lay on mechanistic ideas and gives new value and functions to teachers and educational research. Its main features are:
  - student's software agent collects student's data and stores them in a repository, furthermore, when the student interacts with the e-learning course, it transmit them to the LO/UOL,
  - the teacher's software agent proposes the student's case history to the teacher while suggesting possible didactical routes for the student; soon after teacher's choices are transmitted to the student's repository so that student's software can better guide him/her in the interaction with e-learning materials

Figure 2. Model of the adaptive teaching-learning process as hypothesized in third option



- data coming from student interaction with course materials and the results of evaluation and assessment are respectively transmitted to the teacher's and student's repository.

In the first case the teacher has good elements for planning possible recovering actions, in the second case the student's portfolio and the panorama of student's features can be completed. Figure 2 synthesizes the process described above.

Further elements making the third proposal useful for the integration of e-learning instruments in traditional teaching are:

a) notwithstanding the great deal of study and research carried out until now there is no definite and complete map for all factors influencing/conditioning students' learning,
b) it is not known if it will be ever possible to completely determine all factors influencing students' performances and learning, because of the dependence of these factors from the environment and the learning context (as an example it has to be remembered the case of computer science misconceptions: wrong ideas manifested from students have changed with the time, due to the introduction of GUIs).

A serious consideration of the above statements is fundamental for the individualization of students' learning and for the reduction of teaching automation in e-learning experiences.

REFERENCES

Alvino, S. & Sarti, L. (2004). Learning Objects e Costruttivismo. In A. Andronico, P. Frignani and G. Poletti (Eds.), *Proceedings of Didamatica 2004*. Ferrara: Omniacom.

Ausubel, D. P. (1990). *Educazione e processi cognitivi.* Milan: Franco Angeli.

Bloom, B. (1956).*Taxonomy of Educational objectives*. New York: Longmans & Green.

Cartelli, A. (2002). Web Technologies and Sciences Epistemologies. In E. Cohen & E. Boyd (Eds.), *Proceedings of IS + IT Education 2002 International Conference,* pp. 225-238. Retrieved Sep 28, 2006 from: http://proceedings.informingscience.org/IS2002Proceedings/papers/Carte203Webte.pdf

Cartelli, A. (2003). Misinforming, misunderstanding, misconceptions: What informing science can do. In E. Cohen & E. Boyd (Eds.), *Proceedings of IS + IT Education 2003 International Conference*, pp. 1259-1273. Santa Rosa, CA: Informing Science Institute.

Cartelli, A. (2005). Between Tradition and Innovation in ICT and Teaching. In C. Howard, J.V. Boettcher, L. Justice, K. Schenk, P.L. Rogers & G.A. Berg (Eds.), *Encyclopedia of Distance Learning*, vol. 1, pp. 159-165. Hershey (PA): Idea-Group Publishing.

Driver, R. & Erickson, G. (1983). Theories in action: Some theoretical and empirical issues in the study of students' conceptual frameworks in science. *Studies in Science Education, 10, 37.*

Fini, A. & Vanni, L. (2005). Problematiche non risolte e nuove prospettive dei Learning Object. *Journal of e-Learning and Knowledge Society*, *1(1)*, 143-152.

Jonassen, D. H. (1995). Supporting communities of learning with technology: A vision for integrating technology with learning in schools. *Educational Technology, 35(4),* 60-63.

Koper, R. (2001). *Modelling units of study from a pedagogical perspective: the pedagogical meta-model behind EML.* Heerlen: Open University of the Netherlands. Retrieved Sep 28, 2006 from: http://eml.ou.nl/introduction/docs/ped-metamodel.pdf

Koper, R. (2004). Use of the Semantic Web to Solve Some Basic Problems in Education: Increase Flexible, Distributed Lifelong Learning, Decrease Teachers' Workload. *Journal of Interactive Media in Education*, *6*. Retrieved Sep 28, 2006 from: http://www-jime.open.ac.uk/2004/6

Kovacic, Z.J. & Green, J.S. (2004). Are all learners created equal? A quantitative analysis of academic performance in a distance tertiary institution. *Issues in Informing Science and Information Technology, 1,* 965-976.

Kumar, P., Kumar, A. & Smart, K. (2004). Assessing the impact of instructional methods and information technology on student learning styles. *Issues in Informing Science and Information Technology, 1,* 533-544.

Love, T. & Cooper, T. (2004). Designing online information systems for portfolio-based assessment: Design criteria and heuristics. *Journal of Information Technology Education, 3,* 65-81.

Mialaret, G. (1999). *Il Sapere Pedagogico* (It. trans. by V. A. Baldassarre). Lecce (Italy): Pensa Multimedia.

Nicholls, A. & Nicholls, H. (1983). *Guida pratica all'elaborazione di un curricolo*. Milan (Italy): Feltrinelli.

Measuring the Success of ICT-Based Knowledge Transfer: A Preliminary Study

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ABSTRACT

Knowledge transfer has received increasing attention in recent years. This is evident from many knowledge transfer initiatives and projects reported in the literature. However, how to measure the success of knowledge transfer projects still remains as a challenge because knowledge transfer is a very complex process. This paper focuses on knowledge transfer facilitated by Information and Communication Technologies (ICT). It attempts to develop a conceptual model for identifying the causal factors affecting the success of ICT based knowledge transfer. Drawing from relevant literature it also proposes a set of associated measures for each dimension in the model. The success model of ICT-KT is based on a modification of a Delong & Mclean information system success model. Six dimensions in the model are developed, including Knowledge quality, System quality, Service quality (with sub-dimensions of E-service quality and Extension quality), Use, User satisfaction and Net benefits. Preliminary measures associated with each dimension are discussed and directions for future research identified.

Keywords: ICT based knowledge transfer (ICT-KT); success model; success measures

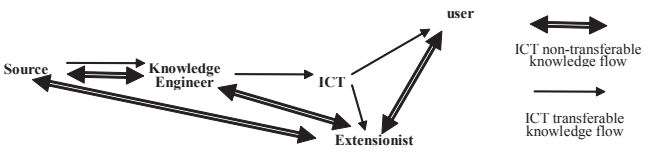
1. INTRODUCTION

In knowledge transfer, "human interaction and the resulting creation of objective knowledge is the key to progress" (Nonaka and Peltokorpi, 2006). In practice, knowledge is transferred not only in the form of one-to-one but also adopting one-to-many approaches. When developing countries need to cope with transferring knowledge to a large number of recipients scattered across remote rural regions, ICT based knowledge transfer (ICT-KT) is an effective solution. Transferring knowledge from a source to a knowledge disadvantaged recipient is defined by Lin et al. (2005) as a sender-advantage asymmetric structure.

Following a sender-advantage asymmetric structure, Feng et al. (2006) investigated a range of ICT-KT projects in China, which were launched for promoting the knowledge transfer from the national key universities to rural farmers. It was found that large amounts of ICT transferable knowledge were codified into expert systems available for non-expert users. As to the remaining ICT non-transferable knowledge a face-to-face approach was adopted. The knowledge extensionist, a role of a broker between expert, knowledge engineer and user, undertakes tasks of transferring ICT-non-transferable knowledge to bridge the communication gap and technical gap between the source and user and ensuring the success of knowledge transfer. The ICT-KT framework is shown in figure 1.

In practice, knowledge can be transformed in many ways to make it transferable. In the context of ICT-KT, face-to-face contact for the enhancement of effective non ICT transferable knowledge transfer has been noted by researchers. In a knowledge transfer process defined by Szulanski (2000) he argues the necessity of an external assistance to the knowledge user. Such close local support is important for a satisfactory level of user's absorption of new knowledge. Hainse and Goodhue (2003) describe a knowledge transfer triangle in transferring knowledge of ERP. The triangle consists of local implementer, ERP knowledge vendor, and the knowledge consultants, who "provide additional skills, knowledge, or simply manpower that is not available at the implementer or the vendor, or is too expensive if procured from the vendor".

Figure 1. The ICT-based knowledge transfer framework



The ICT-KT framework can be conceptually supported by knowledge repository theory (Argote and Ingram, 2000). The theory points out that knowledge transfer takes place in a network, which consists of three basic knowledge repositories (people, tools, and tasks). The ICT-KT framework is a typical knowledge transfer network consisting of the three knowledge repositories.

Regarding the role of an extension service in multi-path knowledge transfer process, Ray and Bhawuk (2002) demonstrate the importance of an extension service in transferring both conceptual and experimental knowledge from the source to recipients in their knowledge transfer scheme. The role of knowledge extensionist in ICT-KT is to enhance the completeness of knowledge transfer when the application of ICT-KT with vast field learners is expected to achieve a high standard of efficiency at the same time.

2. CONCEPTUAL BASIS OF ICT-KT SUCCESS MODEL

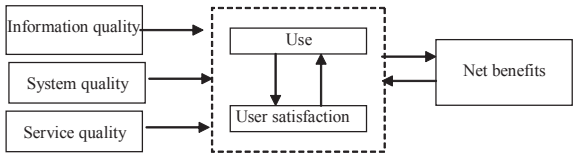
Cummings and Teng (2003) summarise four definitions of knowledge transfer success. The first looks at the engagement of knowledge transfers within a period of time. Based on communication theory, the second defines knowledge transfer as producing satisfactory results to recipients in time and on budget. Underpinned by technology transfer and innovation theory, the third is the re-creation of the source knowledge in the recipient side. The forth approach, drawing from institutional theory, regards knowledge transfer as a recipient acquiring "the ownership of, commitment to, and satisfaction with" the knowledge.

Ko et al. (2000) find that majority of knowledge transfer literature has adopted the source-recipient generic model. They define the knowledge transfer as "the communication of knowledge from a source so that it is learned and applied by a recipient". In management information systems study, communication theory is one of the most important grounds to support the conceptual development. In ICT-KT framework, ICT-transferable knowledge is transferred with its repository, an information system. To measure this part of ICT-KT success, the definition of knowledge transfer success based on communication theory is adopted.

2.1 D&M information Systems Success Model

DeLone and Mclean (1992, 2003) developed the D&M model to measure the success of information systems based on communication theory. Their original model in 1992 has been used by many researchers in the last decade. Communication theory was originally employed by Mason (1978) to measure the information system success. In Mason's study information is regarded as the product and the

Figure 2. The updated D&M model (DeLone and Mclean, 2003)



success of information system is divided into five levels to be measured: production, product, receipt, influence on recipient, and influence on system. Shown in figure 2, D&M further developed and updated this model towards a six dimensions of information system success: information quality, system quality, service quality, use, user satisfaction, net benefits.

2.2 Knowledge Transfer Process Model and the Quality Dimensions

Szulanski (2000) developed a process model to illustrate the process of knowledge transfer. The model consists of four stages of knowledge transfer: (1) initiation, work prior to the transfer; (2) implementation, between the decision to transfer and start of actual use of new knowledge; (3) ramp-up, actual use until satisfactory performance; and (4) integration, work after satisfactory performance being achieved. Four stages of the process model not only indicate a sequence of knowledge transfer process, but also a relationship of causality flows at the same time. This approach is also reflected in D&M model development (DeLone and Mclean, 2003). Underpinned by the same model development strategy, it is argued that a success model for ICT based knowledge transfer can be established based on D&M IS success model.

By combining Szulanski's process model with a causal relationship flow along the process, a holistic view of the knowledge transfer process and ICT-KT success can be drawn in figure 3. Following the process model, the causal relationship can be addressed in sequence of (1) Knowledge Quality and ICT System Quality; (2) Service Quality, with sub-dimensions of E-Service and Extension Service; (3) Use and User Satisfaction; and (4) Net Benefits.

2.3 SERVQUAL, E-S-QUAL and Service Quality

To measure the service quality, Parasuraman et al. (1985, 1988) developed SERVQUAL, which have five measuring dimensions. With the emergence of e-business, Pitt et al. (1995) argue that D&M model is designed to measure the effectiveness of IS system that focusing on products rather than service. With this view in mind they suggest that SERVQUAL is an appropriate instrument for measuring IS service quality. Therefore, Pitt et al. (1995) added SERVQUAL as an extra dimension in D&M model together with system quality and information quality.

The inclusion of SERVQUAL into D&M model provides a possibility to the further development of D&M model toward measuring the success of ICT-KT. With regard to its validity, we argue that the service quality Pitt et al. (1995) investigated is the e-service quality rather than the traditional people delivered service. Therefore, employing SERVQUAL to measuring the quality of information system service can be challenged (Kettinger and Lee, 2005). DeLone and Mclean (2003) realised the limitation of the original model and attempted to modify the model in 2003.

Also influenced by the emerging phenomena of e-business, SERVQUAL has been further adapted to E-S-QUAL, a multiple-item scale for measuring the web based service quality (Zeithaml et al. 2002; Parasuraman et al. 2005). E-service in E-S-QUAL is defined by Parasuraman et al. (2005) as the customer shopping online. Regarding the ICT based knowledge transfer, it is reasonable to adopt the E-S-QUAL to measure transfer service quality. For example, in e-learning system, many learning activities are supported by the ICT system and students pay for receiving education online. Another ICT KT project is online expert systems or web based knowledge repositories. In this case, knowledge recipient may have to pay for receiving knowledge/service from the system.

3. ICT-KT SUCCESS MODEL

The proposed ICT-KT success model is illustrated in figure 4. Based on the updated D&M model (DeLone and McLean, 2003), the model depicts the basic process and causal relationship of ICT based knowledge transfer. Service Quality and Information Quality have been modified to reflect the characteristics of knowledge transfer systems. The success of knowledge quality previously developed based on knowledge transfer process model by Szulanski (2000) is introduced into ICT-KT success model. Service Quality is subdivided into E-service Quality and Extension Quality. Information Quality is replaced by knowledge quality.

4. DISCUSSION ON ASSOCIATED MEASURES IN EACH DIMENSION

Having proposed the ICT KT success model, the following section attempts to discuss the possible measures which can be used in each dimension.

4.1 Knowledge Quality

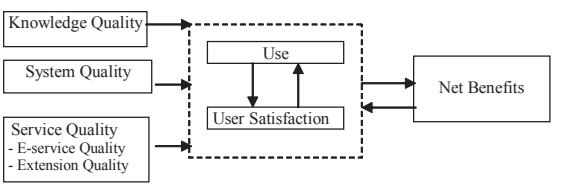
One of the most difficult dimensions to be measured could be the knowledge quality. Kane et al. (2005) empirically tested the influence of knowledge quality to the effectiveness of knowledge transfer. In their definition, knowledge quality is the gap between the knowledge of a source's and a recipient's. With empirical evidence they argue that superior knowledge will be more likely to be transferred from a source to a user than inferior knowledge. To measure the knowledge quality in general, potential items can be drawn from a number of influential empirical studies on knowledge transfer success. The first group of possible measures are as following.

- *Superior knowledge:* knowledge to be transferred is advantaged than the existing knowledge of recipient (Kane et al. 2005)
- *Tacitness:* implicit and noncodifiable accumulation of skills that results from learning by doing (Simonin, 1999)
- *Specificity*: transaction-specific skills and assets that are utilized in production processes and provision of services for particular customers (Simonin, 1999)
- *Complexity:* the number of interdependent technologies, routines, individuals, and resources linked to a particular knowledge or assets (Simonin, 1999);
- *Unproven Knowledge:* Degree of conjecture on the utility of the transferred knowledge (Szulanski, 2000)
- *Embeddedness:* A recognized characteristic of knowledge that can be transferred with people, tools or routines (Cummings and Teng, 2003)
- *Articulability:* the extent to which knowledge can be verbalized, written, drawn or otherwise articulated (Cummings and Teng, 2003)
- *Knowledge distance*: the degree to which the source and recipient possess similar knowledge foundations (Cummings and Teng, 2003)

Secondly, some other literature focuses on the ICT transferable knowledge, or information, in their research context. Holsapple and Lee-post-2006-used quantita-

Figure 3. An holistic view of the knowledge transfer process and ICT-KT success

Figure 4. Proposed ICT-KT success model



tive method to develop matrix measures for e-learning. They empirically verified the causal relationship between knowledge quality and use and user satisfaction in e-learning programmes. Therefore, a group of measures on information quality suggested by DeLone and McLean (1992) can be introduced as the preliminary measures of knowledge quality in general. These measures include: *Importance, Relevance, Usefulness, Informativeness, Usableness, Understandability, Reliability, Currency, Timeliness, Uniqueness, freedom from bias.*

Thirdly, a group of measures suggested by DeLone and McLean (1992) can be introduced as the potential quality measures of knowledge in the format of ICT transferable knowledge. They are *Readability, Clarity, Format, Appearance, Content, Accuracy, Precision, Conciseness, Sufficiency, Completeness, comparability, Quantitativenss.*

4.2 System Quality

In a broad sense knowledge transfer systems are information systems. The quality measures of information systems are still applicable to ICT-KT. Thus, the original measures in D&M model can be employed. The full set of system quality measures can be found in DeLone and McLean (1992).

4.3 Service Quality

Service quality is defined as the gap between expected service and perceived service (Parasuraman et al. 1985). This is true in ICT-KT context. Measures on service quality can be drawn from the general concepts in knowledge management literatures. As discussed in the introduction, ICT based knowledge transfer is normally supported by knowledge extentionist as a complimentary service to enhance the transfer effectiveness and success. Therefore, the service quality should include both E-service quality and extension quality. Further, researchers have noticed that the social-cultural factors play an important role in knowledge transfer (e.g. Alavi et al. 2006). Both e-service and extension service should not be an exemption of their influence.

In marketing theory, user's satisfaction is achieved from entire service they received from different means. Potential measures of general service quality can be:

- *Knowledge friendly:* positive orientation to knowledge exploration, creation and sharing (Davenport, 1998)
- *Clarity:* the project terminology is designed toward most effective communication (Davenport, 1998)
- *Multiple channels:* knowledge transferred through multiple channels that reinforce each other (Davenport, 1998)
- *Protectiveness*: specialised technological, personnel, and price in access to proprietary knowledge (Simonin,1999);
- *Cultural distance*: differentials of values, beliefs, language proficiency and alignment between individuals (Simonin1999; Cummings and Teng, 2003);
- *Organisational distance*: degree of dissimilarity in business practices, institutional heritage, and organisational culture between organisations or communities (Simonin,1999; Cummings and Teng, 2003)
- *Source not Perceived as Reliable:* Degree to which the donor of the best practice is perceived as reliable (Szulanski, 2000)
- *Source lacks Motivation*: Motivation of the source unit to support the transfer (Szulanski, 2000, Davenport, 1998)
- *Barren organizational Context:* Degree to which the organizational context supports the development of transfers (Szulanski, 2000, Davenport, 1998)
- *Project priority:* different degrees of attention and/or resources can be received in knowledge transfer activities (Cummings and Teng, 2003)
- *Transfer activities*: establishment and management of administrative structure based on assessment of knowledge, and the mechanism to facilitating knowledge transfer (Cummings and Teng, 2003)

4.3.1 E-Service Quality

E-Service is provided in accordance with e-commerce and e-business. E-S-QUAL is a set of measures for the E-Service quality. Suggested by Parasuraman et al. (2005), E-S-QUAL has two different measuring scales, the first is a 22-item scale of four dimensions: efficiency, fulfilment, system availability, and privacy; the second is a subscale with 11 items in three dimensions: responsiveness, compensation, and contact. The subscale is developed to measure the quality of service recovery. It is apparent that E-S-QUAL was developed in the context of e-business, not knowledge transfer services specifically. Modifications need to be made to apply their measures in ICT KT.

4.3.2 Extension Quality

Knowledge extension is a sort of service delivered by field extenionist, a face-to-face delivered service. Firstly, empirical measures suggested by KM literature can be adopted as described below:

- *Experience*: the capability in possessing the relevant tacit know-how to fill in the gaps left by codified descriptions(Simonin,1999);
- *Arduous Relationship:* Ease of communication and intimacy of the relationship (Szulanski, 2000)
- *Physical distance*: the difficulty, time requirement, and expense of communicating and getting together face-to-face (Cummings and Teng, 2003)
- *Organisational infrastructure:* establishment of the roles and organisational groups whose members have the skills to serve as the resources for individual projects (Davenport, 1998)

Secondly, SERVQUAL can be adopted as the initial constructs toward the final measures. Parasuraman et al. (1988) define the five dimensions of SERVQUAL are: tangibles, reliability, responsiveness, assurance, empathy. Within the five dimensions, the tangible is a dimension that is not particularly relevant to knowledge extension. A list of 18-item instrument developed for SERVQUAL shown in table 1 in appendix can be adopted as the second group of preliminary scales for further development of Extension Quality of ICT-KT.

4.4 Use and User Satisfaction

Darr and Kurtzberg (2000) argue that successful knowledge transfer occurs when source knowledge is not only shared with but also used by a recipient. Firstly, empirical measures in the KM literature on use and user satisfaction can be adopted.

Use

- *Recipient Motivation*: Motivation of the recipient unit to support the transfer (Szulanski, 2000; Davenport, 1998)
- *Learning cultural:* The need for a culture of learning in an organization or an individual to facilitate learning in general, and knowledge transfer specifically (Cummings and Teng, 2003)

User satisfaction

- *Recipient's Absorptive Capacity:* Ability of the recipient unit to identify, value and apply new knowledge (Szulanski, 2000, Tsai and Tsai, 2005)
- *Recipient's Retentive Capacity:* Ability of the recipient unit to support the routine use of new knowledge (Szulanski, 2000)

Secondly, two dimensions and related measures specified by DeLone and McLean (1992) can be employed as the potential items for measuring the use and user satisfaction of ICT-KT. However, *Information satisfaction* and *Difference between information needed and received* should replace by *knowledge.*

4.5 Net Benefit

DeLone and McLean (1992) proposed a set of measures on the organisational impact in their original model and net benefit in their revised model. Most of those measures on the organizational impact are rather product/service marketing oriented and lack a general scope. Within those measures, *Contribution to achieving goals* is viewed as an appropriate measure for net benefit. DeLone and McLean (2003) suggested five measures for net benefits in the revised model, including *Cost savings, Expanded markets, Incremental additional sales, Reduced search costs, Time savings.* Davenport (1998) points out that the link to economic performance or industry value is a key factor leading to knowledge project success. Following this argument, three potential measures, *Cost savings, Time savings, Improvement of economic performance or industry value* can be adopted firstly.

Secondly, as ICT-KT is, in nature, designed to transfer knowledge in the one-to-many form, measures on impact on individuals should be considered. Argote and Ingram (2000) note that knowledge transfer can take place at both individual level and group level. It is argued that organizational impact can only be realised with successful individual impact. It is inevitable that knowledge transfer at the

organisational level must involve the transfer at the individual level (Tsai and Tsai, 2005). More importantly, ICT-KT at the individual level is crucial in its success. O'Hagan and Green (2004) conclude that the knowledge transfer is dependent on the quality and quantity of social interaction between individuals. When the knowledge is transferred with some tacit components numerous individual exchanges are called for (Nonaka, 1994). DeLone and McLean (1992) suggest a set of decision effectiveness to measure the Individual Impact of IS success. This set of measures can be adapted as the second group of measures on net benefit. The modified two new sets of measures are *Personal valuation of ICT-KT and Willingness to Pay for Knowledge.*

5. FUTURE RESEARCH AND CONCLUSION

Future research will be carried out to test and validate the ICT-KT success model. Although the model is adapted from the D&M model, which has been empirically validated a number of modifications are made in terms of the dimensions and associated measures in the context of ICT-KT. The validation of the model can be achieved using empirical evidence to be collected with the current ICT based knowledge transfer projects in China, such as web based expert systems and web based training and education systems for rural extension in agriculture and aquaculture. Churchill (1979) suggests a procedure for developing multi-item measures for marketing research. The procedure is followed by Parasuraman and his colleagues in developing SEVQUAL and E-S-QUAL. The similar procedure can be employed for developing and refining the measures within each dimension using interview and questionnaire surveys.

This research has conceptually adapted the D&M model for ICT based knowledge transfer success but must be considered a preliminary study in nature. The model facilitates the mechanisms for measuring that ICT-KT actually takes place in both objective and subjective dimensions. However, this model is limited to applications in a sender-receiver asymmetry structure of knowledge transfer, within which the sender is in a knowledge advantaged position.

REFERENCES

Alavi, M., Kayworth, T. and Leidner, D. (2006) "An empirical examination of the influence of organisational culture on knowledge management practices." Journal of Management Information Systems, Vol. 22, No.3: 191-224.

Argote, L. and P. Ingram (2000). "Knowledge Transfer: A Basis for Competitive Advantage in Firms." Organizational Behavior and Human Decision Processes Vol. 82, No. 1: 150–169.

Churchill G. A. (1979) "A paradigm for developing better measures of marketing constructs", Journal of Marketing Research, Vol. XVI: 64-73.

Cummings, J. and B.-S. Teng (2003). "Transferring R&D knowledge: the key factors affecting knowledge transfer success." Journal of Engineering and Technology Management Vol. 20: 39–68.

Darr E. D. and Kurtzberg T. R. (2000) "An Investigation of Partner Similarity Dimensions on Knowledge Transfer", Organizational Behavior and Human Decision Processes, Vol. 82, No. 1: 28-44.

Davenport T. H., De Long D.W., and Beers M. (1998) Successful knowledge management projects, Sloan Management Review, Winter:43-56.

DeLone W.H., McLean, E.R. (2003) "The DeLone and McLean model of information systems success: A ten year update", Journal of management information systems, Vol. 19, No.4, pp. 9-30.

DeLone W.H., McLean, E.R. (1992) " Information system success: The quest for the dependent variable", Information system research, Vol. 3, No.1, pp. 60-95.

Feng W., Duan Y., Fu Z. and Mathews B. (2006) "The Role of an Extensionist in ICT-based Knowledge Transfer", Proceedings of European Conference on Knowledge Management, August, 2006.

Hainse M. N. and Goodhue D.L. (2003) "Implementation Partner Involvement and Knowledge Transfer in the Context of ERP Implementations", International Journal of Human-Computer interaction, Vol.16 No.1: 23-38.

Holsapple C.W. and Lee-Post A. (2006), "Defining, assessing, and promoting E-learning success: An information system perspective", Decision sciences Jonrnal of innovative education, Vol. 4 No.1: 67-85.

Kane A.A., Argote L. and Leine J.M. (2005) " Knowledge transfer between groups via personnel rotation: Effects of social identity and knowledge quality", Organizational Behavior and Human Decision Processes, Vol. 96: 56–71.

Kettinger W.J. and Lee C.C. (2005) "Zones of tolerance: Alternative scales for measuring information systems service quality", MIS Quarterly, Vol. 29 No.4: 607-620.

Ko D., Kirsch L.J. and King W.R. (2005) "Antecedents of knowledge transfer from consultants to clients in enterprise system implementations", MIS Quarterly, Vol.29 No.1: 59-85.

Lin L., Geng X., and Whinston A.B., (2005) "A sender-receiver framework for knowledge transfer", MIS Quarterly, Vol. 29, No. 2, pp. 197-219.

Mason R. (1978) "Measuring information output: A communication systems approach", Information & Management, Vol. 1 No.5: 219-234.

Nonaka, I. (1994) "A dynamic theory of organizational knowledge creation". Organization Science, Vol. 5. No.1: 14–37.

Nonaka, I. and V. Peltokorpi (2006). "Objectivity and subjectivity in knowledge management: A review of 20 top articles." Knowledge and Process Management Vol. 13, No.2: 73-82.

O'Hagan B. and Green M. B. (2004) "Corporate knowledge transfer via interlocking directorates: a network analysis approach", Geoforum Vol. 35: 127-139.

Parasurman A., Zeithaml V.A. and Berry L.L.(1985) "A conceptual model of service quality and its implications for future research", Journal of Marketing, Vol.49: 41-50.

Parasurman A., Zeithaml V.A. and Berry L.L.(1988) "SERVQUAL: A multiple-item scale for measuring consumer perceptions of service quality", Journal of Retailing, Vol.64 No.1: 12-40.

Parasurman P., Zeithaml V.A. and Malhotra A. (2005) "E-S-QUAL: A multiple-item scale for assessing electronic service quality", Journal of Service Research, Vol.7 No.3: 213-233.

Pitt L., Watson R. and Kavan B. (1995) "Service quality: A measure of information systems effectiveness", MIS Quarterly, June: 173-187.

Ray C. and Bhawuk D.P.S. (2002) "From ideas to market applications: dynamics of knowledge transfer and the role of champions", Environmental Engineering Policy, Vol. 3: 33-43.

Simonin, B. L. (1999). "Ambiguity and the process of knowledge transfer in strategic alliances." Strategic Management Journal Vol. 20: 595-623.

Szulanski, G. (2000). "The process of knowledge transfer: A diachronic analysis of stickiness." Organizational Behavior and Human Decision Processes Vol. 82, No. 1, May: 9–27.

Tsai M. and Tsai L. (2005) "An Empirical Study of the Knowledge Transfer Methods used by Clinical Instructors", International Journal of Management Vol. 22 No. 2: 273-284.

Zeithaml V.A., Parasurman A. and Malhotra A. (2002) "Service quality delivery through web site: A critical review of extant knowledge", Journal of the Academy of Marketing Science, Vol.30 No.4: 362-375.

Multi-Layer Decision Support Model for Value and Cost Analysis of IT Solutions: Hierarchical Approach

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ABSTRACT

The article presents mechanisms of value and cost evaluation that accompany decision making processes in hierarchical systems, while performing complex IT projects. Every designing operation, performed in set deterministic or probabilistic conditions, is a decision making activity (selection activity) that initiates expected value and costs that occur with it. AIDA method has been selected as a starting point of the model's structure. The scope of applying of this method has been extended to modeling of decision making process in a hierarchically structured organization. Deliberations have been limited to the deterministic model with the assumption that selection of every decision, from the finite set of variants, is evaluated in two categories: V – expected benefits and C – incurred costs. Making a decision "agreed" in many layers is crucial for hierarchic structures. It is necessary to assure its global realization ability and maximize the expected value in relation with estimated costs. Deliberations are exemplified with a decision making process which accompanies launching a new IT project with cost-based limitations.

INTRODUCTION

The use of multilayer decision support model for value and cost analysis of major IT projects results from the analogy to the manner in which this kind of decisions are prepared and undertaken. The most common practice, present in many enterprises – especially financial institutions and insurance companies, considers two levels of decision making about IT project and their complex structure: strategic decisions level (s) and tactical decisions level (t).

Strategic decisions level considers the following aspects:

(0s) business strategy of the enterprise,
(1s) expected benefits,
(2s) incurred costs,
(3s) available technology,
(4s) reliable suppliers and contractors,
(5s) guaranteed safety.

Tactical decisions level includes the following aspects:

(0t) IT introduction strategy,
(1t) IT introduction program,
(2t) IT projects management,
(3t) scope and cost of IT audit,
(4t) scope and cost of outsourcing,
(5t) license purchase cost,
(6t) infrastructure purchase cost,
(7t) implementation cost.

Both presented decision levels permeate each other creating a network of cause-and-effect relationships. Their solution cannot be unambiguous due to indetermination or random character of macroeconomic (e.g. turbulent market) or technological (e.g. innovations in the areas of nano- and biotechnology) phenomena.

Routine decision making processes in hierarchical systems realization are accompanied by many phenomena which should be identified and managed. In case of unique ventures like IT projects to its managing, in general meaning, specific IT solutions are used. These solutions support: planning and organizing activities, budgeting, technical and logistic operations as well as controlling and corrective actions.

Project management occurs when the variant that has been chosen to realization is revealed from all of its more or less documented variants.

This article deals with the stage of creating and designing an IT project as well as estimating its economical effects for the organization that implements the project.

AIDA* method was selected as a starting point for the creation of the whole model. Its scope of use and implementation was expanded to decision making process modeling in a hierarchically structured organization.

According to the AIDA technique, decision making process is a process of preparing *alternative variants of decision* (AVD) and a process of selecting one of these variants for realization. Determining inwardly alternative *decision areas* (D_i) that consist of *elementary decisions* (d_{ji}) and indicating *mutually contradictory elementary decisions* that are included in different decision areas - is performed during this process.

In order to generate AVD, so called apexes of tree of results are formed. This process is accompanied by estimation of the V value growth and estimation of cost C connected with this project for the organization that implements the project (see Fig. 1).

Successive steps leading to a multilayer decision making model are presented in the following fragments of the article: *Decision making process – basic assumptions; AIDA method; AIDA method in solving a single-layer model; Estimating value and costs in single-layer model; Construction of a multilayer model; AIDA method in solving a multilayer model and Estimating value and costs in multilayer model.*

DECISION MAKING PROCESS: BASIC ASSUMPTIONS

Decision making process is a *alternative variants of decision* (AVD) preparation process as well as selection of one of the variants for further realization.

Preparing the AVD consists of determining relevant *decision areas* (D_i), for a set decision problem, which will provide partials of the *elementary decisions* (d_{ji}) that are not contradictory in constructed AVD model.

This part of the article deals with a single-layer decision-making process model in a strictly theoretical (general) manner.

In order to avoid terminological misapprehensions the meaning of keywords used in the article is presented below:

- *Decision Problem* (DP) – set of decision-making areas that specify particular areas of decision making process,
- *elementary decision* (d_{ji}) – making this decision implicates elaborating D_i and selecting one suitable d_{ji},
- *Variant of Decision* (VD) – sorted n elements indicated for realization, created from single elements (elementary decisions d_{ji}) that belong to sets of elements alternative to each other, namely decision areas (D_i),

- *Decision Preparation Process* (DPP) – process of elaborating D_i as well as AVD generation process connected with indicating *Variants of Decisions* (VDs) that are the most beneficial for further realization,
- *Decision Space* (DS) – collection of all non-contradictory AVDs,
- *Hierarchical system* – from the mathematical point of view it is a partly sorted structure that consist of: elementary decisions, decisions areas and variants of decisoins.

Example of a single-layer DP model in the form of graph is presented in Fig.1. D_1, D_2, D_3 symbols stand for decision making spaces; $d_{11,}$ $d_{21,...,}$ d_{33} symbols stand for elementary decisions.

Capital letters V, C mark the proportional share of a particular decision area in organizations value growth and IT project realization costs. Small letters v, c stand for proportional share of particular elementary decision in proportion to remaining elementary decisions from a considered decision area in organizations value growth and IT project realization costs.

Creation of DP graph model starts from eliminating these D_i, which collections include only one elementary decision and eliminating repetitive elementary decisions.

Apexes of the graph that correspond with elements of one decision making area are connected with lines (dotted line). Lines symbolize the fact that connected elements are alternative. Due to aprioristic collisions of some of the elements, that belong to different decision areas, suitable apexes of the marked with these elements are connected as well (continuous line).

AIDA METHOD

Designing decisions in single-layer model is performed by the activity of defining DP as a decisoin areas collection and defining relationships between elements present in these areas (see Fig. 1) without the necessity to undertake separate analysis of morphological relations between the elements of each collection.

AIDA method elaborated by J. Luckman distinguishes from other well-known methods of morphological analysis (morphological box, randomization with the use of sets, Moles methods) with high efficiency and relative simplicity.[1, 2]

Initial stage of performance of this technique is specifying decision areas recorded as, so called, *Formulating Sets* (FS). Every D_i has homological properties that is its elements in specific variants of the solution can be exchanged by others. Cartesian product of all decision areas determines the *Decision Space* (DS) of particular *Decision Problem* (DP).[3]

AIDA method can be used for two different goals:

- to generate admissible elements of the decision area,
- to generate discrete stages trajectory of solving DP in the DS.

First case presents decision areas decomposition process that leads to the form of AVDs, from which the final result is selected. In second case AIDA is used to generate "quick" variants of decision that are interpreted as discrete stages of *Decision Preperation Process* (DPP) in the DS.

Process of generating elements and trajectories of the DS should be evaluated both in quantitive and qualitative way. The most promising use of AIDA method is in case of major and complex decision areas - that is every time when the moment of making a decision should be preceded with the stage of generating all or almost all VDs.

In some of the practical uses it is necessary to take into consideration the limited available time to take particular decision and costs connected with elaborating DPP – in this aspect the AIDA method can be used to prepare a limited number of decision making variants which should include an optimal variant (it concerns especially the tasks of steering in conditions with system parameters of great dynamics or searching for results variants in conditions that include a considerable number of probabilistic limitations). Second collection of AIDA method uses can be related directly to realization of complex IT projects, which budgets usually account for millions of dollars and the benefits and costs of implementation occur simultaneously with the time of managing the project.

AIDA METHOD IN SOLVING A SINGLE-LAYER MODEL

Any decision area (represented by so called formulating set) will be marked as $\mathbf{D_i}$, and $\mathbf{d_{ji}}$ stands for a j-th elementary decision of this area.

Decision space (DS) of morphological analysis is signified as $\mathbf{D_1 \times D_2 \times ... \times D_m}$ or as a set of vectors $\{<d_{j1}, d_{j2}, ..., d_{jm}>\}$, with the assumption that $\mathbf{d_{ji} \in D_i}$ and that the power of any decision making area $|\mathbf{D_i}|$ is a limited value.

The solution of a decision problem (DP) is the defined set of decision areas $\mathbf{D_i}$ and generated and evaluated correct vectors $<\mathbf{d_{j1}, d_{j2}, ..., d_{jm}}>$ at a decision tree (see Fig. 2).

The essence of AIDA method is to perform the four following steps:

[a] determine inwardly alternative decision areas that describe the set problem,
[b] determine contradictory elementary decisions that are in different decision making areas,
[c] generating and eliminating these VDs of the decision areas which include contradictory pairs of elementary decisions,
[d] sorting and analyzing remaining VDs.

The procedure of generating VDs is based on the decomposition of the DP graph model. Decomposition is based on systematic separating inwardly stable variants of formulating set's. Inwardly stable set is the one which fulfills two conditions:

- It consists of as many decision making elements as there are decision areas,
- It does not include pairs of elementary decisions that eliminate each other.

For example in $\mathbf{D_1}$, $\mathbf{D_2}$, $\mathbf{D_3}$ decision areas (see Fig. 1) the following sets are inwardly stable: $\{\mathbf{d_{11}, d_{22}, d_{33}}\}$, $\{\mathbf{d_{11}, d_{12}, d_{13}}\}$, $\{\mathbf{d_{21}, d_{32}, d_{23}}\}$.

Generating VDs has the following agenda:

(a) the power (number of elements) of each formulating set is specified,

Figure 1. Example of a single-layer DP graph model

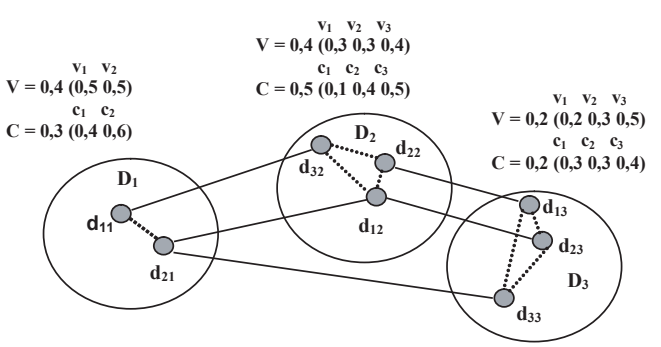
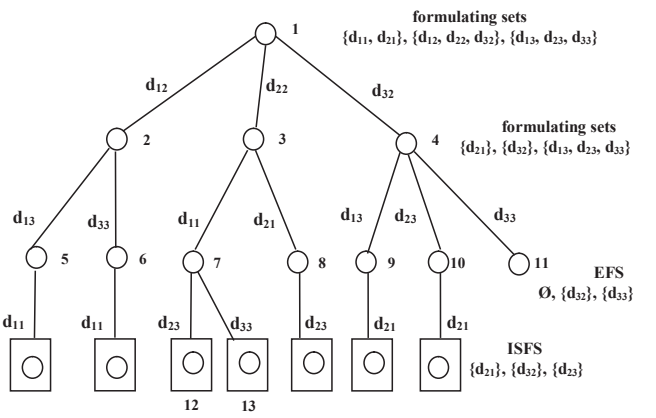


Figure 2. Example of tree of results for single-layer model



(b) formulating sets are sorted according to the decreasing value of their power,
(c) formulating sets of elementary decisions that are included in all decision areas are divided into as many groups of sets as the value of largest formulating set's power,
(d) apexes of the tree of results are formulated together with the lines growing out of them, which have specific groups of formulating sets attributed to them.

Realization of operations (a) to (d) is exemplified at the tree of results in Fig. 2.

It is necessary to take into consideration that while creating formulating sets for newly created apexes of lower levels of the tree, there cannot be any elementary decisions that are alternative to these elementary decisions towards which the formulating sets division takes place. If, due to the division, the power of one of the formulating set becomes equal to 0 (the set is empty) – it indicates that this particular group of formulating sets is eliminated from the process of division and marked as EFS (Eliminated Formulating Sets). If the power of all formulating sets in a particular group equals 1 – this group becomes the variant of inwardly stable set of decisions and is marked as ISFS (Inwardly Stable Formulating Set). Remaining formulating sets are sorted decreasingly due to the value of their power and the realization of (c) and (d) operations is triggered again.[4, 5]

The operations (a) - (d) are repeated until the groups of formulating sets will consist only of EFS and ISFS elements. Groups marked as ISFS are the collection of allowable results that is the set of all possible VDs, which do not include pairs of alternative elementary decisions.

In the tree of results (see Fig. 2), ISFS that reflect the lowest level of apexes are marked with a frame.

The gained ISFS results are:

$\{d_{11}, d_{22}, d_{33}\}$, $\{d_{11}, d_{12}, d_{13}\}$, $\{d_{21}, d_{32}, d_{23}\}$, $\{d_{11}, d_{12}, d_{33}\}$, $\{d_{11}, d_{22}, d_{23}\}$, $\{d_{21}, d_{22}, d_{23}\}$, $\{d_{21}, d_{32}, d_{13}\}$

ESTIMATING VALUE AND COST IN A SINGLE-LAYER MODEL

Process of generating formulating sets for every apex of tree of results (see Fig. 2) is accompanied by estimating of the value growth of the organization implementing the IT project together with estimation of the cost of project's realization (see Fig. 1).

In order for the estimation to be possible an assumption is necessary: every $\mathbf{D_i}$ percentage share, on the scale of **[0..1] x 100**, is set both in **V** value and costs **C** – with additional assumption that sum of each of these shares in all decision areas equals **100**.

For the example presented at Fig. 1 sums of all shares are as following:

$$V_{D1} + V_{D2} + V_{D3} = 100$$
$$C_{D1} + C_{D2} + C_{D3} = 100$$

V-C characteristics for particular $\mathbf{d_{ji}}$ in every $\mathbf{D_i}$ are determined similarly:

$$v_{d11} + v_{d21} = 100 \qquad c_{d11} + c_{d21} = 100$$
$$v_{d12} + v_{d22} + v_{d32} = 100 \qquad c_{d12} + c_{d22} + v_{d32} = 100$$
$$v_{d13} + v_{d23} + v_{d33} = 100 \qquad c_{d13} + c_{d23} + v_{d33} = 100$$

For each group of formulating sets connected with the developed tree apex with **x** index, **max** and **min** of expected percentage value (V_x^{max}, V_x^{min}) and expected percentage cost (C_x^{max}, C_x^{min}) are determined. Results of particular calculations for the presented example at Fig. 1 are collected in Tab. 1.

Analysis of the tree of results presented in Fig. 3 indicates that three of the best relations between cost of IT project realization and increase of organization's value can be achieved in a form of a result marked as No 5, No 6 and No 13.

Upper and lower **V–C** limitations can be used in automatic model revision in models with hundreds or thousands elements. In such case there are aprioric limitations for allowable scope of diversity separately for parameter **V** and **C**. V-trees and C-trees of results are constructed; the best **V/C** solutions are present in a mutual part of both trees.

Reached solution (apex) No 6 with **V/C = 1,68** is present in mutual part of both trees where $\mathbf{V \geq 42}$ and $\mathbf{C \leq 25}$.

CONSTRUCTION OF A MULTILAYER MODEL

In hierarchical systems the decisions are made on several layers according to the situation present in adjacent layers. Process of designing and taking the decision is dependent on the character of the organization – although decisions in higher layers are always based on the decisions in lower layers – and symmetrically: decisions in lower layers are based on decisions in higher layers. Therefore we can observe two interdependent streams of decision preparation.

Fig. 4 illustrates mutual placement of decision making problems at higher (strategic), intermediate (tactical) and operational layers. It is easy to observe that decision area (that includes elementary decisions) at a higher layer becomes a decision problem for the layer placed beneath it.

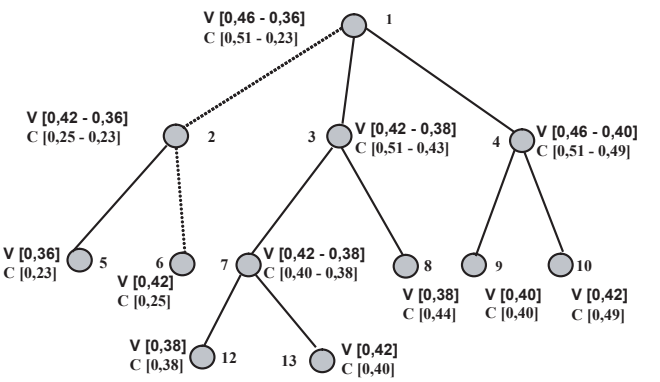
Structure of a multilayer DP graph model (see Fig. 4) is based on the following rules:

- each defined decision area placed at a certain DP layer or at a adjacent layer has all possible elementary decisions determined,
- for a collection of elementary decisions that belong to a decision area of higher layer a DP of lower layer has to be determined, its solutions in a form of alternative variants of decision (AVD) should unambiguously relate to particular elemetary decisions (see Fig. 4, elementary decisions No 5, No 6, No 13 and relevant AVDs as DP solutions in a tactical layer),

Table 1. Example of proportional value estimation for formulating sets

No	Group of formulating sets	next No	V^{max}	V^{min}	C^{max}	C^{min}
1	$\{d_{11}, d_{21}\}, \{d_{12}, d_{22}, d_{32}\}, \{d_{13}, d_{23}, d_{33}\}$	2,3,4	0,46	0,36	0,51	0,23
2	$\{d_{11}\}, \{d_{12}\}, \{d_{13}, d_{33}\}$	5,6	0,42	0,36	0,25	0,23
3	$\{d_{11}, d_{21}\}, \{d_{22}\}, \{d_{23}, d_{33}\}$	7,8	0,42	0,38	0,51	0,43
4	$\{d_{21}\}, \{d_{32}\}, \{d_{13}, d_{23}, d_{33}\}$	9,10,11	0,46	0,40	0,51	0,49
5	$\{d_{11}\}, \{d_{12}\}, \{d_{13}\}$	ISFS	0,36	0,36	0,23	0,23
6	$\{d_{11}\}, \{d_{12}\}, \{d_{33}\}$	ISFS	042	0,42	0,25	0,25
7	$\{d_{11}\}, \{d_{22}\}, \{d_{23}, d_{33}\}$	12,13	0,42	0,38	0,40	0,38
8	$\{d_{21}\}, \{d_{22}\}, \{d_{23}\}$	ISFS	0,38	0,38	0,44	0,44
9	$\{d_{21}\}, \{d_{32}\}, \{d_{13}\}$	ISFS	0,40	0,40	0,49	0,49
10	$\{d_{21}\}, \{d_{32}\}, \{d_{23}\}$	ISFS	0,42	0,42	0,49	0,49
11	$Ø, \{d_{32}\}, \{d_{33}\}$	EFS	-	-	-	-
12	$\{d_{11}\}, \{d_{22}\}, \{d_{23}\}$	ISFS	0,38	0,38	0,38	0,38
13	$\{d_{11}\}, \{d_{22}\}, \{d_{33}\}$	ISFS	0,42	0,42	0,40	0,40

Figure 3. Example of estimating solutions for a single-layer model



- partial overlapping of separate DPs in the form of mutual decision areas is possible (one ecision area belongs to one or more different decision problems),
- decision areas placed on operational layers should include only aprioric elementary decisions which cannot be the result of searching AVDs for even more detailed decision areas,
- number of elementary decisions in particular decision area should be limited to the smallest possible number of the most beneficial solutions according to **V/C** ratio – which means significant value growth in proportion with smallest cost growth,
- values of **V** and **C** in the aspect of cost for any decision area of particular higher layer should be the sum of $\mathbf{V}_s$ and $\mathbf{C}_s$ values for all $\mathbf{s} \in \mathbf{S}$, where $|\mathbf{S}|$ is a number of decision areas partials of a layer that is directly beneath,
- decision-making problems decomposition should be limited to the smallest possible number of layers.

Example

Global expected value of organizations value growth is equal to **V = 300 mln $**, project cost equals approximately **C = 80 mln $**. Decision area including elementary decisions No 5, No 6 and No 13 is placed in the strategic layer (see Fig. 4) and is responsible for **30%** of **V** growth (**90 mln $**) and **40%** of **C** cost (**32 mln $**). Decision areas $\mathbf{D}_1$, $\mathbf{D}_2$, $\mathbf{D}_3$ placed in the tactical layer are responsible for cost-based and percentage share according to values presented in Tab. 2.

Real cost of the IT project is dependent on elementary decisions undertaken on each decision making layers. Real evaluation of organizations value growth will be verified by the market.

ESTIMATING VALUE AND COST IN A MULTILAYER MODEL

Estimating the market value growth created due to engagement of an enterprise in implementation of a new IT project is an endeavor of high responsibility. Commonly encountered issue of significantly exceeding the budget and not being able to meet deadlines for projects of this type has been statistically proved.

Table 2. Example of V-C relation in decision-making layers

	D_1	D_2	D_3	Σ
V [%]	40	40	20	100
C [%]	30	50	20	100
V [mln $]	36,0	36,0	18,0	90,0
C [mln $]	9,6	16,0	6,4	32,0

Figure 4. Multilayer DP graph model (includes the Fig. 1 model with results No 5, No 6 i No 13 at a strategic layer)

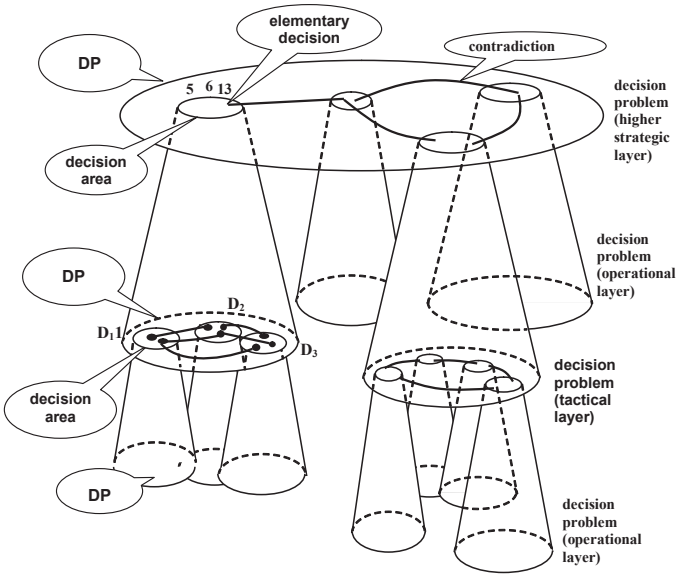


Table 3. Example of three decision variants in tactical layer

No	Groups of formulating sets	Share of AVD in D_1 [mln $]			ΣV / ΣC	V/C
		D_1	D_2	D_3		
5	$\{d_{11}\}, \{d_{12}\}, \{d_{13}\}$	18,00	10,80	3,60	32,40	4,54
		3,84	1,60	1,92	7,36	
6	$\{d_{11}\}, \{d_{12}\}, \{d_{33}\}$	18,00	10,80	9,00	37,80	4,73
		3,84	1,60	2,56	8,00	
13	$\{d_{11}\}, \{d_{22}\}, \{d_{33}\}$	18,00	10,80	9,00	37,80	2,95
		3,84	6,40	2,56	12,80	

On the basis of prior considerations the part of alternative variants of decision (AVD) with the No 5, No 6 and No 13 in particular decision areas has been converted as well as the value of **V/C** relation has been calculated.

The most profitable result has not been changed in proportion to the proportional share and, what is especially intriguing, it proved to be better than a simple reference of expected global organizations value growth (**V = 300 mln $**) to project cost (**C = 80 mln $**), which in this case equals **V/C = 3,75** (see Tab. 3). This result can indicate that decisions reached and estimated in parallel on two layers can be more precise than in a single-layer model.

Presented argumentation has some simplifications that were necessary to separate two layers (strategic and tactical) and prove that calculations elaborated in tactical layer are more precise than simple reference of global **V/C** values in strategic layer in case of the model presented in Fig. 4 .

SUMMARY

Presented approach towards hierarchic decision-making processes modeling in IT solutions has been corroborated with many test-runs performed on IT tools prototypes.[6, 7]

The article deals with an attempt to introduce weighted evaluations of economic type into a hierarchical model, which are assigned to decomposed decision making problems, layers of decisions and areas and particular elements of decisions. It is illustrated with computational examples – however, the Author is aware of the fact, that not all of the issues could be presented in a sufficient level of detail due to the complexity of this problems and editorial limitations.

Main limitation of the presented model is an assumption of model's static nature and lack of probabilistic characteristics – although the latter are being tried to change with the approximation of "percentage share/effect" of particular decision in the whole solution. Another inexactitude would be omitting the influence of synergetic relations at the value and costs. These kind of relations occur naturally due to the correlation between particular decision elements.

Author is aware of listed imperfections of the model and will be gradually eliminating them in further research on the essence and economical characteristics of highly structured decision making processes.

REFERENCES

[1] Krupa T. - Formulating Designing Task with Morphologic AIDA Method. "Designing and Systems" XI, Prace PAN, Warsaw 1990.
[2] Krupa T. – Morphology of Informational Structures – AIDA method in designing. In book "Multilayer Decision Supporting" edited by T. Kasprzak. Wydawnictwa Uniwersytu Warszawskiego, Warsaw 1992.
[3] Krupa T. - System Model for Decision Making Processes Aiding. In book „Computer Aided Management" edited by R. Knosala. WNT, Warsaw 1998.
[4] Ostrowska T., Krupa T. - The Logical Aspects of Tasks and Resource Design. International Conference „Cybernetics and Systems'90". World Scientific, University of Vienna, Vienna 1990.
[5] Krupa T. - Concept of Organizational Change. In book "New Challenges and Old Problems In Enterprise Management" edited by T. Krupa. WNT, Warszawa 2002.

[6] Mursy H., Krupa T. - Computer Method of Analysis of Interconnected Decision Areas. International Conference "Mechanical Design and Production Engineering", Al Azhar University, Cairo 1993.
[7] Kunikowski G., Krupa T. - Morphology Analysis In Land Suitability Assessment. ESRI, San Diego, CA, USA 2006.

ENDNOTES

* Analysis of Interconnected Decision Areas.

1 Krupa T. – Formulating Designing Task with Morphologic AIDA Method. „Designing and Systems" XI, Prace PAN, Warsaw 1990.

2 Krupa T. – Morphology of Informational Structures – AIDA Method in Designing. In book "Multilayer Decision Supporting" edited by T. Kasprzak. Wydawnictwa Uniwersytetu Warszawskiego, Warsaw 1992.

3 Krupa T. – System Model for Decision Making Processes Aiding. In book „Computer Aided Management" edited by R. Knosala. WNT, Warsaw 1998.

4 Ostrowska T., Krupa T. - The Logical Aspects of Tasks and Resource Design. Int.Conf "Cybernetics and Systems'90". World Scientific, University of Vienna, Vienna 1990

5 Krupa T. – Concept of Organizational Change. In book: "New Challenges and Old Problems In Enterprise Management" edited by T. Krupa. WNT, Warszawa 2002.

6 Mursy H., Krupa T. - Computer Method of Analysis of Interconnected Decision Areas. Int. Conf. Mechanical Design and Production Engineering, Al Azhar University, Cairo 1993.

7 Kunikowski G., Krupa T. - Morphology Analysis In Land Suitability Assessment. ESRI, San Diego, CA, USA 2006.

The Adoption and Implementation of Knowledge Management in Healthcare Operations

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ABSTRACT

The importance of knowledge management (KM) to organizations in today's competitive environment is being recognized as paramount and significant. This is particularly evident for health care in this country. The US healthcare system is facing numerous challenges in trying to deliver cost effective, high quality treatments and is turning to KM techniques and technologies for solutions in an attempt to achieve this goal. What is becoming of particular interest is the adoption and implementation of KM and associated KM technologies in the healthcare setting, an arena that has to date been notoriously slow to adopt technologies and new approaches for the practice management side. We examine this issue by studying the barriers encountered in the adoption and implementation of specific KM technologies in healthcare settings. With some empirical data we then develop a model that attempts to draw some conclusions and implications for orthopaedics.

Keywords: healthcare, knowledge management, adoption, implementation, orthopaedics

1.0 INTRODUCTION

The industrial economy has given way to the electronic economy creating an entirely new set of rules, opportunities, threats, and challenges (Accenture). The growth of electronic commerce (e-commerce) is vast, complex, and rapidly expanding. The evolution of the 'Information Age' in medicine is mirrored in the exponential growth of medical web pages, increasing number of online databases, and expanding services and publications available on the Internet. In order to make sense of the mass of data and information that is now being generated, organizations are turning to knowledge management techniques and technologies.

The healthcare sector is no exception to this. What we believe is not only interesting but also critical to understand is the adoption and implementation of knowledge management techniques and technologies in the healthcare sector–an industry that has to date been very slow to embrace new information technologies to benefit the administrative, as opposed to the clinical, aspect of medical practice (Battista and Hodge, 1999). To date, little has been written about knowledge management (KM) in health care, and even less on the phenomenon of the adoption and implementation of KM technologies and systems (Shakeshaft and Frankish, 2003).

In this paper we address the void in the literature by presenting some results from a study of KM adoption in a select healthcare setting. This is a case of KM in orthopedics practice in the United States. We analyze this case with a model that identifies the barriers to the process of adoption and implementation of KM in healthcare organizations. We believe that this type of research may lead to a better understanding of what it is about KM that is so crucial for health care today, and the better processes and mechanisms that would help in its implementation (Eger et al., 2003).

2.0 THE HEALTHCARE INDUSTRY

Health care is not only a growing industry but it is also the biggest service business on the globe. Between 1960-1997 the percentage of Gross Domestic Product (GDP) spent on health care by 29 members of the Organizations for Economic Cooperation and Development (OECD) nearly doubled from 3.9 to 7.6% with the US spending the most–13.6% in 1997 (OECD Health Data 98). Hence, healthcare expenditures are increasing exponentially and reducing them; i.e., offering effective and efficient quality healthcare treatment, is becoming a priority globally. Technology and automation have the potential to help reduce these costs (Institute of Medicine, 2001; Wickramasinghe, 2000).

In their continuing effort to increase the role of technology in their operations, healthcare providers are employing many opportunities to incorporate IT and telecommunications with e-commerce strategies to improve service and cost effectiveness to its key stakeholders. Many such e-initiatives, including the e-medical record, are currently being implemented in various countries; however, these alone have been found to be insufficient in achieving the desired performance and economic goals without also incorporating KM techniques and technologies into clinical and administrative practices (Wickramasinghe and Mills, 2001).

2.1 Key Factors Influencing the US Healthcare Sector

In the US, two key factors are leading the various stakeholders throughout the healthcare industry to adopt various new technologies and their aims are to enable these organizations to practice better management. These factors are: (i) managed care and (ii) the Health Insurance Portability and Accountability Act (HIPAA, Public Law 104-191).

Managed care was introduced over a decade ago as an attempt to stem the escalating costs of health care in the US. It is aimed at creating value through competition, with the intended result of providing adequate quality health care and yet to minimize, or at least to hold, the line on costs (Wickramasinghe & Silvers, 2003) The principal participants involved in any managed care arrangement include the following five categories of stakeholders: the Managed Care Organization (MCO), the purchaser, the member, the healthcare professional, and, if applicable, an administrative organization (Knight, 1998).

The Health Insurance Portability and Accountability Act was signed by President Clinton on 21 August 1996. This Act is definitely providing a strong impetus for the US healthcare sector to embrace various e-technologies because it aims to improve the productivity of the American healthcare system by encouraging the development of information systems based on the exchange of standard management and financial data and by using EDI (Electronic Data Interchange). In addition, the Act also requires organizations exchanging transactions for healthcare to follow national implementation guidelines for EDI established for this purpose. This poses many significant challenges to healthcare institutions. A key challenge is the need to make significant investments in technology to facilitate and enable these functions to take place and to also develop the appropriate standards and protocols required. In 2005-2006 the Bush Administration has also announced several initiatives to encourage the use of information technology in healthcare delivery.

2.2 The Future for Healthcare

Health care has been shaped by each nation's own set of cultures, traditions, payment mechanisms, and patient expectations. Given the common problem facing health care globally, i.e., exponentially increasing costs, no matter which particular health system one examines, the future of the healthcare industry will

be shaped by commonalities based on this key unifying problem and the common solution; namely, the embracing of new technologies to stem escalating costs and improve quality healthcare delivery.

Currently, the key future trends that will perhaps significantly impact health care include: (i) empowered consumers, (ii) e-health adaptability; and (iii) a shift to focus on healthcare prevention. Key implications of these future trends include (i) health insurance changes, (ii) workforce changes as well as changes in the roles of stakeholders within the health system, (iii) organizational changes and standardization, and (iv) the need for healthcare delivery organizations and administrators to make difficult choices regarding practice management (Wickramasinghe, 2000). In order to be well positioned to meet and manage these challenges within the US and elsewhere in the world, healthcare organizations are turning to KM techniques and technologies. Thus, as the role of KM in health care increases in importance, it becomes crucial to understand the process of adoption and implementation of KM systems.

3.0 THE NATURE OF KNOWLEDGE MANAGEMENT

Knowledge is a critical resource in any organization and is also crucial in the provision of health care. Access to the latest medical research knowledge is often the difference between life and death, between accurate or erroneous diagnosis, and between early intervention or a prolonged and costly hospital stay. Knowledge management deals with the process of creating value from an organization's intangible assets(Wickramasinghe and Mills, 2001; Edwards et al., 2005). It is an amalgamation of concepts borrowed from the artificial intelligence/knowledge based systems, software engineering, BPR (business process re-engineering), human resources management, and organizational behavior (Purvis et al. 2001). Knowledge management deals with conceptualization, review, consolidation, and action phases of creating, securing, storing, combing, coordinating, and retrieving knowledge. In essence, then, knowledge management is a process by which organizations collect, preserve, and utilize what their employees and members know about their jobs and about activities and procedures in their organization (Xu and Quaddus, 2005).

3.1 The Need for Knowledge Management

Sustainable competitive advantage is dependent on building and exploiting core competencies. In order to sustain competitive advantage, resources which are idiosyncratic (thus scarce) and difficult to transfer or replicate are required. A knowledge-based view of the firm identifies knowledge as the organizational asset that enables sustainable competitive advantage especially in hyper competitive environments or in environments experiencing radical discontinuous change.

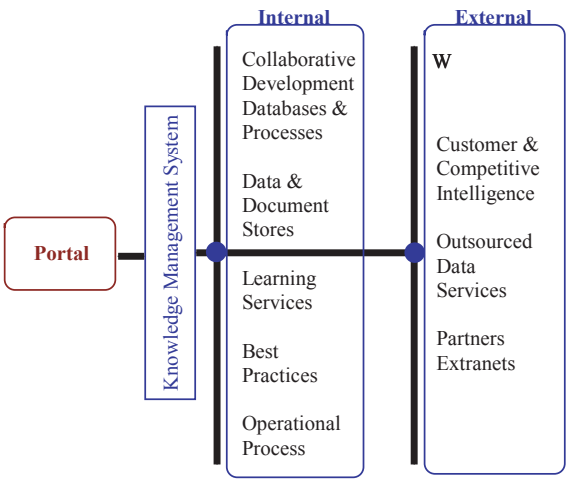
Thus, it makes sense that the organization that knows more about its customers, products, technologies, markets, and their linkages should perform better Gafni and Birch, 1993). Many organizations are drowning in information overload yet starving for knowledge. Knowledge management is believed to be the current savior of organizations, but its successful use entails much more than developing Lotus Notes' lessons learnt databases. Rather it involves the thoughtful design of various technologies to support the knowledge architecture of a specific organization (Wickramasinghe and Mills, 2001).

3.2 The Value of Knowledge Management To Healthcare Organizations

Knowledge management is a still relatively new phenomenon and a somewhat nebulous topic that needs to be explored. However, organizations in all industries, both large and small, are racing to integrate this new management tool into their infrastructure. Knowledge management caters to the critical issues of organizational adaptation, survival, and competence in the face of increasingly discontinuous environmental change (Rubenstein and Geisler 2003). Essentially, it embodies organizational processes that seek synergistic combination of data and information processing capacity of information technologies, and the creative and innovative capacity of human beings.

Knowledge management realizes the importance of safeguarding and using the collective knowledge and information of an organization. Through surveys, interviews, and analysis, knowledge management seeks to excavate, measure, assess, and evaluate the knowledge and information held within an organization with the intention of making the organization more efficient and profitable. Essentially, knowledge management sifts through the collective knowledge of an organization, codifies it into an information base, and then spreads it throughout the organization so it can be easily accessed (Wickramasinghe and Mills, 2001; Geisler, 2006).

Figure 1. Aspects of a generic knowledge management system and their importance in the organization



The knowledge management system is extremely helpful in internal and external sectors of an organization. Internally, knowledge management is designed to enhance the maintenance and organization of the data bases. Externally, it aims to make a better impact on the customer and external partners. Figure 1 depicts the importance of knowledge management in an organization.

3.3 The Role of Knowledge Management in Healthcare Organizations

The healthcare sector is characterized by its diversity and the distributiveness of its component organizations. There is a continuous process of generation of knowledge within each of these components (such as providers, patients, suppliers, payers, and regulators), as well as an immense volume of knowledge created at the interfaces among these organizations(Jadad et al., 2000; Pavia, 2001).

Healthcare provider organizations are special type of organizations in that they are for the most part motivated by topics such as quality and service, but without the profit drivers that animate private industry. At the same time they are highly professional institutions, populated by people with specialized knowledge that needs to be constantly updated, shared, and leveraged (van Beveren, 2003). This phenomenon creates even more pressure on healthcare providers and others in the sector to manage the knowledge that flows through the sector.

Although there has been little empirical investigation of how knowledge management benefits healthcare organizations, it is safe to assume that its contributions would be at least as positive as they are being shown in other sectors of the economy (Eid, 2005).

The role of knowledge management in healthcare organizations would be important in both clinical and administrative practices. Clinical care would be much more effective with increased sharing of medical knowledge and "evidence-based" experience within and among healthcare delivery organizations (Nykanen and Karimaa, 2006).

Administrative practices in healthcare organizations will benefit from the systemic interfaces of knowledge about technology, costs, "best-practices," efficiencies, and the value of cooperation. Such effects of knowledge creation and sharing would make it easier and more effective to manage the healthcare organization.

Finally, the role of knowledge management is especially crucial in the *interface* between the clinical and administrative functions. By and large these two categories of activities are separated by differentiations such as professional specializations, role in the organization, and goals and standards of practice. Hence, there is a tendency to avoid sharing knowledge and exchanging experience-based lessons so as not to upset the existing balance of power of the organization.

4.0 BARRIERS AND FACILITATORS TO THE ADOPTION AND IMPLEMENTATION OF KNOWLEDGE MANAGEMENT IN HEALTHCARE ORGANIZATIONS

There are four categories of barriers to the adoption and implementation of knowledge systems in healthcare organizations. The first is *technology* factors. These barriers are: (1) the attributes inherent in the technology, such as *compatibility* with other systems, *complexity*, and *trialability*; (2) *applicability* to the task for which the technology is being adopted; (3) *ease* of *maintenance*; (4) *quality* (in terms of errors, breakdowns, and non-responsiveness); and (5) ease of *updating* or *replacement*. Relative *ease of use* will impact the degree of implementation of the technology. Technologies that are very complex, not compatible with existing systems, or hard to maintain and to update or replace will be more difficult to adopt (Fichman and Kemerer, 1999; Kaplan, 1987).

The second category of barriers is the set of *organizational* barriers. These include the traditional barriers to technology adoption, such as political rivalries, lack of senior management support for such technology and innovation, and prior experience of the organization with similar types of technologies and their implementation. Unsuccessful past events tend to hinder any current attempts to adopt and implement technology.

In healthcare organizations there is also the added burden of the differences among organizational units in their assessment of needs for the technology and the hindering effects of the high specialization of clinical departments. The reality in such organizations is a considerable differentiation in how needs are assessed and what they mean to other units across the organization. Difficulties in establishing systemic value for a technology will hinder its adoption and implementation. Unless the technology under consideration has a wide appeal to a variety of clinical specialties (e.g., a diagnostic innovation), there will be resistance from other units and specialties to the adoption of a technology whose perceived value is restricted to a single clinical specialty (Scott et al., 2006).

A third category is *human factors*. These include cultural barriers, a complex learning curve needed to implement the technology, and unfavorable perception of the role of the technology, its value to the organization, and its chances of successfully contributing to tasks and goals of the organization Brender et al., 2006; Martens and Goodman, 2006).

In the healthcare environment there is also the impact of barriers inherent in the technological aptitudes of the clinical personnel, and their attitudes towards technological innovations in the practice of medicine (Laupacis, 1992). The usual formula for adoption of technologies by medical professionals is to follow other industries where such technologies have been implemented and successfully diffused. Only then would healthcare organizations assume the risk of adoption and their clinical personnel would be willing to adopt and implement.

The fourth and final set of barriers is the *economic factors* of the cost and cost-benefits of the technology. In the healthcare delivery environment capital expenditures for costly technological innovations are evaluated with extra care. An excellent case must be made for the value to be derived from the adoption of the technology before the purchase is authorized. It is less arduous for healthcare organizations to approve and adopt less costly technologies with widespread use in the organization.

4.1 Facilitators to Adoption and Implementation

The factors that seem to facilitate the adoption and implementation of healthcare technology are not necessarily the inverse or lack of barriers. They are affirmative factors that act to make the adoption and the implementation processes more feasible.

Two categories of these facilitating factors can be described. The first is the pressures that the external environment imposes on healthcare delivery organ izations(Wickramasinghe and Reddy, 2006). This includes such factors as the requirements imposed by payers and regulators for billing and reporting purposes. These requirements may be based on administrative and clinical procedures and methodologies that must be made possible with the adoption and implementation of innovative technologies. Thus, healthcare delivery organizations would feel compelled to act and to facilitate the adoption of these technologies.

The second category includes factors inherent in the processes of healthcare delivery and in the perceived need to make them more productive and more efficient. For example, medical errors are embedded in the processes of healthcare delivery. This problem may trigger and facilitate the adoption and implementation of technologies, whose purpose is to alleviate the problem (Institute of Medicine, 2001).

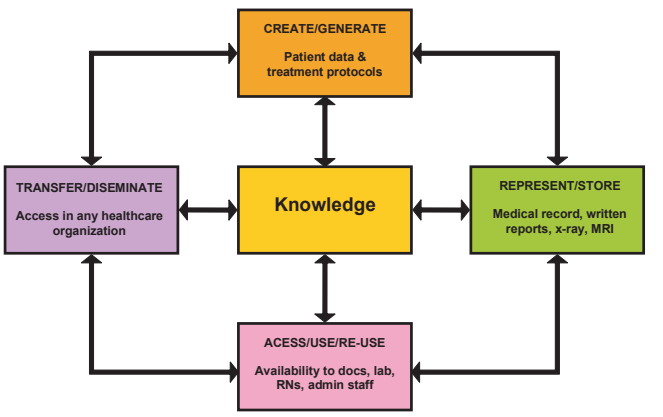
Another example includes the need to make procedures more efficient, due to such economic realities as "capitation," DRGs (Diagnosis Related Groups), and "managed care." When payors set limits to reimbursements for diagnoses and treatments, hospitals will explore ways to be more efficient and to reduce the cost of practice of medicine. Technology becomes one of the solutions, hence the impact of this situation as a facilitator of the adoption and implementation of healthcare technologies (Shakeshaft and Frankish, 2003; Nykanen and Karimaa, 2006; Kaplan, 1987).

5.0 CLINICAL EXAMPLE: OPERATING ROOM

The orthopaedic operating room represents an ideal environment for the application of a continuous improvement cycle that is dependant on the application of the tools and techniques of KM. For those patients with advanced degeneration of their hips and knees, arthroplasty of the knee and hip represent an opportunity to regain their function. Before the operation ever begins in the operating room, there are a large number of interdependent individual processes that must be completed. Each process requires data input and produces a data output such as patient history, diagnostic test and consultations. From the surgeon's and hospital's perspective, they are on a continuous cycle of addressing central issues regarding access, quality and value at the micro level, or individual patient level, as well as at the macro level, or monthly/yearly target level. The interaction between these data elements is not always maximized in terms of operating room scheduling and completion of the procedure. Moreover, as the population ages and patient's functional expectations continue to increase with their advanced knowledge of medical issues; reconstructive Orthopaedic surgeons are being presented with an increasing patient population requiring hip and knee arthroplasty. Simultaneously, the implants are becoming more sophisticated and thus more expensive. In turn, the surgeons are experiencing little change in system capacity, but are being told to improve efficiency and output, improve procedure time and eliminate redundancy. However, the system legacy is for insufficient room designs that have not been updated with the introduction of new equipment, poor integration of the equipment, inefficient scheduling and time consuming procedure preparation. Although there are many barriers to Re-Engineering the Operating Room such as the complex choreography of the perioperative processes, a dearth of data and the difficulty of aligning incentives, it is indeed possible to effect significant improvements through the application of the KM. Figure 2 outlines critical KM steps that become important in such a setting

The entire process of getting a patient to the operating room for a surgical procedure can be represented by three distinct phases: preoperative, intraopertive and postoperative. In turn, each of these phases can be further subdivided into the individual yet interdependent processes that represent each step on the surgical trajectory. As each of the individual processes are often dependant on a previous event, the capture of event and process data in a data warehouse is necessary. The diagnostic evaluation of this data, and the re-engineering of each of the deficient

Figure 2. The key steps of knowledge management



processes will then lead to increased efficiency. For example, many patients are allergic to the penicillin family of antibiotics that are often administered preoperative in order to minimize the risk of infection. For those patients who are allergic, a substitute drug requires a 45 minute monitored administration time as opposed to the much shorted administration time of the default agent. Since the antibiotic is only effective when administered prior to starting the procedure, this often means that a delay is experienced. When identified in the preoperative phase, these patients should be prepared earlier on the day of surgery and the medication administered in sufficient time such that the schedule is not delayed. This prescriptive reengineering has directly resulted from mining of the data in the information system in conjunction with an examination of the business processes and their flows. By scrutinizing the delivery of care and each individual process, increased efficiency and improved quality should be realized while maximizing value. For knee and hip arthroplasty, there are over 432 discrete processes that can be evaluated and reengineered as necessary through the application of a spectrum of KM tools and techniques (Wickramasinghe and Schaffer, 2006).

In terms of the four major categories of barriers and facilitators we identified earlier the case vignette of the operating orthopaedic OR exhibits instances of all of these. In each stage from pre-operative, intraopertive and finally postoperative various clinical and administrative technologies are necessary. By adopting the spectrum of KM tools and techniques what we find is that it becomes easier to monitor and evaluate these various technologies in action which in turn results in more effective use of the technology and efficient surgeries with heightened results. The continuous improvement also facilitates enhanced co-ordination between the various people, form surgeons, to nursing staff and even the patient, involved throughout the pre-operative, intraopertive and postoperative stages; once again with the result of superior operations and the achievement of the six quality aims outlined by the American Institute of Medicine(Institute of Medicine, 2001) and hence addresses many of the human and organizational barriers. Finally, in terms of economic factors, more efficient and effective performance as measured by faster throughput, higher quality and superior results together leads to a decrease in costs which are to a large extent due to the cumulative additive effect of various inefficiencies (Wickramasinghe and Scahffer, 2006).

6.0 DISCUSSION AND CONCLUSION

The preceding discussion has served to highlight the significance and key role for knowledge management in healthcare today. Specifically, this was done by discussing some of the major challenges facing healthcare today in terms of demographics, technology and finance and how KM tools and techniques might help to ameliorate this situation. In addition major barriers and facilitators were identified that must be considered when trying to implement an appropriate KM solution in helahtcare. Finally, an example of how beneficial the incorporation of such a perspective is in redesigning the current state of the orthopaedic OR to a future state of the OR was given. Taken together then, this paper serves to under score the importance of taking a holistic approach to addressing the challenges currently faced by healthcare. Furthermore, by focusing on diagnosing the current state and then finding appropriate solutions so it is possible to prescribe strategies to make the key inputs into the healthcare information system more effective and efficient it will then be possible to realize the value proposition for healthcare. While medical science has made revolutionary changes, healthcare in contrast has made incremental changes at best. The disparity between these two is one of the major reasons why today's healthcare industry is faced with its current challenges. We believe that by embracing the tools and techniques of KM it will be possible for healthcare to make evolutionary changes and thereby meet patients great expectations.

7.0 REFERENCES

Battista, R. and M. Hodge, 1999 "The Evolving Paradigm of Health Technology Assessment: Reflections for the Millenium," Canadian Medical Association Journal 160, no. 10, 1464-1468.

Brender, J. E. Ammenwerth, P. Nykonen and J. Talmon, 2006"Factors Influencing Success and Failure of Health Informatics Systems--A Pilot Delphi Study," Methods in Information Medicine 45, no. 1, 125-136.

Edwards,J. D. Shaw and P. Collier, 2005 "Knowledge Management Systems: Finding a Way with Technology," Journal of Knowledge Management 9, no. 1, 113-125.

Eger,M. R. L. Godkin and S. Valentine, 2001 "Physician's Adoption of Information Technology: A Consumer Behavior Approach," Health Marketing Quarterly 19, no. 2, 3-6.

Eid, R. 2005 "International Internet Marketing: A Triangulation Study of Drivers and Barriers in the Business-to-Business Context in the United Kingdom," Marketing Intelligence & Planning 23, no. 2/3, 266-281.

Fichman, R. and C. Kemerer, 1999 "The Illusory Diffusion of Innovation: An Examination of Assimilation Gaps," Information Systems Research 10, no. 3, 255-261.

Gafni, A. and S. Birch, 1993 "Guidelines for the Adoption of New Technologies: A Prescription for Uncontrolled Growth in Expenditures and How to Avoid the Problem," Canadian Medical Association Journal 148, no. 6, 913-922.

Geisler, E. 2006 "A Typology of Knowledge Management Transactions: Strategic Groups and Role Behavior in Organizations," Journal of Knowledge Management 11, no. 1 ((in press)).

Institute of Medicine, 2001 "Crossing the Chasm-A New Health System for the 21st Century," (National Academy Press, Washington, DC: Committee on Quality of Health Care in America).

Jadad, A. R. Haynes, D. Hunt and G. Brondman, 2000 "The Internet and Evidence-Based Decision Making: A Needed Synergy for Efficient Knowledge Management in Health Care," Canadian Medical Association Journal 162, no. 3, 362-367.

Kaplan, K. 1987 "The Medical Computing Lag: Perceptions of Barriers to the Application of Computers to Medicine," International Journal of Technology Assessment in Health Care 3, no. 1, 123-136.

Knight, W. 1998 Managed Care: What It Is and How It Works, AspenPublication, Maryland

Laupacis,A. 1992 "How Attractive Does a New Technology Have To Be To Warrant Adoption and Utilization? Tentative Guidelines for Using Clinical and Economic Evaluations," Canadian Medical Association Journal 146, no. 4, 473-486.

Martens, B. and A. Goodman, 2006 "The Diffusion of Theories: A Functional Approach," Journal of the American Society for Information Science and Technology 57, no. 3, 330-341.

Nykanen, P. and E. Karimaa, 2006 "Success and Failure Factors in the Regional Health Information System Design Process--Results From a Constructive Evaluation Study," Methods in Information Medicine 45, no. 1, 89-124.

Pavia, L. 2001 "The Era of Knowledge in Health Care," Health Care Strategic Management 19, no. 2, 12-13.

Purvis, R., V. Samamburthy and R. Zmud, 2001 "The Assimilation of Knowledge Platforms in Organizations: An Empirical Investigation," Organization Science 12, no. 2, 117-132.

Rubenstein, A. and E. Geisler 2003. Installing and Managing Workable Knowledge Management Systems, Westport, CT: Praeger Publishers.

Scott, T., T. Rundall, T. Vogt and J. Hsu, 2006 "Kaiser Permanente's Experience of Implementing an Electronic Medical Record: A Qualitative Study," British Medical Journal 331, no. 3 December, 1313-1316.

Shakeshaft, A. and C. Frankish, 2003 "Using Patient-Driven Computers to Provide Cost-Effective Prevention in Primary Care: A Conceptual Framework," Health Promotion International 18, no. 1, 67-77.

Van Beveren, J. 2003 "Does Health Care for Knowledge Management?," Journal of Knowledge Management 7, no. 1, 90-97.

Wickramasinghe, N. and G. Mills, 2001 "MARS: The Electronic Medical Record System. The Core of the Kaiser Galaxy," International Journal of Healthcare Technology & Management 3, no. 5/6 , 406-423.

Wickramasinghe, N. 2000 'IS/IT as a Tool to Achieve Goal Alignment : a theoretical framework' International J. HealthCare Technology Management Vol2. No. 1/2/3/4/, pp.163-180

Wickramasinghe, N. 2003 "IS/IT The Prescription To Enable Medical Group Practices To Manage Managed Care" with J.B. Silvers Health Care Management Science vol. 6 no 2 pp-75-86

Wickramasinghe, N. and H. Reddy, 2006 "Knowledge Management and Evidence-Based Medicine," Working Paper).

Xu, J. and M. Quaddus, 2005 "A Six-Stage Model for the Effective Diffusion of Knowledge Management Systems," The Journal of Management Development 24, no. 4, 362-374.

Aspects of Knowledge Transfer in eXtreme Programming

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ABSTRACT

The reason why software projects remain vulnerable to failure is essentially based on a knowledge management (KM) problem. One observation, however, is that the research in this area assumes, or is restricted to, traditional software development approaches. By excluding newer ways of developing software, such as agile software development, important aspects of KM in software engineering have been omitted. In this paper, a theoretical analysis of extreme Programming (XP) from a KM perspective is presented. The aim is to gain understanding of how the two fields relate but also to investigate to what extent aspects of KM can be beneficial to XP. The result shows that XP is more aligned with KM than expected. More importantly, the result suggests that a creative approach to KM can generate improved efficiency, higher productivity and higher quality in multi-team XP projects. A framework that can be used to analyse how XP supports KM in multi-team settings is also proposed.

1. INTRODUCTION

The failure and cancellation rate of software projects around the globe is still alarming. A significant number of the classic problems of delayed projects, cost overruns and meeting objectives keep being reported in surveys by for example the Cutter Consortium [10] and the Standish Group [20]. The question is why these problems remain, despite well-established knowledge about them.

Backlund [2] explains that the reason to why software projects remain vulnerable to failure is essentially based on a knowledge management (KM) problem. Organisations fail to learn from their own experiences. This is also supported by for example Ye and Fay [21], who argue that many software projects fail particularly because of the lack of knowledge transfer between the members of software project teams.

According to Backlund [2], the solution to this problem is to encourage software developers to learn from their own and others' experiences and to use this knowledge to change their development practices. Iivari [13], Ye and Fay [21] and Wastell [22] go even further and suggest that the software development process should be viewed as an ongoing learning process engaging both domain specialists and software professionals. There is plenty of research arguing for the importance of KM in software development activities. Much of the work in software engineering carried out over the last twenty years should confirm this fact [3]. One observation, however, is that the research in this area assumes, or is restricted to, traditional software development approaches. By excluding newer ways of developing software, such as agile software development [1], important aspects of KM in software engineering have been omitted.

The suggestions made by for example Backlund [2] and Wastell [22] perfectly agree with the principles of the Agile Manifesto, which clearly states the value of individuals and interactions and constant customer collaboration for successful software development project outcomes [1]. The agile principles of daily collaboration between business people and developers, of face-to-face conversation for conveying information and knowledge, of building projects around motivated individuals and of continuous reflection to adjust behavior are only a few examples demonstrating what needs to be in place for a software project to succeed. This makes the agile family of methods a promising candidate to investigate from a KM perspective. Moreover, by elucidating some of the general benefits and challenges of KM and by making them explicit to the agile community may provide insights that could further enhance agile methods, such as eXtreme Programming (XP) [4] [5].

In this paper, the result of a theoretical analysis of aspects of knowledge transfer in XP is presented as a first attempt to clarify and elucidate the relationship between these two domains. The analysis is based on XP as a representative of the group of agile software development methods because XP is the agile method that is most widely used [9][1].

2. WHY KM AND XP?

In today's competitive economy where many organisations uncover the most opportunities from intellectual rather than physical capital [14], it is crucial that knowledge is managed. Knowledge management in software teams is no exception. The large amount of knowledge acquired during software development, e.g. knowledge associated with the development process, the business domain of the project and the developed software [2][13] must be managed for several reasons: (a) as a means to help software development teams to be able to leverage that knowledge and (b) which can prevent software projects from failing as discussed previously [2] [21] [22]. The fact that, organisations that make sure that knowledge transfer is taking place in a systematic and controlled manner have shown to demonstrate great cost savings [6] [12] [14] [16], should be enough as argument in this context. More importantly, the argument applies to XP teams as well. XP is a minimalist, highly disciplined software development method, which when used appropriately, has a proven capability to produce planned results in a timely manner. However, potential method improvements can and should always apply. To be even more efficient, effective, productive and successful, XP teams need to be equipped with appropriate support to further improve and facilitate the development of software. This could, in certain contexts, be achieved by introducing and by clarifying the value of KM to XP. For example, in terms of supporting scalability of XP which is an issue that has been heavily debated over the past years, e.g. by Boehm and Turner [6], Cao et al. [7], Crocker [8], Paulk [17] and Reifer et al. [18]. In small co-located XP teams, managing knowledge and knowledge transfer may not be an issue, but for larger or distributed XP teams, it is believed that KM may provide valuable support for scaling XP. Effective management of knowledge between projects is another issue that calls for further exploration. For example, finding patterns or techniques, e.g. on the basis of retrospectives [21], for fine-tuning behaviour also in inter-project situations could help in achieving gains in performance. Thus, it is argued that a structured analysis of XP from a KM perspective is needed. It is important to gain understanding of how the two fields relate as well as to investigate to what extent aspects of KM can be beneficial to XP. In the following, the results of the first step towards this goal will be discussed.

3. CHALLENGES OF KNOWLEDGE TRANSFER

Knowledge is transferred in organisations everyday, in a controlled or/or uncontrolled way. Ideas exchanged by people in the hallways, information forwarded in emails or posted on notice boards are only a few examples of everyday knowledge transfer. The question is how an organisation or a team can transfer knowledge effectively so that the whole organisation or team can truly benefit from it.

There are several theories about how to control knowledge transfer. For example, Dixon [12] presents a spiral model specifying eight steps that must be taken for creating and leveraging knowledge within an organisation. The model specifies three criteria that determine how a particular transfer method will work in a particular situation. The three criteria: who the intended receiver is, nature of task and type of knowledge to be transferred have an impact on the choice transfer

method and how knowledge can be translated into a usable form [12]. Davenport's and Prusak's [11] reasoning about successful knowledge transfer involves the same ideas. When knowledge is to be transferred, the transfer method must always suit the culture and this involves considering factors that have an impact on the transferring process, such as the kind of knowledge to be transferred and the culture of the team [11]. The latter have also identified a set of common cultural factors, "frictions", which challenge effective knowledge transfer. In Table 1, the frictions and possible solutions to prevent these frictions from occurring are summarised [11].

4. ANALYSIS OF XP FROM A KM PERSPECTIVE

KM is a large multi-disciplinary field. Therefore, it necessarily covers a larger domain than relevant for the analysis focused on in this paper. For example, it specifies a number of areas that primarily describe KM practices and activities from a business and managerial point of view, which are not always specific to software engineering or XP [11][12][14][16]. However, this research aims at clarifying and elucidating the relationship between KM and XP, starting with an investigation to determine whether, and to what extent, XP deals with some of the major challenges of effective knowledge transfer as presented in Table 1 [11]. Consequently, the analysis focuses on this topic.

XP is analysed as a whole method, including its values, principles and primary practices [5]. However, individual parts of XP are discussed when specifically addressing any of the cultural frictions. In Table 2, a summary of the results of the analysis is presented. In the second column, the XP values, principles and practices that are comparable to the solutions suggested by Davenport and Prusak [11] are indicated.

According to Davenport and Prusak [11], the values, norms and behaviours that make up a team's culture are the principal determinants of how successfully important knowledge is created and transferred. This analysis shows that all the XP values, principles and primary practices are in various degree counterparts to the solutions to effective knowledge transfer [11]. In the following subsections an accompanying motivation for the results in Table 2 is presented.

4.1 Values

All of the frictions that can inhibit effective knowledge transfer are accounted for in the values of XP. Lack of trust, lack of time and meeting points, having people from different cultures on the team, intolerance for mistakes and beliefs that knowledge is ascribed to certain individuals or groups [11] are covered by the values of communication, respect, feedback, courage and simplicity [4] [5].

Table 1. Cultural factors that inhibit knowledge transfer and possible solutions [11]

FRICTION	POSSIBLE SOLUTIONS
Lack of trust	Build relationships and trust through face-to-face meetings
Different cultures, frames of reference, vocabularies	Create common ground through education, discussion, teaming, publications, job rotation
Lack of time and meeting places	Establish times and places for knowledge transfers: talk rooms, fairs, conference reports
Status and rewards go to knowledge owners	Evaluate performance and provide incentives based on sharing
Lack of absorptive capacity in recipients	Educate employees for flexibility; provide time for learning; hire for openness to ideas
Belief that knowledge is prerogative of particular groups, "not invented here-syndrome"	Encourage non-hierarchical approach to knowledge; quality of ideas more important than status of source
Intolerance for mistakes or need for help	Accept and reward creative errors and collaboration; no loss of status from not knowing everything

Table 2. How XP deals with "frictions", i.e. with barriers to effective knowledge transfer

FRICTION	XP		
	Values	**Principles**	**Practices**
Lack of trust	Communication; Respect; Courage; Feed-back	Humanity; Mutual benefit; Accepted responsibility; Improvement; Reflection; Opportunity	Whole team; Sit together; Informative workspace; Pair programming; Slack
Different cultures, frames of reference, vocabularies	Communication; Respect; Courage; Feed-back; Simplicity	Humanity; Diversity; Mutual benefit; Improvement; Reflection; Opportunity	Whole team; Sit together; Informative workspace; Pair programming; Stories; Test-first programming
Lack of time and meeting places	Communication; Respect; Feed-back; Simplicity; Courage	Mutual benefit; Diversity; Improvement; Reflection; Opportunity	Whole team; Sit together; Informative workspace; Pair programming; Weekly/Quarterly cycles
Status and rewards go to knowledge owners	Respect; Feed-back; Communication; Courage	Humanity; Failure; Mutual benefit; Reflection; Opportunity	Whole team; Sit together; Informative workspace; Pair programming; Weekly/Quarterly cycles; Continuous integration
Lack of absorptive capacity in recipients	Communication; Respect; Feed-back; Courage; Simplicity	Humanity; Failure; Mutual benefit; Reflection; Opportunity	Whole team; Sit together; Informative workspace; Pair programming
Belief that knowledge is prerogative of particular groups, "not invented here-syndrome"	Respect; Communication; Feed-back; Courage; Simplicity	Humanity; Failure; Mutual benefit; Reflection; Opportunity; Improvement	Whole team; Sit together; Informative workspace; Pair programming
Intolerance for mistakes or need for help	Respect; Communication; Feed-back; Courage; Simplicity	Humanity; Failure; Mutual benefit; Reflection; Opportunity; Improvement	Whole team; Sit together; Informative workspace; Pair programming; Test-first programming

Communication in XP means building relations by conveying information to and within a development team through openness and steady face-to-face conversation, which prevents frictions such as lack of trust and lack of understanding from occurring.

Feedback is closely related to communication and addresses the value of keeping the project and the team on track. It is also emphasised that feedback is most useful if it is done rapidly. The time between an action and its feedback is critical to learning and the ability to making any changes or corrections needed [4]. In this respect, XP encourages effective knowledge transfer, knowledge creation and the establishment of learning environments. More importantly, the overall goal of communication and feedback is to achieve a shared understanding among team members to strengthen teambuilding and the feeling of shared project responsibility, which prevents status and rewards from going to knowledge owners but which also discourages a hierarchical approach to knowledge.

To accomplish good communication and feedback requires respect and tolerance among team members. Therefore, respect is one of the core values in XP. By respecting other peoples' backgrounds and frames of reference, common grounds for constructive collaboration, discussion and knowledge and information exchange can be built. In this context, respect also mitigates the risk for intolerance for mistakes. XP instead pushes for creativity and time for learning. Errors are regarded as a mechanism to learning rather than failure. To be creative and to learn new things also requires courage, which is emphasised through the value of courage in XP.

Related to all the previous values is simplicity, which facilitates communication, feedback as well as courage. For example, a simple design with very simple code or simple documentation can be easily understood by every person in the team, whether a customer or programmer, which also provides a foundation for effective knowledge transfer.

4.2 Principles

The XP principles can be regarded as counterparts to the solutions to overcome cultural frictions in knowledge transfer presented by Davenport and Prusak [11]. The XP principles of humanity, mutual benefit, diversity, failure, reflection, opportunity and improvement are particularly comparable to common ways of resolving cultural problems of knowledge transfer.

The principle of humanity signifies the need to meet basic human needs in projects, such as building relationships and connection, which is primarily accomplished by communication in XP. The most effective way to communicate is through face-to-face conversation because conversation allows dialogue, i.e. it allows explanation, clarification and direct feedback. In this respect, humanity facilitates building relationships which creates incentives to share ideas and knowledge and therefore amplifies knowledge transfer. Davenport and Prusak [11] state that conversation is fundamental to knowledge transfer because it provides a simple way to discover what people know and to share knowledge with colleagues, which results in new or improved knowledge for the whole organisation.

The principle of mutual benefit is probably the most important of all the XP principles. Basically, it means maintaining good working relationships in a project team. By making sure that everyone on a project team are benefited from any project activities, e.g. documentation, provides a starting place for good working environments and gives a concrete incentive for people to share and exchange ideas.

The principle of diversity suggests that effectiveness comes from teams where people come from different backgrounds, with different skills and perspectives. The key is, at any stage of the project, to make people with important or necessary skills available as a resource for a project to succeed. This principle therefore undoubtedly encourages knowledge transfer.

Failure is another principle that clearly encourages knowledge transfer. More specifically, this principle addresses the problem of intolerance for mistakes or need for help which can inhibit effective knowledge transfer. Because valuable knowledge can sometimes be difficult to obtain, one way is to try out different solutions where failure can provide an important learning mechanism [5].

Related to failure are the principles of opportunity, reflection and improvement. In XP, improvement is imperative. To reach quality and excellence, problems need to be seen as opportunities for change, for learning and for improvement. For this to take place, a team needs to reflect on their work, i.e. on how they work. This is realised through project retrospectives [19] or similar techniques, which include analysing factors of success and failure and to openly expose them and to learn from them.

4.3 Practices

The practices of XP can be viewed as "techniques for rapidly building and disseminating knowledge among members of a development team" [5], where the goal is to have all team members share the same view and expectations of the system and the project. As indicated in Table 2, this is primarily achieved by the XP practices of whole team, sitting together, informative workspace, stories, incremental design and pair programming. The first three practices are tightly interrelated. The basic idea of whole team in XP is that the team consists of people with the all skills and knowledge necessary for a project to succeed, which includes both customers and developers. The aim is also to build projects around motivated individuals who share the responsibility for supporting each other's work and the growth and learning of the whole team [5].

The practice of whole team is reinforced by the practice of sitting together. In XP, the whole team works co-located in an open space, which provides time for physical proximity and for meeting and discussing face-to-face. It is argued that the more time the team works physically co-located, the more humane and productive the project [5]. By working together and physically closer to each other improves communication, makes it easier to build relationships and naturally establishes time and places for knowledge transfers, which are keys to overcome many of the cultural barriers to effective knowledge transfer.

In addition, the practice of informative workspace, e.g. a big visible chart, does not only convey project related information to any interested stakeholder, it also serves as a natural meeting point at any time because this is where an XP team gathers for the daily stand-up meeting [4], for project planning or for any discussion for that matter. This prevents a situation where difficulties with finding meeting places would occur. Furthermore, the fact that informative workspaces are visible and open to everyone provides a mechanism for spreading information and knowledge itself, which is also reflected by the name of the practice. In this way, also the problem of beliefs that information or knowledge is sanctioned to particular people, i.e. the "not invented here-syndrome" [11], is solved.

Stories create common ground for discussion and exchanging ideas and knowledge about the system to be developed. Stories also help the team to find common vocabularies and to define a common frame of reference which facilitates knowledge transfer.

From a knowledge transfer perspective, the XP practices of incremental design, weekly and quarterly cycle allow a team to collect information, learn the system and the technology and understand customer needs in small, iterative steps. Such an approach provides time for feedback and for making timely changes and refinements rather than making early design decisions based on speculative guesses which can have a negative impact on the learning process as well as on the project results.

Pair programming involves many well-known knowledge transfer techniques, such as pair work, shadowing and mentoring [12]. More specifically, pair programming provides space for dialogue between two persons and aims to increase overall quality by offering team members the possibility to clarify ideas, exchange knowledge and help each other with the tasks at hand. This is regarded best practice for transferring or recreating tacit knowledge [14]. With shadowing for example, a less experienced developer observes more experienced developers in their activities to learn how their more experienced counterparts approach their work. By discussing his or her observations with the expert, tacit knowledge is made explicit and knowledge transfer is truly achieved [14]. In addition, as all pairs in an XP team rotate on a regular basis enables spreading knowledge about the project throughout the entire team which mitigates the risk of loosing critical knowledge if a person would leave the team.

5. CONCLUSIONS

To successfully transfer an individual's knowledge in practice, a team must actively work out ways to make personal knowledge available to others. This is a central activity in the knowledge creating company [16]. By providing guidance on how to build relationships, create incentives for sharing knowledge, build up acceptance for creative errors and for learning in software projects, this analysis shows that good support for knowledge creation and knowledge transfer can be identified in all the values, principles and practices of XP. More specifically,

based on this analysis, our conclusion is that within a single team XP practices are sufficient for KM and no separate KM is needed. Based on our experiences, the real KM challenge lies in how to share the knowledge created in XP teams with other parts of the organisation. By using the framework used in this analysis it would be possible to analyse how XP supports KM in multi-team settings. Our understanding is that XP does not support KM in these cases. More specifically, the result gives substantial support to an underlying hypothesis that KM can provide valuable support to large XP teams, thereby facilitating scalability - an issue that has been heavily debated over the past years. If the hypothesis were verified, the KM effects measured and empirically validated would provide a good foundation for designing recommendations for how to use KM when scaling up XP.

REFERENCES

[1] Agile Manifesto, Agile Manifesto. URL: http://www.agilemanifesto.org. Accessed in June 2005.

[2] Backlund P., Development Process Knowledge Transfer through Method Adaptation, Implementation and Use. Institutionen för Data och Systemvetenskap, Stockholms Universitet/KTH, Sweden, Ph D Thesis, 2004.

[3] Basili V., Caldiera, G., and Rombach D., The Experience Factory. Encyclopedia of Software Engineering - 2 Volume Set, pp.469-476, 1994.

[4] Beck K., Extreme Programming Explained: Embrace Change. Addison-Wesley, 2000.

[5] Beck K., Extreme Programming Explained: Embrace Change. 2nd Edition. Addison-Wesley, 2004.

[6] Burke G. and Howard W., Knowledge Management and Process Improvement: A Union of Two Disciplines. URL: http://www.stsc.hill.af.mil/crosstalk/2005/06/0506Burke.html. Accessed in December 2005.

[7] Cao L. et al., How Extreme does Extreme Programming have to be? Adapting XP Practices to Large-scale Projects. Proceedings of the 37th Hawaii International Conference on System Sciences, 2004.

[8] Crocker R., The Five Reasons XP Can't Scale and What to Do About Them. URL: www.agilealliance.org/articles/ articles/FiveReasonsXPCantScale.pdf. Accessed in June 2003.

[9] Charette R., The Decision is in: Agile versus Heavy Methodologies. Agile development and Project Management, Cutter Consortium, Vol. 2 (19), URL: www.cutter.com/freestuff/epmu0119.html. Accessed in February 2004.

[10] Cutter Consortium, URL: http://www.cutter.com/research/2004/edge040427.html. Accessed in June 2005.

[11] Davenport T. and Prusak L., Working Knowledge: How Organisations Manage What They Know. Harvard Business School Press, 1998.

[12] Dixon N., Common Knowledge: How Organisations Thrive by Sharing What They Know. Harvard Business School Press, 2000.

[13] Iivari J., Informations Systems Development as Knowledge Work: The Body of Systems Development Process Knowledge. In Information Systems Modelling and Knowledge Bases XI. (Eds. Kawaguci E. et al.), IOS Press, 2000.

[14] Levinson M., The ABCs of Knowledge Management. CIO Magazine, URL: http://www.cio.com/research/knowledge/edit/kmabcs.html#support. Accessed in December 2005.

[15] Marwick Alan D., Knowledge Management Technologies. IBM Systems Journal, Knowledge Management, Vol. 40 (4), 2001.

[16] Nonaka I., The Knowledge Creating Company. Originally published in December 1991. Reprint 91608, Harvard Business Review on Knowledge Management Paper Back Series. Harvard Business School Press, 1998.

[17] Paulk M., Extreme Programming from a CMM Perspective. IEEE Software, Vol. 18 (6), 2001.

[18] Reifer D.J., Maurer F. and Erdogmus H, Scaling Agile Methods. IEEE Software, Vol. 20 (4) pp.12-14, 2003.

[19] Rising L., Patterns and Retrospectives. *Cutter IT Journal*, Vol. 16 (9), 2003. URL: http://members.cox.net/risingl1/articles/Cutter.pdf. Accessed in July 2005.

[20] Standish Group, CHAOS Report. URL: http://www.standishgroup.com/sample_research/chaos_1994_1.php. Accessed in June 2005.

[21] Ye Y. and Fay R., Knowledge Transfer through Asymmetric Pair Programming. URL: http://www.agilealliance.org/articles/articles/AsymmetricPairProgramming.pdf. Accessed in June 2005.

[22] Wastell D. G., Learning Dysfunctions in Information Systems Development: Overcoming the Social Defenses with Transitional Objects. MIS Quarterly, Vol. 34 (4), 1999.

ENDNOTE

[1] XP and its values, principles and practices will not be presented in detail, but we refer to Beck [4][5] when any specific XP concepts are used in the paper.

Adapting Supervised Feature Selection Methods for Clustering Tasks

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ABSTRACT

In this paper, we elaborate on how feature selection methods traditionally used in classification problems can be adapted for clustering problems, assuming that the number of clusters is not known a priori. Computational complexity of each described algorithm is provided. Empirical results in six bioinformatics datasets illustrate that the adaptation of four well-known supervised methods for feature selection (correlation-based, consistency-based, wrapper of k-NN classifier, and C4.5) can be useful for clustering tasks.

1. INTRODUCTION

Successful data mining applications depend on several factors. The availability of suitable feature selection methods is one of such factors. Feature selection involves choosing a subset of original variables (attributes) by eliminating the redundant, uninformative, and noisy ones. This issue has been broadly investigated in supervised learning tasks for which datasets with many features are available, like in text mining and gene expression data analysis. Under this perspective, there are many potential benefits of feature selection like, for instance [3]: facilitating data visualization and understanding, reducing the measurement and storage requirements, reducing training and utilization times, and defying the curse of dimensionality. Many of these benefits can also be achieved in unsupervised learning (clustering). However, most of the existing supervised methods for feature selection rely on assessing how well some features discriminate among a set of predefined classes. These classes are not available in clustering tasks, in which one seeks to identify a finite set of categories (clusters) to describe a given dataset. In this sense, it is difficult to assess the relevance of a subset of features for describing classes that are not known a priori. Since the optimal number of clusters and the optimal feature subset are inter-related, the feature selection task becomes even more challenging when the number of clusters is unknown [7], which is our assumption in this work.

Although many algorithms for clustering have been proposed in the literature, relatively little work has been done on feature selection for clustering [2][7]. Most clustering methods assume that all features are equally important [2]. However, some features may be more important than others for inducing clusters. In these cases, feature selection methods can be useful. Liu and Yu [9] provide a comprehensive survey of feature selection algorithms for classification and clustering. In brief, there are two fundamentally different approaches for feature selection [8]: wrapper and filter. The former evaluates the subset of selected features using criteria based on the results of clustering algorithms, i.e., the clustering method is wrapped into the feature selection procedure. The latter involves performing feature assessments based on intrinsic properties of the data. These properties are presumed to affect the performance of the clustering algorithm, but they are not a direct measure of its performance, i.e., the feature set is filtered without considering the clustering algorithm that will be ultimately used. In general, filters are less computationally expensive than wrappers, which may be superior in relation to the quality of the clusters found. It is also possible to combine filters and wrappers, obtaining hybrid approaches. Doing so, one can expect to have a reasonable tradeoff between efficiency (computational effort) and efficacy (partition quality). In this sense, we here elaborate on how feature selection methods traditionally used in classification problems can be adapted for clustering tasks.

2. CLUSTERING ALGORITHM

We assume that *clustering* involves the partitioning of a set $\mathbf{X}$ of instances into a collection of mutually disjoint subsets $\boldsymbol{C}_i$ of $\mathbf{X}$. Formally, let us consider a set of N instances $\mathbf{X}=\{\mathbf{x}_1,\mathbf{x}_2,...,\mathbf{x}_N\}$ to be clustered, where each $\mathbf{x}_i \in \Re^\rho$ is a vector consisting of ρ measurements. The instances must be clustered into non-overlapping groups $\mathbf{C}=\{\mathbf{C}_1,\mathbf{C}_2,...,\mathbf{C}_k\}$ where k is the number of clusters, such that:

$$\mathbf{C}_1 \cup \mathbf{C}_2 \cup ... \cup \mathbf{C}_k = \mathbf{X}\ ,\ \mathbf{C}_i \neq \varnothing, \text{ and } \mathbf{C}_i \cap \mathbf{C}_j = \varnothing \text{ for } i \neq j. \quad (1)$$

After partitioning the dataset, instances that belong to the same cluster should be more similar to each other than instances that belong to different clusters. Therefore, it is necessary to devise means of evaluating similarities between instances. This problem is often tackled indirectly, i.e. distance measures are used to quantify dissimilarities between instances. Several dissimilarity measures can be used for clustering tasks. We here use the Euclidean distance.

The simplified silhouette [5] is used for estimating the number of clusters. Before describing the *simplified silhouette*, let us introduce the silhouette proposed in [6]. Consider an instance i belonging to cluster $\mathbf{A}$. So, the average dissimilarity of i to all other instances of $\mathbf{A}$ is denoted by $a(i)$. Now let us take into account cluster $\mathbf{C}$. The average dissimilarity of i to all instances of $\mathbf{C}$ will be called $d(i,\mathbf{C})$. After computing $d(i,\mathbf{C})$ for all clusters $\mathbf{C} \neq \mathbf{A}$, the smallest one is selected, i.e. $b(i) = \min d(i,\mathbf{C})$, $\mathbf{C} \neq \mathbf{A}$. This value represents the dissimilarity of i to its neighbor cluster, and the silhouette $s(i)$ is:

$$s(i) = \frac{b(i) - a(i)}{max\{a(i)\ b(i)\}} \quad (2)$$

The higher $s(i)$ the better the assignment of instance i to a given cluster. In addition, if $s(i)$ is equal to zero, then it is not clear whether i should have been assigned to its current cluster or to a neighboring one. Finally, if cluster $\mathbf{A}$ is a singleton, then $s(i)$ is not defined and the most neutral choice is to set $s(i) = 0$ [6]. The average of $s(i)$ over $i = 1,2,...,N$ can be used as a criterion to assess the quality of a given partition. Doing so, the best data partition is achieved when the silhouette is maximized.

The original silhouette [6] depends on the computation of all distances between instances, leading to a computational cost of $O(N^2)$, which is often not sufficiently efficient for real-world applications. To circumvent this limitation, a *simplified silhouette* can be used. The simplified silhouette (SS) [5] is based on the computation of distances between instances and cluster centroids. More specifically, the term $a(i)$ of Eqn. (2) becomes the dissimilarity of instance i to its corresponding cluster ($\mathbf{A}$) centroid. Similarly, instead of computing $d(i,\mathbf{C})$ as the average dissimilarity of i to all instances of $\mathbf{C}$, $\mathbf{C}\neq\mathbf{A}$, distances between i and the centroid of $\mathbf{C}$ are computed. While these modifications reduce the computational cost from $O(N^2)$ to $O(N)$, empirical results [5] suggest that the partition quality may be not significantly affected.

The computation of the original silhouette [6], as well as of its *simplified* version [5], only depends on the partitions found. Therefore, such silhouettes can be applied

to assess partitions found by several clustering algorithms. We adopt the *k*-means algorithm to obtain partitions to be evaluated by the simplified silhouette (SS). Roughly speaking, *k*-means is designed to minimize the sum of distances between instances and nearest centroids. From the SS criterion viewpoint, good partitions are also obtained when this minimization is suitably performed, as well as when the clusters are well separated. Thus, although other clustering algorithms could be used, our approach favors a synergy between *k*-means and SS. In particular, we perform multiple runs of *k*-means (for different values of *k*) and then choose the best obtained partition according to the SS value. It is also known that *k*-means may get stuck at suboptimal solutions for a given *k*. To alleviate this limitation, one can perform multiple runs of *k*-means for a fixed *k*. Fig. 1 summarizes the sampling strategy here used to find data partitions. The *correct* number of clusters k^* is automatically estimated by means of the simplified silhouette.

Provided that the computational cost of *k*-means is $O(t \cdot k \cdot \rho \cdot N)$, where *t* is the number of iterations, the overall computational cost of the sampling strategy for *k*-means (Fig. 1) is estimated as $O((k_{max} - k_{min}+1) \cdot np \cdot (t \cdot k \cdot \rho \cdot N))$. In what concerns the minimum and maximum number of clusters (k_{min} and k_{max}, respectively) let us assume a scenario in which domain knowledge is not available. In such a scenario, searching for a solution in a suitable subset of the search space in terms of *k* is desirable. To that end, a rule of thumb [11] involves choosing values for *k* from the set $\{2,...,N^{1/2}\}$. Then, the resultant overall computational cost of the used sampling strategy for *k*-means is estimated as $O(\rho \cdot N^2)$ - assuming that the number of assessed partitions, *np*, and the number of *k*-means iterations, *t*, are significantly less than *N*. From this point of view, if domain knowledge regarding k^* (or a range for its probable values) is available and $k^* << N$, then the resultant overall computational cost of the used sampling strategy for *k*-means is estimated as $O(\rho \cdot N)$.

So far, we have described a procedure to find data partitions (the *correct* number of clusters k^* is estimated according to the SS criterion), assuming that a set of ρ features is provided. In the next section, we discuss how feature selection methods traditionally used in classification problems can be adapted for clustering problems.

3. METHODS FOR FEATURE SELECTION

Most of the commonly used supervised methods for feature selection rely on assessing how well some features discriminate among a set of predefined classes, which are not known in clustering problems. Therefore, supervised feature selection methods cannot be directly applied in these problems. However, the difficulty originated from the lack of information concerning the classes can be circumvented by assuming that a set of clusters can be modeled as being a set of different classes. Doing so, supervised methods can be adapted for selecting features in clustering tasks. In our work, we hypothesized that supervised methods can be used to determine the relevant features that model a set of clusters obtained by *k*-means. In this sense, a simple alternative involves running *k*-means for all available features and then select the relevant ones according to their importance to the found clusters. Although this approach is reasonable, the optimal number of clusters and the optimal feature subset are often inter-related [7]. Since we assume that the number of clusters is not known a priori, i.e., it is estimated by the silhouette-based clustering method (Fig. 1), we believe that an exploratory approach is better suited for our purposes.

An exhaustive search for all the possible feature subsets is often computationally intractable – the order of the search space is $O(2^p)$. Thus, sequential search algorithms (e.g. forward, backward, and bidirectional) are widely used. Forward methods tend to be particularly problematic when supervised methods are adapted for clustering problems, mainly because it is difficult for them to select feature subsets that are good *copredictors* of the clusters if none of these *copredictors* is a good *predictor* of the clusters by itself [1]. In these cases, backward selection can succeed because it works by eliminating features rather than successively adding them. However, backward methods are often less efficient than forward methods. Although the approach here used does not strictly conform to the commonly used categorization for sequential selection, it can be viewed as a backward method, because it removes features from an initially complete set, as presented in the algorithm illustrated in Fig. 2. This algorithm was designed for exploring the interactions between clustering results (i.e., number of clusters and corresponding partitions) and selected features. As discussed in Section 2, the computational complexity of step 2 is estimated as $O(\rho \cdot N^2)$ when $k_{min}=2$ and $k_{max}=N^{1/2}$ – assuming that domain knowledge is not available to set *k*. Let us call *I* the number of iterations of the algorithm depicted in Fig. 2. Thus, with a little notation abuse, the overall computational cost of this algorithm is $O(I \cdot [\rho \cdot N^2 + M])$, where *M* is the computational cost of each particular feature selection used in step 3. In the following, we briefly describe four well-known supervised feature selection methods that can be used in this step.

3.1 Correlation Feature Selection (CFS)

Correlation-based feature selection (CFS) [4] evaluates subsets of features by means of a heuristic that considers the usefulness of individual features for predicting the class (in our case cluster labels represent the classes) along with the level of inter-correlation among them. Let $\bar{r}_{cf}$ be the average feature-class correlation and $\bar{r}_{ff}$ be average feature-feature inter-correlation. The $Merit_s$ of a feature subset S containing ρ_s features is given by:

$$Merit_s = \frac{\rho_s \cdot \bar{r}_{cf}}{\sqrt{\rho_s + \rho_s \cdot (\rho_s - 1) \cdot \bar{r}_{ff}}} \quad (3)$$

The numerator estimates the prediction capability of the features in S in relation to the cluster, whereas the denominator indicates the redundancy level among them. The correlation between two discrete random variables (features) X and Y is computed according to the Symmetrical Uncertainty (SU):

$$SU = 2 \cdot \frac{H(Y) - H(Y|X)}{H(Y) + H(X)} \quad (4)$$

Figure 1. Sampling strategy for k-means

1. Choose k_{min}, k_{max}, and *np*.
2. SSV← -1; / SSV = Simplified Silhouette Value /
3. For each $k \in \{k_{min},...,k_{max}\}$ do:
   3.1 Generate *np* random initial partitions of instances into *k* nonempty clusters;
   3.2 Run *k*-means for each initial partition generated in step 3.1, and compute its corresponding simplified silhouette. Let the best obtained value be BOV;
   3.3 If (BOV>SSV) then {
   SSV←BOV;
   $k^* \leftarrow k$;
   Hold the corresponding partition for k^*.
   }
4. Return SSV and its corresponding data partition for k^*.

Figure 2. Adapting supervised feature selection for k-means

Let the complete feature set be *C,* and the feature subsets obtained in two consecutive iterations be *S'* and *S''*. The algorithm for feature selection can be summarized as:

1. *S'*← *C*; / initially all features are used to get partitions /
2. Run the adopted sampling strategy for *k*-means considering the feature subset *S'*;
3. *S''* ← {feature subset achieved from supervised selection, for which the clusters of the current partition are considered classes};
5. If (*S''*=*S'*) then:
   5.1 Hold the current partition and the respective feature subset;
   5.2 Stop.
   Else (S'← S'' & go to Step 2);

where *H(Y)* and *H(Y/X)* are given by equations (5) and (6) respectively:

$$H(Y) = -\sum_i p(y_i)\log_2 p(y_i) \quad (5)$$

$$H(Y|X) = -\sum_j p(x_j)\sum_i p(y_i|x_j)\cdot\log_2 p(y_i|x_j) \quad (6)$$

where $p(x_j)$ is the probability for values of *X*. Numeric features are discretized before computing correlations, and a forward selection technique is used to search for the feature subset. The complexity of CFS can be estimated as $M=O(\rho^2 \cdot N)$, then the total computational cost of the algorithm depicted in Fig. 2 is estimated as $O(I\cdot[\rho\cdot N^2+\rho^2\cdot N])$ when CFS is used in step 3.

3.2 Consistency-based Evaluation (CBE)

Liu and Setiono [10] propose that two instances are inconsistent if they match except for their class labels. Assuming that *NC* is the number of distinct combinations of feature values for a given subset of features *S*, the consistency of this subset can be measured by:

$$Consistency_S = 1 - \frac{\sum_{i=1}^{NC}(|D_i| - |M_i|)}{N} \quad (7)$$

where $|D_i|$ and $|M_i|$ are the number of occurrences of the *i*th feature value combination and the cardinality of the majority class, respectively. *N* is the number of dataset instances. Numeric features are discretized before computing the consistency of a given set of features *S*, and a forward selection technique is used to search for the subset of features. The overall computational cost of the algorithm depicted in Fig. 2 is estimated as $O(I\cdot[\rho\cdot N^2+\rho^2\cdot N])$ when CBE is used in step 3.

3.3 Wrapper of k-NN Classifier (W-KNN)

This method uses the *k*-Nearest Neighbor (*k*-NN) classifier [1] as the target learning algorithm to assess the quality of subsets of attributes by means of a forward selection based search. Each feature subset is evaluated according to the *k*-NN accuracy achieved in cross-validation procedure. The *k*-NN classifier was chosen because it is a distance-based method. Since the clustering method used in this work is also based on the computation of distances between instances, a synergy between feature selection and clustering can be favored. The incorporation of W-KNN in the algorithm summarized Fig. 2 leads to a computational cost estimated as $O(I\cdot\rho^3\cdot N^2)$.

3.4 C4.5 Decision Tree

The *C4.5* [12] classifier performs feature selection as part of a decision tree building process, in which a subset of features is selected according to an information gain criterion. We assume that the features selected by *C4.5* can also be interesting to model the clusters of a given partition. More precisely, features selected by *C4.5* will form *S´´* in step 3 of the algorithm in Fig. 2. The overall computational cost of the resultant algorithm is estimated as $O(I\cdot\rho\cdot N^2)$.

3.5 Computational Complexity Summary

It is expected that the number of iterations (*I*) of the algorithm depicted in Fig. 2 is significantly less than both ρ and *N*. Indeed, the experimental results to be reported in the next section somehow support this claim. Considering that this assumption is reasonable, Table 1 summarizes the overall computational costs of the feature selection methods here used (2nd column). In the last column we provide corresponding estimates for applications in which domain knowledge is available to set the number of clusters (see discussion in Section 2 for further details).

Table 1. Time complexity summary

Method	k_{min}=2 and $k_{max}=N^{1/2}$	Domain knowledge
CFS	$O(\rho\cdot N^2+\rho^2\cdot N)$	$O(\rho^2\cdot N)$
CBE	$O(\rho\cdot N^2+\rho^2\cdot N)$	$O(\rho^2\cdot N)$
W-KNN	$O(\rho^3\cdot N^2)$	$O(\rho^3\cdot N^2)$
C4.5	$O(\rho\cdot N^2)$	$O(\rho\cdot N\cdot log_2 N)$

4. EMPIRICAL EVALUATION

The assessment of clustering accuracy often requires datasets for which the clusters are a priori known. We have performed experiments in six bioinformatics datasets [13]. Five datasets, here called Bio1, Bio2, Bio3, Bio4, and Bio5, are composed of 400 genes (instances) described by 20 measurements (features). These are formed by synthetic data with error distributions derived from real-world data, and contain six approximately equal-sized clusters. In addition, we have used a real-world dataset (*yeast galactose*) that is composed of 20 measurements and 205 genes. In this dataset, the expression patterns reflect four functional categories (clusters). The datasets used in the experiments reported here take into account four repeated measurements. From now on, the correct clusters will be called classes, whereas the term cluster will refer to each group of similar instances found by a clustering algorithm. However, although the class corresponding to each gene is known a priori, this information was not used in the clustering process. Thus, the quality of the partitions obtained can be assessed by verifying the degree for which the obtained clusters match the classes. Since the assessed approaches have systematically found a number of clusters that is approximately equal to the correct ones, a simple and intuitive way of evaluating the accuracy of the obtained partitions involves applying some measure of classification quality like the class error (CE), which is the percentage of the instances misclassified in relation to the total number of instances.

In all experiments, we have set k_{min}=2, $k_{max}=N^{1/2}$, and *np*=20, following the elaboration described in Section 3. Tables 2-7 summarize the average results obtained in five runs of each method. In such tables, *I*, ρ*, *k**, *CE*, and *CT* stand for number of iterations, number of selected features, estimated number of clusters, class error and computing times (in a Pentium IV, 3 GHz CPU, 1 GB RAM), respectively. Small variances have been observed for all the assessed aspects. Accordingly, only subtle differences were observed in relation to the found partitions. Finally, the last line of each table refers to the results obtained from the sampling strategy for *k*-means without feature selection.

For most of the assessed methods, the subsets of selected features are significantly smaller than the complete feature sets. In brief, good data partitions were obtained in most of the performed experiments, suggesting that the assessed methods can be useful for clustering gene expression data. CFS presented considerably worse results in most of the performed experiments. CBE, W-KNN, and C4.5, by their turn, have presented similar results, though significantly different results have been obtained for particular datasets. For instance, C4.5 has shown a better performance than both CBE and W-KNN in terms of *CE* in Bio2, although selecting more features. On the other hand, both CBE and W-KNN have provided

Table 2. Dataset Bio1

Method	*I*	ρ*	*k**	CE (%)	CT(s)
CFS	1	17	6	0.00	3.5
CBE	1	2	6	0.50	2.7
W-KNN	1	2	6	0.00	27.7
C4.5	1	2	6	0.00	2.7
All features	-	20	6	0.00	2.0

Table 3. Dataset Bio2

Method	*I*	ρ*	*k**	CE(%)	CT(s)
CFS	1	19	5	16.75	3.1
CBE	1	2	4	33.75	2.1
W-KNN	1	2	4	33.25	25.0
C4.5	1	4	5	16.75	2.1
All features	-	20	5	16.75	1.4

Table 4. Dataset Bio3

Method	*I*	ρ*	*k**	CE(%)	CT(s)
CFS	1	18	6	0.00	2.8
CBE	1	2	6	0.25	2.0
W-KNN	1	2	6	0.00	28.8
C4.5	1	4	6	0.00	2.1
All features	-	20	6	0.00	1.4

Table 5. Dataset Bio4

Method	*I*	ρ*	*k**	CE(%)	CT(s)
CFS	1	11	4	33.50	2.6
CBE	1	2	4	33.50	2.1
W-KNN	1	2	4	33.50	25.6
C4.5	1	4	4	33.50	2.0
All features	-	20	4	33.50	1.5

Table 6. Dataset Bio5

Method	*I*	ρ*	*k**	CE(%)	CT(s)
CFS	1	1	6	0.25	1.8
CBE	1	1	6	0.25	1.9
W-KNN	1	2	6	0.00	39.1
C4.5	1	2	5	17.50	1.9
All features	-	20	4	33.50	1.4

Table 7. Dataset yeast

Method	*I*	ρ*	*k**	CE(%)	CT(s)
CFS	1	1	3	7.80	1.2
CBE	1	1	3	7.80	1.1
W-KNN	2	1	2	47.80	13.0
C4.5	1	2	3	7.32	1.2
All features	-	20	3	7.31	0.8

better partitions than C4.5 in Bio5. Finally, W-KNN has not performed well in *yeast*. In brief, CBE has shown a good tradeoff between clustering quality and computational effort required to achieve it.

To conclude, some results deserve further attention. The features selected in Bio5 allowed finding better partitions than those obtained by all features, illustrating how the removal of redundant and/or irrelevant features may even promote the improvement of the clustering process. Second, one or two features were enough to provide good partitions for *yeast*.

5. CONCLUSIONS

We have described how feature selection methods traditionally used in classification problems can be adapted for clustering problems. Analyses in terms of time complexity have been undertaken for all the studied methods. Also, empirical results in six bioinformatics datasets illustrated the performance of the assessed methods, which in general have provided good data partitions, while reducing the number of features. The results obtained by the consistency-based evaluation [10] suggest that it is promising for applications in which computational efficiency is a central issue.

6. ACKNOWLEDGMENTS

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7. REFERENCES

[1] Cover, T. and Hart, P., Nearest neighbor pattern classification, IEEE Transactions on Information Theory v.13, pp 21–27, 1967.

[2] Dash, M., Liu, H., Feature Selection for Clustering, Proc. of the Pacific-Asia Conf. on Knowledge Discovery and Data Mining, LNCS 1805, pp. 110-121, 2000.

[3] Guyon, I., Elisseeff, A., An Introduction to Variable and Feature Selection, Journal of Machine Learning Research 3, pp. 1157-1182, 2003.

[4] Hall, M. A., Holmes, G., Benchmarking Attribute Selection Techniques for Discrete Class Data Mining, IEEE Transactions on Knowledge and Data Engineering, v. 15, n.3, 2003.

[5] Hruschka, E. R., de Castro, L. N., Campello, R. J. G. B., Evolutionary Algorithms for Clustering Gene-Expression Data, Proc. of the 4th IEEE Int. Conf. on Data Mining 2004, Brighton, UK, pp. 403-406, 2004.

[6] Kaufman, L., Rousseeuw, P. J., Finding Groups in Data – An Introduction to Cluster Analysis, Wiley Series in Probability and Mathematical Statistics, 1990.

[7] Law, M.H.C., Figueiredo, M.A.T., Jain, A.K., Simultaneous Feature Selection and Clustering Using Mixture Models, IEEE Transactions on Pattern Analysis and Machine Intelligence, 26(9), pp. 1154-1166, 2004.

[8] Liu, H. and Motoda, H., Feature Selection for Knowledge Discovery and Data Mining. Kluwer Academic, 1998.

[9] Liu, H., Yu, L., Toward Integrating Feature Selection Algorithms for Classification and Clustering, IEEE Transactions on Knowledge and Data Engineering, 17(3), 1-12, 2005.

[10] Liu, H., Setiono, R., A probabilistic approach to feature selection: A filter solution", Proc. of the 13th Int. Conf. on Machine Learning, pp. 319-327, Morgan Kaufmann, 1996.

[11] Pal, N.R., Bezdek, J. C., On Cluster Validity for the Fuzzy c-Means Model, IEEE Transactions on Fuzzy Systems, v. 3, n. 3, 370-379, 1995.

[12] Quinlan, R., C4.5: Programs for Machine Learning, Morgan Kaufmman, 1993.

[13] Yeung, K.Y., Medvedovic, M., Bumgarner, R.E., Clustering gene-expression data with repeated measurements, Genome Biology, 4(5), article R34, 2003.

An Integrative Framework for Achieving HIPAA-Compliance for Healthcare Information Systems

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ABSTRACT

*Currently the Healthcare industry globally is contending with relentless pressures to lower costs while maintaining and increasing the quality of service. Robust Healthcare Information Systems (HCIS) become critical to enabling healthcare organizations address these challenges. In this paper, we propose an integrative framework for HIPAA compliant, I*IQ HCIS. We base this framework on an integration of the requirements for HIPAA compliance, the principles of Information Integrity (I*I), as well as the healthcare quality aims (Q) set forth by the Committee on the Quality of Healthcare in America (American Institute of Medicine, 2001). The power of this framework is that, while it has been developed taking into account critical issues pertaining to security in the US healthcare environment it is as relevant in any healthcare system. To illustrate its universality we discuss the appropriateness of this system in the UK NHS environment as well.*

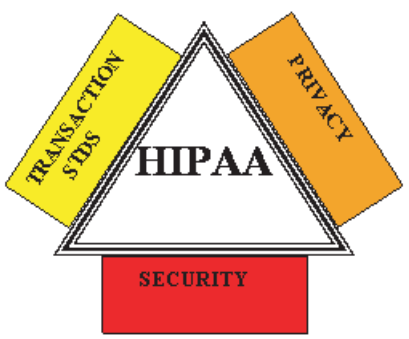
Keywords: HIPAA, Information Integrity, healthcare, healthcare information systems (HCIS), framework, privacy, security, standards, quality, NHS

1.0 THE HIPAA TRIANGLE

In the US, HIPAA (the Health Insurance, Portability and Accountability Act) focuses on three key elements; namely, security, privacy and standards for electronic submissions and exchange of healthcare information (American Institute of Medicine, 2001; HIPPA, 2001; Moore and Wesson, 2002). It is useful to conceptualize this as a triangle (figure 1) which highlights the fundamental elements of the HIPAA regulation; namely, security, transaction standards and privacy.

- **Security:** According to HIPAA, a number of security criteria must be met by all electronic healthcare transactions. Some of these criteria directly affect how healthcare systems can be accessed and interacted with by the users of healthcare information systems. Essentially, these security criteria fall into 3 main categories; namely administrative, physical and technical.

Figure 1. HIPAA triangle



- **Transaction Standards: The Standards for electronic health information transactions cover** certain electronic health transactions, including claims, enrollment, eligibility, payment, and co-ordination of benefits.
- **Privacy:** The final element of the HIPAA triangle deals with ensuring the **privacy of healthcare information.** Specifically, the Federal Register (Vol. 67, No. 157) details all the rules that must be adhered to with respect to privacy. The purpose of these rules is to maintain strong protections for the privacy of individually identifiable health information, addressing the unintended negative effects of the privacy requirements on healthcare quality or access to healthcare, and relieving unintended administrative burdens created by the privacy requirements. Thus, theses privacy requirements cover uses and disclosures of treatment and payment information and create national standards to protect individuals' medical records and other personal health information.

2.0 INFORMATION PRODUCERS, CONSUMERS AND INFORMATION FLOWS WITHIN THE HEALTHCARE SYSTEM

In order to fully capture the flows of information it is necessary to first identify the primary producers and consumers of data and information within the healthcare system. At the center of the information flows is the HCIS because not only does it connect the key players within the healthcare system in an efficient and effective manner but also it forms the central repository for key information such as patient medical records, billing, and treatment details. Hence, the HCIS provides the foundation for supporting the information flows and decision making throughout the healthcare system.

Healthcare procedures such as medical diagnostics, treatment decisions and consequent effecting of these decisions, prevention, communication and equipment usage can be thought of as iatric in nature (Perper, 1994). Integral to these iatric procedures is the generating and processing of information (Moore and Wesson, 2002). The patient naturally provides key information at the time of a clinical visit or other interaction with his/her provider. Such a visit also generates other information including insurance information, medical history, and treatment protocols (if applicable) which must satisfy regulatory requirements, payer directives and, obviously, the healthcare organization's informational needs. Thus, we see that from a single intervention many forms and types of information are captured, generated and then disseminated throughout the healthcare system. All this information and its flows must satisfy some common integrity characteristics such as accuracy, consistency, reliability, completeness, usefulness, usability and manipulability. Consequently, generating a level of trust and confidence in the information's content and processes. Since the information flows across various organizational boundaries, the challenge of ensuring information integrity is further compounded because any integrity problems will propagate with ripple effects following the same trajectory as the information itself. Given the high degree of inter-relatedness between the various players, the consequences of poor quality information (such as the cost of information integrity problems) are multiplied and far reaching. This highlights the need for robust, well designed and well managed HCIS (Applegate et al., 1986; Stegwee and Spil, 2001). Such a perspective

should not be limited to new systems, but rather, equally and perhaps of even more importance, should be applied to existing systems as well.

3.0 INFORMATION INTEGRITY AND QUALITY (I*IQ)

Given the critical role of information both within and between the information produces and consumers in healthcare (Chandra et al., 1995), it is imperative then that the information flowing both within the HCIS and between the key participants in the healthcare system must exhibit both the attributes and dimensions of the information integrity construct as well as satisfy the healthcare quality aims. Specifically, the information should display the attributes of accuracy, consistency, and reliability of content and processes as well as the dimensions of usefulness, completeness, manipulability and usability (Moore and Wesson, 2002; Chandra et al., 1995; Geisler et al., 2003).

3.1 Information Integrity

Information integrity is an emerging area that is 'not just about engineering the right properties of information but it also includes sensitivity to the context in which information is used and the purpose for its usage' (Geisler et al., 2003 p5; MAndke et al., 2003). More specifically it encompasses the accuracy, consistency, and reliability of the information content, process, and system. By focusing on the privacy, security and standards aspects of healthcare information, it would appear that HIPAA implicitly assumes certain characteristics of this information product such as its accuracy and reliability. However, in practice this may not always be the case, and from the perspective of the healthcare organization it is not sufficient to be HIPAA compliant, rather it must also ensure the information product satisfies the principles of Information Integrity (I*I) standards. Implicit in taking an Information Integrity perspective is the shift from viewing information as a byproduct to viewing it as an essential product (Huang et al., 1999). This requires following four key principles; namely that the information must 1) meet the consumers information needs 2) be the product of a well defined information production process 3) be managed by taking a life-cycle approach and 4) be managed and continually assessed vis-à-vis the integrity of the processes and the resultant information [ibid]. In order to actualize this I*I perspective, healthcare organizations then need to implement specific protocols.

3.2 Healthcare Quality Aims

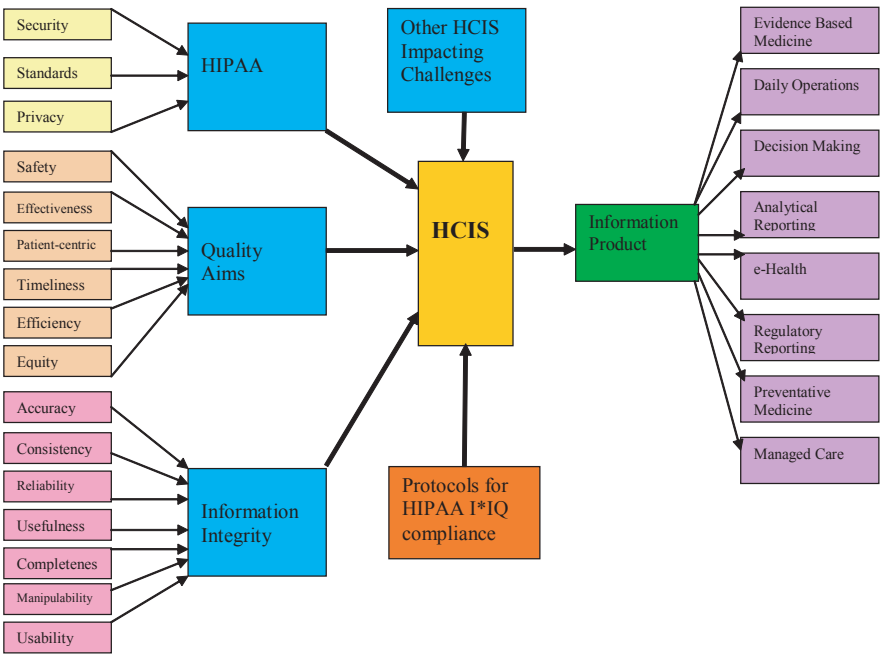
In the final report of the Committee on the Quality of Health Care in America (American Institute of Medicine, 2001), it was noted that improving patient care is integrally linked to providing high quality healthcare. Furthermore, in order to achieve a high quality of healthcare the committee identified six key quality aims; namely, 1) healthcare should be safe – avoiding injuries to patients from the care that is intended to help them, 2) effective - providing services based on scientific knowledge to all who could benefit and refraining from providing services to those who will not benefit (i.e. avoiding under use and overuse), 3) patient-centered – providing care that is respectful of and responsive to individual patient preferences, needs, and values and ensuring that patient values guide all clinical decisions, 4) timely – reducing waiting and sometimes harmful delays for both those receiving care and those who give care, 5) efficient - avoiding waste and 6) equitable – providing care that doesn't vary in quality based on personal characteristics. It is obvious that these quality aims can only be negatively impacted by poor information quality, flow and integrity. Conversely, a higher quality, flow and integrity of information will positively impact these quality aims by helping to reduce the large number of medical errors that currently permeate the healthcare system (Moore and Wesson, 2002; Chandra et al., 1995; Geisler et al., 2003). What becomes critical then is to incorporate these quality aims into the manufacturing of the information product so that the output is quality information. This requires the establishment of an information quality program which serves to: 1) articulate an information quality vision in healthcare business terms, 2) establish central responsibilities for information quality within the information product manufacturing processes, 3) educate the producers and consumers of information on information quality issues and 4) institutionalize and continuously evaluate and develop new information quality skills (Huang et al., 1999).

4.0 PROPOSED FRAMEWORK

Information systems/information technologies (IS/IT) are becoming key enablers and strategic necessities for organizations irrespective of their business sector (Haag et al. 2004; Scott Morton, 1991; Thorne and Smith, 2000). Hence, it should come as no surprise to expect HCIS to play a similar role for healthcare organizations; in particular, they should be viewed as key enablers for healthcare to meet the challenges with which healthcare is currently grappling. In order to systematically maximize and facilitate the full potential of HCIS to enable healthcare organizations cope with today's challenges, it is important to have a guiding to facilitate the design and management of robust HCIS. We propose the following integrative framework as a potential candidate.

The proposed framework integrates the key challenges of 1) the HIPAA triangle, 2) the six healthcare quality aims and 3) the core principles of information integrity currently facing all healthcare organizations in the US (Wickramasinghe

*Figure 2. An Integrative Framework for HIPAA I*IQ HCIS (adapted from Wickramaisnghe, 2006)*



and Sharma, 2005). Further, the framework (via the HCIS) also recognizes the multifaceted nature of the key participants within the healthcare system; in particular, the dynamics of their information requirements with respect to capturing, generating and disseminating of the necessary information. While our discussion focuses on the above three challenges impacting on the design and management of HCIS, the framework acknowledges the existence of other challenges. These challenges, though, are beyond the scope of this paper but are reflected in the framework for completeness. A key component of this framework is the protocols for ensuring HIPAA compliance, observing the principles of information integrity (I*I), and satisfying the healthcare quality aims (Q). Figure 2 depicts the proposed framework. Finally, the framework highlights the major deliverable from the HCIS; namely, the information product and its key applications to various healthcare practices and processes.

5.0 UK NHS ENVIRONMENT

In the UK, the National Health Service (NHS) is the "public face" of the publicly funded healthcare systems. The organisations provide the majority of healthcare in the UK (general practitioners, Accident and Emergency Departments, long-term healthcare and dentistry). Founded in 1948, they have become an integral part of British society, culture and everyday life. Private healthcare has continued in parallel to the NHS, largely paid for by private insurance, but still generally used by a small percentage of the population (and generally as a top-up to NHS services). NHS services are largely free at the point of delivery and are paid for by way of taxation. The NHS's budget for 2005-06 is over £80 billion and the Service employs over 1 million people and is ranked as one of the largest employers in the world. Healthcare in the UK has been the subject of global focus given the radical and far-reaching change programme currently taking place (NHS, 2006).

The lack of sufficient technological safeguards coupled with a lack of a comprehensive security vision and a policy statement on how to ensure healthcare information security are the major obstacles in way of the successful implementation and widespread uptake of the EPR concept. With the NHS, this viewpoint has been corroborated by the British Medical Association who have stated that currently "all the different parts of the NHS are not sufficiently encrypted and encoded up together" to ensure adequate information security to healthcare records (Crossley, 2002) . It is clear that there is existing technology that is in place and is sufficient to ensure that the EPR concept becomes a reality. However, the primary challenge continues to be the elusive hunt for a security mechanism that ensures the security of the information stored in EPR databases (Etheridge, 2001). The proposed integrative framework would be ideally suited to dealing with the new knowledge-based clinical era of the NHS.

6.0 CONCLUSION

In this maze of challenges currently facing healthcare, the need for well suited and high quality information that flows throughout the web of the healthcare system becomes paramount. HCIS can be used to most effectively and efficiently to facilitate the information flows and decision making throughout this healthcare system web. This should come as no surprise, given the general success of IS/IT in many business settings and the fact that healthcare is a data and information rich industry. However, what becomes a critical goal given the pivotal role for these HCIS then is to take a holistic and comprehensive approach to designing robust HCIS and subsequently effectively managing this asset. We have proposed an integrative framework as one approach to meeting this goal. Specifically, our framework considers the three key challenges of HIPAA compliance, the need for embracing the principles of I*I and the need to embrace the six healthcare quality aims. Moreover, the power of this framework lies in its universality since it is as suitable to the US healthcare environment which is essentially a private healthcare model as it is in the UK healthcare system which is dominated by a public model; namely the NHS.

7.0 REFERENCES

[1] American Institute of Medicine, 2001 Crossing the Quality Chasm – A New Health System for the 21st Century Committee on Quality of Health Care in America Institute of Medicine, National Academy Press, Washington, D.C.

[2] Health Insurance Portability and Accountability Act (HIPPA), 2001 Privacy Compliance Executive Summary, Protegrity Inc. May .

[3] Moore, T & R. Wesson 2002. "Issues regarding wireless patient monitoring within and outside the hospital" published in the 2nd Hospital of the Future Conference Proceedings, Chicago, USA.

[4] HIPAA Security requirement Matrix, 2002 - http://www.hipaa.org

[5] J. Perper 1994 "Life Threatening and Fatal Therapeutic Misadventures" in Human Error in Medicine, Bogner, M (Ed.), Lawrence Erlbaum associates, Publishers, Hillsdale, NJ. 27-52.

[6] Applegate, L., Mason, R. and Thorpe, D. "Design of a Management Support System for Hospital Strategic Planning", Journal of Medical Systems (10:1), 1986, pp. 79-94.

[7] Stegwee, R & T. Spil 2001. Strategies for Healthcare Information Systems, Idea Group Publishing, Hershey.

[8] Chandra, R., Knickrehm, M. and Miller, A. "Healthcare's IT Mistake", The McKinsey Quarterly (5) 1995.

[9] Geisler, E., D. Lewis, M. Nayar & P. Prabhaker, 2003 "Information Integrity and Organizational Performance: A Model and Research Directions" working paper

[10] Mandke, V M. Bariff and M. Nayar 2003 "Demand For Information Integrity In Healthcare Management" Forthcoming in The Hospital of the Future conference proceedings.

[11] Huang, K, Y. Lee, and R. Wang 1999. Quality Information and Knowledge Prentice Hall, New Jersey.

[12] Haag, S., M. Cummings and D. McCubbrey 2004. Management Information Systems for the Information Age 4th Edn. McGraw-Hill Irwin, Boston.

[13] Scott Morton, M. 1991. The Corporation of the 1990s New York, Oxford University Press.

[14] Thorne, K. and Smith, M. "Competitive advantage in world class organizations", Management Accounting (78:3) 2000, pp. 22-26.

[15] Wickramasinghe, N. and S. Sharma 2005 "Key Considerations for Ensuring High Quality HIPAA Compliant e-health" International J. Services and Standards (IJSS) vol 1 no. 3 pp. 319-335

[16] Wickramasinghe, N. in press "Patient Centric Healthcare Information Systems: The confluence of ethics, security and effective information systems" in Ed Quinnley, Encyclopaedia on Security and Ethics, Idea Group Hershey

[17] NHS 2006 Connecting for Health website. Available from: www.connectingforhealth.nhs.uk [Accessed 20 Sept 2006].

[18] Crossley, N. 2002. "Health: Access all areas: We all have the right to see our own medical records" The Guardian, pp. 2.16.

[19] Etheridge, Y. 2001. "PKI - how and why it works," Health Management Technology, vol. 22, Iss.1, pp. 20-21.

Distribution-Collaboration Networks (DCN): An Organizational Transformation Perspective on the Development of E-Government Services

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ABSTRACT

The focus of this paper is to show that the development of e-government services needs to be fundamentally reconsidered if it is to achieve its raison d'être – the transformation of bureaucratic public sector agencies into a web of citizen-centric service providers. The status of current e-government initiatives is discussed and an emerging context for developing e-government services is presented: responsibility for public service provision may be distributed to multiple entities, and "public" value no longer needs to be provided by government alone. It can be provided through a system comprised of public agencies, the private sector, community groups, or citizens themselves, using communications networks as a mechanism for process management and conducting transactions. To investigate the intricacies of such a complex system, which we call a Distribution-Collaboration Network (DCN), we have developed a DCN Service Transformation Model. The main properties of this model are presented and its differentiating characteristics are analyzed, from an organizational transformation perspective. Based on that, we present certain guidelines for the development of e-government services along three dimensions: strategy, process engineering and technical infrastructure development.

1. INTRODUCTION

It is no secret that citizens across the globe are now asking for more efficient and effective public services that are citizen-centric - moving away from the bureaucratic status quo of the majority of organizations in the public sector.

Unfortunately, such a modernisation is not a straightforward task. Governments have been experimenting for a long period of time with a number of socio-political theories and models (Carnevale, 2002; Denhardt and Denhardt, 2002; Frederickson and Johnston, 1999; Kettl, 2002; Kettl, 2000). E-government has been more recently recognized by governments, researchers and practitioners alike as a source of potential solutions. This discipline investigates how information and communications technologies (such as wide area networks, the Internet, and mobile computing) can be used by public sector organizations to exchange information with and provide public services to citizens, businesses, and other arms of government.

Current research and practice in the realm of e-government is mostly technology-driven, focused on issues related to the transfer of existing processes and services to the digital world. This is, in turn, reflected on the most widely used e-government service development models.

Such a model is promoted by the European Union's Information Society Directorate General (Bradier, 2004) and is comprised of five different levels: a) *Publish*: services at this level act as passive information bulletin boards; b) *Interact*: citizens can search for and browse dynamic content on the web site of such an e-government service; c) *Transact*: this level corresponds to interactive systems and services, where citizens can exchange information with a government agency; d) *Integrate*: existing processes integrate with e-government activities for e-services belonging to this level; e) *Transform*: encapsulates radical implementations, often including significant process reengineering and new service development.

Cap Gemini, the international management consultancy, has introduced a similar model (Wauters and Van Durme, 2005) comprised of four development levels: *a) Information*: services at this level act as passive information bulletin boards; b) *One-way interaction*: simple interactive services, offering basic functionality, such as downloadable forms; c) *Two-way interaction*: this level corresponds to interactive systems and services, where citizens can exchange information with a government agency; d) *Transaction*: full electronic case handling for citizen requests.

We believe that most of such research efforts are missing the *organisational* and *transformative* aspects of e-government service development. Our baseline argument is that public services (online or otherwise) may be delivered by public sector entities in collaboration with third-party entities, such as the civil society, corporations, etc. The extent of service providers' distribution and the type of service providers' collaboration (organizational transformation issues) may have a severe effect on the development of an e-government service. In turn, this should eventually affect the adoption of the service by the public.

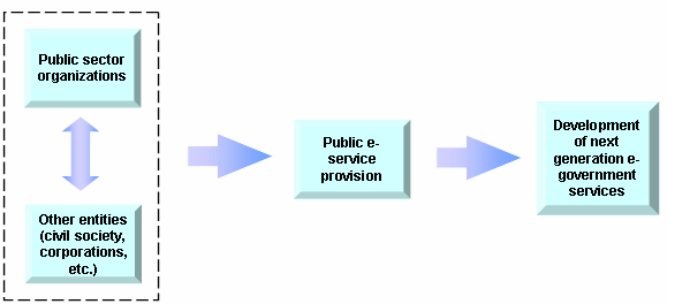
Interestingly, this twin concept of 'distribution – collaboration' is oftentimes not considered in the realm of e-government because:

- Provision of public services (online or otherwise) is considered to be an almost exclusive right of public sector agencies
- Adopting a collaborative model of distributed public service providers will necessitate organisational transformation - a traditionally difficult realm to incorporate in service development.

2. OBJECTIVES

This paper aims to bridge the above research gap by describing an exploration of: a) the organizational structure of systems arising from the creation of different links among entities involved in e-government service provision; b) the influence

Figure 1. Our research model



of this structure on the development (from design to implementation) of e-government services. Figure 1 depicts the broad research model.

Within this model the research question addressed was, "How complex are the organizational transformation issues for e-service provision when multiple and potentially conflicting stakeholders are involved, and how does this complexity map into the implementation of e-government systems?" Thus, the focus of our research is on the interconnection of organizational transformation principles and information systems thinking for developing a new generation of e-government services.

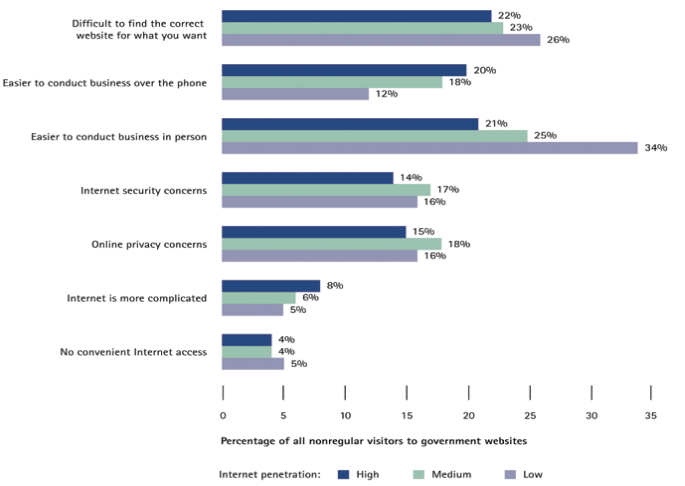
3. METHODOLOGY

Initially, we investigated a number of existing and planned e-government services, mostly developed in European Union countries. The focus was on defining comparison parameters and evaluation criteria, with emphasis on three key realms: strategy, process engineering, and technical infrastructure development.

We also analyzed a large amount of statistical and survey data, collected by government agencies and highly reputable corporations (mainly management consultancies). This analysis was complemented by a review of a number of academic efforts on e-government, systems analysis and design, and organizational transformation.

Finally, the authors' professional experience from their involvement in the development and implementation of e-government initiatives in the UK and Greece provided a set of insightful case studies that were incorporated in this research.

Figure 2. Barriers to More Frequent Use of E-government Services (Average Values from a Sample of 12 Countries – Spain, France, Italy, Singapore, Belgium, Germany, Australia, Canada, USA, Sweden, UK, Ireland – source: Rohleder and Jupp, 2005)



4. E-GOVERNMENT TODAY

The majority of current e-government efforts are focused less on the citizen and more on the public sector organizations' own perspective – the need to move existing processes and services to the digital world. In doing so, significant value can be realized. A recent report from the UK National Audit Office (Rohleder and Jupp, 2005) revealed that 20% of postal applications to the UK's Cattle Tracing System were inaccurate. The result has been that the UK Department for the Environment, Food and Rural Affairs has paid UK£9 million each year since year 2000 in extra staffing costs to rectify the errors. In contrast, the National Audit Office found that only 1% of electronic requests were inaccurate. As a result, the Department for the Environment, Food and Rural Affairs has called for more electronic applications to reduce mistakes, cut the number of extra staff required to correct errors and avoid potential fines from the European Union.

However, from a citizens' perspective, survey data from multiple sources increasingly point to a not-so-positive direction. They point to a citizens' perception that many e-government services have been implemented neither with them in mind nor for the benefit of the civil society but for the convenience and own bureaucratic goals of the government agencies themselves. Figure 2 in the following page shows that citizens across the globe are unsatisfied by the use of current e-government services to interact with public sector organizations (Rohleder and Jupp, 2005).

Indeed, the first three barriers to the use of e-government services (shown in figure 2) encapsulate this dissatisfaction. The cause for these established perceptions may range from citizen frustration when using such services, to lack of marketing e-government services to the citizens. The underlying message, however, is that citizens largely fail: a) to experience tangible benefits from current e-government services, and b) to differentiate them from their offline counterparts.

Finally, from a technology perspective, the current e-services' attempt to simply replicate/transfer internal systems and processes to the Web leaves largely unexploited a core technology for e-government, namely networking. Indeed, the main (and yet unrealized by e-government services) benefit of fully exploiting network technologies is the ability to create new forms of value by focusing on core organizational competencies and creating partnerships for non-core activities.

5. DISTRIBUTION-COLLABORATION NETWORKS (DCN)

The above lackluster results combined with socio-political developments of the recent years are creating new realities for public service provision and the related design of e-government services. These realities point to a new direction of how governments will need to operate from now on and turn the spotlight on the twin concept of 'distribution – collaboration':

- distribution of public service provision to multiple entities (which may not be public sector organizations), and
- collaboration of multiple organizations for delivering public services.

(Tapscott, 2004) describes a number of such recent socio-political realities. First of all, civil society and corporations are now more involved in governance. The private sector, from individual corporations to entire industries, is increasingly focused on competing in a global economy where borders and national laws are seen as irrelevant or hindrances. Civil society - the collection of associations, trade unions, religious and cultural institutions, advocacy groups and people as individuals - is using network-based technologies to communicate and collaborate in ways previously unimaginable. Together, these actors are redefining the nature of public services. For example, civil society organizations, such as the group that created the US environmental initiative Scorecard, are providing new information services that are superior to those currently offered by government.

In addition, citizens increasingly turn to non-governmental entities for receiving 'public value'. Many governments have given priority to their role as financial administrators, focusing on controlling expenditures, paying down debt and trimming entitlements. This is in almost complete contrast to previous generations when public service and the role of government were expanding. Thus, citizens are turning to other entities for services previously offered exclusively by government. For example, corporations now deliver public services ranging from parking tickets to education.

Furthermore, political power is shifting towards collaborative groups of organizations. Communications networks have made geography less relevant to the formation and mobilization of interests and organizations, such as advocacy groups, businesses, cultural associations and trade unions. The declining relevance of borders is a fundamental challenge to the centuries-old basis of national governments and international institutions, most of which are defined by geopolitical power rather than economics or communications. Power is shifting away from national governments towards collaborating supranational organizations, such as the European Union and the World Trade Organization, or local levels of government.

We note that the above realities exhibit a common pattern: responsibility for public service provision is distributed to multiple entities and "public" value no longer needs to be provided by government alone. It can be provided through a system comprised of various public agencies, the private sector, community groups, or citizens themselves, using communications networks as a mechanism for process management and conducting transactions.

We call such a system of distributed organizations that are collaborating for providing public services a Distribution-Collaboration Network (DCN). At an organizational level, it is comprised of interconnected public, private and/or civil society participants. At a technological level, it is supported by network-based technologies (such as the Internet, mobile computing, etc). The importance of DCNs stems from their structure which positions them to deliver a number of benefits over the established bureaucratic forms of government:

- leverage innovation, value and commitment from a broader group of participants
- deliver higher value to the public, including services previously not possible
- deliver services at a lower cost, because the use of network-based organizational and technical infrastructures can significantly lower the search, contracting, and collaboration costs
- in general, introduce new levels of agility, responsiveness and flexibility to the way governments are addressing public needs.

6. THE DCN SERVICE TRANSFORMATION MODEL

Adopting a DCN model of public service provision can have the benefits described above. However, such an adoption entails a new way of thinking from government officials and a challenging organizational transformation for the public sector – both rightfully considered as being difficult tasks to undertake.

Furthermore, such an organizational transformation will be very closely related to the development of a new generation of e-government services aligned with the DCN concept.

Hence, in order to understand the development needs of such services and their impact on the organizational transformation towards a DCN structure, we have investigated a number of existing and planned e-government services, mostly developed in European Union countries. By analyzing their key success factors and limitations, and combining them with lessons learnt from our own involvement in the development of e-government services in the UK and Greece, we developed our DCN Service Transformation Model (depicted in figure 3). In this model, e-government services differentiate along two dimensions, corresponding to the twin-concept underlying a DCN: Service Providers' Distribution, and Cross-Entity Collaboration.

In terms of Service Providers' Distribution, a Low value indicates that a small number (one or two) of statically contracted entities are involved in the development/provision of an e-government service. A High value indicates that responsibility for such service provision lies with a dynamically changing large group of organizations.

In terms of Cross-Entity Collaboration, a Low value indicates that collaboration among involved entities is limited to mostly communication tasks for developing the e-service. In contrast, a High value points to the direction of market-like interactions among service providers.

These two parameters combined define the fundamental characteristics of our model, and their corresponding impact on an organization's transformation towards a DCN structure. Mapping the impact onto guidelines for developing e-government services is achieved by describing it on the basis of certain system-defining parameters:

- *Strategy and Policies*: what are the goals and scope of e-government services to be developed?
- *Processes*: what are the basic processes needed for the execution of Strategy?
- *Technology*: what are the key elements of the technical infrastructure that will enable the successful implementation of Processes?

Based on the above, we can group e-government services that correspond to our model in three major levels: *E-enhanced* services, *Coordinated* services, and *Networked* services.

6.1 E-Enhanced Services

E-government services of this type are under the exclusive auspices of a public sector organization. Usually, a small number of technology firms are contracted for a support role and for infrastructure development. The main focus is on mapping existing processes and organizational structures on the digital realm. Most of the current generation e-government services are of this type.

In more detail, this level is characterized by Table 1.

6.2 Coordinated Services

For delivering Coordinated e-government services, a lead entity (most often but not necessarily from the public sector) coordinates a larger but controlled group

Figure 3. The DCN service transformation model

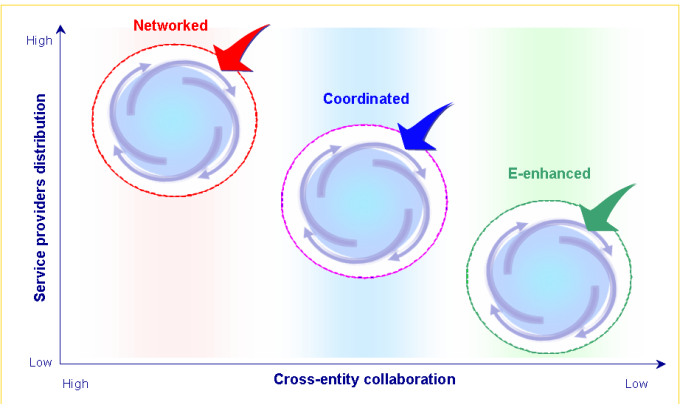


Table 1. E-enhanced services: Key determinant characteristics

Determinant	Characteristics
Strategy and Policies	• One entity for public service provision • "We can do it all ourselves better than others" • Minimal analysis of how well needs are being met • Quality controls are primarily financial • Limited trust of partners
Processes	• Map offline processes to digital realm • Functional silos abound with little formal cross-functional working • Global and local processes conflict or duplicate • Mainly paper-based processes • Front-end webization
Technology	• Little standardisation of data/information definitions between entities involved • Information sharing restricted to non-confidential items

Table 2. Coordinated services: Key determinant characteristics

Determinant	Characteristics
Strategy and Policies	• One leader for group of entities for public service provision • Some recognition of core competencies and the need to work more closely with other organisations • Some trust relationships in place but more individual-driven rather than organisation-driven
Processes	• Limited engineering of cross-entity processes • Processes mostly automated
Technology	• Basic use of collaboration solutions, e.g. web-based email & video/ computer conferencing • Adoption of some common data standards and taxonomies to ease the information flow, e.g. consistent definition of terms • Confidential information shared on an "as-needed" basis

Table 3. Networked services: Key determinant characteristics

Determinant	Characteristics
Strategy and Policies	• One network-based system for public service provision • All policies, functional objectives and procedures are fully aligned and visibly act in accordance with the shared partnership vision • Partners are regularly prioritised and de-prioritised based on their value add to the network • Flat, empowered organisational structure with decisions made at the lowest level possible • Pro-active knowledge sharing to continually deepen relationships
Processes	• Cross-entity processes as *the* modus operandi • Detailed process metrics allow for scenario-based planning and improvements involving all partners • End-to-end processes continually improved with partners
Technology	• Industry standards implemented as an integral part of collaboration platform (SOAP, WSDL, UDDI, WSFL) • Comprehensive use of multimedia to aid interactions • Ubiquitous application level integration with partners • Rich flow of communication upwards, downwards and sideways

of government agencies, businesses and/or civil society groups in order to offer a single point of service. Collaboration among the participating entities is guided and prescribed, and may involve limited cross-entity process reengineering.

In more detail, this level is characterized by Table 2.

6.3 Networked Services

E-government services at this level realize the full extent of Distribution-Collaboration Networks. A large group of organizations (of any type) is participating in the development of the service and such participation can be dynamic and market-like. Cross-entity collaborative processes are in place, data standards have been adopted and there is ubiquitous application-level integration among all involved entities. E-government services of this type are most effectively developed when there is a sense of community among the distributed service providers and a culture of knowledge sharing and consensus can be established.

In more detail, this level is characterized by Table 3.

7. FUTURE WORK

The above research findings are the results of the first phase of our ongoing research initiative on e-government transformation services. There is a number of directions we aim to follow in order to fully understand and develop the DCN system.

First of all, we are intensifying our cooperation with researchers in social sciences, in order to ensure that our work is not an isolated exercise in information systems development. For example, we need to better understand the (potentially conflicting) roles that public service organizations may undertake (supplier, regulator, policy-maker, purchaser, partner, etc.), thus clarifying the roles that they can assume in different DCNs.

In addition, we need to understand the full spectrum of intricacies of complex systems of the kind of a DCN. To that extent, one of the directions we are currently working on is the development of a maturity model, in order to assess an organization's readiness for participating in the development of DCN-type e-government services. A major issue in this effort will be the definition of the organizational and technological parameters (i.e. two of the key transformation drivers) that will be introduced in the maturity model.

Finally, in order to evaluate the practical implications of our propositions, we plan to initiate the development of a service implementation model. Its main goal will be the understanding of critical deployment issues of DCN-type e-government services, for each level of our DCN Service Transformation Model. The development and testing of the service implementation model will be benefited by a parallel project for the design of an e-government service dealing with the issuance of building permits in Greece (this is a Coordinated service, as per our model).

8. CONCLUSIONS

Many of the current e-government services or service development activities have hit a roadblock. Although the initial results were encouraging, survey data increasingly indicate that citizens consider many e-government services to have been implemented neither with them in mind nor for the benefit of the civil society but for the convenience and own bureaucratic goals of the government agencies themselves.

In other words, it seems that many such services were 'assimilated' by government bureaucracies, instead of targeting the original goal of transforming these bureaucracies into citizen-centric service providers.

These lackluster results along with socio-political developments of the recent years are creating new realities for public service provision and the related design of e-government services. These realities point to a new direction of how governments will need to operate from now on and turn the spotlight on our twin concept of 'distribution – collaboration': a) distribution of public service provision to multiple entities (which may not be public sector organizations), and b) collaboration of multiple organizations for delivering public services.

A DCN encapsulates this concept, from a systems point of view, and our DCN Transformation model aims to shed light on its complex structure. Our research findings point to certain basic guidelines for governments to create significant public value through a new generation of e-government services:

- **Determine the roles and/or competencies that public sector organizations must abandon, retain or attain in the digital era.** As part of a DCN, public sector agencies may be able to deliver value in new ways, or create new forms of value for citizens. This, in turn, may necessitate either a handover of their traditional roles (either partially or totally), or the undertaking of new responsibilities to satisfy new roles.
- **Embrace innovative citizen-centric concepts and gear towards their implementation.** DCNs are about sharing power, opening up the decision-making process, and collaborating for creating public value. The corresponding e-government services that can be developed may offer not just the opportunity to 'do the job better' but to re-engage the society in the process of governing.

REFERENCES

Beer, S. (1984) 'The Viable System Model: Its Provenance, Development, Methodology and Pathology', *Journal of the Operational Research Society*, Vol. 35, pp. 7-25.

Boulding, K. (1956) 'General Systems Theory – The Skeleton of Science', *Management Science*, Vol. 2, pp. 197-208.

Bradier, A. (2004) 'Interoperability Issues in the E-government Framework at a Pan-European Level', *Keynote Address to European Commission Directorate General Information Society's eGovernment Workshop on Semantic Interoperability*, Bronnoysund, Norway.

Brown, C. L. (2002) 'G-8 Collaborative Initiatives and the Digital Divide', *Proceedings of the 35th Hawaii International Conference on System Sciences.*

Carnevale, D. (2002) *Organizational Development in the Public Sector*, Westview Press, New York, USA.

Carvalho, J. (1998) 'Using the Viable System Model to Describe the Role of Computer-Based Systems in Organizations', *Proceedings of the World Multiconference on Systems, Cybernetics and Informatics.*

Castellano, M. et al (2005) 'An E-government Cooperative Framework for Government Agencies', *Proceedings of the 38th Hawaii International Conference on System Sciences.*

Chapman, J. (2004) 'System Failure - Why Governments Must Learn to Think Differently', *Second Report - DEMOS Report Series*, London, UK.

Cresswell, A. and Pardo, T. (2001) 'Implications of Legal and Organizational Issues for Urban Digital Government Development', *Government Information Quarterly*, Vol. 18, pp. 269-278.

Dawes, S. and Prefontaine, L. (2003) 'Understanding New Models of Collaboration for Delivering Government Services', *Communications of the ACM*, Vol. 46, pp. 40-42.

Dawes, S. and Oskam, S. (1999) 'The Internet, the State Library, and the Implementation of Statewide Information Policy', *Journal of Global Information Management*, Vol. 7, pp. 27-33.

Denhardt, J. and Denhardt, R. (2002) *The New Public Service: Serving, Not Steering*, M.E.Sharpe Publishers, New York, USA.

Fountain, J. E. (2002) 'Developing a Basic Research Program for Digital Government: Information, Organizations and Governance', *National Workshop Report,* Harvard University, Massachusetts, USA.

Frederickson, G. and Johnston, J. (1999) *Public Management Reform and Innovation: Research, Theory, and Application*, University of Alabama Press, Alabama, USA.

Herring, C. and Kaplan, S. (2000) 'The Viable System Architecture', *Proceedings of the 34th Hawaii International Conference on System Sciences*.

Huang, C-Y. et al (2000) 'Agility of Networked Enterprises – Parallelism, Error Recovery and Conflict Resolution', *Computers in Industry*, pp. 275-287.

Kettl, D. F. (2002) *The Transformation of Governance: Public Administration for Twenty-First Century America*, Johns Hopkins University Press, Maryland, USA.

Kettl, D.F. (2000) 'The Global Public Management Revolution', *Report on the Transformation of Governance*, The Brookings Institution, Washington DC, USA.

LaVigne, M. (2002) 'Electronic Government: Vision of the Future that is Already Here', *Syracuse Law Review*, Vol. 52, pp. 1243-1251.

Lau, E. and Field, T. (2001) 'E-government: Analysis Framework and Methodology', *Report on the Impact of E-government*, Organization for Economic Cooperation and Development (OECD).

Layne, K. and Lee, J. (2001) 'Developing Fully Functional E-government: A Four Stage Model', *Government Information Quarterly*, Vol. 18, pp. 122-136.

Riley, T. B. (2003) 'E-government vs. E-governance', *International Tracking Survey Report Number Four*, University of Glasgow, Scotland, UK.

Rohleder, S.J. and Jupp V. (2005) 'eGovernment Leadership: High Performance, Maximum Value', *Fifth Annual Survey – Executive Government Series*, Accenture, New York, USA.

Shackleton, P. et al (2004) 'Evolution of Local Government E-services: the Applicability of E-business Maturity Models', *Proceedings of the 37th Hawaii International Conference on System Sciences.*

Tapscott, D. (2004) 'E-government in the 21st Century', *Executive Series Report*, New Paradigm Learning Corporation, Ontario, Canada.

Vancouver, J.B. (1996) 'Living Systems Theory as a Paradigm for Organizational Behavior: Understanding Humans, Organizations, and Social Processes', *Behavioral Science*, Vol. 41, pp. 165-204.

Vidgen, R. (1998) 'Cybernetics and Business Processes: Using the Viable System Model to Develop an Enterprise Process Architecture', *Knowledge and Process Management*, Vol. 5, pp. 118–131.

von Bertalanffy, L. (1976) *General System Theory: Foundations, Development, Applications (Revised Edition)*, George Braziller Publications, New York, USA.

Wassenaar, A. (2000) 'E-government Value Chain Models', *Proceedings of the 11th International Workshop on Database and Expert Systems Applications.*

Wauters, P. and Van Durme, P. (2005) 'Online Availability of Public Services: How Is Europe Progressing', *Report on the Fifth Measurement for European Commission Directorate General Information Society*, Cap Gemini Ernst & Young, London, UK.

Wimmer, M. and Bredow, B. (2001) 'E-government: Aspects of Security on Different Layers', *Proceedings of the 12th International Workshop on Database and Expert Systems Applications.*

Design of Reputation Systems in Online Auction Marketplaces: A Comparative Market Study

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ABSTRACT

Reputation systems aim at facilitating the emergence of trust between transaction partners in online auction marketplaces. In this paper the reputation systems of the six largest online auction marketplaces in the German market are evaluated. To this end, a catalogue of criteria regarding design options for reputation systems was developed. Since eBay is widely criticized for shortcomings of its reputation system, it was assumed that its five competitors have a vital interest in distinguishing themselves in this important aspect of auction platform design. The results of the empirical analysis however point to the contrary. Reputation systems largely show a dominant design with only marginal deviations in detail. The reasons for this, the actual differences between the reputation systems, as well as general limitations of reputation systems are discussed.

INTRODUCTION

Online auctions have developed into a successful and widely used trade channel among consumers and businesses. Online auction marketplaces (e.g. eBay) have several advantages for trading partners such as easy market access, fast transactions, or price transparency. However, these advantages come at the cost of several risks, especially from the perspective of the buyer. The buyer cannot see and evaluate the product and thus has to trust in the seller's honesty when determining a bidding strategy. Furthermore, the buyer has to pay the seller upfront and thus to take the risk of being defrauded by not being delivered with the described product.

The auction platform provider is only responsible for running the platform but not involved in the actual transactions. Any transaction risks are borne by the trading partners (Resnick *et al.*, 2000). In order for successful transactions to actually happen, some form of trust has to emerge between the trading partners. Auction platform providers have developed reputation systems in order to facilitate trust emergence and to provide incentives for trading partners to engage in positive trade behavior (Dellacoras, 2003).

The Role of Reputation Systems in Trust Formation

In traditional business relationships trust originates from recurring personal contacts. However, in online platforms anonymous buyers and sellers meet to engage in one off deals. Reputation systems function as mediators between buyers and sellers by allowing the necessary levels of immediate trust to emerge (Dellarocas, 2000; Resnick et al., 2000). Reputation systems collect, distribute, and aggregate feedback about the conduct of market participants (Resnick et al., 2000).

A reputation reflects the past behavior and serves as an indicator for the future behavior of a user ("shadow of the future") (Friedman and Resnick, 2001). A reputation originates from a collection of assessments of past transactions and manifests itself as a score and a list of comments which together are part of the so-called user profile. By doing so, past experiences are shared and made available for all users in the marketplace as a form of public good (Dellarocas, 2004). The reputation of a seller can be seen as a measure of his trustworthiness that holds a certain value (Melnik and Alm, 2002; Shmatikov and Talcott, 2005). This is reflected in the willingness of buyers to pay a higher price for the same item in cases where the seller shows a better reputation (Lucking-Reily *et al.*, 2000; Resnick *et al.*, 2002).

A well-working reputation system is not only important for the actual trading partners, but also for the auction provider whose aim it must be to achieve and maintain a critical mass of buyers and sellers on the platform. If sellers are motivated to behave cooperatively by the reputation system this has a spill-over effect on the reputation of the entire platform. Consequently, a reputation system is a vital component in attracting new users. For the trading partners, the reputation system reduces the uncertainty in transactions over distance; it provides mechanisms that negatively mark deceitful and positively acknowledge cooperative behavior. Moreover, existing user profiles resemble switching costs and increase customer retention. Hence, online auction providers should have a vital interest in the success of their reputation systems.

A Comparative Market Study

Existing reputation systems, especially the one of the market leader eBay, are criticized for a range of shortcomings. Firstly, it is comparatively easy for a seller with criminal energy to forge a reputation of positive feedback by setting up a large number of fake or very low priced transactions or by joining criminal circles of users who exchange positive feedbacks. Secondly, the eBay system allows the users to dish out so-called revenge assessments; it allows the seller to return to the buyer a negative rating out of spite even in cases where the buyer gave a legitimate negative feedback. This opens the door for putting pressure on the buyer. Finally, setting up fake accounts under a false identity is also a considerable problem. This might potentially damage the reliability of the whole reputation system. Given that the eBay reputation system is all but perfect the question arises how other providers go about the design of their reputation systems. How do they differentiate from the incumbent player and which conclusions can be drawn from this for the improvement of the eBay platform?

To pursue these questions, the paper reports on an expert evaluation of reputation systems in the German market for online auctions. Its main research question is: "How do competitors use their reputation systems to differentiate from the incumbent player eBay in order to attract users on the basis of a more advanced and secure reputation system?" This question is based on the assumption that competitors should have an interest to create a more trustworthy environment in order to win over change-willing users. To deal with this question, design aspects of reputation systems were identified based on a combination of literature analysis and empirical investigation. In the following paragraphs a brief overview of these requirements is provided before the evaluation is discussed.

DESIGN REQUIREMENTS OF REPUTATION SYSTEMS

Designing reputation systems is challenging: Buyers want reliable and rich information that supports the identification of trustworthy sellers (Resnick and Zeckhauser, 2001). Reputation systems should ensure fairness in the rating process and encourage the seller to comply with the descriptions of the auction offering and to engage in cooperative behavior (Dellarocas, 2000). Sellers on the other hand want the reputation system to distinguish between good and bad reputations in order to be rewarded for cooperative behaviour. Finally, auction providers want the reputation system to encourage trustworthy behaviour that leads to a cooperative code of conduct on the platform. According to Resnick et al. two phases can be distinguished in a reputation process: 1) In the feedback or rating process users

are assessed by other users and feedback is stored in a database. 2) In the decision process the condensed feedback of all transactions is presented as a seller's profile to support a buyer decision. The following design aspects form the criteria catalogue for the empirical evaluation of the six reputation systems.

Design of the Rating Process

At the end of an auction transaction users have to be motivated by the reputation system to rate their counterparts in a fair and honest manner. In designing the rating processes providers have to take into consideration the following aspects:

- Who is entitled to give feedback (Kollock, 1999)? In a bidirectional feedback process both parties are allowed to rate the quality of the transaction. However, such an approach is prone to the problem of revenge assessments.
- Does the platform provide incentives to give feedback (Resnick and Zeckhauser, 2001)? Here, it is a matter of avoiding the "free-riding" problem by which users benefit from positive ratings of other users but do not place assessments themselves.
- Is the rating mandatory, i.e. are there sanctions for users otherwise?
- How is the assessment structured (Kollock, 1999), i.e. in which way is the feedback extracted, by selecting a judgment from a drop-down list, by allocating point values, by text comments etc.?
- How is a single feedback incorporated in the user profile? Does the system provide a percentage value of positive ratings?
- Is it possible to make amendments to an existing feedback? In case of a conflict does the provider allow to delete a feedback?
- Is it possible to comment on a feedback? This can be helpful in documenting a dispute so that other users are able to judge for themselves.
- Does the system encourage honest ratings (Dellacoras, 2003; Resnick and Zeckhauser, 2001)? Which mechanisms are provided in this context?
- Can feedbacks be hidden? If so, users might be able to hide comments to guise a negative reputation.

Design of the Decision Process

The design of the decision process is crucial, because the usefulness of a reputation system is determined by how good a buyer is supported in accessing existing user profiles. The following aspects have to be dealt with:

- How are potential buyers informed about the feedback mechanism and its role in establishing trust?
- How are the feedback profile and the feedback score presented? Is the buyer able to immediately comprehend the reputation of the seller on the actual auction page?
- How can the buyer access additional information on the seller's reputation?
- How is the feedback history presented? An aggregate score (e.g. the difference of positive and negative ratings) does not reflect the particularities of the underlying auction transactions. Further information on the feedback history is necessary.
- Is there a filter with which the buyer can search in the detailed profile (history) of the seller, e.g. is it possible to filter for negative feedback?
- The profile might be accomplished with additional data on the seller, e.g. information on the registration date or whether the seller is active as a commercial trader or as a private person.
- In addition, the provider might allow users to undergo a specific registration process that incorporates an official identification to confirm the identity of the user and thus to enervate problems of anonymity.
- Is the reputation profile always displayed besides the user name, or only if the user is active as a seller (Resnick and Zeckhauser, 2001)?

RESULTS OF EMPIRICAL EVALUATION AND DISCUSSION

In order to investigate our research questions we evaluated the reputation systems of the six largest online auction providers in Germany. Since Germany is the second largest online auction market[1] our results should be typical of and thus transferable to other Western countries. Using the criteria presented above the following platforms were analyzed: eBay.de, Hood.de, Auxion.de, BesteAuktion.de, Ricardo.ch and Azubo.de[2]. All platforms were evaluated by two experts independently. The results were then discussed; in the few cases where results differed agreement was reached by further specifying the evaluation criteria. Detailed evaluations of the six providers can be found in the appendix; we focus our discussion on significant overlaps and differences.

Dominant Design of Reputation Systems across all Six Platforms

The initial assumption of this study was that competitors should have an interest in differentiating their reputation systems to avoid a range of problems well-known from eBay, and more importantly to gain a competitive advantage to attract new customers. However, this assumption cannot be confirmed based on our study. To the contrary, it turns out that the reputation systems show very strong similarities in nearly all design aspects. This holds true for both the rating process as well as the decision process:

- User assessments on five of the six platforms consist of a text comment plus a rating in the categories "positive" (+1), "neutral" (0) or "negative" (-1). Then an aggregate score is calculated, mostly by adding positive and subtracting negative ratings or by calculating a percentage. Only Azubo came up with a different way of extracting customer assessments (see later).
- All platforms follow the distinction in short user profiles available on the actual auction page and a detailed history accessible on one or more separate pages.
- On all platforms profiles are only shown on the actual auction page; it is not possible to use user reputations as a search or selection criterion in browsing for products.
- The representation of the short profiles generally follows the same patterns although numerical values and symbols vary slightly with most of the competitors showing even less information than eBay.
- On the history page all user comments and ratings are listed and most providers show a breakdown of all ratings as a matrix of the three categories (+ / o / -) and time periods.
- Most platforms provide a function for filtering the list of comments.

Overall, the deviations between the platforms are limited to details and mostly manifest in the fact that the five competitors lack behind eBay in terms of range of features as well as their presentation. Only few features indicate some form of independent development. By and large, we see a dominant design of reputation systems in the market for consumer-oriented online auctions.

A dominant design of a product or a service exists when it permeates a marketplace to the extent that it forces all actors in the market to standardize, e.g. to adhere to the dominant design (Abernathy, 1978). Players newly entering such a market feel immediately constrained in their design freedom while having to take over the established design features (Utterback, 1994). If a dominant design has emerged, design variations only take place within narrowly defined margins. Dominant designs often appear by way of imitation in cases where one dominant player controls the majority of the market (Voss, 2004). Clearly, this well-describes the market for online auction marketplaces in Germany. Moreover, with its transparency and openness the Internet lends itself to imitation processes making it easy for competitors to copy front-end features (e.g. reputation systems) since their design is well visible to the public.

Reasons for competitors imitating the eBay reputation system can lie in reducing the design uncertainty; the auction providers need not experimenting with mechanisms when the dominant player already demonstrates their successful functioning. On the other hand, it can be assumed that eBay's dominance exerts a conditioning effect on consumers. Many consumers have already learned and are accustomed to the interaction with the particular design eBay has chosen for its reputation system. If a competitor wants to deviate significantly from the dominant design, he risks not being able to connect with the established customs inherited by customers. He might thus lose the ability to attract customers who are willing to switch over from eBay. In line with this interpretation, the six reputation systems are found to follow design patterns dominated by eBay with rather marginal differences that lie within the borders of an otherwise uniformly interpreted reputation systems design.

Design Differences in Detail

Drawing from the differences presented in table 1 it can be argued that eBay is one step ahead of its competitors in some important aspects of reputation systems design. This can be seen as typical for a market leader. eBay provides the most comprehensive set of features for buyers to evaluate the past behavior and transaction history of a seller. Only a combination of various types of information about the seller and his activities puts the buyer in a position to comprehend the level of seller reputation, to make an informed decision, and hence to avoid unpleasant surprises. The short profile and rating score is only one source of information

Table 1. Areas in which eBay is ahead of most of the competitors

Design aspects	Explanation
Assessments are counted only from different users (only one per user)	This is an important precondition to prevent problems of friendly assessments with the intention to construct a positive reputation profile. Nevertheless, for smaller auction providers with only few active users in particular product groups of the platform the problem arises that profiles are built much more slowly. This may significantly delay the achievement of a critical mass of users.
Additional user information	eBay provides the most comprehensive list of additional information on the seller while two of the competitors do not even give information about the registration date of the user (is it a newly registered of long established user?).
Underlying auction can be accessed from the comments list in order to learn about the product and its value	The value and type of products sold by a seller in the past gives a good account of his activities: Were many cheap items purchased or sold to quickly build up a profile? Did the seller auctions a different type of product in the past and recently switched to another branch? This can be an indicator for an account that has been hijacked by someone else of for dishonest intentions of the seller (e.g. seller switching from baby clothes to high value tech items).
Profile of the assessing user is displayed in the list of ratings (on the history page)	By doing so, it becomes obvious if a seller receives a lot of assessments of newly registered user that were only set up to artificially improve the profile. Besides, the buyer can see in the profiles of other users if it is likely that the seller will engage in revenge assessments once a problem occurs and the buyer places a negative rating.
Number of withdrawn bids is displayed	How does the seller behave as a buyer? This additional context information can be a valuable jigsaw piece to judge the seller as a person.
Detailed rules of conduct and information on the assessment system available	Education of the users is an essential precondition to avoid cases of misconduct, deception, and fraud. Here, eBay as the market leader is at the center of user fraud and thus is confronted with the majority of security problems. Hence, eBay is very active in the communications department.

which has to be complemented with other information, e.g. on the type and value of products of the underlying auctions that the seller received positive feedback for and the reputation of the users who gave their feedback. Only then is the buyer able to detect cases in which users tried to artificially enhance their profiles. In regards to these features the five competitors all show significant room for improvement. This holds also true for the ways in which the reputation system and its features, the ways of using the system, and means of avoiding problems are communicated by the platform provider (for detailed results please refer to the appendix).

While the incumbent is clearly leading the way in most areas of reputation systems design, some of the differences between the platforms nevertheless reflect some independent development by the competitors. At the same time these differences mark areas in which eBay could further improve its reputation system (see table 2). In particular, the specific filtering options on the detailed history pages are to be mentioned here. These filters allow users to quickly gain an overview of negative assessments, a feature that further improves the buyer's situation in establishing a comprehensive picture of the seller's past behavior. Another feature that can reduce fraud on auction platforms is a mandatory user identification process by means of postal address (Ricardo.ch), telephone number (BesteAuktion), or passport photocopy (auxion.de); introducing such a feature would significantly increase the cost of setting up fake identities at eBay. Finally, Azubo's compulsory and sophisticated feedback mechanism might inspire eBay to move towards a more differentiated way of eliciting feedback in order to give the user a mechanism to utter dissatisfaction with particular seller actions without having to place an overall negative assessment. Without such a mechanism negative conduct might go uncovered since users might simply follow the path of least resistance and place a positive feedback. This might especially be the case when the buyer has to fear negative revenge assessments. However, no competitor had any mechanism in place to prevent such revenge assessments.

Table 2: Measures of competitors that go beyond the features of eBay

Design aspects	Explanation
Mandatory user identification by mail, phone or bank account	A secure identification of the users can help to prevent multiple identities and to expel dishonest users permanently from the platform. However, for a market leader like eBay this can lead to considerable expenses and in the short term might hamper platform growth.
Additional visualization of detailed profile	A bar chart visualization (like the one used by Azubo) can assist the user in quickly comprehending the development of a user's reputation over time.
Possibility to fast and easily filter for negative ratings	This is an important feature to get a comprehensive picture of the seller and his activities. In combination with an easy access to the profile of an assessing user this helps uncovering sellers who engage in revenge assessments.
Differentiation of the judgment in several dimensions (see Azubo.de)	A differentiation in behavior of the seller (communications and shipment) and the product quality allows a better evaluation of a seller. It also allows handing in critical judgments without having to place an entirely negative assessment, which most users want to avoid. Hence, this feature might lead to a more honest rating behavior and richer information.
Incentives to place assessments quickly	The more time elapses until users hand in their assessments the longer can seller misconduct go uncovered. Timely information is essential to limit fraud.
No time restrictions for handing in assessments	An artificial time restriction leads to unwanted tactics like users waiting up to the last second to place negative assessments in order to not having to fear a revenge assessment.

LIMITATIONS OF THE REPUTATION SYSTEMS

Besides the dominant design of their reputation systems the six platforms in our sample also share a set of important limitations, some of which were already mentioned at the beginning of the paper. A comprehensive list of all possible problems would go beyond the scope of this paper; some typical problems however became obvious during the course of our enquiry.

A typical problem mentioned in the literature is the artificial creation of positive profiles by means of so-called 'profile baking circles' in which users exchange positive assessments based on low-value transactions deliberately setup for this purpose (Bhattacharjee and Goel, 2005; Dellarocas, 2000). In order to raise the cost for this kind of tactics eBay decided to only count one assessment per user in calculating rating scores. The competitors however did not follow this measure so far; one reason might be that this would significantly limit the growth of feedback profiles, which is a problem for smaller platforms with only limited numbers of users.

Another problem is that the current profile might not truly reflect a seller's actual behavior at any given point in time, reason being that there is a time lag between the end of a transaction and the buyers handing in their assessments. In addition, the formal clarification process demanded by the providers in case of a dispute also delays the publication of negative assessments. One way to speed up the feedback process is to give incentives for timely assessments, e.g. in terms of an extra quarter point added to the score (see BesteAuktion) and by marking in the profile the existence of an ongoing dispute.

Another significant problem of the reputation systems lies in the possibility of unwarranted revenge assessment. While all providers permit commenting on a negative feedback using a short statement, a deletion of unwarranted assessments is tedious and only possible in special cases and with mutual consent of both parties. Such a process might even reward a seller for putting pressure on a buyer who placed a justified negative feedback. Hence, the risk remains that buyers are blackmailed or that sellers have their reputation damaged by competitors who bid on the seller's auction in order to deliberately harm their reputation (Dellarocas, 2000). Revenge assessments can be prevented by means of making the assessments available only when both parties have finished submitting their feedbacks. Of course, this has to be combined with making feedback mandatory and with speeding up the process. Otherwise users might be able to prevent the other party's feedback from being published by not submitting their own feedback, which would allow them to suppress negative feedback.

CONCLUSIONS

The contribution of this study is twofold. Firstly, a criteria catalogue for evaluating online auction reputation systems was compiled. Secondly, the empirical evaluation of the six largest auction platforms in Germany revealed a dominant design of reputation systems that is shaped and dictated by eBay as the incumbent player. Not only are the competitors not able to differentiate from eBay in this important area of platform design, they even lack behind in terms of range and quality of features. Consequently, eBay is not only able to demonstrate market leadership in economic terms, but also in the design of crucial aspects of the trading platform. It can be argued that, albeit the problems discussed above, eBay's reputation system is up to the task and fulfils customer needs to a satisfactory level as other studies have shown (Resnick and Zeckhauser, 2001; Resnick et al., 2000). However, online reputation systems still have certain limitations in simulating trust mechanisms well-known from traditional off-line markets (Bolton *et al.*, 2004). As we have argued above, there is still considerable room for improvement to tackle some of the most prevalent problems that allow or even abet online auction

fraud. This leaves room for further research on the design of reputation systems, especially since our study took an outside perspective using expert evaluation to rate the reputation systems. Further research should extent our work in two directions: Experimental studies should explore the perspective of average users while international comparative studies should aim at contrasting the situation in different national markets.

REFERENCES

Abernathy, W. J. (1978) The Productivity Dilemma, Baltimore.

Bhattacharjee, R. and Goel, A. (2005) Avoiding Ballot Stuffing in eBay-like Reputation Systems. in Third international workshop on economics of peer-to-peer systems), http://www.stanford.edu/~ashishg/papers/ebay.pdf, [Accessed: 2006-06-06].

Bolton, G. E., Katok, E. and Ockenfels, A. (2004) How Effective Are Electronic Reputation Mechanisms? An Experimental Investigation, Management Science 50(11): 1587-1602.

Dellacoras, C. (2003) The Digitization of Word-of-Mouth: Promise and Challenges of Online Feedback Mechanisms, Management Science 49(10): 1407-1424.

Dellarocas, C. (2000) Immunizing Online Reputation Systems Against Unfair Ratings and Discriminatory Behavior. in Proceedings of the 2nd ACM Conference on Electronic Commerce (Minneapolis), http://ccs.mit.edu/dell/ec00reputation.pdf, [Accessed: 2006-06-06].

Dellarocas, C. (2004) Building Trust Online: The Design of Robust Reputation Reporting Mechanisms for Online Trading Communities, in G. Doukidis, N. Mylonopoulos, N. Pouloudi, (eds.) Information Society or Information Economy? A combined perspective on the digital era: Idea Book Publishing, pp.95-113.

Friedman, E. J. and Resnick, P. (2001) The social cost of cheap pseudonyms, Jounal of Economics and Management Strategy 10(1): 173-199.

Kollock, P. (1999) The Production of Trust in Online Markets, in E. J. Lawler, M. Macy, S. Thyne, H. A. Walker, (eds.) Advances in Group Processes Vol. 16), Greenwich: JAI Press.

Lucking-Reily, D., Bryan, D. and Reeves, D. (2000). Pennies from eBay: The Determinants of Price in Online Auctions. Retrieved 2006-09-25, from http://www.econometricsociety.org/ meetings/wc00/pdf/1736.pdf

Melnik, M. I. and Alm, J. (2002) Does a Seller's Ecommerce Reputation Matter? Evidence from eBay Auctions, The Journal of Industrial Economics 3: 337-349.

Resnick, P. and Zeckhauser, R. (2001) Trust Among Strangers in Internet Transactions: Empirical Analysis of eBay's Reputation System. in Workshop on Empirical Studies of Electronic Commerce), http://www.si.umich.edu/~presnick/papers/ebayNBER/RZNBERBodegaBay.pdf, [Accessed: 2006-07-12].

Resnick, P., Zeckhauser, R., Friedman, E. and Kuwabara, K. (2000) Reputation Systems, Communications of the ACM 43(12): 45-48.

Resnick, P., Zeckhauser, R., Swanson, J. and Lockwood, K. (2002). The Value of Reputation on eBay: A Controlled Experiment. KSG Working Paper Series No. RWP03-007, from http://ssrn.com/abstract=385206

Shmatikov, V. and Talcott, C. (2005) Reputation-based trust management, Journal of Computer Security 13: 167-190.

Utterback, J. M. (1994) Mastering the Dynamics of Innovation, Boston.

Voss, A. (2004) Dominantes Design im Elecronic Commerce – Analysen und Befunde bei Tourismus-Web Sites, Lohmar.

ENDNOTES

1 http://investor.ebay.com/downloads/12105_ebay_GS.pdf

2 Following recent statistics [May 2006] from www.auktionssuche.de these are the six largest consumer-oriented auction providers in Germany; eBay features 15,000,000 auctions while the runner-up Hood.de only accounts for 900,000 auctions.

APPENDIX

Table 3: Detailed evaluation results, part 1

		eBay.de	hood.de	auxion.de	BesteAuktion	ricardo.ch	azubo.de
Rating process (profile building)	Who is eligible to give feedback?	Buyer and seller	Buyer and seller	Buyer and seller	Buyer and seller	Buyer and seller	Buyer and seller
	Is there an incentive/ compensation for giving feedback?	no	no	no	yes, user gets a quarter scoring point	no	no
	Is giving feedback mandatory?	no	no	Yes. When buyer does not give feedback, the seller automatically receives a positive rating.	no	no	no
	Structure of the feedback?	Three categories (positive/neutral/negative) plus short comment.	Three categories (positive/neutral/negative) plus short comment.	Three categories (positive/neutral/negative) plus short comment.	Three categories (positive/neutral/negative) plus short comment.	Three categories (positive/neutral/negative) plus short comment.	Answering of three questions regarding seller user behavior (Answers good/med/poor)
	How is a rating incorporated in the profile?	A score is calculated by adding positive and subtracting negative ratings; only one rating per member is counted.	Like eBay, but all ratings are counted.	Number of positive, neutral and negative ratings are added up as scores; all ratings are counted.	Number of positive, neutral and negative ratings are added up as scores; all ratings are counted.	A percentage of positive ratings in relation to all ratings is cal+G15culated	Answers to the three questions are calculated into a score for the three categories pos/neutr/neg.
	Is it possible to modify or delete an existing feedback/rating?	no, deleting a comment is only possible in special cases and when both parties agree	no, deletion is only possible in special cases (offensive ratings, advertising)	no	no	no, deletion is only possible in special cases (offensive ratings, advertising)	no
	Comments on feedback possible?	yes	yes	yes	yes	yes	yes
	Feedback guidelines: how is fairness and honesty be encouraged?	Detailed guidelines and rules of conduct	Detailed guidelines and rules of conduct	Very limited / no information	Very limited / no information	Detailed guidelines and rules of conduct	Detailed guidelines and rules of conduct
	Is it possible to hide ratings or comments?	No, a user can only declare his profile private and hide ALL ratings.	no	no	no	no	no

Table 4: Detailed evaluation results, part 2

		eBay.de	hood.de	auxion.de	BesteAuktion	ricardo.ch	azubo.de
Decision process (feedback usage)	Where can information regarding the reputation system be found?	Following the link "help" and "ratings" detailed information can be found	Like eBay, but information is quite limited	Only limited information, hidden somewhere in the "help" pages.	Following the link "help & hints" and "other" information can be found (but very limited)	Following the link "help"; information is quite detailed	Following the link "help" - "extra" - "rating system"; information is very limited
	How is the rating score visualised?	Score value, plus coloured star symbol (starting with a score of 10). Powerseller symbol for high volume sellers.	Score value, plus up to 7 stars depending on number of positive ratings (starting with 5), plus percentage value.	Number of positive, neutral and negative ratings are displayed as scores.	Number of positive, neutral and negative ratings are displayed as scores, plus star and crown symbols in gold, silver, bronze depending on number of positive ratings	Percentage value plus a number of up to 4 stars, displayed in 5 different colours. Diamant symbol in addition, when score > 99%.	Score value plus up to 5 stars in 3 different sizes (starting with 5 positive ratings).
	How can further information be accessed?	By clicking on the score value or a dedicated link a page with a detailed profile can be accessed	By clicking on the score value or a dedicated link a page with a detailed profile can be accessed	By clicking on a dedicated link a page with a detailed profile can be accessed	By clicking on the user name a page with a detailed profile can be accessed	By clicking on the user name a page with a detailed profile can be accessed	By clicking on the user name a page with a detailed profile can be accessed
	How is the feedback history be presented?	Table with number of pos/neutr/neg ratings in different time periods / List of ratings, user comments with short profile of this user, date, and link to the resp auction, and whether user was buyer of seller	Table with number of pos/neutr/neg ratings in different time periods (plus visualization as bar chart)/ List of ratings, user comments with short profile of this user, date, and link to the resp auction, and whether user was buyer of seller	Number of pos/neutr/neg ratings / List of ratings, user comments, date, and link to the resp auction, and whether user was buyer of seller (profile of user cannot be accessed)	More or less a list of ratings with comments and short profile of this user (no link to auction or info whether user was seller or buyer)	Table with number of pos/neutr/neg ratings in different time periods / List of ratings, user comments with short profile of this user, date, and whether user was buyer of seller (no link to the auction)	Bar chart visualisation of pos/neutr/neg ratings and using the rating questions / List of ratings, user comments with short profile of this user, date, and whether user was buyer of seller (but no link to auction)
	Is there a filter to search for positive of negative feedback or to change the appearance of the profile?	Filtering for seller/buyer comments and for different time frames (filtering for negative ratings is only accessible when filtering for a time period)	no filter, only one listing	Filtering for pos/neutr/neg ratings and for received and given ratings	Filtering for pos/neutr/neg ratings.	Filtering for pos/neutr/neg ratings and listing of own ratings given by the user.	no filter, only one listing
	What additional user information is available?	"Registered since", "commercial/ private", "my page", plus icon for verified users.	"Registered since", "commercial/ private", "my page"	"Registered since", "my page", "ratings by this user", plus icon for verified users	None	"Registered since", but only accessible in detailed profile	"commercial/ private", "my page"
	Is there a user identity verification?	optional, using the PostIdent by Deutsche Post AG	no, only verification of email address	optional, using passport photocopy	mandatory, by receiving a PIN number over the phone	mandatory, activation code received by post	optional, using a money transfer of one cent to the users bank account
	Is the profile always presented or only for sellers?	always	always	Profile is only shown for sellers, and only in an auction.	always	always	always

On the Determinants of Enterprise Risk Management Implementation

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ABSTRACT

Corporate governance failures and new legislation and recommendations have emphasized the importance of control and risk management in reducing agency costs and preventing fraudulent reporting. The objective of this paper is to investigate how a company's board characteristics influence the decision to invest in enterprise risk management. This paper contributes mainly to field of corporate governance research by providing new evidence on the relationship between board characteristics and enterprise risk management. In addition we also suggest a measure to test the quality of enterprise risk management derived from the COSO theoretical paper on enterprise risk management. The main results of this research is that board independence alone does not induce higher enterprise risk management quality, while boards with a separation of CEO and chairman, boards with both an independent board and a separation of CEO and chairman are more likely to adopt ERM.

1. INTRODUCTION

The Enron failure, together with other high profile corporate collapses, has led to a debate concerning the efficiency and the role of corporate governance. These corporate governance failures culminated in the passage of the Sarbanes Oxley Act (SOX) on July 30, 2002, which have emphasized the importance of control and risk management in preventing fraudulent reporting. While strong theoretical arguments exist as to why a firm should employ enterprise risk management (hereafter referred to as ERM), the main drivers for the implementation have been new corporate governance codes.

The purpose of this paper is to investigate how a company's board characteristics influence the decision to invest in enterprise risk management. This paper contributes mainly to field of corporate governance research by first providing new evidence on the relationship between board characteristics and enterprise risk management. In addition we also suggest a measure to test the quality of enterprise risk management derived from the COSO theoretical paper on enterprise risk management.

The main results of this research is that board independence alone has no significant relationship with the enterprise risk management quality, while the separation of CEO and chairman, or the combination an independent board combined with a separation are more likely to adopt ERM. In what follows, we discuss the background and motivation. Then the focus is on the research method that will be used. Finally, we describe in more detail the results.

2. BACKGROUND AND MOTIVATION

Since the corporate scandals and the creation of new corporate governance codes, enterprise risk management has been considered as a valuable element of the corporate governance structure. Since there is a separation between ownership and control, and managers' objectives are not necessarily aligned with those of the organization, managers may have incentives to behave opportunistic (Jensen and Meckling 1976; Watts and Zimmerman 1983). Existing agency theory proposes a series of mechanisms that seek to reconcile the interests of shareholders and managers, including the utilization of internal control mechanisms such as monitoring by non-executive directors (Fama and Jensen, 1983), monitoring by large shareholders (Shleifer and Vishny, 1986), the incentive effects of executive share ownership (Jensen and Meckling, 1976) and the implementation of internal controls (Matsumura and Tucker, 1992). An additional instrument of shareholder monitoring is the statutory audit whereby independent auditors report annually to shareholders on the appropriateness of the financial statements prepared by management (Watts and Zimmerman, 1983). The clear implication for corporate governance from an agency theory perspective is that adequate monitoring or control mechanisms need to be established to protect shareholders from management's conflict of interest – the so-called agency costs of modern capitalism (Fama and Jensen, 1983).

COSO-ERM (2004) defines enterprise risk management as a process, effected by an entity's board of directors, management and other personnel, applied in strategy setting and across the enterprise, designed to identify potential events that may affect the entity, and manage risks to be within its risk appetite, to provide reasonable assurance regarding the achievement of entity objectives.

In the hypothetical Modigliani and Miller world of corporate finance, risk management does not add value. However, in the non-frictionless environment of the real world, risk management by the firm can create value in one or more of the following ways (Meulbroek, 2002). Risk management can create value: (1) in ways that investors cannot duplicate for themselves; (2) facilitate the risk management efforts of the firm's equity holders; (3) decrease financial distress costs; (4) lower the risk faced by important non-diversified investors (such as managers and employees); (5) reduce taxes; (6) reduce the firm's capital costs through better performance evaluation and reduced monitoring costs; and (7) provide internal funding for investment projects and facilitate capital planning.

While strong theoretical arguments exist as to why a firm should employ enterprise risk management, the main drivers for the implementation have been reports of best practice such as the Joint Australian/New Zealand Standard for Risk Management, Committee of Sponsoring Organizations of the Treadway Commission (COSO) in the U.S. (arising out of control breakdowns in the Savings and Loan industry), CoCo (the Criteria of Control model developed by the Canadian Institute of Chartered Accountants), the Toronto Stock Exchange Dey Report in Canada following major bankruptcies, and the Cadbury report in the United Kingdom.

The purpose of this paper is to investigate how a company's board characteristics influence the decision to invest in enterprise risk management. If enterprise risk management reduces agency costs and improves governance structure, board of directors should be pushing the implementation of enterprise risk management. Two characteristics of the board of directors stand out in the literature as being of the greatest interest for effective corporate governance: independence of the board members and the duality of CEO and Chairman (Willekens and Sercu, 2005).

3. HYPOTHESIS DEVELOPMENT

We consider the relationship between two board characteristics, independence and separation of CEO and chairman and the degree of implementation of enterprise risk management.

Board of Directors

Fama and Jensen (1983) theorize that the board of directors is the highest internal control mechanism responsible for monitoring the actions of top management. Furthermore, Kleffner et al. (2003) investigate the impact of corporate governance recommendations about risk management on the implementation of enterprise risk management amongst Canadian firms. They find that 31 percent of their sample had implemented enterprise risk management (ERM), while 29 percent where at the moment investigating it. The participating companies indicated as most important driving forces behind the implementation the encouragements from the board of directors and the concern for directors' and officers' liability. The study indicates the importance of the demand for effective control and risk

management practices.

Board Independence

In their respective reports on corporate governance, both Cadbury (1992) and Hampel (1998) emphasize the value of increased non-executive representation on boards' suggesting that non-executives are capable of bringing greater independence and impartiality to board decisions. Consistently, Beasley (1996) finds an inverse relation between the percentage of outside directors on the board and the incidence of fraudulent financial reporting. Similarly, Firms with a majority of inside directors are found to be more likely to engage earnings management compared to a control sample matched by industry and size (Peasnell, et al., 2000). Furthermore, non-executives are expected to favor more extensive risk management and (internal or external) auditing in order to complement their own monitoring responsibilities, since they have the objective of identifying and rectifying reporting errors deliberately or otherwise made by managers. In a similar context, O'Sullivan (1997) finds that companies with a higher proportion of non-executive directors are more likely to purchase the monitoring of directors' and officers' insurance compared to boards with a lower proportion of non-executives. This suggests that companies with greater non-executive representation may favor a more comprehensive control, risk management and (internal or external) audit. The incentive of outside directors to prevent and detect such opportunistic reporting behavior by management potentially is driven by three factors:

First, the directors may seek to protect their reputations as experts in monitoring because the market for directors punishes those associated with corporate disasters or poor performance (see Fama and Jensen 1983; Gilson 1989). Second, from a legal liability perspective, directors who fail to exercise reasonable care in discharging their monitoring responsibilities may be subject to severe sanctions (see Gilson 1989). Third, shareholders often suffer significant losses in the wake of financial reporting problems (Beasley et al. 1999), so directors seeking to protect shareholder wealth may seek higher quality controls, risk management and (internal or external) audit.

In order to reduce the likelihood of fraudulent reporting, and opportunistic behavior in general, board could demand investments in higher quality control and risk management practices and/or purchase of higher quality audit services. Numerous studies have reported a positive relationship between the independence of the board and the demand for external audit quality, as measured by the audit fees (O'Sullivan, 2000; Carcello et al., 2002; Hay and Knechel, 2004). Therefore, one may view outside directors as more concerned with the quality of the financial and non-financial reports than are management directors, who face greater conflicts of interest.

HYPOTHESIS 1: *There is a positive relation between the percentage of outside directors on the board and enterprise risk management.*

Separation of CEO and Chairman

The UK Code of Best Practice (Cadbury Committee, 1992) recommends that the positions of chair and CEO should be held by different individuals. In addition, Jensen (1993) points out that when the CEO also holds the position of the chairman of the board, internal control systems may fail, as the board cannot effectively perform its functions including those of evaluating and firing CEOs. Similarly, Fama and Jensen (1983) argue that concentration of decision management and decision control in one individual reduces a board's effectiveness in monitoring top management. There is some evidence in the literature that firms perform better when the CEO and chairman function are separated. Pi and Timme (1993), Baliga et al. (1996) find that firms combining the CEO-chairman titles perform worse than firms that do not combine them.

HYPOTHESIS 2: *There is a positive relation between the separation of CEO and chairman and enterprise risk management.*

HYPOTHESIS 3: *There is a joint positive relation between enterprise risk management on the one hand and board independence and the separation of CEO and chairman on the other hand.*

4. SAMPLE SELECTION

We focus our study on one particular industry to maximize statistical power and because different industries may have different framework and different needs. The sample is composed entirely of firms from SIC code 2834-Pharmaceutical preparations. This industry has been used in previous research (Vanstraelen et al., 2003; Robb et al., 2001). Firms in this particular industry are faced with a wide array of risks and appear to display a sufficient amount of variation in enterprise risk management practices. The pharmaceutical industry is a competitive industry with pressure to perform, generating incentives to cut corners if results are not satisfactory. In addition, the SEC enforcement list contains several pharmaceutical companies that manipulated numbers in response of bad results. Therefore, we believe that focusing on this sector will allow us to study the impact of board characteristics on enterprise risk management. We selected randomly 100 firms, however because of missing data we only retained 75 firms. The data we collect is related to the fiscal year 2003. To assess the quality of enterprise risk management, we use publicly available data, such as 10-K's, proxy statements related to fiscal year 2003 and the company website. All other data is electronically collected via Datastream.

5. RESEARCH METHOD AND DEFINITION OF VARIABLES

We propose an Ordinary Least Squares to test our hypotheses. We test the quality of the ERM against the board characteristics, board independence and separation of CEO and chairman position, firm size, free float, leverage, beta and the auditor.

$$ERM = f(BODI, SIZE, BETA, LEV, DT, EY, KPMG, PWC) \quad (1)$$

$$ERM = f(CEOC, SIZE, BETA, LEV, DT, EY, KPMG, PWC) \quad (2)$$

$$ERM = f(BODI, CEOC, BODICEOC, SIZE, BETA, LEV, DT, EY, KPMG, PWC) \quad (3)$$

Quality of Enterprise Risk Management

We use the COSO (1992, 2004) framework and prior work by Knechel (2002) to define relevant control and risk management procedures and derive an aggregate enterprise risk management measure. We use control and risk management measures which reflect the organization's own assessment of control and risk management efforts. For each company, the annual report was evaluated for information about specific types of controls and risk and related enterprise risk management practices. We consider 7 aspects of ERM, similar to COSO-ERM framework (2004). Similar to Knechel (2002), we expect that the disclosure of control and risk management practises indicates that the organization is very sensitive to the need to identify and manage those specific risks. The measure of enterprise risk management we use is composed out of 91 questions, scoring 1 or 0. The total average score is about 32%, which means that on average firms provide information on 32% of enterprise risk management issues included in our framework.

Independent Variables

A number of typical measures of the quality of the board were included in the model. Consistent with this previous research (e.g. Carcello *et al*., 2002), we examine the following measures of the quality of the board of directors.

- BODI: Percentage of the Board of Directors that are considered to be independent.
- CEOC: Dummy = 0 if the CEO is also the Chairperson of the Board of Directors, 1 otherwise. We attach a positive value to the separation of CEO and chairman.
- BODICEO: Dummy = 1 if both the board is independent and the CEO and Chairman different persons.

Control Variables

- ***Agency costs.*** Agency costs arise from both equity and debt financing. We include free float (FF) to control for agency costs of equity, and leverage (LEV), measured as long-term debt over total assets, as a proxy for the agency costs between a company and its outside debtholders (Watts and Zimmer-

man 1986). Milgrom and Roberts (1992) argue that larger shareholders are possibly more willing and able to play an active monitoring role. Therefore, the agency cost of equity will be higher for firms with high public ownership and hence more need for enterprise risk management.

- ***Size.*** We include firm size, measured by total assets. Company size is associated with both internal and external agency costs (Adbel-Khalik, 1993).
- ***Beta.*** We include a measure for the perceived amount of risk by investors. We hypothesise that firms with high beta risk are perceived to be more risky. This may be because a firm is operating in a more volatile environment.
- ***Audit Firm.*** We believe that audit firms may have an impact on the implementation of enterprise risk measurements. This variable can take 5 different values: Non-Big 4, KPMG, E&Y, D&L and PwC. We take as reference category the non-Big 4 auditors.

6. RESULTS

We first discuss the descriptive statistics. In figure 1, we present and interpret the most important descriptive information for the dependent variable. We observe that firms score well on objective setting and risk identification, while they score weakly on control activities score and monitoring. In addition, we see a large variation in the total enterprise risk management scores between the minimum total score of 2 and a maximum of 75, with 67% of the observations between 17 and 41.

Next, we present descriptive statistics for the test and control variables. On average the pharmaceutical firms have large boards (an average of 8 members). The average board independence is around 73% and in the majority of the cases the CEO occupies the seat of the chairman of the board (contrary to corporate governance recommendations).

The pharmaceutical firms are on average relatively large, with a mean of 6802 million dollars of assets. Furthermore, the average firm has more than 50% of its shares are publicly traded. The average market risk (beta) is 1,57 time higher compared to the overall stock exchange and on average 18% of the total assets consist of long term debt.

High correlation amongst independent variables could affect the significance level of the variables. We checked for multicollinearity and found no problem (value of VIF of 2,34). We first test the relationship between ERM implementation and board independence, subsequently the relationship between ERM and separation of CEO and chairman and finally the relationship between ERM the combination of independence with separation as test variable. We depict the results in figure 3.

We see that our proposed models are all significant and explain between 30% and 38% of the variance in the dependent variable. The first model, with board independence as test variable is strongly significant, but board independence does not help to explain the variance in the dependent variable significantly. Therefore we can not reject hypothesis 1. Besides, we conclude from the first model that all control variables show the expected sign, except the leverage. We expected a positive relationship rather than a negative. Leverage and the beta risk are weakly significant, while firm size and the KPMG auditor are highly significant. Free float, Deloitte, Ernst & Young and PwC show a non-significant relationship.

In the second model, we introduce the separation of CEO and chairman as test variable. We predicted a positive sign, given that it takes 0 if there is no separation and 1 if there is separation. The model now explains more of the variance in the dependent variable, with an adjusted R^2 of 28% and is highly significant ($p < 0,00$). The test variable is highly significant ($p < 0,00$) and positive, indicating a positive relationship between enterprise risk management practices and the separation of the CEO and chairman. In contrast to board independence, the separation of CEO and chairman has a positive influence on the adoption of ERM practices. It may be that the board independence shows no results because the board operates differently when the CEO is also the chairman. Jensen (1993) points out that when the CEO also holds the position of the chairman of the board, internal control systems fail, as the board cannot effectively perform its key functions including those of evaluating and firing CEOs. Similarly, Fama and Jensen (1983) argue that concentration of decision management and decision control in one individual reduces a board's effectiveness in monitoring top management.

Furthermore, we investigate the influence of an independent board with a separation of CEO and chairman on the adoption of internal control measures. We obtain a slightly improved model, compared to model 2. The test variable is highly significant. From the results above we conclude that the separation of CEO and Chairman plays an important role in the adoption of enterprise risk management. In addition, model 3 tests whether there is an interaction effect between the separation of the CEO and chairman and an independent board work even better.

Figure 1. Descriptive statistics of enterprise risk management scores

	average	max score	median	min	Max	st dev	average %
Internal environment	5,12	17,00	5,00	0,00	14,00	3,21	0,32
Objective setting	2,64	6,00	3,00	0,00	6,00	1,21	0,44
Risk identification	11,75	25,00	11,00	0,00	23,00	3,86	0,47
Risk response	6,50	25,00	6,00	0,00	21,00	4,13	0,26
Control activities	1,53	9,00	1,00	0,00	7,00	1,65	0,17
Information and communications	0,84	3,00	1,00	0,00	3,00	0,69	0,28
Monitoring	0,65	5,00	0,00	0,00	3,00	0,85	0,13
Total score	29,03	91,00	23,50	2,00	75,00	11,65	0,32

Figure 2. Descriptive statistics of test and control variables

	Var	mean	median	st dev	min	max
Board size		8,47	8,00	2,80	5,00	20,00
Number of independent member in the board		6,24	6,00	2,68	1,00	18,00
Board independence (%)	BOD-I	72,6%	76,4%	16,8%	0,0%	100%
Number of executives in the board		1,79	1,00	1,17	0,00	7,00
Percentage of executives in the board		21,9%	16,7%	13,6%	0,0%	70,0%
CEO = CHAIR	CEOCHR	54,3%				
Total assets (in million $)	TA 2003	6801,92	229,898	17,74	2,179	117000
Free float	FF	57,5%	52,0%	21,4%	13,0%	99,0%
Beta	BETA	1,57	1,27	1,08	0,43	3,22
Leverage	LEV	18,3%	7,3%	23,6%	0,0%	87,9%

Figure 3. Regression results: ERM explained by board characteristics

		Model 1	Model 2	Model 3
C		-4,45 (-,442)	-14,693 (-1,54)	-9,563 (-1,43)
BOD-I	+	1,47 (,158)		-8,27 (-,950)
CHCHC	+		7,911*** (2,72)	-5,301 (0,22)
BOD-I CEOC	+			26,552*** (2,997)
FF	+	2,402 (,268)	6,246 (1,000)	6,146 (1,047)
LEV	+	-9,941* (-1,748)	-9,102* (-1,699)	-8,434 (-1,645)
SIZE	+	1,765*** (3,103)	2,278*** (4,118)	2,227*** (4,172)
BETA	+	1,500* (1,047)	1,366* (1,795)	1,393* (1,799)
D&T	?	3,804 (1,134)	2,230 (,788)	2,006 (,745)
E&Y	?	4,011 (1,505)	3,315 (1,127)	2,990 (1,034)
KPMG	?	11,641*** (2,876)	13,06*** (3,66)	14,29*** (3,889)
PwC	?	-1,472 (-,351)	-4,812 (-1,16)	-3,435 (-1,014)
R^2		,296	,360	,394
adj R^2		,198	,280	,293
Prob(F-stat)		,004	,000	,000

We observe that the board independence and separation of CEO and chairman become insignificant, while the interaction term is highly significant. It seems that it is important to combine a separation of CEO and chairman with an independent board to stimulate enterprise risk management adoption. Our results are in line with the results from Kleffner et al. (2003) which indicates the importance of the board in stimulating the adoption of control and risk management measures. We repeated the analysis using an equally weighted measure for enterprise risk management quality and obtain very similar results.

7. CONCLUSION

The paper analyses how board characteristics are related to the adoption of enterprise risk management. We found that board independence alone has no significant relationship with the ERM quality. The separation of the CEO and the chairman and the combination of an independent board with a separation of CEO and chairman, however are significantly related to the adoption of ERM. Firms with a separation of CEO and chairman, or firm with an independent board combined with a separation are more likely to adopt ERM. Given that board members have incentives to promote ERM in order to reduce own responsibility, our results indicate the importance of the separation of CEO and chairman in the adoption of enterprise risk management.

REFERENCES

Abdel-khalik, A. R. 1993. 'Why do private companies demand auditing? A case for organisational loss of control'. Journal of Accounting, Auditing and Finance, 8(1): 31-52.

Baliga, B.R., R.C. Moyer and R.S. Rao. 1996. CEO duality and firm performance: What's the fuss? Strategic Management Journal 17: 41-53

Beasley, M. S. 1996. An empirical analysis of the relation between the board of director composition and financial statement fraud. *The Accounting Review* 71: 443 465.

Cadbury Report. 1992. *Report of the Committee on the Financial Aspects of Corporate Governance*. London: Gee & Co.

Carcello, J.V., Hermanson, D.R. Neal, T.L. and Riley, R. R. Jr., (2002). "Board Characteristics and Audit Fees." *Contemporary Accounting Research* 19 (Fall): 365 384.

Committee of the Sponsoring Organizations of the Treadway Commission. 2004. Enterprise Risk Management*, Integrated Framework (COSO-ERM Report)*. New York: AICPA.

Fama, E. F. and M. C. Jensen. 1983. Agency Problems and Residual Claims. *Journal of Law and Economics* 26, no. 2: 327-349.

Jensen, M. C. and W. Meckling. 1976. The Theory of the Firm: Managerial Behavior, Agency Costs and Ownership Structure. *Journal of Financial Economics* 3: 305-360.

Jensen, M. C. 1993. The modern industrial revolution, exit, and the failure of internal control systems. *Journal of Finance*, 48, 831–880.

Gilson, S. 1989. Management turnover and financial distress. *Journal of Financial Economics* (December):241-262.

Hay, D. and W.R. Knechel, 2004."Evidence on the Association among Elements of Control and External Assurance", Working paper, University of Auckland

Knechel, W.R. (2002). "The Role of the Independent Accountant in Effective Risk Management". *Journal of Economics and Management* (February).

Knechel, W. R. and M. Willekens. 2004. "The role of risk management and governance in determining audit demand, Working Paper

Kleffner, A., R. Lee, and B. McGannon. 2003. The effect of corporate governance on the use of enterprise risk management: Evidence from Canada. *Risk Management and Insurance Review* 6 (1): 53-73.

Matsumura, E. M., and R. R. Tucker. 1992. Fraud detection: A theoretical foundation. *The Accounting Review* 67 (Fall): 753–782.

Meulbroek, L. 2002. A Senior Manager's Guide to Integrated Risk Management, *Journal of Applied Corporate Finance* Vol. 14, No. 4.

Milgrom, P., and J. Roberts. 1992. John, *Economics, Organization and Management* 1992, London: Prentice-Hall

O´Sullivan, N. 1997. "Insuring the Agents: The Role of Directors´ and Officers´ Insurance in Corporate Governance", Journal of Risk and Insurance, 64 (3), pp. 545 556

O'Sullivan, N. 2000. "The Impact of Board Composition and Ownership on Audit Quality: Evidence from Large UK Companies," *British Accounting Review*, 32 (December): 397-414.

Peasnell, K.V., P.F. Pope and S. Young. 2000. Detecting earnings management using cross-sectional abnormal accrual models. *Accounting ad Business Research* 30: 303- 326.

Pi, L. and S.G. Timme. 1993. Corporate control and bank efficiency. *Journal of Banking and Finance* 17: 515-530.

Robb, S., L. Single and M.T. Zarzeski .2001. Nonfinancial disclosures across Anglo-American countries. *Journal of International Accounting, Auditing and Taxation* 10 (2001): 71-83.

Shleifer. A. en R. Vishny. 1986. Large Shareholders and Corporate Control, *Journal of Political Econonzy,* juni, 461-488.

Vanstraelen Ann, Zarzeski Marilyn, Robb Sean W.G. 2003. Corporate nonfinancial disclosure practices and financial analyst forecast ability across three European countries. *Journal of international financial management and accounting*, p. p. 249-278

Watts, R.L., and J.L. Zimmerman. 1986. Positive Accounting Theory. *Englewood Cliffs, NJ: Prentice-Hall.*

Willekens, M. and P. Sercu. 2005. Corporate governance at the crossroad. *Intersentia.*

Incorporating Personal Information into RDF

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ABSTRACT

This paper introduces an RDF-based ontology to model personal information. The triples construct is applied to 'atomic' private statements. RDF is divided into two modes: personal information mode (PIRDF) and non-personal information mode. PIRDF is a restrictive version of RDF where its constructs follow the triple format such that the semantic subject of the atomic private statement coincides with the subject of the RDF triple. Also, related (compound) pieces of personal information are made in an RDF independent collection to preserve their relationship. Literals are not allowed to embed personal information. These restrictions do not introduce any change in the syntax of RDF. Privacy protection mechanisms can be constructed upon PIRDF.

INTRODUCTION

The Resource Description Framework, RDF, is a framework for describing and interchanging machine-understandable metadata. It facilitates knowledge sharing and exchange through automated processing of Web resources in such areas as content rating, intelligent agents, intellectual property, and privacy preferences and policies. According to the World Wide Web Consortium, "Using a metadata schema to describe the formal structure of privacy practice descriptions will permit privacy practice data to be used along with other metadata in a query during resource discovery, and will permit a generic software agent to act on privacy metadata using the same techniques as used for other descriptive metadata" (Kim et al. (2002). Of special importance in the context of Semantic Web is to automate interaction regarding personal information and autonomously decide what information to exchange. A fundamental abstraction in achieving this is identifying basic 'units' of personal information.

In this paper we discuss how to define and incorporate these 'units' of personal information into a Semantic Web service model. It also proposes to construct an ontological foundation for modeling identifiable-person type of resources separate from other types of entities. Accordingly, our RDF model consists of 'person-resources' represented as nodes that refer to identifiable persons and statements about these persons. One clear advantage of such a model is that there are well-defined nodes of distinct entities: identifiable persons. In general, resources are divided into resources that represent identifiable persons and resources that identify anything else. The basic characteristic of personal information is that it uniquely identifies a real person. This person is not an interpretation that depends on namespaces. He/she is a single person who has been or was documented to exist in this world and may have several identities and descriptions. Identifiable human beings are the only "resources" that have this ontological unique identification.

Section 2 discusses related works that deal with privacy in RDF. Its contention is that there is no current work on personal information ontology below the level of specification languages for privacy policies and a user's privacy preferences. The materials in section 3 are a review of the personal information definition and classification given in Al-Fedaghi (2005), where "atomic units" (RDF triple-like constructs) of personal information are introduced. Section 4 gives our main contribution: describing refined 'atomic personal information' (called self-statements) and mapping them to (private) triples. In this paper we assume familiarity with RDF.

PRIVACY AND RDF

Our work aims at developing a model - based on personal information ontology - for RDF that is used for the purpose of analyzing and classifying personal information. 'Personal information ontology' in this paper refers to the categories of personal information that exist in the privacy domain, thus, the ontology produces a catalog that details the types of pieces of information and their relationships that are relevant for privacy (Jacob, 2003). We deal with the following problems:

(a) How to define personal information, its types, its relationships, and its mappings to its proprietors? The answers to these questions are adopted from Al-Fedaghi (2005).
(b) How to represent personal information in the RDF model? The answer to this question is accomplished through mapping personal information statements to RDF triples and imposing some restrictions on these triples.

We concentrate on a version or mode of RDF that involves only personal information. For example, *John is 32 years old,* is atomic personal information because it embeds a single referent of type *person*. *This conference is in Canada* is non-personal information because it does not embed a referent of type person. *John likes Mary* is compound personal information because it embeds two referents of type person. The atomic personal information *John's car is White* embeds two assertions:

(1) The non-personal information *The car is White,* and
(2) What we call 'self-statement': *John has a car*. This self-statement forms our 'private RDf triple' with the person-resource: John.

Currently, in such formalisms as P3P (see Al-Fedaghi (2006)) and RDF there is no explicit distinction between personal information and "owned" information. The P3P works even if the data is not "private" in the sense that it refers to a *person*. In our ontology of personal information, the system would "recognize" personal information and would distinguish it from non-personal information. Agents will be able to recognize that the requested data is private data (of the agent's owner or otherwise) and responds accordingly. We propose to mold pieces of personal information in a restricted form of RDF.

There are several attempts to link personal information to RDF. RDF is proposed as a mechanism to create a "privacy ontology group with a charter" (Hogben, 2002). Kolari et al.(2005) propose to overcome the problem of restrictive expression capabilities of APPEL through "the use of privacy policies described in an RDF based policy language, Rei, which can make policy decisions over actions and associated restrictions modeled using a Web privacy ontology" (Kolari, 2005). We claim that our ontological treatment of personal information in the context of RDF is a useful contribution to building privacy into the Semantic Web. According to Kim et al. (2002), ontology for building privacy into the Semantic Web is needed now.

PERSONAL INFORMATION

We view 'personal information' as a symbolic form that 'informs' about a single human being. 'Information' here means the 'semantic content' of a linguistic statement or assertion. A personal information theory includes a universal set of personal information agents, $Z = V \cup N$, of two fundamental types of entities: *Individual* and *Nonindividual*. *Individual* represents the set of natural persons V and *Nonindividual* represents the set of non-persons N in Z.

Definition: Personal information is any linguistic expression that has referent(s) of type *Individual*. Assuming that p(X) is a sentence such that X is the set of its referents, there are two types of personal information:

(1) p(X) is atomic personal information iff X ∩ V = is the singleton set {x }.
I.e., atomic personal information is an expression that has a single human referent.
(2) p(X) is compound personal information iff | X ∩ V | > 1.
I.e., compound personal information is an expression that has more than one human referent.

In Al-Fedaghi (2005), the relationship between individuals and their own atomic personal information is called *proprietorship*. Proprietorship of personal information is different from the concepts of possession, ownership, and copyrighting. If p is a piece of atomic personal information of v ∈ V, then p is proprietary personal information of v and v is its *proprietor*. Proprietorship gives "permanent" rights to the proprietor of personal information.

One of the most important acts on personal information is the act of *possession*. A single piece of atomic personal information may have many possessors; where its proprietor may or may not be among them. A *possessor* refers to any agent in Z that knows, stores or owns the information. Human beings are conceptualized as personal information proprietors; however, they are not the sole sources of this information. For example, companies and government agencies in N can produce and possess (non-proprietary) personal information.

Any compound personal statement is privacy-reducible to a set of atomic personal statements (Al-Fedaghi, 2005). For example *John and Mary are in love* can be privacy-reducible to *John and someone are in love* and *Someone and Mary are in love*. Atomic personal information is said to be *self-statement* if its *subject* is its proprietor and 'only its proprietor'. A framework for the derivation of self-statements from atomic personal information is given in another paper. For example, *John's house is burning* is not self-statement because it expresses two pieces of information: (a) *John has a house* and (b) *The house is burning*. Statement (a) is self-statement because its 'subject' is its proprietor. The statement (b) is non-personal statement because its 'subject' is not a person but a house. The term 'subject' here means the entity about which the information is communicated. It is an important notion when it is tied with the notion of 'subject' in RDF triples. In many cases the 'semantic subject' means that the individual affects (agent) or is-affected-by (patient) something, as reflected by the verb of the sentence. For example, in *The company invited John to an interview*, it is not clear that John is the (semantic) subject. However, *John is invited to an interview by the company* shows that John is being subjected to an action. The principle that we will follow is: the proprietor of the atomic statement has priority in being a subject when there is another entity that has a claim to being a (semantic) subject of the verb. For example in *John trained the do*g and *The dog is trained by John,* the subject is John. In *John's house is burning,* John clearly has less claim for the verb of "burning', while in *John trained the do*g, John is the trainer and the dog is the trainee, hence both have equal claim to the verb.

A self-statement's structure is the typical (subject, predicate, object) form of assertions. The (semantic) 'object' here is either an 'attribute' of the subject (e.g., tall, brave, etc.) or a non-individual entity (e.g., as in *John trained a dog*, *John derives the car*, *John loves stakes*, etc.) Every atomic personal statement is reducible to a set of self-statements and non-personal statements. Here, because of space limitation we claim that this is intuitively reasonable. It reflects the common sense notion, that a statement is about entities in reality, which can be classified into different categories (ontological objects).

PERSONAL INFORMATION RDF

The basic RDF model contains statements as parts of descriptions of some resources. We propose two modes of the RDF model:

(1) Personal Information mode of RDF (PIRDF) that facilitates all dealings with personal information.
(2) Non-personal information mode of RDF, which is the ordinary mode of RDF.

Any information in the non-personal information mode of RDF is considered as non-privacy-related information, while information in PIRDF is handled as privacy-related information of some proprietor. PIRDF may include non-personal information, but this personal information is there because it 'complements' the semantics of some personal information. For example, in *John takes drug x23 which is used to treat cancer*, both the self-statement *John takes a drug* and the non-personal information *The drug is called x23 and used to treat cancer* are handled by PIRDF. These statements are treated as a collection of triples in order to facilitate reconstructing the semantics of the original statement, if such reconstruction is needed. Also, treating a set of statements as an RDF collection is the method used in PIRDF to represent compound personal information.

Personal information in PIRDF is treated in a special way to protect the privacy of proprietors. We will not deal with this side of PIRDF, and concentrate in this paper on the method of describing personal information in PIRDF. Our strategy is not to introduce any new feature to the standard RDF, rather we propose measures that restrict modeling triples in a way suitable for personal information. These restrictions are as follows:

(1) The subject of any RDF triple that represents self-statement is always a proprietor. It is also allowed to have the proprietor as the object in a reification statement with attribute: subject. The reason for making the proprietor as the subject of this type of triples is because it is the "semantic" subject of the corresponding self-statements. Thus, we merge the 'triple subject' with the semantic subject. This provides unique identification of personal information according to the content of the triple (subject + type: person), hence, it is not necessary to 'RDF-type' private statements. The resulting graph reflects the proprietor as the center of his/her personal information sphere as shown in figure 1.

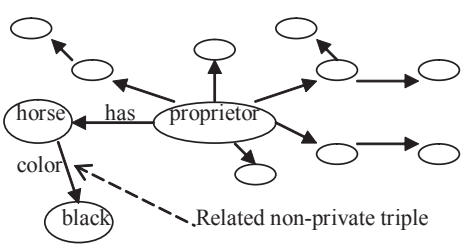
Compound personal information is represented as a set of triples of atomic personal information in an RDF collection. The reason for this is to allow the system to clearly identify the proprietor of any piece of personal information. Thus, the triple (John, threatens, Alice) is not allowed and replaced by (John, threatens, someone) and (Alice, being-threatened-by, someone). The method of representing these two triples without persons being allowed as objects is an open problem. Notice that the purpose in this type of modeling is to clearly distinguish John's personal information from Alice's personal information. It is possible that Alice is not permitted to know who threatens her (e.g., mental health confidentiality); however, she may have the right to know that she is the object of a threat.

A "resource" is defined in RDF as *anything that has identity*. In general, according to RFC 2396 (Berners-Lee et al., 1998) "A resource can be anything that has identity... Not all resources are network "retrievable"; e.g., human beings, corporations, and bound books in a library can also be considered resources." PIRDF describes a special type of resources: 'identified persons' class that is defined as the RDF schema vocabulary:

:Proprietors rdf:type rdfs:Class.

We denote this type of resource as 'person resource', for short, *pe*source. This pesource is an *information entity* that is realized through a set of atomic personal information. Every pesource is uniquely identified in the PIRDF. A person as an 'information entity' is a known ontological concept. According to Floridi (1998), all objects including human beings are 'information objects': "[A] person, a free and responsible agent, is after all a packet of information... We are our information... personal information is a constitutive part of a me-hood" (Stein et al., 2000). We observe that there is a difference between the conceptualization of a human being as an information entity and as a personal information entity. Thus, for us a pesource is an information entity formed from a set of pieces of atomic personal information.

Figure 1. The proprietor is always the (semantic and syntactical) subject of the private triples



PIRDF maintains the informational ontology of each proprietor through maintaining his/her personal information. It identifies pieces of personal information of each proprietor. These pieces of personal information are treated with special consideration in terms of: operations that include: disclosure, possession, consistency, sharing, etc. Non-personal information is treated in an ordinary way.

Using our terminology for personal statements, we can categorize triples that correspond to personal statements as follows:

(a) A non-private triple is a triple that does not contain any resource that denotes a person.
(b) A private triple is a triple that represents a self-statement.

In RDF, the subject is the node the statement is about. It is either an URI reference or a blank node. In PIRDF, the proprietor is always the subject of private triple. We assume that all personal information statements are in the form of self-statement. The subject of personal information triple refers to the subject of a self-statement.

Example: Suppose that we have the atomic information *Ernest Hemingway's FAREWELL TO ARMS is located at AF.123*. It embeds the two statements:

(a) Ernest Hemingway authored FAREWELL TO ARMS
(b) FAREWELL TO ARMS is located at AF.123

PIRDF gives special considerations to represent facts about persons, not about books, houses, etc. Assume that Ernest Hemingway is an entity of type person declared as proprietor in :Proprietors**.** Being a subject of triple (a) represents an implied type of the triple, thus we don't have to introduce the type 'private' to be associated with statement (a). A private triple is a triple where the subject is of type person. This is a very useful convention.

Alternatively, We could have considered both:

Ernest Hemingway authored FAREWELL TO ARMS,
FAREWELL TO ARMS is authored by Ernest Hemingway

as forms of personal information. However, in this case we have to distinguish between the "semantic subject" (what the statement is about) and the RDF subject. In *FAREWELL TO ARMS is authored by Ernest Hemingway,* the (privacy) "semantic object" is Ernest Hemingway while the RDF subject is (the book): FAREWELL TO ARMS.

In the original example, the other piece of information: *FAREWELL TO ARMS is located on AF.123* is non-personal information. Hence, it has no special consideration in PIRDF. It could be represented, if we like, as *AF.123 is the location of FAREWELL TO ARMS*.

In PIRDF world, the distinction between private and non-private triples is important. PIRDF is a partial, simplified conceptualization of the world created for the purpose of handling personal information and defined in a formal, machine-processable language.

In RDF, URIs identify network-accessible things, things that are not network-accessible, and abstract concepts. In PIRDF, identifiable network-accessible 'things' are of two kinds: privacy-based and non-private-based things. Without loss of generality, we assume privacy-based things are textual materials. Similarly, things that are not network-accessible are categorized into persons and non-persons.

In RDF, a URI is just a node that has a URI label on it, where the URI identifies the resource represented by the node. Since the URI directly identifies the resource represented by a node, RDF assumes that nodes with the same URI represent the same resource. A URI may be complemented with an optional fragment identifier, URIref. In PIRDF each proprietor is mapped uniquely to a single entry in the vocabulary pirdf:proprietor. This does not prevent from using different synonyms that are mapped to a single URIref in pirdf:proprietor. In principle, a proprietor may choose to have several "personal information personalities" through having more than one URIref in pirdf:proprietor. In this case he/she has two different "personal information spheres." This is an implementation issue similar to the problem of the uniqueness of RDF resources. However, the uniqueness of proprietors is easier to handle because of the already ultra-importance of identification of persons inside and outside the network. We will assume that each proprietor identifier represents a single person.

Example: Consider the following familiar compound personal information:

Ralph Swick says that Ora Lassila is the creator of the resource http://www.w3.org/Home/Lassila.

According to the W3C Recommendation (1999), figure 2 represents its graph form. We can criticize this graph representation on the ground that it does not correspond with the linguistic structure of the statement, which is in the triple form,

(*Ralph Swick says* (*Ora Lassila is the creator of the resource http://www.w3.org/Home/Lassila*)).

The main "subject" in the graph is the 'statement', while the original main subject *Ralph Swick* has become a value of an attribute to the statement. So, semantically, the whole graph is about 'the statement': about its subject, its object, its predicate, and its 'attributer'. This is not a suitable graph representation in PIRDF, because personal information is always about the proprietor: he/she is the subject.

Figure 3 shows the graph form of the given statement in PIRDF.

It has two atomic statements:

(1) *Ora Lassila is the creator of the resource http://www.w3.org/Home/Lassila.*
(2) Ralph Swick says statement (1)

This example illustrates another allowable position of the proprietor in PIRDF: as an object of the attribute: subject. Clearly, this case is syntactically discoverable.

The two atomic pieces of personal information (1) and (2) embed identities of proprietors. The personal information (1) is represented in the shown triples. Notice that PIRDF assumes that the only way to identify a proprietor is through his/her pirdf:proprietor identification.

Example: Suppose the we want to express the statement (Johannesen, 2004): *Tom borrowed a book from Mike*. In RDF, this can be expressed through a blank node that has connections to different properties as follows:

Figure 2. Reification in RDF

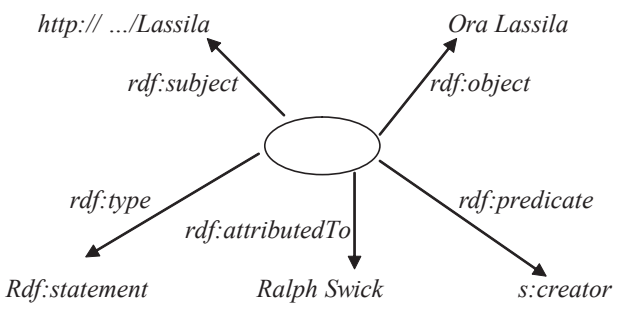
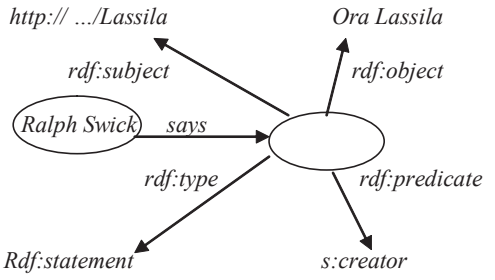


Figure 3. Reification in PIRDF



_:a rdf:type x:Borrowing
_:a x:who prs:Tom
_:a x:fromWhom prs:Mike
_:a x:what _:b
_:b rdf:type x:Book

This specification is described as "not the easy way to do the Semantic Web" (Johannesen, 2004). In PIRDF, the compound personal information *Tom borrowed a book from Mike* can be implemented as a collection of two triples: *Tom borrowed a book* and *Mike has a book* as shown in figure 4. Thus, the notion of compound personal information embeds the concept of a set.

Example: Consider the familiar RDF expression: (:Jane :daughterOf :John, : Jennifer). It can be represented in PIRDF as shown in figure 5.

Different personal assertions are distinguished as follows:

The personal information of Jane: *Jane is the daughter of some parents*
The personal information of John: *John is the father of someone*
The personal information of Jennifer: *Jennifer is the mother of someone*

It may sound somewhat odd to say that *Jane is the daughter of some parents*. However, imagine that the graph represents the database of an adopting agency. Then even Jane should not know her parents without permission.

The design of PIRDF requires several modifications with regard to literals. The general rule here is, it is not allowable to make literal personal information. Thus, *The newspaper headline is: John is a killer* may be described in RDF as the triple (<http://…newspaper> <http://…headline> "John is a killer"). However, in PIRDF, it is necessary to factor out personal information as shown in figure 6.

CONCLUSION

We have introduced elements of 'personal information modeling' in RDF. The proposed model is based on two foundations: defining personal information in terms of statements that refer to persons, and representing statements as RDF triples. The result is a preliminary RDF-based ontology of personal information. Space limitation does not allow more details to achieve further specification of such ontology. Our contribution is a first step towards focusing on the problem of personal information ontology below the level of modeling privacy preferences and policies.

Figure 4. Graph of Tom borrowed a book from Mike in PIRDF

Figure 5. Jane is the daughter of John and Jennifer in PIRDF

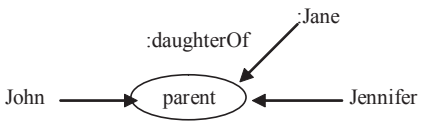
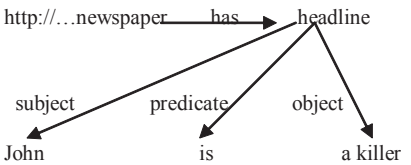


Figure 6. PIRDF allows the proprietor to be the object, if the attribute is 'subject'



There are several extensions to the basic PIEDF model. For users, their triples include:

- Private triples and related non-private triples,
- Sets of triples that represent compound personal information,
- Triples that represent personal information in the possession of the user.

Thus, in building a rules system, each of these types of personal information is treated differently. Generally, how PIRDF influences the rule system and policy language needs to be investigated. Also, several constructs of PIRDF present interesting issues in the new formalisms such as OWL (see Al-Fedaghi (2006)).

REFERENCES

Al-Fedaghi, S. (2006). Personal Information Flow Model for P3P, W3C Workshop on Languages for Privacy Policy Negotiation and Semantics-Driven Enforcement, Ispra (Italy), 17-18.

Al-Fedaghi S. and Ahmad, M. (2006). Personal Information Modeling in Semantic Web, The Asian Semantic Web Conference (ASWC), Beijing, China, September 3-7.

Al-Fedaghi, S. (2005). How to Calculate the Information Privacy. Proceedings of the Third Annual Conference on Privacy, Security and Trust, October 12-14, St. Andrews , New Brunswick, Canada.

Berners-Lee T., Fielding, R. Irvine, U. C. and Masinter, L. (1998). RFC 2396: Uniform Resource Identifiers (URI): Generic Syntax, August. http://www.ietf.org/rfc/rfc2396.txt?number=2396

Floridi, L. (1998). Information Ethics: On the Philosophical Foundation of Computer Ethics, ETHICOMP98 The Fourth International Conference on Ethical Issues of Information Technology. http://www.wolfson.ox.ac.uk/~floridi/ie.htm.

Hogben, G. (2002). Development of a Data Protection Ontology, Joint Research Centre, Ispra, 27 May. http://64.233.179.104/search?q=cache:tMF0U4WW_iQJ:p3p.jrc.it/presentations/Data%2520Protection%2520Ontology.v2.ppt+privacy+rdf&hl=en

Jacob, Elin K. (2003). Ontologies and the Semantic Web, Bulletin of the American Society for Information Science & Technology, Apr/May. http://www.findarticles.com/p/articles/mi_qa3991/is_200304/ai_n9235530

Johannesen A. (2004). shelter.nu, 24 Mar 2004, http://www.shelter.nu/blog-078.html

Kim, A., Hoffman, L. J., and Martin, C. D. (2002). Building Privacy into the Semantic Web: An Ontology Needed Now, Semantic Web Workshop, Hawaii USA, http://semanticweb2002.aifb.uni-karlsruhe.de/proceedings/Position/kim2.pdf

Kolari P., Li D., Shashidhara G. Joshi, A. Finin, T. and Kagal, L. (2005). Enhancing Web Privacy Protection through Declarative Policies, proceedings of the IEEE Workshop on Policy for Distributed Systems and Networks (POLICY 2005), June, 2005. http://ebiquity.umbc.edu/_file_directory_/papers/156.pdf

Resource Description Framework (RDF) Schema Specification (1999). W3C Proposed Recommendation 03 March, http://www.w3.org/TR/1999/PR-rdf-schema-19990303/

Resource Description Framework (RDF) Model and Syntax Specification, W3C Recommendation 22 February 1999

Stein, L., D. Connolly, D. McGuinness (2000). DAML-ONT Initial Release, http://www.daml.org/2000/10/daml-ont.html

What Practitioners Are Saying About the Unified Modeling Language

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INTRODUCTION

The Unified Modeling Language (UML) was formally introduced in the late 1990s, with much of it based on earlier object-oriented systems analysis and design (OOAD) methods. The UML quickly became the language of choice for modeling object-oriented systems and there are now numerous books, many written by practitioners, which describe the UML and suggest approaches for using it. The UML has continued to evolve, notably with the release of UML 2.0, driven largely by a "best practices" approach. This paper offers qualitative evidence of the broad scope of practitioner views on the UML in the form of comments from by UML practitioners in response to a survey on UML usage patterns. The range of comments suggests some interesting directions for future research.

RESEARCH METHODOLOGY

A web survey containing 38 questions, many with multiple parts (e.g., a list of possible reasons for not using a particular UML diagram), was developed and posted on the web in March 2003. The Object Management Group (OMG) supported the project by sending an email to their members to inform them of the survey, and by posting a link on their main web page. The survey was "intended for current systems analysts/architects who have used or considered using the UML in systems development projects" and some initial items asked about that experience. A few respondents did not belong to our target population, but no reported comments or data come from them. There were no rewards offered for participating, except for a copy of the results, so there was no incentive for non-UML practitioners to complete the survey with fictitious responses.

Most of the questions used standard Likert scale items and check boxes. Some of this quantitative data was presented and analyzed in Dobing and Parsons (2006). Respondents were also given substantial opportunities to add comments and further explanations. This paper focuses on these written responses, selected from 52 surveys. While these comments may not always reflect the majority views of the UML practitioner community, they are useful in identifying issues and concerns among a group of people who are largely committed to the UML and to its continued improvement.

The quotes provided in this paper are generally as submitted with any minor modifications (generally to preserve grammatical correctness) inserted in square brackets. Typographical errors have been corrected without any indication. Any use of upper case for emphasis has been left as in the original.

RESULTS

This section addresses some important UML issues which received higher levels of written responses. As might be expected with a relatively new language, it is being used in quite different ways by different people. As one respondent put it:

Used, vs. used appropriately, is probably a telling difference. Many places are using the components but in a relatively brain-dead manner. I don't think this is a UML issue. It is a brain-dead issue.

Of course, one developer's "best practice" can be another's "brain-dead manner." Our goal is not to offer solutions but simply to identify some of the issues about which UML practitioners feel strongly and are trying to address. These, in turn, should be useful in guiding further research in this area.

Use Cases

The UML is a language and not a development methodology, but all the major books on the subject adopt the "Use Case-driven" approach espoused by Jacobson (1992). There are some critics (e.g., Anderson, 1999; Simons, 1999), but most warn about incorrect application (e.g., using too many, going into too much detail, etc.) and do not reject Use Cases completely. However, our survey found that only 63% of respondents employed Use Cases in at least one-third of their projects. One respondent was "curious [about our] bias … towards Use Case narratives" saying "This is not a mandatory way to elicit initial requirements." Others described Use Cases as "close to useless," "just unformatted text notes," and "too imprecise to invest much effort in." "The ambiguity of Use Cases in particular is problematic." Another argued for a more limited role, saying "They are critical in defining the boundary behavior of the system but only that." Thus, there is a sharp discrepancy between practice and conventional wisdom in the literature.

One respondent questioned whether the Use Case Narrative is a model, asking:

Use cases allow technologists to build something that resembles a business solution. They are useless in modeling the actual business processes. ... Yes, you can put some information into a narrative, but is that a model?

Perhaps the key underlying issue concerns the role of Use Cases in requirements gathering, which is their intended purpose, and in design where the other UML diagrams are more relevant. One respondent stated:

Use Cases MUST be combined with functional requirements and constraints. Use Cases only show the behavior of the system.

Behavior is, of course, exactly what a Use Case Narrative is designed to show, 'what' not 'how' (Jacobson et al., 1994, p. 146). Whether the 'how' includes the user interface remains a concern. Constantine and Lockwood (1999, p.102) argue in favor of 'essential' Use Cases, which exclude interface details, claiming that "conventional use cases typically contain too many built-in assumptions … about the form of the user interface." But respondents who commented on this issue generally took the opposite view. One stated that "end-users have difficulties [when] validating a Use Case Narrative without any draft of the UI." Another goes further, saying, "It is easier for clients to understand the functionality of software through user interface sketches." While it is important to "promote better Use Case writing styles," there was no consensus among our respondents on what the style should be.

Use Cases were acknowledged to be useful in "defining test cases" and "effort estimation." The associated Use Case Diagrams, which generally were viewed less favorably, provide an "overall view" and help with "scheduling [and] risk assessment." While consistent with the literature, these are not generally considered the key reasons justifying Use Case development.

Other respondents identified alternatives. One "eliminated Use Case Narratives in favor of Activity Diagrams" while another said that "a state model hierarchy is sufficient." 'State model hierarchy' is not a UML term, or even one commonly associated with system development, but is used in connection with knowledge bases for expert systems. Some indicated they use "text" instead but without specifying how their documentation differs from Use Cases.

Another issue with Use Cases is their organization and maintenance. This is particularly true for those who favor more of them with more detail. One respon-

dent who did not use them stated, "My guess is it would be too hard to store and recover the Use Case narratives to use them in later [maintenance]." Of the 39 respondents who reported the number of Use Cases on "typical" projects, the top 15 ranged from 100 to 800. We did not ask about average length. One proponent said, "our typical Use Cases consume one - two pages each." but an infrequent user said that "Use Cases tend to become remarkably complex and highly error prone - have seen Use Cases as large as 250 pages." One reason for this variation may be the lack of any official UML specification. The OMG (2005. p.574) simply states that "Use Cases are typically specified in various idiosyncratic formats such as natural language, tables, trees, etc." There are now several books devoted to Use Cases (Armour and Miller, 2001; Cockburn, 2001; Adolph and Bramble, 2003; Bittner and Spence, 2003; Denny, 2005; Övergaard and Palmkvist, 2005) along with a few web sites, notably Cockburn's (http://www.usecases.org). But that isn't sufficient for one respondent who argues, "too much written but still too little [clarity on] what goes where [and] tools - little benefit for the time and effort invested in Use Cases."

There is insufficient understanding of why so many practitioners are avoiding Use Cases and what they are using as alternatives. Also, if a project has no Use Cases it certainly isn't Use Case driven. What, if anything, is driving their projects?

Activity Diagrams

We would expect differences of opinions on all UML diagrams but, after Use Cases, they were expressed most sharply for the Activity Diagram. One proponent stated, "We are currently using Activity Diagrams for the detailed specification of all Use Cases" while another said they were "useful to understand business activities [and] useful to understand the flow of activities in a Use Case." Another called for client involvement, "These being the only container we have that can hold business process information, it is critical that business people are engaged as much as possible." Their role was explained more fully:

Activity diagrams are very important when the client begins to describe process-like behavior and logic. Good to help understand and convey a business process, or an underlying algorithm. In these cases, I think an Activity Diagram is essential – compared to pure text.

However, others took strongly critical positions. One simply said, "'Activity' actually - sorry – sucks." According to different respondents, "they are very time-consuming to produce," have "unclear semantics and an unclear connection to the rest of the UML Diagrams," do not represent "the concept of a 'business process,'" are redundant "if Use Cases are well written and well modeled," lack a "wealth of information" about them in the literature and have "very poor tool support and integration (via tools) with the rest of the notation." Some suggested modifying them, "[without] the Erikkson Penker extensions … UML Activity Diagrams would be pretty useless for business modeling" and "we used Activity Diagrams, but with our own semantics." Others said "they need to be more like DFDs if they're to be useful" and "neither the concept of a 'business process' is well represented, nor is the value of good old DFD diagrams available." The latter respondent also claimed to "have developed an interesting and useful notation for processes/tasks/workflow." Alternatively, perhaps they are not sufficiently connected to the Class Diagram:

UML does not handle business process modeling. Activity Diagrams are the nearest, but: (a) I want to show classes, not instances. (b) I want to show resources (as classes!) input and output…

Thus, practitioners seem to have very different expectations for how Activity Diagrams should be used, and thus on how they should be improved.

Project Communication

Communication within the project team has long been considered critical for successful outcomes. Questions on this topic generated a large number of responses. As noted earlier, the UML literature generally stresses the importance of Use Cases for client-analyst communication and the remaining diagrams for analyst-programmer communication. (However, it should be noted that not all projects have distinct clients, analysts and programmers.) In our survey, respondents reported that clients were more involved with the more technical UML diagrams than the literature would suggest (Dobing and Parsons 2006). However, this may reflect the types of clients involved in these projects. In some cases, the clients were likely engineers. And in any organization, when introducing new technology the initial clients are often chosen based on their enthusiasm for trying new approaches.

Some respondents supported the view in the UML literature. For example, one respondent said, "[The Class Diagram] is too far from the business customers and users to be effective [or] useful," while another described it as "the most important diagram for technical members." The separation of Use Cases and Class Diagrams was also mentioned:

Class diagrams are nearly all at a design level, so have little to do with requirements (except that they result from requirements).Class diagrams are essential to deriving/documenting a long-lived, robust, software architecture.

These problems may be exacerbated when analysts take the view of the respondent who said "the only benefit of Use Case diagrams is to please managers."

Simply put, "The only problem is communicating with people not familiar with the UML." But how should that familiarity be achieved? One view is that clients, in general, will not be interested in or able to understand the UML. Those holding this view argue that the UML is "too geeky and techie for non-technical people" and "[our clients] eyes glaze over when we try to present UML/UP artifacts." If analysts proceed anyway, "explaining the notation sometimes dominates the discussions." As a result, there is "little involvement of key business people." These respondents conclude: "give up on this goal" and "don't try – UML is technical, clients are not."

Others see training as the solution. They emphasized the "need to educate clients … in UML," and called for "more awareness programs conducted in the industry." "The most important one is to get the client understanding OO and UML formalism, once this is achieved, you're in heaven." In some earlier informal discussions with early adopters of the UML, we found that sending both developers and clients to joint training sessions was common. Perhaps more efforts of this type are needed. Another said, "Other parties usually don't speak UML. You guys should do something about it." It's not clear if this refers to the OMG or academics, but as members of the latter group we need to think about whether students outside Information Systems majors should be exposed to the UML.

The complexity of the UML is a concern when training anyone in its use, and particularly clients. Simplification is one suggestion:

I think the only way is to teach clients to understand UML diagrams at the necessary conceptual level. This can be achieved by publishing a set of simple articles that use the minimal UML notation and describe [to] customers how it should be read. ... Maybe there is a need to define [a] basic subset used for Analysis. Maybe there should be subspecs describing these basic aspects.

More specifically, "Stereotypes and fancy arrowheads on class and sequence diagrams are details that are lost on the client."

Training is also needed within the technical staff, along with changes in attitude. There were references to "overnight experts [who] refuse to listen to anyone who's done the work before," "people not being able to model … modeling is HARD" and "misunderstanding of the object oriented concept (for analyst and programmers)." There were concerns about both "Luddite programmers," who are presumably experienced but not in object-oriented methods or the UML in particular, and "new staff and novice software developers."

Some of the solutions suggested include consistent terminology across products ("Terminology is the key to success … Visio calls this that and IBM calls this that and J2EE calls this that …"),, "introduce a Use Case Flow Diagram" (to show possible flows), "low-fidelity pieces – sort of a 'UML for Dummies'," agile modeling (and some related practices), and executable UML (which received quite strong support).

As system projects, development teams, and the number of stakeholders affected become continually larger, communication becomes even more important. A common language, such as the UML, can be very helpful. However, the wide variation in how the UML is used, including how it is augmented and handled by different tools, limits that commonality.

Augmenting the UML with Additional Modeling Approaches

We asked respondents which other modeling constructs they have used to augment the UML. The suggestions were numerous and varied. Entity relationship diagrams were the most popular. One reason was that "data is persisted in an RDBMS," e.g., "an Oracle database." E-R Diagrams were not being used instead of the Class Diagram. Of the 17 respondents who reported using E-R Diagrams specifically or just data modeling in general, 15 said they used Class Diagrams on every project. Other older approaches used include Data Flow or Process Flow Diagrams and, more generally, Structured System Analysis and Design. Respondents did not address whether they were using older approaches to phase in conversion to UML or if they planned to retain them in the longer term, although one said that flowcharts were an "appeasement for crusty [business analysts]" and another noted that "[customers] have a tradition of descriptions in a certain format and are not used to a UML view of the system." Some respondents also mentioned using alternative object-oriented approaches, including OMT (Booch), Shlaer-Mellor, Class Responsibility Collaborator (CRC) cards, and Coad/Yourdon.

There were six respondents who used supplementary approaches for user interfaces. As one respondent noted, "UML does not really cover this as such." Respondents were later asked about possible difficulties that had occurred that "could be attributed to the UML." Of the five categories listed, user interface was checked most frequently (36%). Thus, this would appear to be area for further development within the UML. One respondent suggested a possible product:

Lucid [from elegance technologies (www.elegancetech.com)] is a framework for user interface development. It is used very frequently in my company because there are no tools in UML for user interface modeling.

There are other products in this domain, although none were recommended in this survey.

Respondents also used additional tools for enterprise architecture, including Popkin Software and ICONIX. Others did not specify the approach used, e.g., "P2P, 2-tier, n-tier, centralized and distributed architectures."

There is a long list of other products being used to augment the UML, including IDEF (Knowledge Based Systems), Business Process Modeling (OMG), TurboCase (Hatley-Pirbhai method real-time systems) code prototypes ("see it, believe it!") and "ad hoc bubble diagrams." Six respondents reported using their own approaches and another five used various extensions (e.g., "a proprietary spatio/temporal extension" and "extensions for web applications") to the UML.

In answering this question, a number of criticisms of the UML were also put forward. They said the UML is "just a language, so [it] is just adequate for 'drawing' thoughts" and "the UML just a notation." The latter is correct, but many of the alternatives suggested are essentially notations as well. Another said:

[UML] methods ... are too constraining for the average customer. They want to do UML but balk at all the discipline and structure that is required to make it work.

In summary, the UML is often being used with other approaches. Some pre-date the UML and are used for continuity; others supplement the UML to provide additional capabilities. The extent and variety of these practices is a challenge to the claim of a "Unified" language.

Tools

Considerable dissatisfaction was expressed with both the quality ("nobody really implements the standard") and cost of UML tools available at the time this survey was completed. Rational products were used most frequently, with TogetherSoft a distant second. There were over 40 products mentioned in total, but this includes Microsoft Office products (e.g., using Word for Use Cases) and other system development tools not specifically designed for the UML market. Visio came third, but again cannot be considered a full UML tool although it does support the notation. The highly fragmented nature of this market is clearly an issue in the development of good UML tools, and no doubt contributes to problems getting different tools to work together. One, perhaps too cynical, observation was that developers see providing greater interoperability as a competitive disadvantage:

this is not a priority for CASE tool developers as this would allow analysts to change the tools they use in a too easy way.

One lengthy response sums up the general feeling:

One point that might be of more use is asking why there are no (zero) tools that completely support the full UML spec? As well as why tools are of such minimal use on large projects. Who is directing these tool development projects? I guess they start with Use Case diagrams of the problem domain. That would contribute to the use - but I think the problem is elsewhere. You should find a small group of enterprise architects who have also developed large real-world projects and fund them to develop usable tools. The reason I participated in this survey is in the hope we might someday see a tool that provides 15% of what is needed.

Software development tools have generally not received much attention from academic researchers. However, they can have considerable influence over how their underlying methodology is used.

CONCLUSIONS

A survey of UML use revealed considerable differences in the level of use and perceived value of UML diagrams (Dobing and Parsons 2006). This paper provides clues about possible reasons for these differences and points to opportunities for further research.

One concern is that the informality and lack of standards for writing Use Case Narratives limit their usefulness, both for documenting business processes and for supporting the development of other UML artifacts, especially in view of the amount of effort needed to create them. Given that UML advocates often prescribe a "Use Case driven" approach, research is needed to better understand why practitioners disagree on the value of Use Cases, as well as to develop and evaluate potential guidelines for using them consistently and effectively.

A second issue arising from the comments is the lack of agreement on the role and value of Activity Diagrams for describing business processes, as well as their relationship to Use Case Narratives and other UML diagrams. Some respondents found them to be very useful, while others held the opposite view. This suggests the need for research to better understand the role Activity Diagrams should play in UML models.

Another concern raised in the comments from respondents is the (un)suitability of UML diagrams for communication with clients. Despite quantitative evidence that clients are more involved in the development, review, and approval of UML artifacts than the existing practitioner literature suggests (Dobing and Parsons 2006), comments suggest that these diagrams are too technical for clients to understand and use. Clearly, there is a need for research to examine the use and usefulness of UML diagrams in communicating with clients.

Finally, despite the scope and complexity of the UML, some organizations are augmenting it with other modeling approaches. Further research is needed to understand whether this is done to accommodate transitions from older methods to the UML, or because of perceived limitations of the UML.

In conclusion, despite the standardization UML has brought to object-oriented analysis and design, there is a wide range of opinions about how to use the language and how useful the various constituent diagrams are. This offers a significant opportunity for researchers to contribute to a better understanding of effective UML adoption.

REFERENCES

Adolph, S., & Bramble, P. (2003). *Patterns for Effective Use Cases.* Boston: Addison-Wesley.

Anderson, D. (1999). Use Cases Still Considered Dangerous. *UIDesign.Net*, Oct. 1999. Available: http://www.uidesign.net/1999/imho/oct_imho.html

Armour, F., & Miller, G. (2001). *Advanced Use Case Modeling.* Boston: Addison-Wesley.

Bittner, K., & Spence, I. (2003). *Use Case Modeling.* Boston: Addison-Wesley.

Cockburn, A. (2001). *Writing Effective Use Cases*. Boston: Addison-Wesley.

Constantine, L. & Lockwood, L. (1999) *Software for Use.* Reading, MA: ACM Press.

Denny, R. (2005). *Succeeding with Use Cases: Working Smart to Deliver Quality*. Upper Saddle River, NJ: Addison-Wesley.

Dobing, B. And Parsons, J. (2000). Understanding the Role of Use Cases in UML: A Review and Research Agenda. *Journal of Database Management 11*, 4, 28-36.

Dobing. B and Parsons, J. (2006). How the UML is Used." *Communications of the ACM* 49, 5, 109-113.

Jacobson, I., Christerson, M., Jonsson, P., and Overgaard, G. (1992) *Object-Oriented Software Engineering: A Use Case Driven Approach.* Addison-Wesley.

Jacobson, I., Ericsson, M., And Jacobson, A. (1994) *The Object Advantage: Business Process Reengineering with Object Technology.* Addison-Wesley.

OMG. (2005). Unified Modeling Language: Superstructure, Version 2.0, formal/05-07-04. Available: http://www.omg.org/technology/documents/formal/uml.htm.

Övergaard, G., & Palmkvist, K. (2005). *Use Cases: Patterns and Blueprints.* Indianapolis, IN: Addison-Wesley.

Simons, A. (1999). Use cases considered harmful. In *Proceedings of the 29th Conference on Technology for Object-Oriented Programming Languages and Systems (TOOLS)*, 194-203.

Would the Best Candidate Please Step Forward? Reflections on the Pros and Cons of Different Support Mechanisms for Online-Questionnaire Design

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1. INTRODUCTION

The popularity of the Internet makes it an attractive option for conducting surveys – it has even been predicted that online-questionnaires will replace traditional delivery methods [3]. Although online-questionnaires offer many [e.g., 7, 15, 24] advantages over traditional paper-based questionnaires, the nature of the electronic medium itself brings some unique challenges [e.g., 3, 6, 11, 15]. To support the creation of online-questionnaires that fully exploit the advantages whilst addressing the challenges, guidelines have been derived to support online-questionnaire design [22].

An environmental scan of existing online-questionnaire design tools found that little, if any, support is currently incorporated within tools to *guide* online-questionnaire design according to the essence of these guidelines [24]. A logical step towards better supporting online-questionnaire design is, therefore, to practically and effectively incorporate the online-questionnaire design guidelines into design tools. This paper reflects on the pros and cons of various candidate support mechanisms which we considered during the realization of this step. The discussion is, necessarily, biased towards our goal and constraints; it is not our intention to extrapolate generic implications from our reflections, but rather to discuss our systematic comparison process and resulting observations in the hope that both may be useful to researchers and developers faced with a similar challenge.

Section 2 provides some limited background information about online-questionnaires and the guidelines derived to support their design; readers are referred to [22-24] for more detail. Section 3 reflects on a comparison of candidate support mechanisms which we undertook to identify appropriate mechanisms for incorporating the guidelines into a commercially available online-questionnaire design tool. The paper concludes with an outline of our planned future work.

2. BACKGROUND

Generating a respondent-friendly questionnaire can pose many challengers for designers, especially inexperienced designers [23, 30]. Design is a complex activity, often involving too much information to feasibly consider without support [10]; *with* support, however, there is potential for designers to be more productive and to produce better quality artifacts [30]. One means by which to provide such support for online-questionnaire design is in the form of design guidelines.

Until recently, online-questionnaire design guidelines have, however, been somewhat scarce [6, 25, 34, 39]. In an attempt to overcome the lack of a practical reference guide, Lumsden [22] derived an extensive set of online-questionnaire design guidelines from principles in the relevant domains of website, paper-questionnaire, and online-questionnaire design. Informed by research on website design, the guidelines have a strong focus on accessibility and usability, such as issues concerning visually impaired users and the elderly [24].

Despite their relevance there are, however, several problems generally associated with the practical use of guidelines [16, 18, 26]: when manifested as a physical document, guidelines are often impractical and therefore ignored [16]; when they must be manually located from a central source they become de-contextualized, lessening their apparent applicability and/or reducing awareness of guideline violation [18]; designers may not know how to interpret and apply abstract guidelines correctly [16, 26]; and guidelines can conflict with one another – increasing the cognitive demands placed on designers [16, 26] – and some (e.g., those relating to design consistency) can be hard to manually enforce. Limiting the practical effectiveness of guidelines, these issues can be addressed by incorporating guidelines into design software and thereby making guidelines an integral and active part of the design process.

Rarely do available online-questionnaire design tools incorporate support for the essence of Lumsden's guidelines [24]. In the rare instances where guidelines are incorporated, they are typically conveyed via defaults and non-context sensitive help facilities. Where defaults are used, designers are not advised about the possible side effects of modifying the default choices. Non-context sensitive help facilities, such as documentation commonly found under a help menu, provide inadequate support because designers must discontinue their design activity and manually search for design guidance – the interruption, combined with inconvenience, making this an unlikely occurrence.

In a trial evaluation of Lumsden's guidelines, based on their current hardcopy manifestation, they were shown to add considerable value to the resulting design of an online-questionnaire [23]. For reasons already noted, it is unlikely that the guidelines will achieve widespread practical adoption and impact in their current paper form. Our aim is, therefore, to investigate how best to incorporate the guidelines within an online-questionnaire design tool such that they inform the design from a practical, active (as opposed to their current passive) perspective.

Online-questionnaire design tools are complex applications and, since current tools (as already mentioned) provide minimal active design *guidance*, we investigated other genres of software design tools in order to systematically review potential candidate support mechanisms for use within the context of online-questionnaire design tools. The remainder of this paper discusses the results of this evaluative process.

3. ASSESSING CANDIDATE SUPPORT MECHANISMS

We define a *support mechanism* to be a user interface element (or set of related elements) that assists a designer in creating better products and/or in solving problems.

To allow us to *systematically* assess existing support mechanisms relative to our problem domain, we had to first establish a set of criteria to guide our comparison. We based our set of criteria on the fact that design support within an online-questionnaire design tool should [24]:

- point out sub-optimal decisions;
- be context-linked to actions;
- set up best choices by default;
- educate a designer about guidelines; and
- automate certain tasks.

We added the criterion that the support mechanism within the tool should be able to provide suggestions to the designer, as well as a number of other criteria as

Table 1. A consequence table

	Primary Supports			
Criteria	critic	wizard	knowledge repository	automated design creator
Increases chances of creating respondent-friendly questionnaires	1st	2nd	4th	3rd
can point out sub-optimal decisions	Y			
can be context-linked to actions	Y	Y		
can set up best choices by default		Y		Y
can educate user about guidelines	Y		Y	
can automate tasks		Y		Y
can provide suggestions	Y			
Approach meets desirable implementation criteria	1st	3rd	4th	1st
been implemented in a web environment	Y	Y	Y	Y
could encode all guidelines (All, Most, Some, None)	Most	Some	None	Most
could be implemented within my time frame	Y	Y	Y	Y
Supported by others' research	1st	3rd	4th	2nd
positive author comments	1st	3rd	4th	2nd
negative author comments	1st	3rd	4th	1st
Overall:	1st	3rd	4th	2nd

shown in Table 1. We used *consequence tables* [17] (see Table 1) to support our goal-specific comparison process.

3.1 Support Mechanisms

Via a systematic literature review, we identified several potentially appropriate support mechanisms – originating in critiquing systems [31, 36, 38], learning systems [21, 29, 40], help systems [1, 2, 5], and automated systems [4, 20, 35] – and categorized the mechanisms as follows:

- Critics;
- Wizards;
- Knowledge Repositories;
- Automated Design Creators; and
- Scaffolds and Supplementary Supports.

Critics

A *critic* is an intelligent agent that provides assistance during the design process [31] by analyzing a designer's solution [36]. A critic can analyze a design according to various criteria, such as guideline adherence, completeness, design consistency, and alternative design choices [37]. Feedback from the analysis is then presented to the designer (often as a list of messages); once the feedback is considered, appropriate design modifications can be made. Critics are found in critiquing systems – these systems are responsible for generating and presenting critic feedback, activating and de-activating critics, and updating internal design representations.

Wizards

A *wizard* guides a user through a process on a step-by-step basis [1]. A user is typically presented with options for selecting/entering desired preferences and properties; the wizard then automatically performs corresponding tasks based on the user's specifications.

Knowledge Repositories

A *knowledge repository* stores and displays information that can assist a designer in making educated design decisions. Some systems have included design guidelines as hypertext references so that a designer is not required to laboriously reference a paper document [18, 19]. Others have included statistics about past design decisions [16] so that such knowledge can provide additional context.

Automated Design Creators

Some researchers are concentrating on *automated generation techniques*, such as methods found in the fields of expert systems [20, 35], generative programming [4, 33], and model-driven development [9, 14]. A common aim among these systems is to provide a designer with the ability to specify design requirements and/or objectives after which the system produces a corresponding design. Some systems allow a designer to manually modify the solution once generated [9].

Scaffolds and Supplementary Supports

Scaffolds are defined as "*software features that address the cognitive obstacles learners face so they can engage in the work in an educationally productive manner*" [29, p.81]. With the support of scaffolds, students are often able to successfully perform work which likely would not otherwise have been possible [29].

A natural bi-product of providing practical guidance to designers during the creation of an online-questionnaire – and an important anticipated outcome of exposure to appropriate support mechanisms during design activities – is furthering the learning of online-questionnaire designers. As such, although our educational objective is not as explicit as it is in e-Learning systems, we chose to include scaffolds in our evaluation because we believe scaffolds may be a useful approach for conveying the information contained in guidelines.

We classify a range of other mechanisms as *supplementary supports* – e.g., templates, hypertext, defaults, and examples – which can be used by any of the primary mechanisms previously described. For example, a wizard can use hypertext to link to other actions in an interface.

3.2 Candidate Comparison

We believe that the nature of scaffolds and supplementary mechanisms makes them better suited, and more powerful, as complementary supports in our context; for instance, a critic that alerts a designer to an ill-advised modification of a default property offers more support than a system that only includes defaults with no advising capabilities. With this in mind, we systematically compared the relative merits of the other mechanisms to act as a primary support. Table 1 shows our primary comparison criteria, divided into sub-criteria. The "positive/negative author comments" sub-criteria are further divided as shown in Table 2; we evaluated each on the three point scale shown. The following discussion is from the perspective of comparing a critiquing system to the remaining three candidates relative to our specific goal; this standpoint was adopted both for ease of discussion and because, upon initial review, the critiquing approach seemed potentially the most capable of meeting our specific needs. In essence, the discussion serves to confirm this observation.

3.2.1 Favorable Characteristics

Since many critiquing systems demonstrate the potential to include a large number of guidelines, it seems that a critic has the capability of supporting the majority of Lumsden's extensive guidelines. This is important because it maximizes the comprehensiveness of active support that can be offered to a designer. Consider this capability in comparison with the other noted mechanisms. Since a wizard is primarily suited towards procedural tasks, it is likely that a wizard could only provide active support for very specific guidelines – for instance, those guidelines

Table 2. Assessed positive and negative criteria – Yes = Y; Sometimes/Somewhat = S; No = N

		Primary Supports			
	Criteria	critic	wizard	knowledge repository	automated design creator
Positive	promote reflection on decisions	Y	N	N	S
	reduce design error costs	Y	Y	S	Y
	support during design context	Y	S	N	S
	novice considers expert issues	Y	N	S	N
	designed for real work environments	Y	Y	Y	S
	part of natural design process	Y	N	S	N
	ideal for structured tasks	S	Y	N	Y
	no need to search for guidance	Y	Y	N	Y
	can link to other UI services	Y	Y	Y	Y
	ideal for novice users	N	Y	S	S
	user acquires knowledge	Y	S	S	S
	guidance is searchable and/or explorable	S	N	Y	N
	good for consistency & low-level issues	Y	Y	N	Y
	decisions can be made for user	N	S	N	Y
	user can guide system to desired solution	N	N	N	S
	speed up development	S	S	S	S
	improve quality of work	S	S	S	S
Negative	potential for designer resistance/reluctance	N	S	Y	N
	feedback may not be viewed	S	Y	Y	Y
	designer may be left to perform many manual tasks	N	S	N	Y
	feedback may be irrelevant	S	Y	S	Y
	creativity may be stifled	S	S	Y	N
	concentration may be interrupted	S	Y	N	Y
	designer may not be encouraged to reflect on decisions	S	S	Y	N
	mechanism is often explicitly invoked	Y	N	N	S
	cannot run concurrently while designer modifies design	Y	N	Y	Y
	assistance opportunities typically designer responsibility	Y	N	N	Y
	mechanism not well integrated into design environment	Y	Y	N	Y
	feedback may be overwhelming	S	Y	N	Y
	designer may be forced to read documentation	S	Y	N	Y
	designer may lose feeling of being in control	Y	S	Y	S
	designer's knowledge may not contribute to design	Y	S	Y	S
	resulting interfaces tend to look similar to one another	Y	N	Y	N

that pertain to the suggested structure (i.e., page breakdown) of an online-questionnaire. A knowledge repository is a passive form of support that is likely to manifest as a de-contextualized hyperlinked manual of guidelines, which would have to be manually searched by the designer. Finally, although an automated design creator could also encode a large portion of the guidelines, Eisenstein and Puerta have argued that "*the only way to build a system that is usable in real-world design projects is to focus on those areas of design that are particularly amenable to automation and leave other areas of design in human hands*" [8, p.75]. On this basis, it is likely that automating all of Lumsden's guidelines is not appropriate, albeit a semi-automated approach might be suitable. This is, in fact, the approach of critiquing systems: they provide an automated analysis tool that focuses on tedious and low-level details (a task ideally suited to computers), while leaving the designer in charge of making final design decisions.

A second attractive feature of a critic is its ability to encourage a novice designer to think like an expert [30]; critics actively bring relevant issues and possible trade-offs to the designer's attention. In comparison, wizards seldom allow such opportunities to present themselves since they are automated tools that aim to *hide* details from a user. Despite the expert knowledge contained within a knowledge repository, the process of obtaining this information is far too passive and laborious to make it a viable means by which to encourage expert thinking. Although an automated design creator can also encourage expert thinking (e.g., [8, 28]), the process is not as explicit as in a critiquing system. Further criteria favoring a critic include its ability to explicitly educate a designer about guidelines, as well as actively pointing out sub-optimal design decisions and providing suggestions on possible fixes [37]. Using a wizard can lead to some transfer of knowledge, but not to the extent that comes from interacting with a critic, and very rarely are explicit educational opportunities provided in an automated design creator. A knowledge repository can promote learning, but in a reactive fashion. None of the other three approaches offer analysis and advice provision capabilities.

Finally, the concept of critiquing is a *natural* part of design [31]; to improve an artifact, a designer must determine whether aspects of the design need improving and if so, the means by which to make the corresponding improvements.

3.2.2 Unfavorable Characteristics

While there are many favorable characteristics to support the critic approach, we must equally consider the disadvantages or unfavorable characteristics of this approach. Principal amongst these is the potential for user reluctance; one study showed that critics were seen to challenge designers' authority and the critiquing was perceived as antagonistic [37]. The study viewed negatively the fact that designers anticipated the criticism and performed design actions in an effort to avoid the firing of feedback (although some might argue it to be a positive outcome). Whatever one's stance, a subsequent study [30] suggests that, unsurprisingly, it is the design of the critic feedback and corresponding interaction, as opposed to the critic metaphor itself, that determines designer response to the support mechanism.

While the possibility exists for a designer to resist a critic, the same risk is equally real for the other three support mechanisms. Novice users prefer lots of guidance and limited choices, while expert users tend to favor less guidance and the availability of many options [27]; as such, it is highly likely that a wizard could be viewed as restrictive by experienced designers. Users rarely consult passive documentation and online-help [2] and so although, being easily ignored, knowledge repositories are less likely to meet explicit resistance, as a solution in our context they are less likely than a critic to be effective *because* they can so easily be disregarded. Finally, automated design creators are often criticized on account of the limitations they place on the extent to which a designer can actively bring his/her knowledge to the design process [38] and users of expert systems typically resent being placed in a passive human-computer interaction role [35]. In contrast, researchers have argued in favor of critics because such mechanisms

encourage collaborative problem solving [12, 31, 35, 38]. Instead of a one-sided problem solving approach, both the designer's and system's knowledge play a key role in the design process [38].

Robbins [31] asserts that existing critiquing systems force the designer to engage in too many manual tasks, namely: modifying a design in response to critic feedback; enabling/disabling relevant/irrelevant critics; and instructing the system in how a critique was resolved. Although theses issues are important, they are essentially facets of the interaction design (and hence, usability) of a critic as opposed to concerns about its inherent ability as a concept to effectively support a designer. Furthermore, leaving the designer in control is a *strength* of critiquing systems; the ability to, for example, manually modify a design is a desirable characteristic in such software. A wizard can be used to start a design session from a default template, but complete construction of a questionnaire is unlikely to be possible without some manual designer intervention. Indeed, only certain aspects of questionnaire creation are amenable to automation and manual design decisions and modifications are unavoidable. Of all four mechanisms, knowledge repositories place the heaviest manual burden on the designer; guidelines must be manually searched, read, and interpreted. At the other end of the spectrum, as already mentioned, an automated design creator typically does not provide *enough* opportunities for manual intervention. Although some automated design creators (e.g., [33]) allow a designer to actively engage with the system and manually select components for the later automated generation phase, we believe that having to choose a multitude of low-level design components places no fewer demands on the designer than a critiquing system.

Finally, critiquing systems are sometimes criticized on account of the degree to which they can potentially interrupt a designer's task concentration [13]. While certainly a valid concern, interruption is not always a negative issue; a critic educates a designer by posing appropriate questions in real time and reflection is encouraged. Reflection is a part of the mental process during design and researchers [13, 32, 37] often cite psychological theories to support the use of the critic mechanism on these grounds.

4. SUMMARY AND FUTURE WORK

As the first step towards incorporating guideline support within an online-questionnaire design tool, we have conducted an environmental scan of appropriate design support mechanisms used in other genres of software design tools. We have concluded that the advantages of a critic outweigh its potential disadvantages within our specific context. We believe that this natural user interface metaphor, which encourages self-critiquing of a work-in-progress, is the most appropriate mechanism for supporting an online-questionnaire designer.

We observed that critiquing systems normally focus on visual feedback – typically relying on the presentation of textual messages to convey critiques. Alternative modalities (such as audio feedback) could prove to be beneficial in better supporting designer-critic dialogue; indeed, Ericsson suggests that "*better cues are needed*" to signal comments needing immediate attention [10]. We therefore propose to investigate alternative means of presenting critic feedback to a designer. Once we have completed our development phase, we intend to conduct extensive usability studies to determine the precise aspects of our design that do and do not work in the context of online-questionnaire design; on the basis of the findings of such studies, we hope to improve on our initial design and identify which components of support benefit from automation and which should be left in the control of the designer.

As noted in the introduction, we acknowledge that the discussion presented here is biased towards our goal and constraints. Although we have not, therefore, extrapolated generic implications from our reflections, we hope that this discussion concerning our comparative observations will prove useful to researchers and developers faced with a similar challenge. Furthermore, we hope our observations might also prove useful in terms of knowing what to look for when selecting a well-supported online-questionnaire design tool in the future!

REFERENCES

1. Ames, A.L., Just What They Need, Just When They Need It: An Introduction to Embedded Assistance. in *19th Annual International Conference on Computer Documentation*, (Santa Fe, USA, 2001), 111-115.
2. Baecker, R., Showing Instead of Telling. in *20th Annual International Conference on Computer Documentation*, (Toronto, Canada, 2002), 10-16.
3. Couper, M.P. Web Surveys: A Review of Issues and Approaches. *Public Opinion Quarterly*, **64**(4). (2000). 464-494.
4. Czarnecki, K., Overview of Generative Software Development. in *International Workshop on Unconventional Programming Paradigms*, (Le Mont Saint Michel, France, 2005), 326-341.
5. Delisle, S. and Moulin, B. User Interfaces and Help Systems: From Helplessness to Intelligent Assistance. *Artificial Intelligence Review*, **18**(2). (2002). 117-157.
6. Dillman, D.A. *Mail and Internet Surveys: The Tailored Design Method*. John Wiley & Sons Inc., New York, 2000.
7. Dillman, D.A., Tortora, R.D. and Bowker, D. *Principles for Constructing Web Surveys*, Washington State University, Pullman, Washington, 1998.
8. Eisenstein, J. and Puerta, A., Adaptation in Automated User-Interface Design. in *5th International Conference on Intelligent User Interfaces*, (New Orleans, USA, 2000), 74 - 81.
9. Eisenstein, J. and Puerta, A., Towards a General Computational Framework for Model-Based Interface Development Systems. in *4th International Conference on Intelligent User Interfaces*, (Los Angeles, USA, 1999), 171-178.
10. Ericsson, M. *Commenting Systems as Design Support*, Department of Computer and Information Science, Linköping University, Linköping, Sweden, 1996, 193.
11. Evans, J.R. and Mathur, A. The Value of Online Surveys. *Internet Research: Electronic Networking Applications and Policy*, **15**(2). (2005). 195-219.
12. Fischer, G., Lemke, A.C., Mastaglio, T. and Morch, A.I. The Role of Critiquing in Cooperative Problem Solving. *ACM Transactions on Information Systems*, **9**(2). (1991). 123-151.
13. Fischer, G., Nakakoji, K., Ostwald, J., Stahl, G. and Sumner, T., Embedding Computer-Based Critics in the Contexts of Design. in *SIGCHI Conference on Human Factors in Computing Systems*, (Amsterdam, The Netherlands, 1993), 157-164.
14. Fraternali, P. and Paolini, P., A Conceptual Model and a Tool Environment for Developing More Scalable, Dynamic, And Customizable Web Applications. in *6th International Conference on Extending Database Technology*, (Valencia, Spain, 1998), 421-436.
15. Fricker, R.D., Jr. and Schonlau, M. Advantages and Disadvantages of Internet Research Surveys: Evidence from the Literature. *Field Methods*, **14**(4). (2002). 347-367.
16. Grammenos, D., Akoumianakis, D. and Stephanidis, C. Integrated Support for Working with Guidelines: The Sherlock Guideline Management System. *Interacting With Computers*, **12**(3). (2000). 281-311.
17. Hammond, J.S., Keeney, R.L. and Raiffa, H. *Smart Choices: A Practical Guide to Making Better Decisions*. Broadway Books, New York, 2002.
18. Henninger, S. A Methodology and Tools for Applying Context-Specific Usability Guidelines to Interface Design. *Interacting With Computers*, **12**(3). (2000). 225-243.
19. Iannella, R. HyperSAM: A Management Tool for Large User Interface Guideline Sets. *ACM SIGCHI Bulletin*, **27**(2). (2002). 42 - 45.
20. Liao, S.H. Expert System: Next Term Methodologies and Applications—A Decade Review from 1995 to 2004. *Expert Systems with Applications*, **28**(1). (2005). 93-103.
21. Luchini, K., Quintana, C. and Soloway, E., Design Guidelines for Learner-Centered Handheld Tools. in *CHI'04*, (Vienna, Austria, 2004), 135-142.
22. Lumsden, J. *Guidelines for the Design of Online-Questionnaires*, NRC, Fredericton, NB, 2005.
23. Lumsden, J., Flinn, S., Anderson, M. and Morgan, W., What Difference Do Guidelines Make? An Observational Study of Online-Questionnaire Design Guidelines Put to Practical Use. in *19th British HCI Conference*, (Edinburgh, UK, 2005), 69-83.
24. Lumsden, J. and Morgan, W., Online-Questionnaire Design: Establishing Guidelines and Evaluating Existing Support. in *IRMA'2005*, (San Diego, USA, 2005), 407-410.
25. Norman, K.L., Lee, S., Moore, P., Murray, G.C., Rivadeneira, W., Smith, B.K. and Verdines, P. *Online Survey Design Guide*, University of Maryland, 2004.
26. Preece, J., Rogers, Y., Sharp, H., Benyon, D., Holland, S. and Carey, T. *Human-Computer Interaction*. Addison-Wesley, Boston, MA, 1994.
27. Priestley, M., A Wizard for Wizards: Decision Support for the New or Despairing User. in *16th Annual International Conference on Computer Documentation*, (Quebec, Canada, 1998), 98 - 102.

28. Puerta, A. A Model-Based Interface Development Environment. *IEEE Software*, **14**(4). (1997). 40-47.
29. Quintana, C., Krajcik, J. and Soloway, E., A Case Study to Distill Structural Scaffolding Guidelines for Scaffolded Software Environments. in *CHI'02,* (Minneapolis, USA, 2002), 81-88.
30. Robbins, J.E. *Cognitive Support Features for Software Development Tools*, University of California, Irvine, 1999, 231.
31. Robbins, J.E. *Design Critiquing Systems*, University of California, Irvine, California, 1998.
32. Robbins, J.E. and Redmiles, D.F. Cognitive Support, UML Adherence, and XMI Interchange in Argo/UML. *Information and Software Technology*, **42**(2). (2000). 79-89.
33. Schlee, M. and Vanderdonckt, J., Generative Programming of Graphical User Interfaces. in *Working Conference on Advanced Visual Interfaces*, (Gallipoli, Italy, 2004), 403-406.
34. Schonlau, M., Jr., R.D.F. and Elliott, M.N. *Conducting Research Surveys via E-mail and the Web*. RAND, 2002.
35. Shepherd, A. Knowledge-Based Expert Systems: Critiquing versus Conventional Approaches. *Expert Systems with Applications*, **14**(4). (1998). 433-441.
36. Silverman, B.G. Survey of Expert Critiquing Systems: Practical and Theoretical Frontiers. *Communications of the ACM*, **35**(4). (1992). 106-127.
37. Sumner, T., Bonnardel, N. and Kallak, B.H., The Cognitive Ergonomics of Knowledge-Based Design Support Systems. in *CHI'97*, (Atlanta, USA, 1997), 83-90.
38. Tianfield, H. and Wang, R. Critic Systems - Towards Human-Computer Collaborative Problem Solving. *Artificial Intelligence Review*, **22**(4). (2004). 271-295.
39. Umbach, P.D. Web Surveys: Best Practices. *New Directions for Institutional Research*, 2004 (121). 23-38.
40. Winnips, J.C. Support of Active, Self-Reliant Learning via the WWW by Means of Cue Scaffolding. *International Journal of Continuing Engineering Education and Life-Long Learning*, **10**(1-4). (2000). 296-313.

Trust Within the Established Inter-Organizational Information Sharing System

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ABSTRACT

Trust is often considered to be a primary factor in the implementation of a collaborative information sharing system. These systems have become more common in organizations since the increase in the need to be more efficient and effective. Trust, it is often said, must be present prior to the exchange of often sensitive information. Based upon the results of a mail-based survey, we did not recognize trust in an established information sharing system as a key success factor, since it is replaced by contractual agreements defining the limitations of the transferred information usage. The derivation of the theory and the supporting evidence relating to information sharing is presented.

1. INTRODUCTION

Trust is often stated in literature as being of critical importance in the creation and maintenance of an information sharing system. These systems are becoming quite common as the need for systems efficiency becomes not only important but necessary. The necessity for increased responsiveness has resulted in various types and levels of communication between elements in an organization's supply chain being established. Information sharing presents many distinct advantages to an organization but simultaneously opens the firm's critical and often sensitive information to the review of persons outside the firm. The structures that are needed to ensure a successful implementation are not identical though to those that ensure the successful maintenance of the same information sharing system. Trust, though critical in the implementation, is replaced by legal and contractual stipulations as the system ages.

The literature shows a multiple models of diverse elements in a complex series of theories that the respective authors say affect inter-organizational information sharing. These factors are predominantly influenced by individual behaviors, organizational behavior, inter-organizational relationships, and others that can be distributed into broad political and social contexts (Schermerhorn 1975). The importance of interorganizational information sharing is that it provides benefits to organizations including economies of scale, lower overhead and reduced risks (Alexander, 1995). The technology theory influencing information sharing is a vast and dynamic collection of database, communications, and network theories.

In this paper we deal with the role of trust within the information sharing systems. Based upon the results of a mail-based survey, we determined 10 key success factors for an established information sharing system. Trust, which did not occur as a factor among them, seems to be replaced by contractual agreements defining the limitations of the transferred information usage. Some our conclusions are based also on field studies of the FLUID-WIN and SEAMLESS projects (Delina 2007).

Empirical Research on Information Sharing

Theoretical studies, and simulations to justify such, abound while empirical pieces are primarily limited to a few case studies with quite few broad-based empirical studies existent. In the short amount of time that Information Sharing has been studied, the trends in the dissolution of vertical integration have strengthened and alliances within a supply chain have become more common. Organizations have changed in that they now need to gather materials or goods in a manner and at a speed that the demands of the customer are considered.

In the development stages of interorganizational information systems, the structures underlying the system implementation are dynamic and complex. Two or more organizations are involved and numerous technological and social considerations must be made. Compromise is often necessary to accomplish any goal and such is more often the rule than the exception. Under these circumstances, trust is necessary since adjustments to contractual stipulations would be a hindrance. Information sharing structures for post hoc implementations have been but minimally explored.

Often, information sharing occurs in an ad hoc fashion via methods that are devised anew with each interchange: that is, single-use, single-purpose mechanisms. Trusting that the organization, that the information is being given access to, is not entirely self-serving in that it serves the purpose of not requiring a revision of contractual agreement each time as an exclusion to that contract presents itself.

However, as the system of sharing becomes more mature and the volume and frequency of information sharing grows, a more permanent mechanism for defining the limitations of the information exchange and usage often becomes beneficial, one that can function repeatedly and serve a variety of purposes. Strategic information is of great interest in sharing and infrastructure-building, due to the high cost of its production, its potential for re-use, and its value in strategic decision making. An information-sharing infrastructure links organizations with common goals and tasks by means of defined standards, navigation and conversion tools, shared "framework" information, and institutional structures such as supply-chain relationships.

Inter-Organizational Information Sharing Literature Review

Inter-organizational information sharing is not a new concept but has been widely researched over the past thirty-five years since the empirical research of Schermerhorn (1977). These organizations work in a cooperative/competitive manner described by Lado et al. (1997). Aspects of trust in information exchange have been researched by Thompson (1991) and Thompson & Hastie (1990). Kemp & Smith (1994) found that the level of information shared correlated to the benefit derived for each participant. Though mature computer-based information sharing organizations and structures have not specifically been investigated, findings regarding more traditional means of information sharing have found that (1) shared information is based upon an initial expectation of trust (2) shared information results in faster mutual decisions (3) higher costs (4) decreased complexity (Butler 1999) (5) that shared information has strategic importance (6) correlated strategies (Doyle & Snyder, 1999) (7) a shared vision (8) mutual understanding and (9) routinization of synergistic interactions (Jassawalla & Sashittal, 2000).

The structure of the paper is to describe existing industry structures and benefits in section 2. Research objectives are described in section 3 with a comprehensive description of the methodology employed in section 4. The empirically derived model and descriptions of the factors is presented in section 5 followed by the conclusions in section 6.

2. INDUSTRY STANDARDS ON INFORMATION SHARING

Standards do not yet exist for database structures but information sharing between autonomous organizations is often desired or mandated. By autonomous firms using compatible data descriptions, data can be shared without translation or modification. Enterprise Resource Planning systems, with their limited array of translation

capabilities can communicate with a like system with little or no modification to either system. The effect is often described as "seamless" since the transaction of information sharing works in a like manner as a request or transmittal of data from an internal source (Palaniswamy, Frank, 2000). The evolution of business database systems towards "common" systems software definition is having the effect of achieving a minimum standard of compatibility that should eventually create a voluntary standard for data sharing.

Information sharing can reduce the cost of failure, operational costs and improve the scheduling and efficiency of current resources. It also provides intangible benefits such as improved quality with increased customer and shareholder satisfaction. To place confidence upon the achievement of these goals in something as intangible as trust is unlikely in an organization, that must report to its owners the detail of its actions. Such situations eventually result in written agreements that describe the actions and responsibilities of the organizations involved. These formal agreements are legally binding contracts and have legal remedies available with possible penalties for the firm violating the contract. Trust, being intangible does not always have legal remedies for its violation.

As organizations increasingly access the benefits offered by the inexpensive computer and communications technology, the problems and concerns that accompany the benefits become more apparent. The information that can be used to improve the actions of the supply chain and simultaneously reduce associated expenses is also often of a critical nature and need be protected from competitors and others.

Shared information can have a distinct influence on organizational cultures, strategies and behavior. Using shared information is often either a technological problem or an organizational one. It is difficult to fully anticipate how the information will be retrieved, combined, and employed. This tends in the implementation stage to disrupt most rigidly hierarchical organizational structures and influences the formation of more "organic" managerial structures. These organic structures then evolve, along with the information system, back to the more rigid, less organic structures involving contracts rather than trust to oversee the actions of the participants.

3. RESEARCH OBJECTIVES

This research examines the aspect of trust of information sharing and how relationships are mediated by that trust within an established information sharing. Trust aspects in information sharing are often considered to be crucial in previous studies of factors influencing the success of information systems. The research described here is that of already established. No study to date investigates what influence trust constitutes in an established information sharing system. Several studies have investigated the importance of trust in implementing an information sharing system but none to date have sought to explain "trust" as the system evolves. This study will seek to fill this void.

Trust is considered in this research as a feeling or belief that a partner organization will act in the best interests and without malice in actions that involve their partner. Providing strategic information without cost to supplier chain partners can strengthen the both organizations and provide a competitive advantage. Trust, it is said, is required in implementing a system of information sharing since strategic information could be used either constructively or destructively. But, as this research reveals, the need for trust is not constant and as the information sharing system ages and evolves, it diminishes in importance to the level of insignificance.

4. RESEARCH METHODOLOGY AND RESEARCH DESIGN

This study was of organizations that were determined a priori to have a need for sharing information. The keywords used in gathering the list of organizations were such that the organizations in the study were those that had suppliers and would place a greater level of demand on those suppliers than what would be considered normal. The organizations studied were chosen because of the production of products that had a great variety of demand and product parameters, those factors that had already been determined to affect supply chain performance and costs. Though previous empirical studies have found that trust exists in implementing an information sharing system, this study infers through its failure to discover a correlation that at some point following the implementation, the importance of trust diminishes. The firms involved in the study still benefited from sharing information but that they did not place any reliance on trust. The action of information sharing correlated to producing competitive rewards with few concerns of vulnerability as earlier studies had found.

The systems involved in this study, though physically more vulnerable because of increased levels of access, were typically not very complex though and thus correctable should any such problem occur. Organizations that share information with their supply chain partners have the ability to create highly efficient supply chains. This efficiency translates into increased customer satisfaction through improved quality and responsiveness, and increased revenue due to lowered costs. Sharing information with supply chain partners will initially need trust to counter the lack of an established system to manage the information transfer and usage but then evolve into contracts and formal agreements that regulate the application and ownership of the information.

A total of 680 questionnaires were directed to organizations drawn at random from a meta-search of organizations that met a predefined list of criteria. The questionnaire was composed of 121 questions all based on either yes/no answers or a Likert scale. In total, two questionnaires were mailed along with two follow-up requests to each firm selected for the survey. From the returned questionnaires, 110 were found to be usable, which represented a response rate of 16.1%. Surveys were returned from employees of organizations in various geographic locations and within various positions in their respective supply chains. The firms were both service and physical goods manufacturing firms of various sizes.

Multiple principal component based factor analyses with post hoc validation modeling were conducted to assess the validity of the survey measures and to determine the underlying factors and components influencing the success of an information sharing system; "success" being defined in this instance as a system that is used and provides some economic benefit. The factor analysis was applied to the survey responses and questions that had linear statistical similarities were clustered together. These clusters were clarified using Lisrel, a Structural Equation Modeling program, to strengthen the internal cohesiveness of the individual factors. The elements comprising the factors have individual internal correlations to the factors of at least 50 percent. These conglomerate factors were all statistically related to the factor defining success. The factors all have chi-square values exceeding 2.5. An ARTMAP neural network was used to correlate the factors to Successful Information Sharing, basing success on the financial viability of the firm and its respective industry, after sufficient time had passed to generate an effect. The ARTMAP correctly classified the firms, based upon these factors, 90 percent of the time. The scale for success was 6 categories ranging from high profitability in a growth industry to severe financial duress or bankruptcy.

5. RESULTS

The components – factors - identified by the factor analyses are: (1) Centralized Information Sharing Control, (2) Maintain and Update Information Sharing Rules, (3) Significant Exchange of Information, (4) Defined Use of Information, (5) Collaboration with Suppliers, (6) Cooperative Competition, (7) End-to-End Connectivity, (8) Formed Supply Alliances (9) Replace Traditional Communication with IT, and (10) Share Frequently with Suppliers. These are illustrated in Figure 1 and each of these components is discussed in the following.

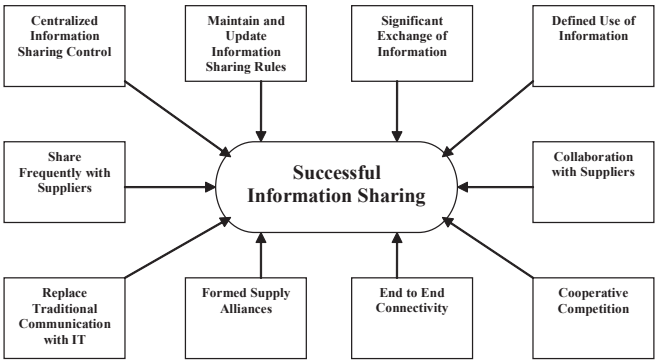
Centralized Information Sharing Control

Information is often critical and possibly of a sensitive nature to a firm. Not all information is shared and often decisions are necessary that limit or restrict the disclosure of information. These decisions, to both maintain accountability and consistency are best accomplished in a centralized "information clearing house". Though many studies have decreed that information is best used when disseminated throughout the organization, the control of such information is best suited to a centralized location.

Maintain and Update Information Sharing Rules

The sharing of information is not a fixed and static structure that needs no maintenance. As the type and level of information changes so must the rules regulating how, what, when, etc. must change to suit the conditions of information exchange. This provides the organizations within the system a level of security and confidence that the information that they provide and receive is within a set of defined uses while outside of their control. These rules also provide a basis for legal remedies should any organization with the chain act improperly with the information that the access or disseminate. It is interesting to note that "trust"

Figure 1.



is not existent within the model. Trust is an important aspect in developing a relationship for information sharing since the structures are either not or just minimally defined and abuses can occur. The more mature system uses rules and contracts to define contingencies.

Significant Exchange of Information

The cost to maintain information sharing systems must be offset by a benefit in excess of such cost in order to justify the continuation of the system. A high level and significant quantity of relevant shared information communications can represent both increased profitability and reduced costs to organizations. Organizations maintain an information-sharing environment with their supply chain partners to their mutual benefit. Information sharing is an economically viable alternative to forecasting and other estimates of an organizations supply chain partner's actions.

Defined Use of Information

Information within the organization receiving it must have a purpose and that purpose should be known to the organization that supplies the information. There are two primary reasons for this (1) the organization that provided the information will have a greater sense of security in knowing that the intent of requesting the information is for some purpose that is beneficial to the receiving organization. This will minimize the probability of misuse. (2) In understanding the potential use of the requested information the firm that provides the information may be able to improve on the type, level or transmittal of the requested information in such a way that improves the efficiency of the action. Organizations in a supply chain are concerned not only about the information gathered and/or mined by their supply chain partners but also as to the intent behind the use of the collected data (D'Amico, 2000).

Collaboration with Suppliers

An organization that works cooperatively with their suppliers can benefit in reduced inspection costs, increased responsiveness, product development input and improved profitability. Collaborating with ones suppliers would imply that information is being exchanged. The action creates the structures and system that provides the basis of information sharing. Collaboration, when the tenets of the action are mutually defined, can greatly benefit all the firms involved.

Cooperative Competition

Organizations have learned over the past years that to compete in a "cut throat" manner is often detrimental to each organization in the long run. The new levels of competition enabled by reduced trade barriers and increased levels of foreign competition have forced organizations to reevaluate their relationships with their competitors. Organizations now often act in such a way as to be competitive but to respect each other's markets and not to intrude. New markets or those not previously serviced by a direct competitor are open for exploitation but the traditional environs of a competitor are perceived as "off limits". There are numerous examples of two primary competitors in all out trade wars with the result of each losing a significant portion of their traditional markets to a third previously unconsidered competitor.

End-to-End Connectivity

End-to-End Connectivity is the establishment of communications resources to span the breadth of the supply and distribution channels. The information that is gathered form customers is thus available to suppliers thus reducing the whiplash effect that so often is disruptive to estimating trends in inventory levels. This component stresses the need for physical linkages from one end to the other of all the supply and distribution channels to gather and disseminate the maximum amount of information available and allow for its direction to the appropriate individual or organization. The information flow then assumes a matrix structure not unlike the early structure of the Internet since it is comprised of a simple series nodes and pathways through which information is channeled and reviewed.

Formed Supply Alliances

An established, lengthy, and cooperative relationship between a supplier and the supplied organization creates faith and defined cooperation between the elements of a supply chain. Trust is not significant here in that such is not legally defensible nor is it readily defined in what is permitted or restricted. An alliance that defines specifically each others actions and responsibilities creates the need and the basis for greater levels of information sharing. Supply chain alliances affect the costs, the responsiveness and the viability of the organizations involved.

Replace Traditional Communication with IT

The traditional means of communication in organizations, telephone, facsimile machine, mail all have difficulties in the transmission and distribution of information or data. Using the communications tools of EDI, the Internet, or more advanced Enterprise Systems, a firm can redistribute, store, sort and distribute to multiple sources the information or data that is gathered. The structure of the connections of these tools does not eliminate the more traditional means of communication but instead augments the tools to make the organization's information sharing more efficient and effective.

Share Frequently with Suppliers

When information is sporadically shared, the structures and efficiencies achieved languish and deteriorate. Information flow that is relatively constant allows an organization to have confidence in its value since it is validated by the information of a similar nature that follows. Frequency provides a usage and justification to the monetary outlays for the associated physical and organizational structures that are used to share information.

6. CONCLUSIONS

Integrating and sharing information in interorganizational settings involves a set of complex interactions. The organizations involved must establish and maintain collaborative relationships in which information and data of a sensitive and critical nature is transferred outside of the direct control of the organization. The sharing processes often involve significant organizational adaptation and maintenance. The purpose of this research is to develop a model of information sharing structures in these settings. Many organizations are looking for ways to optimize their supply chains as a means to create a competitive advantage. Consequently, these same organizations are modifying their business processes to accommodate the demands that sharing information places on an organization. To that end, this study addresses the issue of developing a comprehensive model regarding the supply chain system and the solutions needed to optimize it. The exploratory model does suggest that supply chain managers should consider the components of the model in order to achieve supply chain success. Though there were a great number of responses on the returned surveys that indicated that the respondent firms lacked "trust" in both their suppliers and customers, these same firms conducted business with these same firms and individuals with little to no intent of implementing any change. "Trust" is seemingly to abstract a factor to precisely define. Our contention is that "trust' does exist but is not specifically and uniquely defined. The actions of the firms would indicate that given a structure of defined uses and responsibilities of information that sufficient "trust", whether specifically defined as such, does exist.

REFERENCES

1. Abuhilal, Laith; Rabadi, Ghaith; Sousa-Poza, Andres: (2006) Supply Chain Inventory Control: A Comparison Among JIT, MRP, and MRP With Information Sharing Using Simulation, Engineering Management Journal. Rolla: Jun Vol. 18, Iss. 2; p. 51
2. Alexander, Ernest: (1995), "How organizations act together, interorganizational coordination in theory and practice", Amsterdam: Gordon and Breach Publishers
3. Bakos, J. Yannis: (1991), "Information links and electronic marketplaces: the role of interorganizational information systems in vertical markets", Journal of Management Information Systems, Vol. 8 No. 2, Fall, pp. 31 - 52
4. Butler J. K.: (1999) "Trust expectations, information sharing, climate of trust, and negotiation effectiveness and efficiency".
5. D'Amico, E.: (2000) "Is it safe yet?", Chemical Week, Vol. 162, n. 36, September 27, pp. 35-36.
6. Delina, R., Azzopardi, J., Bucko, J., Frank, T., Mihók, P.: (2007) Financial Services in Web-based Platforms, submitted manuscript to IRMA Conference 2007.
7. Doyle, Maura P. & Snyder, Christopher M., (1999) "Information Sharing and Competition in the Motor Vehicle Industry," Journal of Political Economy; 107:1326-1364.
8. Grijpink, J.H.A.M. (1997). Keteninformatisering, met toepassing op de justitiële bedrijfsketen. (Value chain information application, with an application to the juridical supply chain). Den Haag: SDU.
9. Jassawalla, Avan R., & Hemant C. Sashittal (2000), „Cross-functional Interactions in New Product Development Processes," Research-Technology Management, 43 (01): 46-49.
10. Kemp, K. E. & W. P. Smith (1994). „Information exchange, roughness, and integrative bargaining: The roles of explicit cues and perspective-taking." The International Journal of Conflict Management 5: 5-21.
11. Kocabasoglu,Canan; Suresh, Nallan C (2006) Strategic Sourcing: An Empirical Investigation of the Concept and Its Practices in U.S. Manufacturing Firms, Journal of Supply Chain Management. Tempe: Spring,Vol.42, Iss. 2; pg. 4
12. Lado, Augustine A, Boyd, Nancy G, Hanlon, Susan C. (1997) "Competition, cooperation, and the search for economic rents: A syncretic model", Academy of Management. The Academy of Management Review. Briarcliff Manor: Jan 1997. Vol. 22, Iss. 1; p. 110
13. Palaniswamy, Rajagopal & Frank, Tyler G., (2000), "Enhanced Manufacturing Performance with ERP Systems", Information Systems Management, Summer
14. Schermerhorn, John R., (1975) "Determinants of interorganizational cooperation", Academy of Management Journal. Briarcliff Manor: Dec., Vol. 18, Iss. 4; p. 846
15. Schermerhorn, John R., (1977) The Academy of Management Journal, JSTOR, 20, No. 1, 148-153 Information Sharing As An Interorganizational Activity
16. Soliman, Khalid S., Janz, Brian D., (2004) "Interorganizational Information Systems: Exploring An Internet-Based Approach"
17. Thompson L. & Hastie R. (1990), Social perception in negotiation, Organizational Behavior and Human Decision Processes, 47, 98-123
18. Thompson, Lawrence M., (1991) Industrial data communications: Fundamentals and applications, Instrument Society of America

Simulation-Based Decision Support: From Experience Towards Knowledge

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ABSTRACT

This paper analyzes simulation as a knowledge base for decision support and its' usefulness in application on three cases: 1) post-decision analysis of the reengineering process, 2) warehouse optimization in an uncertain environment, and 3) decision-making process supported by simulation in a laboratory environment. The paper describes the methodological aspect of simulation as part of the anticipative system and the practical application of simulation and interaction between user, simulation model and scenario in the process of seeking for a solution to a managerial problem as decision support in a business system. Results of all three cases show the effectiveness of simulation in decision support and prove simulation to be a powerfull tool in organizational learning.

Keywords: simulation, learning, reengineering, information, warehouse optimization

1. INTRODUCTION

The role of simulation methodology in the decision assessment of complex systems is constantly increasing. Human knowledge, simulation model and decision methodology combined in an integral information system offers a new standard of quality in management problem solving. Simulation model is used as an explanatory tool for a better understanding of the decision process and/or for learning processes in enterprises and in schools. Many successful businesses intensively use simulation as a tool for operational and strategic planning and enterprise resource planning (Schniederjans and Kim, 2003; Muscatello et. al, 2003). Experiences described in literature, (Homer, 1996) emphasize that in a variety of industries actual problems can be solved with computer simulation for different purposes and conditions. At the same time, potential problems can be avoided and operative and strategic business plans could also be tested. Currently the most intensive research efforts are concentrated on a combination of simulation methods and expert systems (Dijk et. al, 1996; Coyle, 1996). Although there is a considerable amount of work devoted to simulation methodology, there is a lack of its application in practice especially in small- and mid-sized companies. The reason lies not in the methodology itself; the real reason is rather in the problems of methodology transfer to enterprises and the subjective nature of decision-making. However, there are several problems, objective and subjective, that are the reason why this well established methodology is not used more frequently.

One of the objective problems is model validation, which is very important for any model-based methodology. The validity of the model of a given problem is related to the soundness of the results and its transparency for users. According to Coyle (1996), a valid model means well suited to a purpose and soundly constructed. According to Forrester (1968), it is pointless to discuss validation without reference to a particular situation. There is no way to prove usefulness of the model of complex systems such as enterprises in advance (Forrester, 1994).

The second problem, the subjective one, is related to the transparency of the methodology and data presentation (Kahneman and Tversky, 1979), preferences of the decision-maker to use a certain decision style and poor communication between methodologist and user. The simulation methodology is a paradigm of problem solving where the personal experience of users as well as their organizational culture play an important role (e.g., in transition countries: market economy, ownership, etc.). This article describes tree different cases demonstrating the usefulness of simulation methods for decision assessments in enterprises.

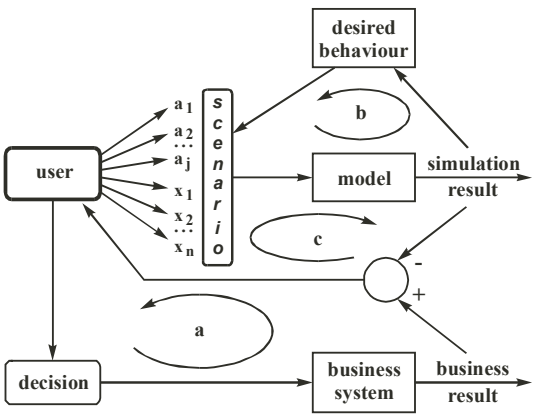
2. SIMULATION METHODOLOGY AS A BASE FOR DECISION SUPPORT

Many authors prefer the simulation method as a holistic approach for assessment of decision-making (Gopinath and Sawyer, 1999; Simon, 1997; Sterman, 2000) however; user confidence in it is of crucial importance (Chen and Liaw, 2001). The main problems of each managerial system are the comprehensiveness of information concerning the state and the environment within appropriate time. This means that a mathematical model of the process and a model of the environment are required. However, in enterprises processes due to the complex dynamics resulting from the stochastic interaction and delay it is hard task to get a confident model. Decision-makers though cover a broader perspective in problem-solving than could be obtained solely through simulation. Both simulation interacted with human experience create a new quality at the condition that users is convinced in the value of simulation methodology. The principal representation of the proposed approach is shown in Figure 1 where the principle of interaction between the user, simulation model and scenario interaction is exposed (Kljajić, 1994).

The following three basic loops are emphasized:

a) The causal or feed-back loop, representing the result as a consequence of former decision-making, and being a part of management experience and history of the system. From the learning aspect this loop could be named "learning by experience".
b) The anticipative or intellectual feedback loop, which provides the feed forward information relevant for decision making. This loop consists of the simulation model of the system, criteria function and scenarios. The simulation scenarios consist of two subsets: a subset of input that anticipates the state of nature

Figure 1. The principle diagram of the simulation methodology for decision support in enterprises



(exogenous scenarios) – and a subset of alternatives (endogenous scenarios). They give the answer to the basic question concerning the problem situation for which the answer is being sought. In literature it is known as the *what-if* analysis. The generation of scenarios of the simulation system that responds to the *what-if* is based on different scenarios anticipating future impacts of the environment on the system.

c) The *a posteriori* information loop represents the pragmatic validation of the model concerning model applicability and former decision-making. This loop represents the pragmatic validation of the model. A comparison of prior information concerning the simulated impact of the selected strategy on system behaviour with the actual results allows us to evaluate the value of the model and improve it. In this way learning is enabled on the basis of *a priori* assumptions on the model and not just on the basis of empirical experiences.

Loops a) and b) are the basic ones for learning and knowledge acquisition for improved decision-making. Loop c represents the pragmatic validation of the model which supports users' confidence in the simulation methodology.

3. POST-DECISION ANALYSIS OF PRODUCTION LINE SELECTION BY SIMULATION METHODS

Described methodology was applied in a medium-sized factory, a manufacturer of concrete goods, for the purpose of reengineering process assessment. Due to the increased demand for a specific article and better quality requirements of products, the firm's management considered investing in a new production line. The decision assessment has been organized at two hierarchical levels. The model at the top level is used for the assessment of the enterprise's strategy (continuous simulation). At the bottom level the model is used for discrete event simulation (DES), necessary for operation planning and testing production performance. The system structure of the simulation model consists of entities connected in a flow diagram in Figure 2. The diagram is sufficiently abstract to allow understanding of the problem and precise enough to provide valid experimentation on the model. As soon as one becomes satisfied with the "picture" of the process, he/she proceeds to the building of the simulation model. From the decision-making aspect the state equation of the simulated system is described by Equation (1):

$$y(k+1) = f(y(k)\ x(k)\ a)\ \ k = 0,1,2,..N \tag{1}$$

where $y \in Y$ represents the vector of state variables such as inventory, cash, income, liabilities, backlog, etc., $x_i \in X$ represents the system input: market demand, and $a_j \in A$ represents the control variables (alternatives). The decision strategy was defined as: choose the alternative a_j for the market demandy x_i and its probability $p_i \in P$, which satisfies the performance function reflected by the manager's preferences. Performance of alternatives $a_i \in A$ in Equation (1) was obtained through DES as shown in Figure 2. Two criteria were considered:

Maximal expected value (EV) (of profit) defined by Equation (2):

$$\max \boldsymbol{E}\ \ (a_j) = \sum_i C_{ij}\, p_i \tag{2}$$

where C_{ij} represents the values of the i-th input at j-th alternative, and linear weighted sum of multiple criteria defined by Equation (3):

$$\max J(a_j) = \sum_{r=1}^{m} w_r J_r(a_j) \tag{3}$$

where w_r represents the weight of the r-th objective, which reflects the decision-maker's business policy preference. The individual objective $J_r = q(y,x,a)$ in Equation (3) is a function of the state of the system, the state of the market and the chosen alternative in achieving the goal. The multiple criteria and its weighting for the evaluation of scenarios were defined by the decision group using the group support system. Saaty's AHP method (1990) was used to determine the relative importance of the objectives w_r and a pair-wise comparison of alternatives a_j for the r-th objective. The alternatives a_i in Equation (1) represents suppliers of the new production line, which were considered in the decision-making besides the existing technology. The suppliers denoted as alternatives: $a_i = a_1, a_2, a_3, a_4$ and their costs in monetary units as: c_i= 0, 371, 392, 532, respectively. Experts estimated the market demand X_i and its probability $p(X_i)$ for the next 5 years. For a detailed description of alternatives one should look at Kljajić et al. (2000). The financial aspect of reengineering was modelled as the continuous simulation model. The block diagram in Figure 2 shows the main material, financial and information flows of the manufacturing system. Net income is represented as an element dependent on different supplier options simulated on DES. This approach provides a unique framework for integrating the functional areas of management – marketing, production, accounting, research and development, and capital investment. An expert group determined Unit Sale Price and Market Demand Function necessary for different production scenarios. The scenarios are defined as a combination of: Unit Sale Price, Unit Production Costs, Market Demand and Other Operating Expenses. Market demand is defined on the basis of current orders and future estimation, which was determined by the company's expert group. The production plan forms the input for DES with the purpose of evaluating the utilization and capacity constraints of the considered alternative. The simulator of the business system allows us to make an analysis of the investment effects, depreciation plan, risk of drop in sales, delivery time and change in sale prices. The model is used for predicting financial and production system efficiency. Four scenarios representing the market demand were simulated for each alternative. The EV of the payoff for alternatives for the 8-year period were computed according to Equation (2).

Several other requirements for the new technology were additionally imposed: Quality of Products, Net Profit, Risk of Company Ruin, Market Demands and Flexibility of Technology. The decision group consisting of enterprise experts carefully determined the relation between the key criterions.

As a result of the decision-making and final judgment, alternative a_3 was chosen. It scored first rank, evaluated by the EV and multicriteria evaluation, considering the period of an 8-year horizon. The longer time period, however, proposed as the best solution alternative a_4, which had been seriously considered for the final judgment.

Data obtained from the production of concrete goods over the past four years, which is a reasonable period for post-decision analysis, were used for the model validation of the decision process. Validation was carried out by comparing the business outcomes with the anticipated responses of the business model according Figure 1. Figure 3 represents EV of Net Income of the selected alternative a_3 (Curve 1), the actual Net Income (Curve 2), and the estimated Net Income in case decision makers would have selected alternative a_4 (Curve 3) in time (from 0 to t_0 the first four years, and from t_0 to 96 months the future four years).

We see that the curves 1 and 2 correlate, both staying in the average region of positive performance of the analysed production process. The observed increase at the beginning in Curve 2 (actual Net Income) is due to one year loan moratorium. However the predicted value of Curve 2 (from t_0 on) is slightly below EV. These results can be explained by lower demand, which should reflect in lower Net Income. Curve 3 represents estimated Net Income in case decision makers would have selected a_4. It is characterized by a fully automated production pro-

Figure 2. Causal loop diagram of the simulation model for decision assessment

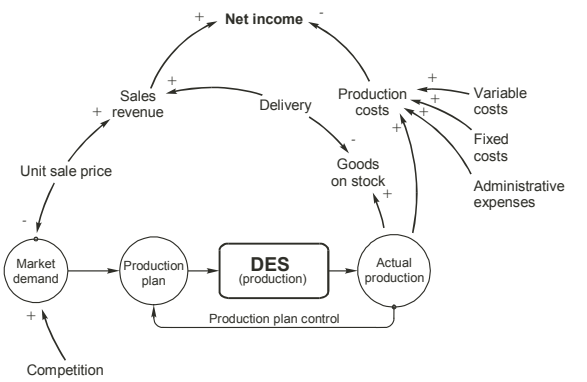
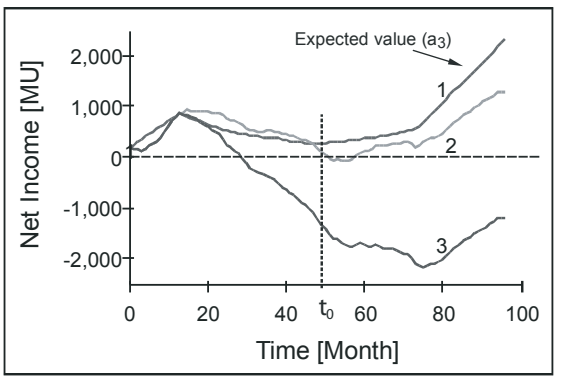


Figure 3. EV of Net Incom (Curve 1), realized Net Income (Curve 2) and predicted Net Income of the alternative a_4 (Curve 3)



cess, which can ensure a high quality and quantity of products and was seriously considered for purchase.

One can learn from this lesson what would happen if we had chosen alternative a_4 instead of a_3. At the anticipated ratio of demand on the market sales it could not cover the financial burden of such volume. This means that the company would suffer a financial crisis shortly after the implementation of such technology.

4. WAREHOUSE OPTIMIZATION IN AN UNCERTAIN ENVIRONMENT

In this case, we were dealing with a typical warehouse for storing products for further build in. The consumption of products depends on a production plan, which can be predicted with a certainty for six weeks. Lead time, for every product, is not variable. The problem occurs at defining the ordering quantity, because we have to consider the past orders and the variable consumption of a specific product. Long lead times also represent a problem, because they are usually much longer than the time period in which the production plan can be predicted with a certainty. The main goal of optimization was to rationalize warehouse ordering process, this means determining the interval between orders and the quantity to be ordered, so that the warehouse will operate with minimal common costs.

From control point of view, our problem can be described with the difference equation:

$$x(k+1) = x(k) + d(k) - p(k)\,, k = 0,1,2..n \tag{4}$$

$$x(0) = x_0$$

where *x(k)*, represents stock variable, *d(k)* material delivery and *p(k)* production process. The delivery function *d(k)* is delayed for an average time of an order *o(k)*. Time delays are stochastic.

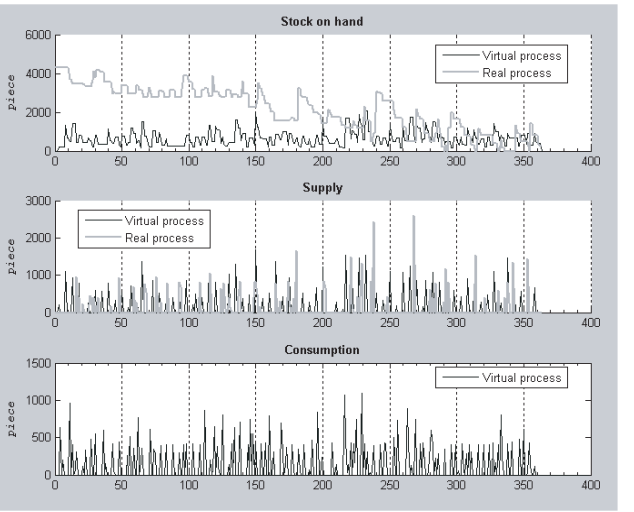
$$d(k) = o(k - \varphi(\tau_d)) \tag{5}$$

where $\varphi(\tau_d)$ represents discrete uniform probability density function *(pdf)*. In order to compensate the stochastic delivery delay, the order policy *o(k)* has to be defined as:

$$o(k) = f(x(k),\ d(k - \varphi(\tau_d)),\ p(k + \tau_p)) \tag{6}$$

where τ_d represents the time delay and τ_p the production plan. It is necessary to find such *o(k)* to minimize the following cost function:

Figure 4. Stock, supply and consumption dynamics for the observed case



$$J(o(k)) = \sum_{0}^{n} q(x(k),\ u(k),\ w(k)), k = 0,1,2,..n \tag{7}$$

for $x\min \le x \le x\max$. In equation (7) *c* and *h* represents the cost of units of material on stock and its transportation.

In order to improve the stock control problem, a simulation approach has been chosen where heuristics and fuzzy control algorithm were tested.

The experiment was performed with the actual historic data for seven years provided by the observed company. The results for one case (product) are presented. The company has confirmed the simulation inventory level dynamics based on the above-mentioned data. They have also confirmed the validity of the costs the simulation model has calculated. The model was changed in the "ordering" module to try out new ordering strategies. A Monte Carlo simulation was used for variation of consumption unreliability. Fifty simulation runs for every strategy on new simulation models were run, using only consumption data. On the basis of these simulation runs, average costs and average stock-outs were calculated. With several simulation runs and a calculation of average values, we have tried to minimize the influences of the random generator, which represents the stochastic environment.

Figure 4 presents results for the Real Process and Virtual Process. The Real Process is represented by the brighter line and the Virtual Process is represented with a darker line. The first graph presents stock level dynamics, the second delivery dynamics and the third the consumption dynamics throughout simulation time (time unit is weeks). The results shown in Figure 4 can be used to indicate similarities or differences between the two processes. The supply dynamics graph indicates some similarities in the ordering strategy – some peaks (representing order quantity) are very similar but with some time delay. However, the simulation results of ordering have produced much lower costs than the Real one for the 65%.

The simulator also allows us to compare two methodologies used in the ordering process: heuristics of the warehouse operator and algorithm based on simulation and fuzzy logic. From the Figure 4 one can observe, from the stock variable, the operators' "learning by experience". Namely, starting from high stock value, the operators' ordering strategy slowly improves over time approaching optimal strategy obtained by simulation. From the obtained results we can deduct about the usefulness of simulation method for the operator training for new ordering strategy.

5. DECISION-MAKING SUPPORTED BY SIMULATION MODEL AND GROUP FEEDBACK INFORMATION

The goal of the conducted experiment was to acquire knowledge of the group decision process supported by the system dynamics (SD) model and influence of feedback information. A model of the business system was applied at the experi-

ment with decision groups. The model consists of: production; workforce and marketing segments that are well known in literature (Hines, 1996; Sterman, 2000 and Škraba et. al, 2003). Model shows that Product Price (r_1) positively influences Income. However, as prices increase, Demand decreases below the level it would otherwise have been. Therefore the proper pricing that customers would accept can be determined. If Marketing Costs (r_3) increase, Demand increases above what it would have been as a result of marketing campaigns. The production system must provide the proper inventory level to cover the demand, which is achieved with the proper determination of the Desired Inventory value (r_4).

The experiment considered the task of strategy determination with an explicitly defined multicriteria function. The optimal criteria function value (CFV) was determined at $J = 1.5$.

Experiment was conducted under three experimental conditions: a_1) determination of business strategy without application of a formal model, a_2) determination of the strategy with application of a formal SD model and, a_3) determination of the strategy with application of a formal SD model with subjects interaction supported by the group feedback information. 147 senior university students participated in the experiment. We hypothesized that the model application and group feedback information positively influence the convergence of the decision process and contribute to higher criteria function values.

The results of the decision process conducted under experimental conditions: a_1) (N_1=52), a_2) (N_2=55), and a_3) (N_3=40) presented as deviation of CFV from the optimal CFV, are shown in Figure 5.

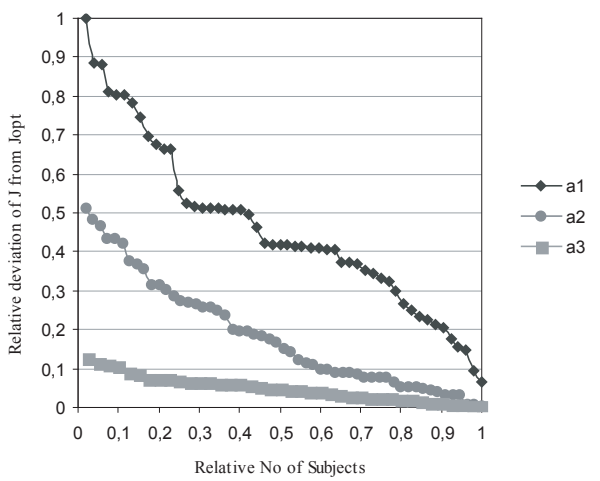
The lowest deviation values were obtained in experimental condition a_3) where group information feedback was applied. Results marked a_2) and a_3) were gathered with the aid of the SD model, and the results marked a_1) where assessment was done without a formal model, were gathered by writing them in a paper form. The single factor ANOVA showed that there are highly significant differences in CFV among groups on a $p = .000$ level of confidence. Therefore, the hypothesis that the model application and group feedback information positively influence the convergence of the decision process and contribute to higher CFV was confirmed.

The anticipative value of information using Shanon - Harkevič equation can be measured:

$$I(a_i) = k \log(p(a_i) / p_0) \qquad (8)$$

where p_0 and $p(a_i)$ represent the probability of achieving a goal without or with information, respectively, and a k constant. In practice, it is impossible to get a probable released goal in advance. This problem derives from the nature of the decision process. However, the simulation model of the process and anticipation of possible future impact from the environment can provide useful information to management. In our case, it is obvious and can be observed in Figure 5. Let us suppose that objective function equation can take each value from the unit square interval with equal probability if the experimental subject has no knowledge of the goal. The probability p_0 is then reciprocal to the unit square area of $P0 = 1$. In our case it means maximal entropy of the experiment. With experimental condition a_1), a_2) and a_3) we introduced information proportional to the area of reduction. By estimating the area $P1=1/2$, $P2=1/4$, and $P3= 1/16$ and taking its reciprocal value we obtained the probability of $p(a_i)$. Using equation (8) we can estimate the information content of the experimental condition. In the tested case, based on equation (8) where $k = 1$, the following is noted: $I(a_3) = 4$, $I(a_2) = 2$, $I(a_1) = 1$, and $I(a_0) = 0$ bit. (Note that due to the normalization of the area in Figure 5 and $P0=1$, reference is being made to the relative value of information obtained through experiments a_1, a_2 and a_3, where generality is not being affected).

Figure 5. Normalized deviations of CFV from the optimal CFV for experimental conditions a_1), a_2), and a_3)



6. CONCLUSIONS

This paper analyzes simulation as a knowledge base for decision support and its' usefullness in application.

Four years of experience in a concrete production company, where new production line was chosen by employing simulation methodology, was analyzed. The predictive validation of the simulation model as well as simulation methodology for decision assessment was done by comparing actual data with those predicted of the chosen alternative in four years period. A comparison showed that the gained predictions were a relevant estimation of future company development after the reengineering process was completed. More over, post decision analysis showed how good was the rational decision of alternative a_3, comparing to the competing alternative a_4.

Warehouse optimization in a production company by simulation methodology was studied. The simulation model was validated on a company's historic data. The results also show how the operators' ordering strategies improved in time as he/she learned from experience. The same experiences one could aquire by experimenting on a model in shorter time.

Influence of the SD model and group feedback information on a decision-making process was analyzed in a laboratory setting. Hypothesis that the model application and group feedback information positively influence the convergence of the decision process and contribute to higher CFV was confirmed.

The basic advantage of the described approach lies in the interactivity and transparency of the model representation. By experimenting on a simulation model, the user enhances knowledge about the studied process and improves judgment about alternatives. In this way the range of *bounded rationality* in decision-making could be enhanced.

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REFERENCES

Chen, L.H., & Liaw, S.Y. (2001). Investigating resource utilization and product competence to improve production management – An empirical study. International Journal of Operations & Production Management, 21(9), 1180-1194.

Coyle, R.G (1996). System Dynamics Modelling: A Practical Approach. London: Chapman and Hall.

Dijk, J.N., Jobing M.J., Warren J.R., Seely, D., & Macri, R. (1996). Visual Interactive Modelling with SimView for Organizational Improvement. Simulation, 67(2), 106-120.

Forrester, J.W. (1994). System Dynamics, Systems Thinking, and Soft OR. System Dynamics Review, John Wiley & Sons, 10(2-3), summer-fall.

Forrester, J.W. (1968). Industrial Dynamics – A Response to Ansoff and Slevin. Management Science, 14(9), 601-618.

Gopinath, C. & Sawyer, J.E. (1999). Exploring the learning from an enterprise simulation. Journal of Management Development, 18(5), 477-489.

Homer, B.J. (1996). Why we iterate: Scientific modelling in theory and practice. System Dynamics Review, John Wiley & Sons, 12(1), 1-19.

Kahneman, D. & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. Econometrica, 47, 263-291.

Kljajić, M. (1994). Teorija sistemov. Moderna organizacija, Kranj.

Kljajić, M., Bernik, I. & Škraba, A. (2000). Simulation Approach to Decision Assessment in Enterprises. Simulation, Simulation Councils Inc., 199-210.

Muscatello, J.R., Small, M.H. & Chen, I.J.(2003). Implementing enterprise resource planning (ERP) systems in small and midsize manufacturing firms. International Journal of Operations & Production Management, 23(8), 850-871.

Saaty, T.L. (1990). Multicriteria Decision Making: The Analytic Hierarchy Process. Pittsburg: RWS Publications.

Schniederjans, M.J. & Kim, G.C. (2003). Implementing enterprise resource planning systems with total quality control and business process reengineering – Survey results. International Journal of Operations & Production Management, 23(4), 418-429.

Simon, H. (1997). Models of Bounded Rationality, Vol. 3, The MIT Press.

Škraba, A., Kljajić, M. &Leskovar, R. (2003). Group exploration of system dynamics models – Is there a place for a feedback loop in the decision process?. System Dynamics Review, 19, 243-263.

Sterman, J.D. (2000). Business Dynamics: Systems Thinking and Modeling for a Complex World. Boston MA: Irwin/McGraw-Hill.

Keeping High Quality in Higher Education with Less Funding: Possible?

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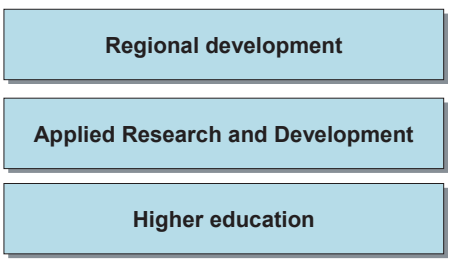
1. INTRODUCTION

The quality of the education is one of the key areas universities and universities of applied sciences should focus on (Ministry of Education Finland 2003). The focus of all development actions should clearly be on quality and impressiveness of operations as well as in strenghening internationalization (Opetusministeriö 2006). Quality of education is also emphasized in the development plan of the Regional Council of Southwest Finland (Varsinais-Suomen liitto 2005). While focusing on quality the institutes should take care of that also national and international compability remains and gets better (Ministry of Education Finland 2005). Globalization and competition have led to a situation where the trust into your own national higher education quality is not enough rather in every country the higher education should be understandable and trusted also internationally (The Finnish Higher Education Evaluation Councill 2005).

At the same time as quality is emphasized more duties are presented to Universities and Universities of Applied Sciences. In Finland, for example, in 2003 applied research and development was introduced as the third main duty in the new act of Universities of Applied Sciences (see Figure 1). The other two main duties are higher professional education and regional development. Despite these new duties the funding was not increased. In addition to new duties also requirements to provide even more high-cost hands-on-training and working life related education have increased. (Ministry of Education Finland 2005) This places Universities of Applied Sciences in a very challenging position; how to maintain quality and correspondence to working life in education?

Ministry of Education understands that unfortunatelly these cannot be provided at the moment due to tight costs and suggests that combining research- and development and services with education might be the solution and a source for additional funding (Ministry of Education Finland 2005). Using R&D to serve also education is a natural way to increase working life focused education. This focusing on working life requirements in education is constantly mentioned in different reports and publications. For example the president of European University Association writes that higher education institutes have to educate experts to working life requirements (Winckler 2006). Also many Finnish future evaluation reports define that it is essential that expert resources match with the working life positions (Ruokanen 2004; SITRA 2005; Wikström, Haikkola et al. 2005). Universities of Applied Sciences should focus on educating professional experts capable of really doing things. The aim of Universities of Applied Sciences should not be in producing new knowledge rather in using and applying it (Ruokanen 2004). In addition, Ministry of Education has stated that more and more quick changes in our environment and working life requires that interaction between education, research and working life should be further promoted (Ministry of Education Finland 2003). Will this be also the solution for the funding problem and the quality matter as well?

Figure 1. Main duties of Universities of Applied Sciences



This paper presents a case study. We present the actions and ideas that the faculty of Telecommunication and e-Business at Turku University of Applied Sciences has taken to survive with the funding. We start with the research methodology and describe our current environment we are operating in. In section 3 we introduce our solutions. In section 4 we talk about the challenges we still have to tackle. Finally, section 5 is for discussion.

2. RESEARCH METHODOLOGY

This paper uses qualitative approach and is a descriptive single case study. In general, a case study aims for in depth-understanding of the context of the phenomenon (Cavaye 1996). Furthermore, a descriptive case study presents a complete description of a phenomenon within its context (Yin 2002). A case study is well-suited to capturing the knowledge of practioners and to document the experiences of practice (Benbasat, Goldstein et al. 1987). This paper follows interpretitive tradition of the case research. It means that there is no objective reality, which can be discovered by researchers and replicated by others (Walsham 1993; Broadbent, Darke et al. 1998). During the period this paper is about (2004-2006) the researcher acted like action researcher (Walsham 1995) as he was a member of the case organization.

The unit of analysis in this research is the faculty of Telecommunication and e-Business at Turku University of Applied Sciences. Universities of Applied Sciences are normally regional higher education institutions providing higher professional education with close connection to working life. In Finland there are in parallel with Universities of Applied Sciences traditional Universities that focus more on scientific research and provide higher education in connection with it.

The faculty of Telecommunication and e-Business operates in two cities and has eight different degree programmes. Four of the programmes are arranged in Turku and rest four in Salo. We educate both bachelors of engineering and bachelors of business administration. Optimal study time for engineering students to study their 240 ECTS (see http://ec.europa.eu./education/programmes/socrates/ects/index_en.html) is four years whereas optimal study time for business administration students is three and half years as their degree program is 210 ECTS. The faculty has approximately 1500 students of which roughly 550 study in Salo campus and 950 in Turku campus. Our degree programmes are listed in the Table 1.

The main research question in this paper is: **How to keep up high quality in higher education with less funding**? The basic idea is to describe the actions and solutions we have introduced to solve the challenging funding situation.The first thing we must understand is the basic structure of the funding; how funding is defined; from where the funding is coming; why there are less funding available.

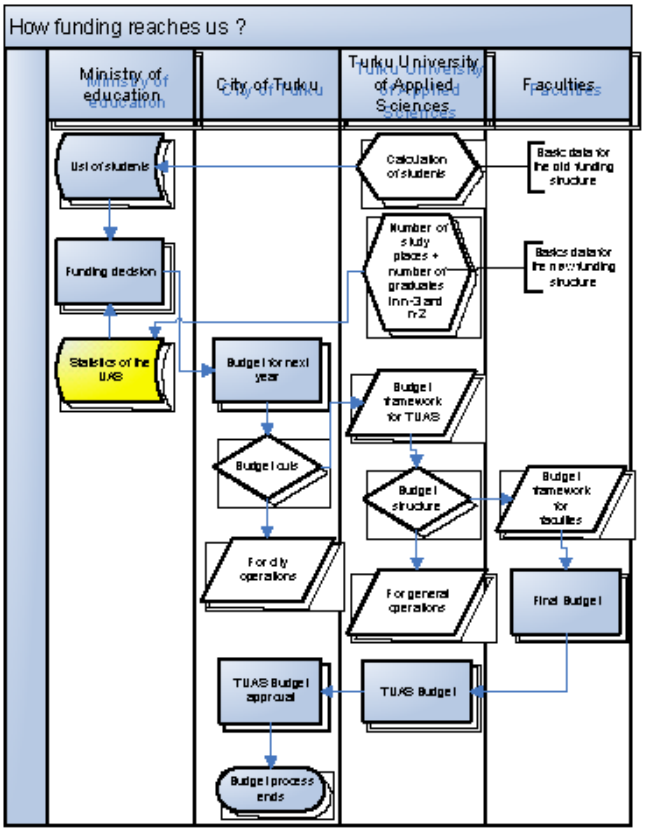
Figure 2 shows the overall structure of the funding. Ministry of Education gives the basic funding to the administrator of the University of Applied Sciences. In our case the ministry funding is paid to City of Turku. The city is expected to forward the same amount to the University of Applied Sciences. However, there aren't any regulations about what will happen if this is not happenning.

Earlier the funding based only on number of students present at certain moment. There were two so-called calculation days when the number of students was calculated. Only students studying within the normal study time were accepted. If someone has exceeded his normal study time he was not accepted to the count of the students. The new 2003 act changed the funding structure significantly. Now 70% of the funding is defined by the number of study places and 30 % is based on number of graduates within two previous years.

Table 1. Degree programmes in telecommunication and e-business

Degree Programme	Credits ECTS	Discipline	Students
Library and Information Services	210	Information Services	85
Business and Administration - English/German - Finnish	210	Business	176
Business Information Technology - English - Finnish	210	Information Systems	196
Information Technology - English - Finnish	240	Information Tech-nology	727
Electronics	240	Computer Engineer-ing	259

Figure 2. Funding process at Turku University of Applied Sciences



The basic funding that City of Turku receives for Turku University of Applied Sciences has steadily increased, but the problem is that they do not forward all of the funding to the university. For example in 2007 the sum that we receive is about 4.4 million Euros smaller than the original funding from the Ministry of Education. Another problem is that the budget framework has been almost the same for many years and not even index revisions have been done. However, at the same time salaries have raised 2 to 3 percentages per annum.

Data for this paper is collected through active observations, own experiences and active involvement in daily operations of the faculty during 2004-2006.

3. OUR SOLUTIONS

Basically there are two ways to survive when funding is decreasing. You have to cut your costs and you have to increase your income. Table 2 lists solutions that we have taken during recent years when our basic funding has not increased.

Most of our costs come from salaries and side costs. Teacher resources are expressed in working hours. The more resources we give for some task the more expensive it is. An obvious target for cost cutting was therefore number of contact hours that are the most typical item in teachers' yearly working hours. However, we wanted to do this cost cutting in a controlled way. Therefore we defined quite precise guidelines how to define resources for different tasks. We needed an exact guideline that defined for example what the basic resource is for a teacher per one credit in a course/project. This basic resource may then rise if certain circumstances are fulfilled, but it may also drop if other circumstances are fulfilled. The circumstances that raise the resource are for example

- first time implementation of a course
- foreign language
- new pedagogigal method will be introduced in the course.

The circumstances that lower the resource are for example

- pedagogigal methods used
- same course is delivered many times.

Altogether, the basic starting resource per one credit is now lower than it used to be.

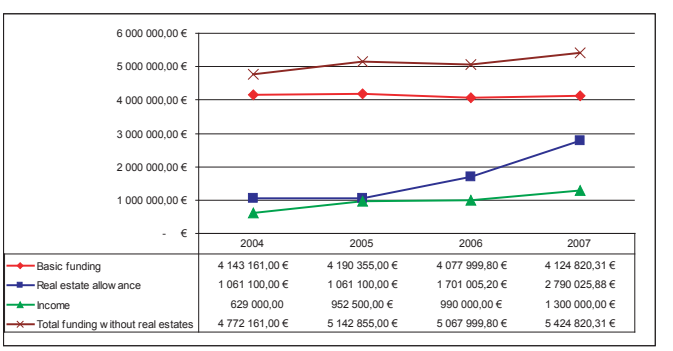
At the same time students own responsibility was increased. This reducement did not lower the quality rather it helped us to improve the quality because we had to think more carefully how we implement our courses.

In practical level we have done many other reforms as well. We have used a lot of time redefining and improving our general processes and actual study process as well. We have increased co-operation between degree programmes and disciplines. Different degree programs have more common studies than earlier. At the same time we have introduced different pegagogigal methods to make studying more interesting. We have introduced for example problem based learning in topics like entrepreneurship and computer architectures. In addition we have more learning-

Table 2. Solutions to survive

Solution	Cut costs	Increase income
Reduce salary costs	X	
Improve your processes	X	
R&D-manager		X
Applied R&D		X
Connect R&D and teaching	X	
Connect R&D and International partner network		X
Structural arrangements	X	
Teaching arrangements	X	

Figure 3. Funding during 2004-2007



by-doing projects with real-life assignments. Altogether we have enabled multi-disciplinary learning (Kontio 2006). The goal of these reforms was to provide necessary amount of high-quality courses with reasonable costs.

The most important solution to keep up the quality was the decision to determinedly increase our income. For this purpose a R&D-manager was hired and assistants to her. The R&D-manager is responsible to follow all kinds of funding sources and to help setting up project and funding applications to various financiers. The expertise for the project contents comes from our teachers, but the project management is helped by R&D-manager and/or the assistants. The teacher expertise is essential for our applied R&D-projects and therefore we have to make room for this work in teachers' yearly working hours.

Figure 3 shows that our efforts have been successful. Our income has risen since 2004 very rapidly and is now over two times more than in 2004. The main financers of our income are European Union, National funding agencies and companies participating in different projects. This income increase has provided us additional resources and a way to develop our operations.

An essential idea of our project proposals is that there is some connection to our higher education process. This means that students earn part of the needed credits in R&D-projects. Making this possible requires that the project proposals always have some connection to the curriculum. However, even more important is that the proposals have working life partners and other partners as well. The connection to curriculum is either made through a large R&D-module, a single course or thesis. The connection requires that the curriculum is flexible and these things can be done within the education.

Thesis is the most typical way how students earn credits in R&D-projects. Thesis topics are part of the projects and supervisor resources come from the the project funding not from the basic funding. Another typical way to connect R&D-projects and teaching is to provide our processes as pilot environments. This way teaching serves the R&D-project and pilots the developed results or provides a test bed for developing something new. Examples these kinds of projects are for example

- SEM-to-SME: The goal was to progress teaching of entrepreneurship in participating institutes by applying Student Entrepreneurship Model developed in Turku University of Applied Sciences.
- CIP Worklab: The goal was to study how working life expertise in library and information services could be collaborated with the higher education of the same field.
- Mobile TV: The goal was to study different technologies of digital video broadcasting according to the goals set by the collaborating companies.
- AMK-WLAN: The goal was to study wireless networks in Finnish Universities of Applied Sciences and to provide suggestions how to build a nation wide wireless network.

Another example of supporting income increase is creating connection with our international affairs and R&D. Traditionally our international affairs have concentrated on managing student and teacher exchange. We wanted to benefit from this existing partner network more and we created a network of R&D-peoples with our partner institutes. Now our R&D-coordinators can easily look for possible partners to different project proposals; they have the contacts and knowledge of the key interest areas in different institutes.

We have also done structural arrangements in our faculty to decrease costs and to improve quality. We close down two of our English degree programmes and join them to equivalent Finnish degree programmes. This way the basic student group size of a degree programme is getting bigger. We have also sharpened our degree programmes and defined clearer focus for each of them. We have for example reduced the number of specializations in each degree programme. We have also screened out overlapping programmes. For example we screened out our Finnish internet technology programme and concentrated this field in our English programme. Similarly we defined that IT programme in Salo campus focuses on software engineering instead of embedded systems that is one of the focus areas in Turku campus.

4. CHALLENGES

We have done quite a lot to survive with the budget where the basic funding has stabilized in a certain level. These introduced new methods and arrangements provide us the necessary growth and playground, but there are still challenges that we need to focus on.

A big challenge is to get more and more of our teachers involved with R&D-projects. At the moment there are only limited numbers of active teachers taking part in R&D. Usually these teachers are also the most wanted in teaching courses. The work load of some teachers is getting too heavy and we need to find additional personel in our R&D-projects. The problem is not that there is lack of R&D or project skills among the rest of the teachers rather quite many have come to our institute especially because they want to teach! Our idea of combining teaching with R&D-projects hopefully also eases this fundamental problem. Usually these projects also give additional resources to teacher compared to a normal resource defined in a normal course.

The previous figure (Figure 3) showed that our income has constantly rised. The second challenge is to keep the responsibility of making income relatively equal within our eight different degree programmes. However, we cannot spread the income goal just by dividing it into eight parts and defining it as the income goal for a degree programme. We must understand and know the differences of our degree programmes. In some degree programmes the R&D-readiness is higher than in others i.e. there is for example stronger working life knowledge and they might have more teachers with a post-graduate degree. Our solution to support this is that we have a R&D-team where every degree programme has own representatives. This team coordinates and plans our R&D-actions and therefore the role of the representatives is very important. A representative is like a messenger for the rest of the degree programme. As R&D-projects provide natural learning environments it is important that the messages from R&D-team are understood in the degree program.

Our third challenge is quite near to the second one. The challenge is that we have defined a goal for 2007 that in every degree programme there should be a large 2-3 years R&D-project worth at least 120000 euros per year. If we succeed in this challenge degree programs have additional resources through there projects and better opportunities to arrange the education. This challenge automaticly defines our fourth challenge i.e. we need people that are fluent in writing and generating good and realiable applications to the funding sources. At the same time we need people who know different funding possibilities and the content and focus areas of these funding programs. Our R&D-manager and her assistants have actually offered these services, but the more projects and applications there will be the less time they can offer for one application/proposal.

The fifth challenge we are facing is the fact that part of our basic funding bases on the number of graduates. Therefore it is essential that the number of drop-out students stays low and majority of the students graduate. Our challenge is to provide as interesting and versatile education that students stay with us. Introducing problem-based learning and learning-by-doing have both been answers to this way. However, we must constantly gather feedback and develop our study methods better. The majority of our basic funding is based on number of study places in our degree programmes and there we are facing a challenge that we cannot really interact any more. Statistics Finland has produced a statistics about young generations entering higher education between 2006 and 2025. The statistics show for example that in our region the number of young people is first rising but drops until the end of the period. This is just a fact that will influence higher education in Finland, but there is not much to do about it. A possible way to tackle this challenge is to concentrate even more on R&D. While less teachers are needed in actual teaching there are more teachers for projects.

Final challenge is the need for additional structural changes that are in connection with the statistics mentioned above: less young people need less study places. We need to alter our structures into more cost efficient direction and focus on providing high quality education in our special fields. An additional possibility is to collaborate with tradional universities and take advantage of the best practices in both systems.

5. DISCUSSION

The idea of this paper was to describe how to keep up high quality with less funding. Quality of education is very essential for every higher education institute. For us the quality issue has concreted because our basic funding has kind of stabilized into the level where it currently is. While the cost are all the time raising we needed to take actions to keep the educational level and to improve the quality of it. Of the two choice strategies for surviging with descreasing budgets we have built our solution more based on the increasing income. The increasing income does not alone solve our challenges with the quality of education but it gives us the opportunity to develop our operations and take advantage of the increased

funding. For example the new pegadogial methods (problem-based learning and learning-by-doing) are both direct answers to the quality issue. They are both also answers to the requirements that we should educate experts that are capable of really doing things.

The combination with R&D and education has proven to be a success story. However, we must emphasize that this has not meant that basic education is paid with R&D-funding. Our curricula have clear places for R&D-projects and our students work on these projects like normal developers and researchers. Students' work has thus very clear development or research targets. Now that some of the total credits are financed through R&D-projects we have actually more resources to arrange the rest of the courses and credits. We have turned the new additional duties into our victory. A good example is one of our small degree programmes Library and Information Services. Year 2006 was the first ever in the history of the degree programme when the budget is in balance. The reason is obvious; there are two quite large R&D-projects that cover part of the credit production.

R&D-projects provide us also a natural way to increase working life based education. R&D-projects themself provide us information what is happening in working life but they are also concrete examples of the working life for students. Students' commitment to real-life projects is also much better than in dummy projects. It is not only the students who gain from R&D-projects. These projects benefit our teachers as well. Being part of these projects a teacher gets up-to-date feeling and observations what are the challenges companies are working on at the moment. This information serves again education when the teacher is planning his/her teaching. Altogether we have ideas to further strengthen the relationship between education and working life. There is a worldwide innovative initiative that aims to bring engineering education and real-world demands on engineers closer to each other (CDIO 2006). Our aim is to start own development project based on the CDIO ideas in 2007.

In our case the individuals have been in a central role. We have very motivated and open-minded degree programme managers and a R&D-manager who share this common idea about creating relationships between teaching and R&D. Everyone has understood that R&D is giving us new opportunities; it is not cutting the teaching resources rather vice versa. The positive atmosphere feeds new R&D-initiatives among our teachers and is generating kind of avalanche among R&D. Increasing income leave more and more money for teaching. We have introduced versatile teaching methods that would have not been possible without additional funding.

Finally, our experiences are very encouraging and we see that there are ways to keep high quality even when the basic funding mechanism is not increasing. We also see that the solution is not to downsize operations rather look for new opportunities and new ways of doing things.

REFERENCES

Benbasat, I., D. K. Goldstein, et al. (1987). "The Case Research Strategy in Studies of Information Systems." MIS Quarterly 11(3): 369 - 386.

Broadbent, M., P. Darke, et al. (1998). "Successfully completing case study research: combining rigour, relevance and pragmatism." Information Systems Journal 8(4): 273 - 289.

Cavaye, A. L. M. (1996). "Case Study Research: a multi-faceted research approach for IS." Information Systems Journal 6: 227 - 242.

CDIO. (2006). "The CDIO Initiative." Retrieved 15.6.2006, from www.cdio.org.

Kontio, J. (2006). Enabling Multidisciplinary Learning - A Descriptive Study. 2006 IRMA International Conference, Washington, D.C., USA, IDEA Group Publishing.

Ministry of Education Finland (2003). "Education and Research 2003-2008; Development plan." Publications of the Ministry of Education Finland 2004:8: 59.

Ministry of Education Finland (2005). "Tekniikan alan korkeakoulutuksen ja tutkimuksen kehittäminen." Opetusministeriön työryhmämuistioita ja selvityksiä 2005:19: 91.

Opetusministeriö (2006). Korkeakoulujen rakenteellisen kehittämisen periaatteet; Keskustelumuistio 8.3.2006. Opetusministeriän monisteita 2006:2.

Ruokanen, T., Ed. (2004). Roadmap to Finland's Future Success, Finnish Business and Policy Forum EVA.

SITRA (2005). Making Finland a leading country in innovation : Final report of the competitive innovation environment development programme: 35.

The Finnish Higher Education Evaluation Councill (2005). "Korkeakoulujen laadunvarmistusjärjestelmien auditointi - Auditointikäsikirja vuosille 2005-2007."

Walsham, G. (1993). Interpreting Information Systems in Organizations. Chichester, Wiley.

Walsham, G. (1995). "Interpretive case studies in IS research: nature and method." European Journal of Information Systems 4: 74 - 81.

Varsinais-Suomen liitto (2005). Varsinais-Suomen maakuntasuunnitelma 2025. Turku, Varsinais-Suomen liitto.

Wikström, K., P. Haikkola, et al. (2005). Teknologiateollisuuden tulevaisuus ja liiketoimintamahdollisuudet Varsinais-Suomessa. Turku, Åbo Akademi & Turku Science Park.

Winckler, G. (2006). "The Contribution of Universities to the competitiveness of Europe." Retrieved 6.9.2006, from http://www.eua.be/eua/jsp/en/upload/EUA_Winckler_Handout_160306.1142503397992.pdf.

Yin, R. K. (2002). Applications of Case Study Research, SAGE Publications Inc.

An Evaluation Framework for Requests for Proposals of Municipal Wireless Networks: A Case Study of Three Municipalities

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INTRODUCTION

A municipal wireless network (MWN) is a government-sponsored wireless metropolitan area network (MAN). The number of municipal wireless networks proposed and built in the U.S. has continued to grow over the last five years, with some analysts are forecasting an 8,400% increase in area covered by MWNs by 2010 in the U.S. (Information Week, 2006)

When a municipality (i.e., town, city, or county) decides that it needs an MWN, it typically partner with vendors who can supply the expertise to design, install, and operate the network, as well as the necessary equipment. To find such partners, they issue a Request for Proposals (RFP), a document which details the municipality's goals, its business model for funding the deployment and future maintenance of the network, and any relevant constraints and assets the city may have. Issuing a clear and effective RFP is crucial to the success of the ensuing project. Effective RFPs clearly articulate the city's goals along with a realistic business model so that vendors can respond with valid and diverse proposals (Richardson, 2005). Ineffective RFPs may fail to attract vendors, give rise to projects which may never be completed, or produce networks too expensive to maintain in the long run.

In this paper, we formalize an evaluation framework that can be used by decision makers and city planners to specify their RFPs for MWNs. In addition, the paper conducts a case study of three municipalities; it applies the developed framework to actual projects of three cities in order to assess the likelihood of the success of the ensuing projects. It is found that an effective MWN RFP forms the basis for planning a successful project. Such RFP includes clearly-defined goals and financial models, which should be clear as to avoid the need for later clarification. An effective RFP should result in a network built on schedule and on budget during deployment, as well as a network consuming predictable expenses to run. Finally, the RFP should communicate in detail the types of services the city expects from the network, so the vendor can work to deliver them and the city can avoid future issues of accountability.

MOTIVATIONS OF MWN DEPLOYMENTS

A *municipal wireless network* (MWN) is a wireless metropolitan area network that is sponsored, and possibly built and operated, by a municipal government (which may be a town, city or county). It is built to provide wireless MAN service to people, typically within the city limits of a municipality but sometimes exceeding them based on cooperative agreements (Cherry, 2006). The service may be offered at low or no cost. Municipalities deploy MWNs for four major reasons: to stimulate economic development, to provide a last-mile alternative, to address digital divide issues, and to enhance city services (Shamp, 2004).

In terms of *economic development*, a major hypothesis among municipal governments is that the municipal supply of broadband Internet service to its constituents will directly stimulate a city's economy, as well as induce people to both visit the city and possibly relocate to it (Ford, 2005; Ford and Koutsky, 2005). This goal may include promoting the city's reputation as a technologically advanced community, bringing in tourists and encouraging people to move to the city. Research has indicated that MWNs have a positive impact on business vitality in communities (Ford, 2005; Ford and Koutsky, 2005; Goth, 2005).

In terms of *last-mile access* issues, in some cases incumbent carriers may not be interested in deploying a broadband communication network to a city or to an area of a city due to a perceived low ROI. The low ROI may be due to the fact that broadband deployment is expensive and requires much capital invested upfront with uncertain demands and future revenues. In other cases, broadband services may be available only at a high cost from a monopoly carrier in the city. In all these cases, a city may decide it has an obligation to provide another last-mile alternative to its citizens.

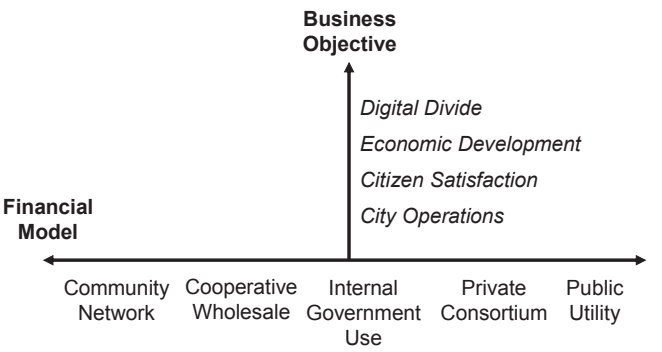
Digital divide may also be a reason behind an MWN deployment. Digital divide refers to the gap between those who have ready access to computers and the Internet and those who do not have access to those technological resources. The economically disadvantaged and those with low literacy skills (computer or otherwise) are more at risk of being on the disadvantaged side of the gap. As a result, they may be increasingly marginalized in a modern knowledge-based economy. Many cities see a great need to close this divide and treat MWNs (in combination with computer training and low cost computer programs) as a way to do so.

Lastly, many cities want to deploy MWNs in order to streamline and enhance *city services* and help their municipal workers to more effectively perform their jobs. The municipal employees include emergency responders such as police or firemen and other workers such as parking enforcers and building inspectors. In addition, cities also want to make it easier for its citizens to access city services by providing web portals to city departments, accessible via the MWN.

EVALUATION FRAMEWORK

A successful deployment of MWNs requires that there be a clear purpose for such a network and a set of identified benefits. It is necessary to balance competing or overlapping objectives and establish priorities so that outcomes are clear and can be measured. Municipalities should carefully evaluate community needs so that technological, financial and opportunity readiness can be realistically assessed. The Civitium report (Richardson, 2005) starts with the RFP Lifecycle process with business planning. Intel (Intel, 2005) puts business plan development very early in the process, placing it just after identifying a core action group and reaching out to technology providers. Five business models are currently used by communities to deploy wireless broadband and "choosing a business model that provides sufficient funding and allows the community to meet its project objectives is critical – and can be difficult." (Stone and Richardson, 2005, p. 10) Other models in the literature, such as strategic alliance and new operator (Chang, Yu, and Tsai, 2006),

Figure 1. An evaluation framework of MWN RFPs



are also included in the proposed set of five models. The five financial models are built from different mixes of public and private funding streams, acknowledged capital assets, and control opportunities:

- Community Network: This type of network is wholly funded by the government through grants, taxes or other revenue.
- Cooperative Wholesale: Government funds the deployment, serves the public needs and sells excess capacity to private providers.
- Internal Government Use: Public or grant monies fund the broadband deployment for government use only (e.g., police, fire, and utility).
- Private Consortium: Both community and subscribers pay for service though the community may also leverage city assets.
- Public Utility: This model is akin to that used for water and gas in which there is a separate enterprise that may show annual profits and losses.

The model fundamentally affects the city's priorities. If the city feels that its operational needs are already well met and that invigorating the business community is paramount, then clearly the model would not be one of focusing on city operational needs. If a controlling piece of legislation prohibits a network wholly funded by the municipality, then a community network model would not apply. Therefore, city stake-holders need to clarify and prioritize the near-term benefits they seek and assess how the MWN fits into the city's strategic objectives.

In addition, an effective RFP for a MWN should contain evidence of a community process in which one or more of the following business objectives can be identified and prioritized in the context of the municipality: (Intel, 2005, p. 6)

- City Operations: Increase efficiency through real-time, high-speed, remote access to databases related to government services (e.g., police and building inspection)
- Citizen Satisfaction: Improve access to services and enable a higher degree of interactivity with and responsiveness from those services.
- Economic Development: Enhance local commerce through improved business and community support.
- Digital Divide: Assure egalitarian access to the network through affordability and publicly accessible environments.

By combining the five financial models and four business objectives, this study proposes an evaluation framework shown in Figure 1. Through the RFP, the vendor should be given clear directions regarding the city's business intent so that the competing implementation factors of cost, speed, and quality of service can be optimally balanced for the local application. If an issued RFP does not communicate such intent, a vendor is then typically left to making best guesses (usually biased to lowest cost) and would not be able to deliver a clear and effective response. In this study, we analyze three cases of RFPs issued by municipalities around the U.S. and examine their business objective and financial model.

RESULTS

Houston, Texas

Houston covers an area of 639 sq. miles and has 2 million people. Within its city proper, it has 40 colleges, universities and institutes. The city released its RFP for a city-wide wireless network (Houston, 2006) on March 17, 2006.

Business Objective: Improve City Services

Throughout the RFP, though there are statements regarding the digital divide and reference to public safety, the document emphasizes city or public services as the business priority. Houston's objective is to expand the network's use beyond the intelligent parking meters to work-order management of field personnel and automation of traffic signaling with the ultimate goal of fundamentally reducing the city's communications expenses (Houston, 2006, p. 10). The goal of public access is primarily achieved through a financial model in which service providers offer affordable and reasonable rates to businesses and consumers.

Financial Model: Private Consortium

Houston adopts a view that the city sets policy and serves as a catalyst and service providers are the financiers and managers (Houston, 2006, p. 20). The clearest indication of Houston's expected financial model for the MWN is the statement on "Private Sector Cooperation – The City's role shall be that of a catalyst – to improve and enhance the market for broadband services in Houston. The City seeks to fulfill this role by collaborating with the private sector in a mutually-beneficial partnership." (Houston, 2006, p. 11) This is followed by Section 2.4 on "Use of City Assets" and the statement "The City intends to leverage its significant real estate holdings, as well as rights…" The same section gives more details on the number and placement of signal towers, traffic lights and other rights the city intends to contribute.

Nevertheless, buried in the business model statement the city claims all rights to the "Capture Portal in terms of both revenue related to commercial content and advertising on this page, as well as management of the pages' design, branding, layout, development and maintenance" (Houston, 2006, p. 21) which suggests that the MWN will be branded as the city's own. Thus one can surmise that the city's expectation is that the service provider's financial model will largely depend on its ability to sell network access to other service providers and retailers.

Conclusion

The Houston RFP provides a clear and workable perspective on the city's MWN. It is non-ambiguous on the city's intentions, which is improving its operations though "Value to the Community". In addition, this value is measured by the wholesale, discounted, and promotional rates offered to the population and is listed first in the evaluation criteria (Houston, 2006, p. 17). In this respect, "Value to the City" in terms of compensation and proposed rates will undoubtedly weigh heavily and be less negotiable in meeting expectations.

Fairfax, Virginia

The city of Fairfax, Virginia covers 6.3 sq. miles and has a population of 22,000. It published an RFP on March 16, 2006 for the installation of a Wi-Fi network that will encompass the city as well as some of the immediate surrounding areas. An analysis of the Fairfax RFP shows that the RFP is not clear on the scope of the network, how it is to be built, or who will pay for it. The RFP may need more clarification and detail as to the city's expectations.

Section 3 "Goals" of the RFP is where the RFP defines its goals for the network. The critical goals (Section 3.1) for this project are loosely defined. For example, Section 3.1.1 requires that the network encompass a "service area consisting generally of the City of Fairfax" (Fairfax, 2006, p. 4) but does not specify exactly where the coverage boundary should be.

The RFP may have intended to keep requirements at a high level based on the first paragraph of Section 12.0 "Definitions of Basic Requirements". Paragraph 12.1 states: "Throughout this RFP, the City has elected to define basic requirements for the network, while encouraging maximum flexibility and creativity by Offerors. The requirements below are defined on a summary level, and Offerors are encouraged to propose (and elaborate on) a solution that best meets the City's stated goals." (Fairfax, 2006, p. 11) However, when evaluated using the proposed framework, this open, summary approach does not clearly define the business objectives of the network, and the responding vendors may have to estimate more detailed objectives and devise solutions that may be suboptimal.

A later section, Section 14.0 "Business Model and Policy Questions", does not contain a more detailed description of the MWN's business model. The section contains a series of questions put forth to the vendor to clarify how its proposal will meet Fairfax's needs for a wireless network. As an example, Section 14.2 asks: "How does your proposed solution/approach specifically address the

City's stated goals and requirements?" (Fairfax, 2006, p. 13) According to the proposed framework, a better approach would be that the city first answers these questions by means of focus groups, town hall meetings, and/or surveys before issuing an RFP.

The Fairfax RFP does not specify much detail in terms of specific business objective and financial model. As a result, vendors may not be able to provide focused responses to the RFP. Based on the proposed framework, it is recommended that cities first identify the feasibility of the project and specifically discern how best to build the network.

South Sioux City, Nebraska

South Sioux City, Nebraska has an area of 30 sq. miles and a population of 12,000 people. In contrast with Houston and Fairfax, South Sioux City has a completed, deployed MWN. South Sioux City's MWN is entirely devoted to city services. It is noted that Nebraska is one of the 15 states with "anti-MWN" legislation, having passed State Bill LB-645 which categorically forbids municipalities from providing communications and information services of any kind to citizens (Freepress, 2006).

Business Objective: Improve City Services

South Sioux City had a legacy mobile wireless network used by 20 police and emergency vehicles. The legacy network was an 800MHz leased radio system used to connect to the city's own local-area network. The legacy technology had a limited bandwidth, and it severely limited the ability of public safety officers to transmit or receive video/photo data concerning suspects during investigations. In addition, the leased radio system had a yearly maintenance cost of $27,000 (South Sioux City, 2006). As a result, the city chose to roll out a new MWN using pre-certified WiMAX technology. The technology satisfies the requirements of mobile access (i.e., maintaining connection while clients are moving at vehicular speeds) and long range.

Financial Model: Internal Government Use

In addition to a well-scoped business objective, South Sioux City also has a clearly-defined financial model for its MWN. The initial capital investment for the MWN was funded by a Department of Homeland Security grant, and maintenance costs are covered by the retirement of the legacy radio system.

Conclusion

Due to a well defined scope of work and an established budget, South Sioux City was able to effectively increase the capacity of their wireless network from 9600 bps (using the legacy system) to 1.5 Mbps downstream and 512 Kbps upstream (using the pre-certified WiMAX technology). The MWN covers the entire target population, and the coverage even exceeds the original target in some areas. The success of South Sioux City's MWN has led to similar deployments of MWNs by several other municipalities in Iowa, Nebraska, and Minnesota adopting similar business objectives and financial models (South Sioux City, 2006).

DISCUSSIONS

In addition to the important criteria of business objective and well-defined financial model, there are other factors for municipalities to consider when deliberating an MWN deployment. These factors include municipal characteristics and legal issues.

Municipal Characteristics

Many different municipalities are considering MWN deployments, from 50-person townships, to rural counties covering hundreds of square miles, to major cities with millions of people. The particular characteristics on the city have a large effect on design, expectations, and costs. These characteristics include:

- City-specific requirements: What area of the city and what percentage of that area must be covered? What is the minimum desired service level (bandwidth)? How will the backhaul be handled?
- City assets: What assets does the city bring to the table? Many cities can offer utility or light poles, or rooftops of government buildings as places to site antennas. They may also have an existing fiber optic network which can be leveraged as backhaul connections.
- Maintenance operations: Once deployed, the MWN has to be maintained and operated. The responsibility of maintenance has to be clearly defined (e.g., maintained by city workers, vendors, or both).
- Evolution path: Due to rapidly evolving technologies, an MWN can be expected to become obsolete in three to five years, the timeframe of which generally follows typical IT upgrade cycles. The city needs to clearly specify what the expected life of the deployed MWN is and what process to take to initiate the upgrade cycle for the next MWN.

Legal Issues

There are two major legal considerations for municipalities considering the deployment of an MWN. The first is the primary hurdle: state and federal law. Currently, there are legislations pending at both the federal and state levels concerning the role of public entities in deploying telecommunications services which have traditionally been provided by the private sector. There are currently federal bills in committees in both the House and the Senate regarding MWNs. One is Senate Bill S.1294 (Community Broadband Act of 2005), which is an amendment to the Telecommunications Act of 1996 intended to preserve the right of localities to provide broadband services (S.1294, 2005). A competing House Bill, H.R. 2726 (Preserving Innovation in Telecom Act of 2005) actually prohibits municipalities from providing broadband or telecommunication services unless private enterprise has already failed to do so (H.R.2726, 2005). Since federal laws may supersede state laws, any municipality interested in deploying an MWN should maintain an active political presence and be cognizant of the legislative environment. However, given the popularity of MWNs (and subsequent legal challenges that will arise from cities fighting any federal law prohibiting MWNs), it seems unlikely that any congressional passage will have a major effect in the immediate future.

Regarding state legislation, there are two states—Iowa and Ohio—that have pending "anti-MWN" legislation, and 15 states that have already passed laws prohibiting or restricting MWN deployment. One such state, Pennsylvania, has a compromise law that allowed the Philadelphia MWN project to go forward, but prohibits other municipalities from deploying MWNs (Hamblen, 2005; Patton, 2006).

The second legal issue is obtaining licenses in the event an MWN deployment uses wireless technologies that operate in licensed spectrum (regulated by the Federal Communications Commission). Many wireless technologies use unlicensed bands, but the advantage of using licensed band is a lower interference generated by competing systems (of carriers or consumers). Municipalities wishing to deploy MWNs in licensed spectrums need to coordinate with the FCC

CONCLUSION

This paper discussed the motivations for MWN deployments and proposed an evaluation framework of RFPs issued by municipalities. The research considers three municipalities and applies the developed framework to their actual projects. It is found that an effective MWN RFP forms the basis for planning a successful project. Such RFP includes clearly-defined goals and financial models, which should be clear as to avoid the need for later clarification. From the cases studied, regardless of the size or scope of the RFPs, clear business objectives and focused financial models should increase the likelihood of useful vendor responses. In addition, vendor proposals can be fairly compared. In contrast, responses to an RFP that lacks a clear business plan and financial model may only be compared either quantitatively (by cost, for example) or qualitatively, and thus cannot be uniformly evaluated. Moreover, other factors such as city characteristics, costs, and legislative environment which influence the MWN design and analysis process are also discussed.

REFERENCES

Chang, S., Yu, H., and Tsai, J. (2006) "How to Operate Public WLAN Business: The Case of Taiwan," *Journal of American Academy of Business*, vol. 8, pp. 253-259.

Cherry, S. (2006) "A Broadband Utopia," *IEEE Spectrum*, vol. 43, pp. 48-54.

Fairfax (2006) "City of Fairfax Request for Proposals, Wireless Broadband and Other Data Services," http://www.fairfaxva.gov/Docs/CITYWIRELESSRFP.pdf (Retrieved October 1, 2006)

Ford, G. (2005) "Does Municipal Supply of Communications Crowd-Out Private Communications Investment? An Empirical Study," Applied Economic Studies, Birmingham, AL.

Ford, G. and Koutsky, T. (2005) "Broadband and Economic Development: A Municipal Case Study from Florida," Applied Economic Studies, Birmingham, AL.

Freepress (2006) "Community Internet-Broadband as Public Service: Corporate or Local Control?" http://freepress.net/communityinternet/=munibroad (Retrieved September 30, 2006)

Goth, G. (2005) "Municipal Wireless Networks Open New Access and Old Debates," *IEEE Internet Computing*, vol. 9, pp. 8-11.

H.R.2726: Preserving Innovation in Telecom Act of 2005 (109th U.S. Congress).

Hamblen, M. (2005) "Political Animals: City CIOs are using Hot New Technologies to Raise Revenues—and IT's status," *InformationWeek*, February 28, pp. 35-36.

Houston (2006) "Digital Houston Initiative Information Technology Department (ITD) Request for Proposal," http://www.houstontx.gov/it/digitalhouston20060317.pdf (Retrieved October 1, 2006)

InformationWeek (2006) "Metro Wi-Fi Networks Expected to Grow 8,400% by 2010," *Information Week*, March 15.

Intel Corp. (2005) "Digital Community Best Practices," Intel Corp., http://www.intel.com/business/bss/industry/government/digital-community-best-practices.pdf (Retrieved October 1, 2006)

Patton, S. (2006) "Wi-Fight," *CIO*, April 1, pp. 50-54.

Richardson, G. (2005) "Municipal Wireless: Request for Proposal (RFP) Best Practices," Civitium LLC, Alpharetta, GA.

S.1294: Community Broadband Act of 2005 (109th U.S. Congress).

Shamp, S. (2004) "Wi-Fi Clouds and Zones: A Survey of Municipal Wireless Initiatives," MuniWireless, http://www.muniwireless.com/reports/docs/Wi-Ficloudszones.pdf

Stone, M. and Richardson, G., (2005) "Wireless Broadband: The Foundation for Digital Communities," Civitium LLC, Alpharetta, GA.

South Sioux City (2006) "South Sioux City ITEP - Final Project Report", received via e-mail from Lance Martin, Communications Director for South Sioux City, April 23.

Improving Work Autonomy in Workflow Systems: A Configuration Choice

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INTRODUCTION

Some 40 years ago, software engineers had to take care of implementing each piece of the information system they were developing themselves, including the operating system, database routines, and user interface. Workflow systems (WfS's) have been positioned as the latest step in a trend where generic tasks are taken out of applications (Van der Aalst and Van Hee, 2002). Just like there are now off-the-shelf system solutions for data management, workflow takes care of coordinating the steps in a business process – freeing programmers from the need to hard-code this logic.

The principal advantage of employing a WfS is that it brings back the focus of IT support for business operations to the *entire* business process, instead of its elementary processing steps. This *process-orientation* or *process-awareness* in present WfS's is also pleaded by advocates of movements that emerged in parallel to workflow management, like Business Process Redesign (Davenport and Short, 1990) and Supply Chain Management (Christopher, 1992). Organizational advantages of process-orientation have clearly materialized in the form of improved business performance, reduced number of inter-functional conflicts and an improved "esprit de corps" (McCormack, 2001).

However, there are also indications that the use of a WfS may not be received with enthusiasm alone. Employees (the potential users) and work psychologists fear that WfS's might lead to a mechanical approach to office work, where man is seen as an exchangeable resource (like a machine) and not as a human being. In a study by Küng (Küng, 2000, p. 310), an interviewee at an organization described the effects of a WfS introduction like this: "Jobs became more monotonous. The system forces the employees to work strictly according to the process definition. Through the use of the workflow system, we now have some kind of 'chain production' in the office." Interestingly, the same empirical study has concluded that overall job satisfaction across the 5 various studied WfS implementations was influenced positively!

This is a paradoxical situation, which has not been dealt with satisfactorily so far. The main premise of this paper is that workflow systems are so inherently flexible, i.e. they can be configured in so many different ways, that the effects on job satisfaction may be highly dependent on the chosen configuration, e.g. compare (Poelmans, 2002). In earlier exploratory work (Vanderfeesten and Reijers, 2006), we identified a number of WfS "tuning" options that may influence the job satisfaction of employees positively (in particular their autonomy), while keeping the essence of the delivered support from a business perspective intact. The current paper builds on this work by proposing a fine-grained model of work distribution, which helps to understand how different configuration decisions may influence job satisfaction. Limited case studies within three organizations using this model indicate that in practice very restrictive configurations are in effect, which offer much room for improving the autonomy of employees using WfS's.

This paper is organized as follows. First we give more background for the two areas on which this research is built: workflow and job design. These two areas are linked by looking at the impact of workflow systems on task characteristics, mainly autonomy. Next, we focus on a very specific part of workflow systems: the distribution of work in a workflow system. We elaborate on the configuration options a workflow system has in this respect and on their impact on work autonomy. The paper ends with some concluding remarks and limitations of this approach.

WORKFLOW SYSTEMS AND WORK AUTONOMY

In this section we first clarify a number of important concepts in the area of workflow systems. Next, we elaborate on the area of job design and finally we summarize related work in the combination of these areas.

Workflow Systems

A workflow system is a software product that supports the specification, execution, and control of business processes (Ellis & Nutt, 1993; Georgakopoulos, Hornick & Sheth, 1995; Jablonski & Bussler, 1996). It is a proactive system that manages the flow of work and that defines, creates, and manages the execution of workflows through the use of software that is able to interpret the process definition, interact with workflow participants and where required, invoke the use of IT tools and applications (WfMC, 1999). Commercial WfS's have been around since the early nineties; while their conceptual predecessors can be traced back to the seventies (see e.g. Ellis, 1979). They have become "one of the most successful genres of systems supporting cooperative working" (Dourish, 2001, p.52).

To enable a workflow system, a process model has to be defined. Such a process model is a static representation of the steps (*activities*) in the process and the order in which they have to be executed. Moreover, the process definition also contains information about the people (*resources*) that are allowed to execute the steps (e.g. information on authorization, roles, knowledge, capabilities that are needed).

The process model describes in general the way how incoming *cases* are handled step-by-step. A certain case has specific characteristics that determine its right way through the process model. When an activity in the process model has to be executed for that case the workflow system checks which resources are allowed to execute the *activity instance* and it sends this piece of work to the individual or shared worklist of the authorized employees. The employee selects the piece of work, performs it and finishes it. Depending on the configuration of the workflow system the control of the execution process is entirely with the system or for large parts with the employee.

Job Design

From the area of job design a number of studies is available that deal with the impact of jobs having certain characteristics on the humans performing this job. By job design we mean the content of the job that an individual or group undertakes (for example the tasks and roles they fulfill) and the methods they use to undertake their work (Holman, Clegg & Waterson, 2002). The most dominant framework in the area of job design is developed in the 1970's by Hackman and Oldham (Hackman & Oldham, 1975, Hackman & Oldham, 1976). This model is used to define task characteristics and to understand their relationship to employee motivation, performance and satisfaction. According to this theory a job can be characterized in terms of five core job dimensions:

- **Skill variety** – the degree to which the job requires a variety of different activities so the worker can use a number of different skills and talent.
- **Task identity** – the degree to which the job requires completion of a whole and identifiable piece of work.
- **Task significance** – the degree to which the job has a substantial impact on the lives or work of other people.
- **Autonomy** – the degree to which the job provides substantial freedom, independence, and discretion to the individual in scheduling the work and in determining the procedures to be used in carrying it out.

- **Feedback** – the degree to which carrying out the work activities required by the job results in the individual obtaining direct and clear information about the effectiveness of his or her performance.

Workers who have jobs that score highly on these task characteristics are more motivated, more satisfied and work harder (Robbins, 2001). Thus, when a job scores high on these task characteristics this has a positive influence on, for instance, the productivity of the employee. Autonomy seems to be the most important task characteristic.

The Impact of Workflow Systems

Implementing a workflow system in an organization can have great effects on various parts of this organization. Remember for instance, the quote of the employee in the interview that stated that his work had changed to a more chain production like environment.

According to Sarmento this impact of the implementation of a workflow system can be observed in several domains (i.e. productivity, knowledge, collaboration, coordination, and communication), and at different levels of abstraction (the organizational level and the task level) (Sarmento, 2000a; Sarmento, 2000b). In this paper we particularly focus on the impact on users' productivity on the task level.

There is a large body of academic research that is focused on examining the determinants of computer technology acceptance, (e.g. Moore and Benbasat 1991, Taylor and Todd, 1995). Utilization studies are rare in the field of WfS's, although a seminal case study on the (lack of) acceptance of a WfS is reported by Bowers et al. (1995). User satisfaction with information systems, i.e. the extent to which users believe the information system available to them meets their information requirements, has also gained much research attention (e.g. Ives et al., 1983; Gelderman, 1998), but not in particular in relation to WfS's. A notable exception is the work by Poelmans (2002), which includes the tentative conclusion that not the selection of the right WfS, but the way it is configured and implemented is crucial in the success of a workflow implementation. Success is measured in terms of perceived usefulness, quality of information, and end-user satisfaction.

In our previous work we have generated a number of general tuning measures to reconfigure a workflow system according to the users' needs (Vanderfeesten & Reijers, 2005, Vanderfeesten & Reijers, 2006). These tuning measures mainly focus on improving the autonomy of the employee working with a workflow system, to overcome the problem of very rigid systems and boring, monotonous work. After the more general tuning measures, a detailed focus on the process of working with a workflow management system is taken in this paper. In the remainder of this paper we will specifically look at the work distribution in a workflow system and its effect on autonomy.

DISTRIBUTION OF WORK IN WORKFLOW SYSTEMS

A workflow system is driven by a static and abstract model of the business process that is supported by the system. As we have seen earlier such a process model consists of a number of activities and their respective ordering. When a new case (e.g. an insurance claim of a specific person for a specific accident) arrives at the process it will follow a route through this process model**.** All the abstract activities in the process model are instantiated for this specific case and for every activity a *'work item'* is created.

The course of instantiating and executing a work item is explained in Figure 1. When a case arrives at a certain step in the process model the right *'activity instance'* is generated. Next, the resources that are authorized to execute the activity instance are assigned, which makes it a *'work item'*. The work item then is distributed to the right resource(s) and, finally, is selected and executed by the right resource(s).

For this research we specifically focus on the distribution procedure of a work item, because we believe this part of the execution chain has the highest potential to improve work autonomy. Going into more detail for the distribution procedure, we identify three steps: notification, receipt, and scheduling. In the *notification* step the system notifies the authorized employee(s) that a certain work item is ready to be executed. In the *receipt* step the employee(s) receive(s) the work item on his/her worklist. Finally, the work items to be executed are *scheduled*, either by the system or by the employee, and the execution is started (see Figure 2).[1]

Figure 1. The relationship between cases, activities, and resources

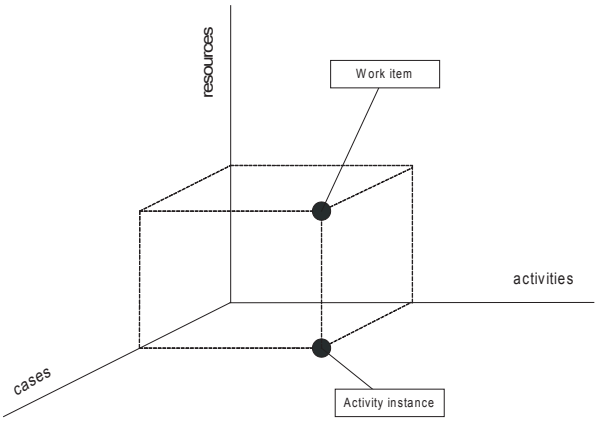
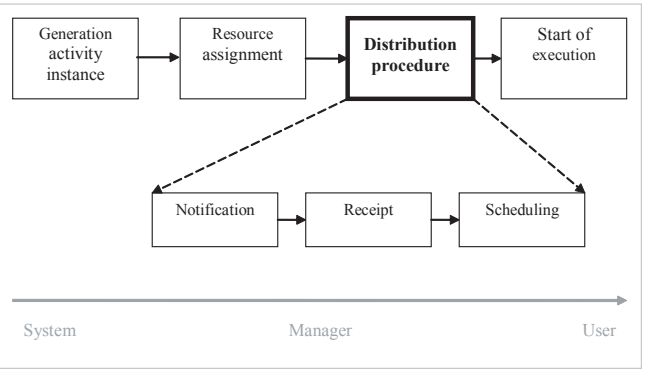


Figure 2. The steps of the execution chain, that are taken for the execution of an activity instance



Note that the influence of the user changes in the chain of steps that is described in Figure 2: the generation of an activity instance and the resource assignment is completely done by the workflow system itself, while the receipt, scheduling and start of execution require an increasing involvement from the user.

For each of the steps in the distribution procedure several configuration options are available. These configuration options are identified by critically assessing several theoretical descriptions of workflow systems (zur Muehlen, 2004; Zeng & Zhao, 2005; Russell, ter Hofstede, Edmond & van der Aalst, 2004). Due to space limits we will not elaborate on all of them but we will give some examples to show their meaning.

In the notification step for instance the work items can be *allocated* or *offered*. In case of allocation, the workflow system puts the work item on the worklist of an employee, while in case of offering the work item is presented to the employee and the employee himself/herself decides whether it will be put on his/her worklist. It is clear that the latter case increases the autonomy of the user.

A second configuration option in the notification step is the notification to *one* or *more employees*. In case of more employees, the employees have the freedom to choose work items, which will increase their autonomy.

One of the configuration options in the receipt step is the *selection* or *acceptance* of a work item. When a work item is notified to the employee(s), the employee can select it from the list or accept it. By selecting, the employee makes a conscious decision, which also will improve the sense of autonomy.

Another option is the transportation to the individual worklist in the receipt step. This can be done directly to the *individual worklist* or through a *shared worklist* from which the employee can select one of the items. Through a shared worklist

the employee has an overview of all the work and the work that is performed by his/her colleagues, which will improve autonomy and task significance.

Finally, one of the options in the scheduling step is the *time of execution*. When execution has to be started immediately after notification and acceptance, the employees have less freedom than when they can determine themselves at which time they start execution of the work item.

Of course not every arbitrary combination of configuration options is possible; some choices exclude others. For example, when choosing a notification to one employee the transport to the individual worklist cannot go via a shared worklist. And in the case of individual worklists (without a shared worklist in between) in combination with the allocation of work items, the employee will only be able to select work items instead of accepting them.

The two most extreme distribution scenarios are:

(1) a work item is offered to more employees on a shared worklist, one of them selects the work item, puts it on his/her own worklist and starts the execution of the work item whenever he or she feels like doing it.
(2) A work item is allocated to only one specific employee. The employee has to accept it (rejection is not possible) and has to start working on it immediately.

From these two scenario's it is clear that the first one provides the most freedom and autonomy to the employee.

Case Studies

As a first step in our empirical investigations on the distribution of work in workflow systems, we have conducted six exploratory case studies. In these case studies three organizations were involved: a Dutch banking and insurance company, a Dutch bank and a Dutch municipality. For each organization two important processes have been studied on the distribution patterns that were used. The first company uses two different workflow systems: COSA and SAP. The other two companies use only one system for both processes: Staffware.

First, we examined whether the configuration options were really present in the systems. Next, we investigated the situation for the specific processes, by studying the process models, interviewing system developers and other stakeholders, and by checking documentation about the configuration options. Among the results of these case studies are two remarkable conclusions:

(1) In *all* cases, some kind of standard configuration of the workflow system was used, which provided little autonomy. This standard configuration consists of a shared worklist from which all authorized employees can select the work items they are going to perform. Indeed, the employee has some autonomy, but it could still be increased. For instance, in the Dutch banking and insurance company, the COSA system provides for a way to select work items an employee wants to work on from a shared worklist, transfer them to the employee's individual worklist and start execution of the work item whenever the employee prefers. However, this configuration was not used in our case study.
(2) The type of software program seems to be an important determinant for the available configuration options. In the cases of the Dutch bank and the Dutch municipality, the Staffware system was used. Staffware does not provide a facility to reject a work item or send a work item to another employee. Thus, all possible configurations with an offering pattern are not valid, which restricts the number of possibilities to increase autonomy.

CONCLUSION

In this paper we argued that the human side of IT is very important and that it does not need to be difficult to take people into consideration in the development of a workflow system. By only making small configuration changes in a workflow system, the system can be much more pleasant to work with. We believe that the degree of work autonomy is very important for employees, so that problems of chain production work in the office can be overcome (i.e. very mechanistic and boring work).

In earlier work we already identified some general 'tuning' measures to increase the autonomy of employees working with workflow systems. In this paper, we deepened the focus of these measures on a specific part of the workflow system: work distribution. We presented our hypotheses on several configuration options and we conducted six exploratory case studies to investigate the current situation of work distribution in organizations.

The most important limitation of this work is that we look at a small and very specific part of the workflow system. However, we feel this is the most important part of the system concerning people, since the work distribution is the step in the whole process where the work is actually offered to specific employees. Thus, this exactly is the part where autonomy is created for employees or where it is reduced.

Another limitation is that this is still a very theoretical approach, only supported by a small number of exploratory case studies. Therefore, it would be good to conduct a bigger field research, investigating the possibilities that current systems offer to adjust their configuration and the degree to which these possibilities are actually used in organizations to avoid monotonous and boring work.

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REFERENCES

Aalst, van der, W.M.P. and Hee, van, K.M. (2002), Workflow Management: Models, Methods, and Systems, MIT Press, Cambridge.

Bowers, J. M.; Button, G.; and Sharrock, W. (1995) 'Workflow from Within and Without: Technology and Cooperative Work on the Print Industry Shopfloor', in H. Marmolin, Y. Sundblad, and K. Schmidt (eds.): *Proceedings of the Forth European Conference on Computer-Supported Cooperative Work (ECSCW'95)*, Kluwer, Dordrecht, pp. 51-66.

Ives, B.; Olson, M.H.; and Baroudi J.J. (1983) "The measurement of user information satisfaction", *Communications of the ACM,* vol. 26, no. 10, pp. 785-793.

Christopher, M. (1992) *Logistics and Supply Chain Management*. Pitman Publishing, London.

Davenport, T. and Short, J. (1990) The new industrial engineering: Information technology and Business Process Redesign. Sloan Management Review 31(4):11-27.

Dourish, P. (2001) "Process descriptions as organizational accounting devices: the dual use of workflow technologies". In: Ellis, C.A., and Zigurs, I. (eds.), *Proceedings of the ACM 2001 International Conference on Supporting Group Work*, New York, ACM Press, pp. 52-60.

Ellis, C.A. (1979) "Information control nets: a mathematical model of office information flow". In: Roth, P.F., and Nutt, G.J. (eds.) *Proceedings of the ACM Conference on Simulation, Measurement and Modeling of Computer Systems*, New York: ACM Press, pp. 225-240.

Ellis, C.A., and Nutt, G.J. (1993) "Modeling and Enactment of Workflow Systems". In: *Application and Theory of Petri Nets*, Lecture Notes in Computer Science nr 691, Springer-Verlag, Berlin, pp. 1–16.

Gelderman, M. (1998) "The relation between user satisfaction, usage of information systems and performance". *Information & Management*, vol 34, no. 1, pp. 1-53.

Georgakopoulos, D.; Hornick, M.; and Sheth, A. (1995) "An Overview of Workflow Management: From Process Modeling to Workflow Automation Infrastructure". *Distributed and Parallel Databases*, vol. 3, pp.119-153.

Hackman, J.R., and Oldham, G.R. (1975) "Development of the Job Diagnostic Survey". *Journal of Applied Psychology*, vol. 60, pp. 159-170.

Hackman, J.R., and Oldham, G.R. (1976) "Motivation through the design of work: test of a theory". *Organizational Behavior and Human Performance*, vol. 15, pp. 250-279.

Hammer, M, and Champy, J. (1993) *Reengineering the corporation: a manifesto for business revolution*, Harper Business, New York.

Holman, D.; Clegg, C.; and Waterson, P. (2002) "Navigating the territory of job design". *Applied Ergonomics*, 33. pp. 197-205.

Jablonski, S., and Bussler, C. (1996) *Workflow Management: Modeling Concepts, Architecture, and Implementation*, International Thomson Computer Press, London.

Kueng, P. (2000) "The Effects of Workflow Systems on Organizations: A Qualitative Study". In: Aalst, Wil M. P. van der; Desel, J; and Oberweis, A. (eds.), *Business*

Process Management, Models, Techniques, and Empirical Studies, Lecture Notes in Computer Science 1806, Springer Verlag, Berlin, pp. 301-316.

Kueng, P., and Hagen, C. (2004) "Increased performance through business process management: an experience report from a Swiss bank". In: Neely, A. et al. (eds.), *Performance Measurement and Management – Public and Private*, Cranfield, pp. 1-8.

McCormack, K. (2001) "Business process orientation: do you have it?", Quality Progress, Vol 34 No 1, pp. 51-58.

Muehlen, M. zur. "Organizational Management in Workflow Applications – Issues and Perspectives". *Information Technology and Management Journal*, vol. 5, no. 3, pp. 271-291.

Moore, G.C. and Benbasat, I. Development of an instrument to measure the perceived characteristics of adopting an information technology innovation. Information Systems Research, 2(3), 192—222, 1991.

Poelmans, S. (2002) *Making Workflow Systems Work: An Investigation into the Importance of Task-appropriation Fit, End-user Support and other Technological Characteristics*. Ph.D. thesis. Doctoral dissertation series Faculty of Economic and Applied Economic Sciences nr 161., Katholieke Universiteit Leuven.

Robbins, S.P. (2001) *Organizational behavior,* Prentice Hall, New Jersey.

Russell, N., ter Hofstede, A.H.M.; Edmond, D.; and van der Aalst, W.M.P. (2004) Workflow Resource Patterns: Identification, Representation and Tool Support. In: O. Pastor and J. Falcao e Cunha, editors, *Proceedings of the 17th Conference on Advanced Information Systems Engineering (CAiSE'05)*, volume 3520 of Lecture Notes in Computer Science, pages 216–232. Springer-Verlag, Berlin, 2005

Sarmento, A., and Machado, A. (2000a) The adoption of workflow systems: proposal of a model for a methodology to analyse the impact of workflow systems in organizations. In: *Proceedings of the 2nd international conference on Enterprise Information Systems (ICEIS'00)*, pp. 349-355. Stafford, UK.

Sarmento, A., and Machado, A. (2000b) Impact Evaluation of organisational changes enabled by workflow systems. In: *Proceedings of the 6th international workshop on groupware (CRIWG '00)*, Madeira, Portugal, pp.134-137. IEEE Computer Society.

Taylor, S.A., and Todd, P.A. (1995) "Understanding Information Technology Usage: A Test of Competing Models". *Information Systems Research*, vol. 6, pp 144-176.

Vanderfeesten, I., and Reijers, H.A. (2005) A human-oriented tuning of workflow management systems. In: Aalst, W.M.P. van der, et al (eds.), *Proceedings of the 3rd International Conference on Business Process Management (BPM 2005)*, Lecture Notes in Computer Science 3649, pp. 80-95. Springer Verlag, Berlin.

Vanderfeesten, I., and Reijers, H.A. (2006) "How to increase work autonomy in workflow management systems?" *Management Research News*, vol. 29, no. 9 (to appear).

Workflow Management Coalition (1999). Terminology and Glossary (WFMC-TC-1011). Available on: http://www.wfmc.org.

Zeng, D.D., and Zhao, J.L. (2005) "Effective role resolution on workflow management". *Informs Journal on Computing*, vol. 17, no. 3, pp. 374-387.

ENDNOTE

[1] Note that the work items in a workflow system usually are presented to the employee in a clear way. The worklist often looks like the inbox of an e-mail program.

Blended Learning in the Bachelor of Economics and Business Administration for Large Scale Courses: Qualitative and Economic Effects

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1. PROJECT PROBLEM

Approx. 2,000 students complete the 'Bachelor of Business Administration' or 'Bachelor of Business Economics' Programme in the Department of Economics and Business Administration at Justus-Liebig University Giessen. During the first four terms, all the students attend the same compulsory courses on the basics of economics and business adminstration. The following are some of the compulsory courses:

- Introduction to Business Administration
- Basic Costing
- Basic Finance
- Introduction to Economics
- Mathematics and Statistics
- Corporate Accounting (Bookkeeping and Financial Accounting)
- Business Planning and Organization
- Operations Research
- Basic Information Management

These compulsory courses each consist of a lecture (2 hours a week) and a complementary seminar (also 2 hours a week). The lectures are all held in a large lecture theatre to an audience of 400-700 students present. The accompanying seminars are a consolidation of the content of the lectures, using practical applications, examples and tasks. The content of the seminars mainly involves applying a calculation method to solve a business problem. In all the seminars the software product Microsoft Excel (spreadsheet) is used to practise the methods of calculation, as this is also the instrument that is most frequently implemented in business practice. At the end of term, the students are required to attend an examination for each compulsory course, which is based on the content of the lecture and its accompanying seminar.

The compulsory course 'Basic Information Management' provides an example of the problems typically arising from the accompanying seminar. Until winter term 2005/2006 these seminars were attended by groups of maximum 20 students in the department's PC pool (limited number of PC working places). In order to offer all students a place in a seminar we therefore had to carry out 22-24 seminars per term, for which we hired, instructed and paid 10-12 tutors. By winter term 2005/2006, the organisational workload and the financial expense of this had reached a scale that was no longer feasible for the department. An additional problem was that the students were attaining varying levels of knowledge by the end of term due to the sheer quantity of seminars and tutors. Ultimately, the course was characterized by all the well-known problems of large scale courses – problems with organisatisation, finance and quality. These problems exist in all the compulsory courses mentioned above to a similar extent and, as a result, the entire department and all its lecturers and students are affected.

2. PROJECT OBJECTIVE

In summer 2005, the Department of Economics and Business Adminstration launched a pilot project to solve this problem. In winter term 2005/2006 (October 2005 to February 2006) the accompanying seminars for the compulsory course 'Basic Information Management' were no longer carried out as a multitude of seminars with student presence, but were offered to approx. 500 student as web-based trainings (WBT) online for self-study. The SCORM-compatible WBT was available in the students` personalized website area at all times ('SPIC' – Students Personal Information Center; executed in the learning management platform 'WPS' – Schwickert 2004, WPS 2006). Each student can therefore see individually which WBT has been completed, when and how often it has been completed and the test results achieved.

The WBT was not intended as an introduction to the software products MS Excel and MS Access – we assumed that students already had a basic knowledge of the software. The WBT was primarily intended to teach students how the software products can be used to solve business problems.

The self-study per online WBT was accompanied by components requiring presence, so that the students were not left completely to their own resources. This included an introductory session at the beginning of term, a briefing session mid-term, an examination training session at the end of term (all in a big lecture theatre for all students) and an open weekly advisory service in the PC pool to deal with individual questions. This mix of e-components and presence components was intended to greatly simplify the organisation of courses, significantly reduce the funds required and standardize the knowledge transfer at the desired level for all students.

3. PROJECT IMPLEMENTATION

In June 2005, a project seminar was started at the Chair of Business Administration and Information Management. Project seminars are an integral part of the compulsory program for the depth subject Information Management in the Economics and Business Administration Course at Justus-Liebig University Giessen. A project seminar deals with a real IT problem. In a period of approx. 3-4 months a team of 3-4 students of the depth subject Information Management work practically towards finding a solution for the IT problem. This can, for example, be the planning and design of a software product, or it can also be a survey of a specific IT topic. In this case, the task of the team of 4 students was to create an integrated series of web-based trainings (WBT) for the seminar mentioned above.

In the period from June 2005 to the end of October 2005 the team created a total of 13 WBT using MS Excel and MS Access to solve business problems. During the 5-month project Prof. Schwickert and two of his research assistants were intensively involved, advising the team. First, a content concept for the entire WBT series was drawn up, based on the materials that had been tried and tested in the previous presence seminars. Then the materials were divided between the individual WBTs and structured into indvidual scripts for each WBT. From mid-August 2005, the individual WBTs were produced successively. The authoring tool EasyProf and the tools TurboDemo, Captivate and Photoshop were deployed.

Each WBT was initially produced as a protype and subsequently developed further in an evolutionary manner with 1-2 weekly reviews. The team was able to base the production of the WBTs on a methodic and didactic concept and a layout and design concept that had been developed in a research project at the Chair of Business Administration and Information Management from April to July 2006 (Schwickert et al. 2005).

In the first half of October 2005, all WBTs were subjected to final intensive quality control by three student test groups. In the last week of October 2005 all WBTs were made available to approx. 500 students online. The WBTs of this series can be used online at http://wi.uni-giessen.de/ gi/home/Schwickert/elearning/ online (WBT 2006).

4. RESULTS AND EXPERIENCES

The course was carried out as described in '2. Project Objective'. The frequent use of the WBT and very low use of the accompanying support – the online forum and the presence advisory service – were particularly striking. Also surprisingly, the examination results on the WBT contents were visibly better better than in the previous terms, during which the seminars had been held face-to-face in classrooms.

- E-Learning Component 1:
  The subject matter of the seminars accompanying the lectures was offered online to the students in a series of 13 consecutive WBTs (each with learning contents, practical exercises and tests) for self-study. From October 2005 to June 2006, we registered a total of approx. 16,700 WBTs completed by, suprisingly, approx. 800 different students.
- E-Learning Component 2:
  Throughout the lecture period, we offered a supervised online forum in which the students could discuss the seminar contents with eachother and the lecturer. This forum was only moderately used.
- Presence Component 1:
  At the beginning, during and towards the end of the lecture period we held three presence sessions ('briefings') in a lecture theatre, at which Prof. Schwickert was availabe to consolidate and explain certain contents. The initial session was attended by approx. 450 students, the middle session by 200 students, the final session by only approx. 100 students.
- Presence Component 2:
  Throughout the lecture period, we offered two 2-hour open advisory sessions per week in the PC pool. These advisory sessions were used by only approx. 20 students!
- Presence Component 3:
  The final examination which was based on the contents of the lectures and seminars was, as accustomed, a presence examination (half of the tasks on the lecture contents, half on the seminars) held at the end of the lecture period. The examination tasks on the contents covered by the WBT were more difficult than in previous terms, when the contents were taught face-to-face. Nevertheless the examination results on these contents were significantly improved.

From an organisational point of view, the entire course ran smoothly. While approx. 30-40 students (of approx. 500 participants) experienced some technical problems using the WBT online from their work stations at home during the first weeks of term, by mid-November 2005 we registered no more problems at all. The workload for supervising the online forum was marginal, the two 2-hour open advisory sessions in the PC pool could have been halved.

While it had cost approx. 9,000 euros per term in previous winter terms to employ tutors to carry out the presence seminars, the total direct costs in the 2005/2006 winter term amounted to 3,000 euros. This amount was necessary for the purchase of authoring tools and the employment of a student tutor to carry out the weekly presence advisory sessions.

Finally, the quality objectives were fulfilled. The significantly improved examination results with a higher requirement level speak for themselves. The widespread student acceptance for this type of teaching was reflected in the online evaluation of the course. In the approx. 200 completed questionnaires there was not one single negative evaluation of the seminar. Far from it – the quality and the 'learning aptitude' of the WBTs were consistently assessed very positively, as was the possibility to complete the WBTs where they wanted and when they wanted. Similarly, students appreciated the fact that the transfer of knowledge was not completely electronic, but accompanied by periodic briefings and an advisory service on site.

The quality of the teaching program is enhanced decisively by the blended learning concept, due to the fact that the course materials – their quantity, contents and external form – are presented to all the students uniformly. In conventional classroom seminars these characteristics depend heavily on the individual qualifications of the numerous tutors and the varying levels of previous knowledge of the seminar particpants. The project demonstrates that WBTs make it possible to boost the level of subject matter without making excessive demands on the students and guaranteeing individual supervision.

In the next two winter terms 2006/2007 and 2007/2008 the compulsory course 'Basic Information Management', which was tested in this pilot project, will continue to be offered in this same form with online WBTs. The costs for acquiring the authoring tools no longer apply, the WBTs can be used again without modifications, the presence advisory sessions will be halved. In the next winter terms the costs incurred for the seminar accompanying the compulsory course 'Basic Information Management' will amount to max. approx. 1,200 euros. In comparison to winter 2004/2005, when the exercises were last carried out as presence seminars, the costs will have been cut by approx. 85%.

5. ORGANISATIONAL FRAMEWORK AND PERSPECTIVE

A further result of the pilot project at the Chair for Business Adminsitration and Information Management was that a concept has been developed on the basis of which the other chairs in the department can integrate blending learning using the model described with WBTs. This includes an organisational process model, a didactic guideline on WBT authoring, ready-made WBT templates and suitable authoring tools.

Since May 2006, this concept has been applied to the compulsory course 'Introduction to Business Administration'. This course will be offered in winter term 06/07 (starting October 2006) for approx. 700 first year students. The lecture on 'Introduction to Business Adminstration' will be held as a presence course, as in the past. The subject matter covered in the complementary practical seminars will be offered in a series of successive WBTs online for self-study, supported by presence briefings, tutor advisory sessions and supervised online forums. In this case also, a team of students has worked under supervision on an integrated WBT series within the framework of an information management project seminar. The WBT series has been ready for use since September 2006.

In November 2006, a WBT project seminar, based on the concept from the pilot project, will be launched to support the large scale 'Costing' course. The same is scheduled for the basic education in mathematics and statistics, as well as for basic finance from January 2007.

Blended learning is therefore spreading rapidly and 'bottom up' within the department. The individual chairs in the department are ultimately convinced because the quality of studying and teaching in the Department of Economics and Business Administration benefit from the increase in student motivation to learn. Similarly, the quantitative benefit is driving the project forwards. Considerable financial economies, particulary as regards personnel costs, have been achieved. It's worth emphasising that no chairs have had to make specific investments for blending learning, other than the one-time purchase of authoring tools (approx. 1,000 euros) As demonstrated in the project, it can be achieved with the resources available: good students and good staff. A WBT series covering a complete seminar course can be developed and ready for operation without problem within 3-4 months.

By mid-2007 accompanying exercises will be offered for five of the nine compulsory courses mentioned in chapter one online per WBT, based on the concept resulting from the pilot project. In year 2007 alone, a reduction in costs of approx. 40,000 euros will be achieved and this, importantly, without reducing the quality of education.

REFERENCES

SCHWICKERT, A. C. AND HILDMANN, J. AND VOSS, C., 2005. ´Blended Learning in der Universitaet – Eine Fallstudie zur Vorbereitung und Durchfuehrung´, in PROFESSUR BWL-WIRTSCHAFTSINFORMATIK (eds.), *Arbeitspapiere WI, 9/2005*. Giessen: Justus-Liebig-Universität.

SCHWICKERT, A. C., 2004. ´Dezentrales Web Content Management´, in GEBERL, S. AND WEINMANN, S. AND WIESNER, D. F. (eds.), *Impulse aus der Wirtschaftsinformatik*. Heidelberg: Physica.

WBT, 2006. *Die WBT-Serien des Fachbereichs Wirtschaftswissenschaften an der Justus-Liebig-Universitaet*, viewed 8 September, 2006, <http://wi.uni-giessen.de/gi/home/Schwickert/elearning/>

WPS, 2006. *Informationen zum WPS*, viewed 8 September, 2006, <http://www.web-portal-system.de/>

The Consumer Ethics of the Virtual Environment: An Aetiology

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INTRODUCTION

Free-form, massive multiplayer online games have resulted in the migration of many real world activities to virtual worlds and environments. These often exceed what is possible in the 'real' physical world, but in most cases are still just reflections of it. In this paper we will focus on the commercial applications that virtual worlds can host and more specifically on the potential ethical issues that arise when trading in virtual environments. We will present the case of *Second Life* and illustrate some of the key consumer-related ethical issues that arise from this virtual environment.

The next section examines important key attributes of the virtual environment of Second Life and illustrates its popularity and usage. This is followed by an analysis of consumer ethics within the game, whilst a separate section outlines a number of key recommendations. The last section concludes our analysis.

WHEN PLAYING IS LIVING

"Online games" mostly refer to games that are played over the Internet using PCs and game consoles. Such games are often based on existing stand-alone games that have been extended to support a small number of players or may even involve thousands of players simultaneously. Massively Multiplayer Online Role Playing Games (MMORPG) usually evolve around a theme that defines the goals of the game or encourage a free-form style of playing, leaving this up to the participants.

One of the most popular MMORPGs is Second Life, which according to its web site (www.secondlife.com) on the 1st of October 2006 had more than 800,000 users, 343,000 of whom had logged in the system within the previous 60 days, and had spent around $382,000 in the preceding 24 hours. The popularity of Second Life is not only due to the fact that participating is inexpensive, as creating a basic account is free (premium accounts cost around $72/year), but mainly due to the opportunity it provides the participants with to make anything they want out of the game. In Second Life users create the game, develop characters, objects and so on, and developers mainly manage the game and provide creative tools (Working Party on the Information Economy, 2005). To participate in Second Life a user needs only to download and install the required software. The user can then connect to the grid and customise the avatar, i.e. the virtual character that will be representing him or her in the virtual world, when exploring the grid, and interact with other users and the various in-world (i.e. within the virtual world) objects and buildings.

As the game has its own in-world currency that can be exchanged for real world currency, it is not surprising to find that many businesses in and out of Second Life have been established to cater for the in-world needs. Architects, fashion designers, automotive manufacturers, realtors and night club owners are a few among the growing number of entrepreneurs who provide their products and services in-world.

In a presentation in March 2006, Philip Rosedale and Cory Ondrejka (2006) of Linden Labs, the company developing and managing Second Life, provided an array of interesting statistics that illustrates the penetration and economic potential of the game:

- 25% of Second Life's users were from outside the USA, with the UK being the second-largest country of origin.
- The average age of users was 32, and the median age of users was 36.
- 43% of users were female, 50% were female 'by use'.
- There were $5 million USD in virtual transactions per month conducted between users.
- 180,000 distinct objects were sold in a 30-day period roughly spanning February, 2006.
- 75% of users were buyers, 25% were sellers. Among the sellers 'low hundreds' of them identified Second Life as their full-time job.

Perhaps more important than the above demographics about Second Life users is the reference of Ondrejka, the vice-president of product development at Linden Labs, to the '1% rule' (Arthur, 2006) that 60% of their users create their own content compared to less than 1% of readers of the online encyclopaedia, Wikipedia (Keegan, 2006). This suggests that more than half of the users can potentially assume a selling role in-world.

As no licence is required, establishing an in-world business is relatively straight forward. In fact, if the business does not require retail space (e.g. if one selects to become a bodyguard or dancer or a private detective) then one is already in business by simply connecting to the grid. On the other hand, if it does require space (e.g. if someone decides to become a casino operator or a vacation resort owner), one may need to first buy land in order to develop a property on it or alternatively rent space from someone else. Trading also takes place on the web and many in-world entrepreneurs and companies maintain web sites that promote and sell their products and services.

The next section will discuss the implications of in-world consumer behaviour focusing on the ethical-related issues arising, in other words focusing on the computer ethics emanating from the consumer presence in Second Life (for computer ethics see for example Spinello and Tavani, 2001).

CONSUMER BEHAVIOUR & ETHICS OF THE VIRTUAL ENVIRONMENT

Before addressing the consumer-related ethics within the virtual environment, it is appropriate to illustrate the key stages of the computer ethics revolution. In the 1940s and 1950s, the seminal work by Wiener (1950) provided the concrete foundations of computer ethics research and analysis, followed by further work in the 1960s and 1970s by Parker (1968) and by Weizenbaum (1976) and Maner (1980) respectively. The above researchers were pioneers in the evolving field and were located in the US. Nevertheless, by the 1990s, that field attracted large interest from other continents, especially from Europe. In terms of providing a definition of the computer ethics phenomenon, Bynum (2001, p.16) indicates its overarching and broad dimensions by noting that: "computer ethics identifies and analyses the impacts of information technology on social and human values like health, wealth, work, opportunity, freedom, democracy, knowledge, privacy, security, self-fulfilment, etc".

Moor (1985) also argued that the information technology (IT) revolution would be a two-stage process; the first one focusing on the technical development and use of IT whilst the second stage aiming to bring together the technical and social aspects by blending the IT systems and processes with the human and social interactions concerned. We could argue that Second Life is part of the second stage considering its strong human, social and consumer element, even though all these aspects are evolving at a very fast pace.

As far as the consumer element is concerned, which is the purpose of this section, the virtual environment that games like Second Life create and in particular the avatars, behind which one could hide, may change the perceptions and behaviour of consumers. For example, in real life one may not want to be seen in a specific setting (e.g. purchasing appealing lingerie at a retail store), but would not mind going to that retail store in the form of an avatar. Avatars may provide a stronger

sense of protection as they wrap a protective privacy layer around the real user. However, as the user is immersed in the game and spends more time developing a character and relationships and links with other ones, this may result in changes in the avatar's behaviour. One may not have to 'worry' about the implications of being seen by real people in an in-world shop, but this may also apply to an avatar seen in a retail store by other avatars. Hence, we are witnessing the emergence of two types of consumer behaviour (one real and one virtual) with distinctive ethical repercussions.

Similarly, Johnson (2001) notes the three key characteristics emanating from the Internet technology in relation to ethical concerns. The first one is scope, due to its global reach and interactive nature; secondly, the anonymity as was pointed out earlier and the reproducibility of information via that technology. Accordingly, in Second Life, one can earn money by undertaking various in-world activities. However the ability to exchange real money for in-world money suggests that those privileged in the real world can become privileged in the virtual world too. Supporting a virtual lifestyle could be equally as expensive as the real one. The user's spending power can determine to a great extent their decision making when it comes to spending. Still, as many real-world needs simply do not exist or at least could be 'avoided', users may decide to prioritise their needs based on different criteria (Foxall et al., 1998). These could be more influenced by the latest in-world trends, which may be completely different from the real-world ones. More interestingly, at the consumer level, there may exist two completely different sets of rules when it comes to spending decision-making, as a virtual character may represent a persona which is completely different from the real one.

In addition, in-world consumers are as open to manipulation as happens in the real world (see for example, Crisp, 1987), although one should emphasise two important points. The first is that although the social, educational and economic barriers to entering a virtual world are virtually non-existent, virtual worlds are often populated by well-defined types of users. What differentiates these users is not their real-world attributes and characteristics, but their in-world ones, which they can use to manipulate others. This is especially true in cases where more experienced users take advantage of 'newbies', i.e. inexperienced users. On the other hand, avatars are controlled at the end of the day by real people and how quickly experience is gained and how this is applied to protect oneself or manipulate someone else depends on the individual. Therefore, one could argue that avatars are equally prone to being manipulated.

It is worth mentioning that all users have to behave and act according to the defined sets of rules that owners and developers of the game, i.e. Linden Lab for Second Life in this case, have set. These are appropriate for the theme of each world and ensure not only that there is a framework within which avatars need to operate, but also that real world users are protected too. For example privacy and harassment issues are always taken very seriously. Enforcing these is a non-trivial task. In fact, in many cases it may not be possible actually to do so. Consequently great emphasis is put on peer monitoring, with users reporting behaviours that do not meet the set standards. The organisers are then called to investigate each case and decide whether there has been a violation and what action needs to be taken. In addition to the organiser's rules, other sets of rules adopted by the communities themselves may also apply. These could be simple etiquette rules or even terms and conditions which an avatar has to comply with, if access to a product or service or location is to be granted.

Another important issue when considering consumer ethics in a virtual world is to examine which code of 'ethics' actually applies. Is it the one that applies in the real world or is it a new code of ethics that arises from the very nature of the world in which the users operate? For example, the nature of the products and services traded can cause deviations from real-world ethical standards. The above raises the question whether any real life consumer segments are applicable in the virtual environment and whether some of those lose their importance. Are we dealing with a different set of consumer segments in the virtual world and overall, which are the key real-world attributes (lifestyle, age, gender, class, occupation, income, etc) that influence and contribute to the virtual world behaviour?

Finally, other themed MMORPGs may encourage 'unethical' behaviour according to real-world behaviour in order for the user to achieve the desired aim. Within some MMORPG worlds, killing or stealing may be actions that should be taken, as otherwise there will be little point in participating. An example with commercial focus would be that of the pyramid scheme in Eve Online, which allowed a user to net 700 billion ISK (game currency), which could be converted to more than $119,000 if sold on Ebay (Spamer, 2006). This example illustrates how manipulation is possible, even when it comes to well-known real-world exploitation schemes. Considered within the games boundaries one could argue that profiting from such a scheme would not have been unethical or illegal. On the other hand, the ability to convert in-world currency to real currency does raise questions about what indirect impacts on the real world such cases may have. Virtual worlds are not isolated artificial spaces anymore, but vibrant, highly-interactive and quickly evolving places that can reach the real world in numerous direct and indirect ways.

RECOMMENDATIONS

The previous section highlighted many ethical issues and raised a range of questions. There is an urgent need for the development of appropriate frameworks (although this in itself raises the issue of who decides what is 'appropriate' or not) that will guide the commercial development of MMORPGs and other interactive virtual environments, especially when in-world currencies could be converted to real world money. There are currently no specific policies or regulatory frameworks in relation to commercial activities in virtual environments, notwithstanding the fact that the virtual environment represents a very recent phenomenon.

Taking into account the global use of virtual environments, an important question is whether the introduction of a global advisory or event regulatory body could have a universal appeal and influence, or whether different countries, organisations or communities might introduce separate legislative codes. The former requires the development, introduction and conformance to the same set of standards of conduct and, at the same time, consideration of the country-specific similarities and differences such as consumers' income inequalities, the divide between information rich and information poor citizens and the existing country legislative procedures to name but a few. In light of this, Spinello (2000) considered some options for possible internet governance and provided three top-down models: first, direct government-state intervention, secondly, coordinated international intervention and thirdly, self-internet governance. Spinello (2000) illustrates the major costs and benefits of adopting each model. For example, the first model (direct government – state intervention) could be abused by consumers who look around for more relaxed country environments and, overall, it entails a strong enforcement difficulty. The second model (coordinated international intervention) could potentially address the shortcomings of the first model due to the global nature of virtual environments as it would be possible to transcend geographical boundaries, although at the same time, it could become cumbersome due to implementation and bureaucracy problems. The third model (self-internet governance) is the favourite choice for the US government, but nevertheless it has some key problems related to accountability and management of politics between the stakeholders involved.

Still, it could be the basis of the introduction of community advisory or regulatory bodies at a game-level, so that the unique attributes and characteristics of each game and community are taken into consideration. Their members could represent all major stakeholder groups and especially the gamers. Although initially this could be perceived by game developers as giving away significant control power it would help build trust and confidence in the game's platform, ensuring its longer term prosperity. Also, the opportunity for all stakeholders to take part in the decision making process would ensure that the development of the game is directly influenced by those that matter the most: i.e. the users. Allowing stakeholders to be actively involved could make them feel more valuable, which would further build the feeling of trust among the members of the community. For example, such bodies could act as a barrier for possible manipulation of consumers' privacy and guarantee the continuous protection of consumer interests, while for the firms involved an open democratic forum could help increase the credibility and legitimacy of trading. Such community bodies could then collectively interface with real-world bodies like consumer associations or policy makers.

Another issue to consider is whether all consumers / citizens were given the chance to participate in that environment and, therefore, try to maximise possible social inclusion. In light of this, we need to examine the financial implications and especially the cost of acquiring virtual objects and property and the resultant transactions between buyers and sellers. For example, who is going to monitor such transactions and who will authenticate and validate them? What about overcharging and possible avoidance of opportunistic behaviour, which is commonplace in the UK physical property market? Will any legal documents be issued, such as the virtual property equivalent of deeds? Questions such as these are often addressed by the terms and conditions of each game, which are drawn up by the

company developing the game. In many cases this could lead to controversy. For example in Second Life the terms and conditions state that Linden Lab has the absolute right to manage, regulate, control, modify and/or eliminate the in-world currency as it sees fit at its sole discretion, without any liability to the users. This highlights the implicit risks that a growing number of entrepreneurs take when trading in such emerging markets.

To address ethical consumer and business issues such as these we would suggest three overarching levels: firstly, the micro level, where we are encountering consumer-specific issues; secondly, the meso level, where we are encountering the firms and the resultant IT systems used; thirdly, the macro level, where we are dealing with governments, regulatory bodies and other stakeholders which will be responsible for setting the agenda for the ethical use of these systems by all participants involved. To maximise the effect of these upon issues of consumer ethics, ongoing discussion between participants of these three levels is needed. We suggest the immediate introduction of standards of conduct for both the users – consumers and firms involved. The participating firms will have to consider the corporate social responsibility dimensions and it is our suggestion that a corporate ethical responsibility matrix (and indices) could be further developed and refined based on an ongoing dialogue. In addition, a stakeholder analysis could also be co-employed, especially at the macro-level of the proposed framework, which could maximise an analysis of social responsibility matters by highlighting to firms their key ethical responsibilities. According to Spinello (2000), some of the key stakeholders to be included in that analysis are the individual users and households, consumer associations, firms, non-profit organisations, software and other IT vendors, internet service providers, regulatory agencies and organisations, interest groups, national and local governments and media.

This generates a number of interesting challenges for marketers who do not necessarily know to whom they are marketing and how the decision making process actually takes place. The key emerging question is who decides on what to spend when in a virtual world? Is it the avatar or the real user behind it and which one is mainly expressed? In Second Life, where there is no defined goal for the users to achieve, other than what they feel is of interest for them, the activities that take place are more often similar to the activities undertaken in real life. As a result, one would expect that the ethics sets would be comparable in most cases. This argument could be extended to consumer ethics as well, as most of the transactions undertaken are based on real transacting models and the in-world currency is linked to real world currency. Second Life itself has a defined set of Community Standards, but these are mostly behavioural guidelines rather than an attempt to provide a consumer or business behaviour framework.

In fact, it is questionable whether the developers of a world such as that of Second Life could and would actually try to enforce regulatory frameworks, as it was demonstrated in the CopyBot case. CopyBot started as an attempt to reverse engineer Second Life, but was then used to copy other users' content. This caused the community to protest against those using CopyBot and as a result Linden Labs had to proclaim the use of such software as a violation of their terms and conditions (Linden, 2006). Still, in the short term, without the tools to protect assets and monitor any copying they could only act on users' abuse reports. Not surprisingly this has serious implications for those in-world entrepreneurs that were trying to make a profit who felt threatened and many of them participated in an anti-CopyBot boycott (Neva, 2006). Many other users felt threatened too. As Wagner James Au (2006a) pointed out: "in a world where everyone by definition can, with a few clicks, become a content-creating entrepreneur, the debate has become egalitarian, pitting creator against creator, each with their own personal view of what constitutes theft and fair use, and the degree of faith they place in having their IP rights kept sacrosanct in Second Life". A few days later it seemed that the users' worst fears had not materialised (Au, 2006b), but nevertheless this example demonstrates the potential implications and challenges of adopting and enforcing regulatory frameworks.

The above indirectly challenges a fundamental aspect of MMORPGs, that of gaming. MMORPGs such as Second Life should not be seen just as games, but as highly complex communities. Only then does the real significance of the issues discussed above become clear and potential solutions could be sought. The degree of applicability of the recommendations made will depend on the nature of virtual worlds and more specifically on their various themes. The theme will probably dictate potential approaches to regulating the environment and equally importantly the degree of regulation that is needed.

CONCLUSIONS

During the past few years, we have witnessed the evolution and development of the phenomenon of massively multiplayer online role playing games and the vast majority of indications predict that its popularity will soar. The focus of this exploratory paper was on the consumer ethics that such environments may raise and their potential implications. We have also provided recommendations that can be taken up by policy makers, firms, consumer associations and other stakeholders.

We hope that the current paper has shed some light on the consumer-related ethical issues of virtual environments and other similar 'spaces' in general, in their present state, and highlighted their broad and overarching nature. Future research could consider an interdisciplinary research approach by bringing social scientists and natural scientists together, including consumer marketing researchers, psychologists, computer engineers and lawyers to name but a few. It could also consider both qualitative and quantitative approaches which could result in models to test the strength of relationships between the variables of interest.

REFERENCES

Arthur, C. (2006). *What is the 1% rule?* Retrieved 17 August 2006, from http://technology.guardian.co.uk/weekly/story/0,,1823959,00.html

Au, J. W. (2006a). Copying a controversy. Retrieved 30th November, 2006, from http://nwn.blogs.com/nwn/2006/11/second_life_clo.html

Au, J. W. (2006b). Who's afraid of the copybot? from http://nwn.blogs.com/nwn/2006/11/whos_afraid_of_.html

Bynum, T.W. (2001) "*Ethics and the information revolution*" in Spinello, R.A. and Tavani, H.T. (eds.) Readings in Cyberethics, Jones and Bartlett, pp. 9-25.

Crisp, R. (1987) Persuasive advertising, autonomy, and the creation of desire. *Journal of Business Ethics, 6:* 413-418.

Foxall, G. R., Goldsmith, R. E., and Brown, S., (1998) *Consumer Psychology for Marketing,* International Thompson Business Press, London.

Johnson, D.G. (2001) "*Ethics on-line*" in Spinello, R.A. and Tavani, H.T. (eds.) Readings in Cyberethics, Jones and Bartlett, pp. 26-35.

Keegan, V. (2006). *Slices of life in a parallel universe*. Retrieved 2006, 20th September, from http://technology.guardian.co.uk/opinion/story/0,1824034,00.html

Linden, C. (2006). Use of copybot and similar tools a tos violation. Retrieved 30th November, 2006, from http:http://blog.secondlife.com/2006/11/14/use-of-copybot-and-similar-tools-a-tos-violation/

Maner, W. (1980) *Starter Kit in Computer Ethics*, Helvetia Press.

Moor, J.H. (1985) "*What is computer ethics?*" in Bynum, T.W. and Ward, T. (eds.) Computer and Ethics. Blackwell, pp. 266-75.

Neva, P. (2006). Hundreds of SL stores shutter doors! Retrieved 30th November, 2006, from http://www.secondlifeherald.com/slh/2006/11/hundreds_of_sl_.html

Parker, D. (1968) "Ethics for information systems personnel" *Journal of Information Systems Management,* pp.44-48.

Rosedale, P., & Ondrejka, C. (2006). *Glimpse Inside a Metaverse: The Virtual World of Second Life*, from http://video.google.com/videoplay?docid=-5182759758975402950&q=%22second+life%22&pr=goog-sl

Spamer, M. (2006). *EVE Online Rocked by 700 Billon ISK Scam*. Retrieved 1st October, 2006, from http://games.slashdot.org/article.pl?sid=06/08/23/1918246

Spinello, R.A. (2000) *Cyberethics: Morality and Law in Cyberspace*, Jones and Bartlett Publishers.

Spinello, R.A. and Tavani, H.T. (eds.) (2001) *Readings in Cyberethics*, Jones and Bartlett Publishers.

Weizenbaum, J. (1976) *Computer Power and Human Reason: From Judgment to Calculation*, Freeman.

Wiener, N. (1950) *The Human Use of Human Beings: Cybernetics and Society*, Houghton Mifflin.

Working Party on the Information Economy. (2005). *Digital Broadband Content: The online computer and video game industry*: Organisation for Economic Co-operation and Development.

Efficient P2P Knowledge Sharing: Performances and Incentives

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ABSTRACT

In this paper, we address the performance issue of Peer-to-Peer (P2P) knowledge sharing community based on two indices: the knowledge variety and the knowledge transfer. For each performance index, we examine Nash equilibrium and social equilibrium of knowledge contribution. While under-provision of knowledge contribution is a common phenomenon, the equilibrium results drawn from each criterion are significantly dissimilar. Results reveal the condition for the social optimality to sustain. Thus, in order to enhance the performance of knowledge sharing, incentive mechanisms are presented to realize an efficient knowledge sharing community.

Keywords: knowledge sharing, performance index, incentive mechanism, ash equilibrium, Social optimum.

1. INTRODUCTION

The concept of the knowledge sharing is becoming an emerging topic. Global operating firms especially capitalize this concept and take advantage of differences in labor costs, human capitals, and suitable production sites. For example, Toyota has opened up several subgroups of manufacturing sites in China and Southeast Asia to gain the labor advantage. Another example is that Microsoft has established numerous local headquarters in different countries to recruit the local human capitals and to convert their expertise into localized software product. Evidence has shown that organizations that are capable of transferring knowledge more effectively are more likely to sustain in the industry than those that have less capability of doing that (Argote, Beckman, and Epple, 1990).

Others view knowledge sharing or transfer should be incentive-aligned. Since the interest between the employees and employers does not always consistently work on the same direction, literatures has shown that incentive, the essence of motivation, plays a role in inducing employees to operate in the firm's interest. (Prendergast, 1999) The subtle question left to ponder will be how to carefully design a compensation contract, including options, discretionary bonuses, profit sharing, and efficient wages, and if the incentive needs to be immaterial only, material only, or rather a blended of both. (Semar, 2004) While material incentive are mostly in the form of direct monetary allowance, immaterial incentive is associated with working environment, contract extension, corporate resource assignment, etc.

Other than the incentive issue, knowledge sharing or knowledge transfer is the process, through which one group is affected by the experience of another (Argote, 1999). Intra-units are learning and benefiting from each other in order to speed up the production process or lower down the unnecessary labor costs. Transferring knowledge, whether at the individual, group, department, or division level is a usually laborious and time-consuming, and difficult task. Obviously, such transference needs a channel. Tsai (2001) claims the fact that prior to achieving access to a new knowledge, it needs to require a networking effect. With a great design of unit network, such channel will be a way to stimulate and support innovative activities. Moreover, in Swart and Kinni's work (2003), they suggest that for the success of the organization, knowledge be integrated between different units and be shared throughout. The rational is that the critical knowledge and skills may become localized within the project team as time passes (Wegner, 2000; Yanow, 1999).

The above studies have addressed the importance of knowledge sharing and incentive. Building the suitable environment and setting up the incentive will function to promote knowledge sharing or motivate staffs. In this paper, we focus on establishment of the knowledge sharing indices on a Peer-to-Peer (P2P) environment: knowledge variety and knowledge transfer. The proposed performance metrics are critically important and easily justified. Participants will benefit from the knowledge variety provided in the community. On the other hand, participants also benefit from more replicas of the same knowledge in a decentralized sharing environment because it is more likely a participant can get the knowledge from a closed participant. Consequently, the performance cost of knowledge can be improved. Through these indices, we may understand how parameters, two that will be proposed and each of which has its own appropriate quality, affect the sharing performance. We further introduce the concept of Nash equilibrium. Nash (1950) showed that in any finite game (i.e., a game in which the number of players n and the strategy sets $S_1, S_2, S_3, ..., S_n$ are all finite) there exists at least one Nash equilibrium. Note that Nash equilibrium is often generalized as a non-cooperative outcome. We make use of this concept, combine with another concept—the social optimum, generalized as a cooperative outcome, simply representing the summation of all individuals' payoffs, and incorporate the issue of incentive into the framework, which helps maintain the social optimum. Incentive, furthermore, can be analyzed in the context of public good provision. There are a few discussions regarding public goods, including Samuelson (1954), Olson (1965), Smith (1980), Cornes and Sandler (1984, 1985), and Andreoni (1985). Of these researchers, Samuelson and Olson are the classics references on the public good theory and the related topics in group size. Smith conducted his experiment to determine if the public good are subject to "free ride" in a voluntarily sharing environment. Cornes and Sandler, and Andreoni claimed that a consumer's utility depends not only on the aggregate amount of contribution, but also on his own contribution.

The idea that emerges in our study is the assignment of incentive. We attempt to establish the condition for the incentive that will mitigate "free ride" phenomenon and further make the social optimum sustainable. Our results show that knowledge contributions are quite different based on the knowledge variety and knowledge transfer performance criteria.

The remainder of this paper is organized as follows. In section 2, we discuss the knowledge indices. In section 3, we analyze the performance and incentive mechanism based on knowledge availability. In section 4, we re-examine the performance and incentive mechanism based on knowledge transfer. We provide a discussion in Section 4 and present the conclusion in Section 5.

2. PERFORMANCE INDEX OF KNOWLEDGE SHARING

When we evaluate a salesperson working performance, we often check on the number of orders he can get for the company. If the number of orders is massive, he may be evaluated as a great salesperson with an outstanding performance. Similarly, the knowledge sharing performance can be evaluated based on the knowledge varieties and the needed time for participants in the knowledge sharing community to retrieve certain knowledge. An efficient community may enlarge the knowledge pool and shorten the time for information retrieval. Suppose a knowledge worker has a need to retrieve a knowledge that is related to his work. If she acquires the relevant information in a short period of time and is satisfied with it, we say the knowledge sharing community has a distinguished performance in directing her to the correct knowledge. The knowledge sharing community has a bad performance, otherwise. Thus, we propose two simple but

important factors that will affect the efficiency of knowledge sharing. They are the knowledge availability and the knowledge transfer. One the one hand, knowledge availability index reflects the possibility degree an (ad-hoc) requested knowledge can be found through the community, alternatively, we can interpret the index as the maximum number of knowledge varieties participants can retrieve from the community. On the other hand, knowledge transfer index represents the expected effort (e.g. delay time) for completing a knowledge transfer of certain type of knowledge request. The transfer effort can be indirectly measured according to the expected replicas of a homogeneous knowledge provided in the community since the performance can be improved by selecting a better partner to conduct the knowledge transfer activity. We conduct the analysis under self-enforced and efficient knowledge sharing configurations according to these two performance considerations and suggest the incentive mechanisms for aligning the objective of individual participant and the organization.

3. KNOWLEDGE AVAILABILITY (VARIETY)

Before we make knowledge communicated in the community, it is important to understand that the formation of knowledge involves difficulties and the nature of knowledge is structural. There are various attempts to describe "knowledge" as the term "structure." Rauch-Hindin (1988) firstly noted the presence of structure in knowledge. Then Gaines, Rappaport, and Shaw (1992) further defined four types of knowledge structure: informal, structured, formal, and computational knowledge. When the information becomes knowledge and pooled into the community, we are concerned with the sharing performance. In this section, we propose that the knowledge variety is the factor that will affect the performance for knowledge sharing in the community. We will make the following assumptions. At first, we assume that the participant will receive the value of v_i from process of the successful sharing of certain knowledge. She will, of course, incur the cost of c_i if she shares certain knowledge. Secondly, more knowledge variety is better for the knowledge sharing environment. More varieties mean that the difficulty level for requesting a random type of knowledge will be reduced and it becomes easier for any participant to gain that random type of knowledge in the community. Then, let M_0 denote the number of elements in the knowledge domain and i be the participant who provides a random type of knowledge. If each knowledge variety has the same popularity, then we assume x_i is the probability that participant i shares an arbitrary file. We further assume $0 \le c_i / v_i \le 1$, which is the cos-benefit ratio of knowledge sharing. Since no one is willing to pay more than what she receives, thus, the ratio of c_i / v_i, which does not exceed one, makes intuitively sense. In the context of reliability, we denote $H = 1 - \prod_{i=1}^{n}(1 - x_i)$ as a probability that the knowledge sharing process is successful in the community. Multiplied by the maximum number of knowledge elements M_0, this gives the expected number of knowledge varieties, M, the following expression

$$M(x_1, x_2, \cdots, x_n) = HM_0 = \left(1 - \prod_{i=1}^{n}(1 - x_i)\right)M_0 .$$

Furthermore, the expected payoff to agent i is taken to be

$$U_i = v_i M - c_i x_i M_0 = v_i \left(1 - \prod_{i=1}^{n}(1 - x_i)\right)M_0 - c_i x_i M_0 \qquad (1)$$

3.1. Nash Equilibrium (Self-Enforced Community)

In this section, we examine the outcome where single participant chooses effort unilaterally.

Equation (1) can be rewritten as

$$U_i = v_i \left(1 - \prod_{i=1}^{n}(1 - x_i)\right)M_0 + \left(v_i \prod_{j \ne i}^{n}(1 - x_j^*) - c_i\right)x_i M_0 .$$

The above equation represents a non-cooperative utility function. The individual objective is to maximize this utility function subject to the following best response knowledge sharing function given to the participant i, which is

$$x_i^* \begin{cases} = 1 & if \ \prod_{j \ne i}^{n}(1 - x_j^*) > c_i / v_i \\ \in [0,1] & if \ \prod_{j \ne i}^{n}(1 - x_j^*) = c_i / v_i \\ = 0 & if \ \prod_{j \ne i}^{n}(1 - x_j^*) < c_i / v_i \end{cases}$$

See Fig 1 below for how participant i respond according to other participants' move.

Whether the participant i's best response is to share or not share depends solely on where $\prod_{j \ne i}^{n}(1 - x_j^*)$ lies. Given $\prod_{j \ne i}^{n}(1 - x_j^*)$ lies above $\frac{c_i}{v_i}$, the participant i must share in order to make the sharing community successful. In contrast, given $\prod_{j \ne i}^{n}(1 - x_j^*)$ lies below $\frac{c_i}{v_i}$, the participant i may choose not to share. The necessary condition for a knowledge sharing community to emerge is $0 < H < 1$. If the participant i contributes, we have $0 < x_i < 1$; that is, the equilibrium knowledge sharing level of each participant can be drawn by solving the following equations simultaneously.

$$\prod_{j \ne i}^{n}(1 - x_j) = c_i / v_i, \ \forall i \in \{1, \cdots, n\}$$

After some mathematic simplifications, we obtain the knowledge availability equilibrium

$$H^{N^*} = 1 - \left(\prod_{i=1}^{n} \frac{c_i}{v_i}\right)^{1/(n-1)} \qquad (2)$$

and the knowledge sharing level of participant is

$$x_i^{N^*} = 1 - \frac{v_i}{c_i}\left(\prod_{i=1}^{n} \frac{c_i}{v_i}\right)^{1/(n-1)} \qquad (3)$$

Under Nash equilibrium, Equation (2) is the optimum probability that the knowledge sharing community will work. In other words, it indicates the optimum probability that a participant gives a random type of knowledge, needed by the members in the knowledge sharing community. Equation (3) is the optimum probability that an arbitrary given file is shared by a participant. In practice, this probability needs to exhibit an upward trend as the number of participants who possess a random type of knowledge increases. The number of knowledge varieties in equilibrium is $M^{N^*} = \left(1 - \left(\prod_{i=1}^{n} \frac{c_i}{v_i}\right)^{1/(n-1)}\right)M_0$. We will compare this probability with the probability under the social optimum level.

3.2. Social Optimum (Efficient Community)

We perform similar calculations in this section so as to derive the socially optimal content availability H^{W^*} in the community and individual knowledge sharing level $x_i^{W^*}$. The difference between the social optimum and Nash equilibrium is that while Nash equilibrium focuses on the unilateral optimization, the social optimum dwells its focus on the coordinated effort. Precisely, Equation (1) needs to be adjusted so as to maximize social benefits subtracted by social costs.

$$U_w = \sum_{i=1}^{n} U_i = \Sigma_{i=1}^{n} v_i \left(1 - \Pi_{i=1}^{n}(1 - x_i)\right)M_0 - \Sigma_{i=1}^{n} c_i x_i M_0 \qquad (4)$$

Similarly, the socially optimal individual knowledge sharing level is given by solving the following equations simultaneously.

$$\Pi_{j \ne i}^{n}(1 - x_j^*) = \frac{c_i}{\Sigma_{i=1}^{n} v_i}, \ \forall i \in \{1, \cdots, n\} \qquad (5)$$

Finally, the optimality functions for both H^{W^*} and $x_i^{W^*}$ are as follows:

$$H^{W^*} = 1 - \left(\prod_{i=1}^{n} \frac{c_i}{\Sigma_{i=1}^{n} v_i} \right)^{1/(n-1)} \quad (6)$$

$$x_i^{W^*} = 1 - \frac{\Sigma_{i=1}^{n} v_i}{c_i} \left(\prod_{i=1}^{n} \frac{c_i}{\Sigma_{i=1}^{n} v_i} \right)^{1/(n-1)} \quad (7)$$

Socially optimal number of knowledge varieties is

$$M^{W^*} = \left(1 - \left(\prod_{i=1}^{n} \frac{c_i}{\Sigma_{i=1}^{n} v_i} \right)^{1/(n-1)} \right) M_0 .$$

Investigating these two functions, we realize that $x_i^{W^*} \geq x_i^{N^*}$ and $M^{W^*} \geq M^{N^*}$. We turn to the related interpretation of public good. In a centralized environment developed in our model, $x_i^{W^*} \geq x_i^{N^*}$ reflects the fact that pure public goods would be undersupplied by voluntary contributions and that there exists an incentive for a participant to free ride since no one can be excluded from the benefits of public good. By definition, free-ride means that contributing less than his marginal valuation to the cost of the public good.

In an extreme case, when $x_i^{N^*} \cong 0$, non-provision of public goods becomes a consequence of the strong free riders phenomena.(Brubaker, 1975) However, any level below $x_i^{N^*}$ suggests the sub-optimal quantities of public goods.

3.3. Socially Optimal Compensation

Inconsistent interest between personal level and social level contributes to the difference in effort level. Under Nash condition, the participant *i* cares about personal interest only and maximizes it, whereas in the social optimum situation, the sharing effort is underprovided. However, a proper amount of compensation makes the participant *i* not play Nash and still exert the sharing effort even in the social situation.

For simplicity, the sharing community is divided into two categories: one group consisting of only one participant, *i*, the other group consisting of all other participants. (e.g. $\sum_{j \neq i}^{n} paticiapnt\ j$) The proposed incentive framework is a treatment for the participant *i* only and does not have any power to predict the amount of incentive requested by any other participants in the other category. Two assumptions are subtle. At first, the incentive will make participant who receives it share. Secondly, it is a possibility that other participants who do not receive any compensation may free ride. The following is the proposed framework.

Proposition 1: *The social level of effort can be induced and be optimally sustainable when the incentive compensation, r_i, equals $\frac{c_i \Sigma_{j \neq i}^{n} v_j}{\Sigma_{j=1}^{n} v_j}$ for the participant i.*

Proof. At first, let U', denoted as the compensation function, entails an incentive term, $r_i x_i M_0$. This function and Equation (1) are very much the same with exception of $r_i x_i M_0$. Our objective is to derive the value of this incentive.

$$U' = v_i \cdot \left(1 - \prod_{i=1}^{n} (1 - x_i)\right) M_0 - c_i x_i M_0 + r_i x_i M_0 \quad (8)$$

The best response knowledge sharing function of participant *i* is given by the following expression:

$$\left(v_i \prod_{j \neq i}^{n} \left(1 - x_j^*\right) - c_i \right) + r_i = 0 \quad (9)$$

Equation (5) can be rewritten as

$$\left(v_i \prod_{j \neq i}^{n} \left(1 - x_j^*\right) - c_i \right) + \Sigma_{j \neq i}^{n} v_j \prod_{j \neq i}^{n} \left(1 - x_j^*\right) = 0 \quad (10)$$

Investigating Equation (9) and Equation (10), we understand that

$$r_i = \Sigma_{j \neq i}^{n} v_j \prod_{j \neq i}^{n} \left(1 - x_j^*\right).$$

Substituting $\prod_{j \neq i}^{n} \left(1 - x_j^*\right) = \frac{c_i}{\Sigma_{i=1}^{n} v_i}$ into r_i, r_i becomes the following expression:

$$r_i^{W^*} = \Sigma_{i=1}^{n} v_i \prod_{j \neq i}^{n} \left(1 - x_j^{W^*}\right) = \frac{c_i \Sigma_{j \neq i}^{n} v_j}{\Sigma_{i=1}^{n} v_i} \quad \square \quad (11)$$

Equation (11) indicates a unique value of the incentive, which is a minimally required compensation for the participant *i* in the knowledge sharing community. Moreover, Equation (11) suggests a redistribution of wealth. Varian (1986) studies this topic and stated that any change in the wealth distribution that increases the aggregate wealth of current contributors will necessarily increase the equilibrium supply of the public good. This viewpoint corresponds to our result. The amount of incentive implies an increase in supply of public good. If this amount of incentive is in its optimal condition, then it is immediate that the supply of public good is also in its optimality.

4. KNOWLEDGE TRANSFER (REPLICA)

In previous section, we have examined the knowledge sharing community configurations based on knowledge variety. We further introduce another performance index, the knowledge transfer. The performance of knowledge transfer is closely associated with the number of replicas of a given knowledge in the community. Different from the knowledge variety, the knowledge replica is defined as coexistence of homogeneous knowledge. In the knowledge sharing community, we need some identical knowledge to exist because this helps participants more easily gain certain type of knowledge from a "closer" community member. Since x_i is the probability that the participant *i* shares certain knowledge, we denote the expected number of replicas of a type of knowledge in the community as $R(x_1, x_2, \cdots, x_n) = \sum_{i=1}^{n} x_i$. We further assume that the transfer effort (e.g. delay) between any two participants is a random variable with value drawn from a transmission delay density function. Participants always retrieve knowledge from a community member with a minimum transfer effort. Denote the expected minimum transfer effort among *k* community members by $T(k)$. Using order statistics, we have:

$$T(k) = \int_0^{\infty} t \cdot k \cdot (1 - F(t))^{k-1} \cdot f(t) \cdot dt ,$$

where *f*(*t*) and *F*(*t*) are the PDF and CDF for the transfer effort. In this paper, we analyze the community configuration based on uniform distribution $U[0, T_0]$, where T_0 is the upper bound of transfer effort. Thus, given individual knowledge sharing level $(x_1, x_2, \cdots, x_n)$, the expected transfer effort is:

$T(R) = \left(\sum_{i=1}^{n} x_i + 1\right)^{-1} T_0$.

Lastly, we denote the value of a transfers knowledge as v_i , and assume the cost of transfer effort (e.g. delay cost) and sharing cost for a knowledge are β_i and c_i respectively. The utility function is defined as follows:

$$U_i = v_i - \beta_i T(R) - c_i x_i = v_i - \beta_i \left(\sum_{i=1}^{n} x_i + 1\right)^{-1} T_0 - c_i x_i \quad (12)$$

4.1. Nash Equilibrium (Self-Enforced Community)

Following similar approach, individual's self-selected knowledge sharing level can be obtained by solving the first-order conditions simultaneously:

$$\frac{\partial U_i}{\partial x_i} = \beta_i T_0 \left(x_i + \sum_{j \neq i}^{n} x_{j \neq i}^{\ *} + 1 \right)^{-2} - c_i \leq 0, \forall i$$

The best response knowledge sharing function for participant *i* is

$$x_i^{N^*} = \max \left\{ \sqrt{\frac{\beta_i T_0}{c_i}} - \left(\sum_{j \neq i}^{n} x_{j \neq i}^{\ *} + 1 \right), 0 \right\} \quad (13)$$

Thus, the expected number of knowledge replicas of a type of knowledge is

$$R^{N^*}(x_1, x_2, \cdots, x_n) = \sum_{i=1}^{n} x_i^{N^*} = \max_i \{\sqrt{\frac{\beta_i T_0}{c_i}} - 1\} \quad (14)$$

We can easily find that the self-selected knowledge sharing level is

$$x_i^{N^*} = \begin{cases} \sqrt{\frac{\beta_i T_0}{c_i}} - 1 & \text{if } i = \arg\max_j \{\beta_j / c_j\} \\ 0 & \text{otherwise} \end{cases}$$

For a self-formed knowledge sharing community, only the participant with the maximum ratio of transfer effort cost (e.g. time value) to sharing cost contributes knowledge.

4.2. Social Optimum (Efficient Community)

We are concerned with the social optimum so we sum up the utility from all participants and get the following expression:

$$W = \sum_{i=1}^{n} U_i = \sum_{i=1}^{n} \left(v_i - \beta_i \left(\sum_{i=1}^{n} x_i + 1 \right)^{-1} T_0 - c_i \cdot x_i \right) \quad (15)$$

With first-order condition:

$$\frac{\partial W}{\partial x_i} = \Sigma_{i=1}^{n} \beta_i T_0 \left(\sum_{i=1}^{n} x_i + 1 \right)^{-2} \le c_i, \forall i \quad (16)$$

Socially optimal expected number of replicas of a type of knowledge is:

$$R^{W^*}(x_1, x_2, \cdots, x_n) = \sum_{i=1}^{n} x_i^{W^*} = \max_i \{\sqrt{\frac{\Sigma_{i=1}^{n} \beta_i T_0}{c_i}} - 1\} \quad (17)$$

Finally, the socially optimal individual knowledge sharing level is derived:

$$x_i^{W^*} = \begin{cases} \sqrt{\frac{\Sigma_{i=1}^{n} \beta_i T_0}{c_i}} - 1 & \text{if } i = \arg\min_j \{c_j\} \\ 0 & \text{otherwise} \end{cases}$$

For an efficient knowledge sharing community, only the participant with the minimum sharing cost is required to contribute knowledge.

Investigating Equations (14) and (17), we realize that $R^{W^*} \ge R^{N^*}$. This finding suggests that more knowledge replicas increase the knowledge density in the sharing community and shorten the transferring distance among participants. For such shortened distance, the transfer of the knowledge may become easier.

4.3. Socially Optimal Compensation

In this section, we return to consider the optimal incentive to induce the sharing effort in social level for the participant *i*. See the following framework.

Proposition 2: *The social level of effort for the participant i who have the minimum sharing cost can be induced and be optimally sustainable when the incentive compensation,* r_i, *equals* $\Sigma_{j \ne i}^{n} \beta_j T_0 \left(\sqrt{\frac{\Sigma_{i=1}^{n} \beta_i T_0}{\min_i \{c_i\}}} \right)^{-2}$.

Proof. Similar to the proof in **Proposition 1**, we, at first, impose an incentive term r_i on Equation (12). Thus, it becomes

$$U_i' = v_i - \beta_i \left(\sum_{i=1}^{n} x_i + 1 \right)^{-1} T_0 - c_i x_i + r_i x_i \quad (18)$$

The first-order condition for Equation (18) is

$$\frac{\partial U_i'}{\partial x_i} = \beta_i T_0 \left(x_i + \sum_{j \ne i}^{n} x_j^* + 1 \right)^{-2} - c_i + r_i = 0 \quad (19)$$

Secondly, we rewrite Equation (16)

$$\left(\beta_i T_0 \left(\sum_{i=1}^{n} x_i^* + 1 \right)^{-2} - c_i \right) + \Sigma_{j \ne i}^{n} \beta_j T_0 \left(\sum_{i=1}^{n} x_i^* + 1 \right)^{-2} = 0 \quad (20)$$

Investigating Equation (19) and Equation (20), we understand that

$$r_i^{W^*} = \Sigma_{j \ne i}^{n} \beta_j T_0 \left(\sum_{i=1}^{n} x_i^* + 1 \right)^{-2} = \Sigma_{j \ne i}^{n} \beta_j T_0 \left(\sqrt{\frac{\Sigma_{i=1}^{n} \beta_i T_0}{\min_i \{c_i\}}} \right)^{-2} \quad \square,$$

which is exactly the incentive condition under which the participant *i* needs to be compensated to exert the social optimal level of effort. For our purposes, the incentive mechanisms in this section and in Section 3.3 affect the participant *i*only and do not apply to any other knowledge contributors. This mechanism also reveals a compensating relationship between the participant *i* and the operator in the sharing community. We see that the community in general could benefit by the participant *i*'s contribution. The participant *i* receives the compensation $r_i^{W^*}$ in exchange.

4. DISCUSSION

There is more to the issue of incentive than just the Nash and social optimum configurations. Consider the following prisoner's dilemma. In Prisoner's dilemma, each player has two strategies: confess (or fink) and not confess (or be mum). Playing Fink is the dominated strategy for both players, then (Fink, Fink) is the unique solution to this game, a so-called Nash equilibrium. Let's classify it as a non-cooperative outcome and compare it with another outcome (Mum, Mum), classified as a cooperative outcome. Even though the cooperative outcome allows both parties to gain the most benefits, it is relatively unstable because either player has an incentive to deviate against each other to gain the free charge. Thus, the non-cooperative outcome of (Fink, Fink) will be an equilibrium, at which no one has an incentive to deviate.

Our model is really an extension and application of the prisoner's dilemma. Owing to the insight derived from the prisoner's dilemma, there is no cooperation in its one-period design. Cooperation cannot be maintained in the one-period game because there are no future periods to impose punishment on the behavior which deviates from a cooperative solution. (Pecorino, 1999) Thus, to quantitatively determine the amount of incentive in our model is indeed an initiative. This amount of incentive will guarantee that for a particular participant in the knowledge sharing community, he will achieve the cooperative outcome and maintain the cooperation as equilibrium.

Nevertheless, our model is still a one-period game and cannot be generalized to predict the equilibrium in the context of infinitely repeated game. Other than the assignment of incentive, what conditions will make the game that is played infinite times sustainable? Or, stated differently, what conditions will affect participants' sharing decision? What is the setting of this super game? And, how will all other participants, not just a particular participant, be facilitated to achieve the cooperative outcome? Those questions remain the core focus in the next research stage and will help to devise a cooperative mechanism.

5. CONCLUSION

This paper allows us to draw the conclusion in two ways. At first, we obtained the relationship between the knowledge sharing performance and factors that might affect the performance. Interestingly, as the numbers of varieties and replicas go

upward, there is a positive effect in the knowledge sharing. Thus, in order for knowledge sharing to be successful, the amount of knowledge has to be both extensive and intensive. Secondly, we proved that a proper incentive assignment may enhance the knowledge sharing. This may be seen as a social optimum condition if it needs to be achieved.

We must emphasize that it remains possible, of course, that there are other undefined factors other than knowledge variety and knowledge replica that may affect the sharing behavior. Thus, the methodological design in this paper limits the interpretations. Future research is needed on the implications for knowledge sharing in organizations. For example, suppose new member who want to search for some specific knowledge, how may the searching time vary under variety-intensive condition? In addition, categorization of knowledge according to its properties may become another factor to affect the knowledge sharing performance. The rationale is that item that is always properly stored means that it will be found easily.

REFERENCES

Argote, L., Beckman, S.L., & Epple, D., "The persistence and transfer of learning in industrial settings," Management Science, 36, 140–154 (1990)

Argote, L. "Organizational learning: Creating, retaining, and transferring knowledge," Boston: Kluwer Academic, (1999)

Argote, L., & Ingram, P., "Knowledge transfer: A basis for competitive advantage in firms," Organizational Behavior and Human Decision Processes, 82, No.1, 150-169, (2000)

Andreoni, J., "Privately provided public goods in a large economy: The limits of altruism," Journal of Public Economics, 35(1), 57-73, (1988)

Brubaker, E., "Free ride, free revelation, or golden rule?," Journal of Law Economics, 18, 147-161, (1975)

Bergstrom, T., Blume, L., Varian, H., "On the private provision of public goods," Journal of Public Economics, 29, 25-49, (1986)

Chow, P.K., Yeung, D.S., "A Multidimensional knowledge structure," Experts Systems with Applications, 9, No. 2, 177–187 (1995)

Cornes, R., and Sandler, T., "Easy riders, joint production, and public goods," Economic Journal, 94, (1985)

Gaines, B.R., Rappaport, A.T., & Shaw, M.L.G., "Combining paradigms in knowledge engineering," Data & Knowledge Engineering, 9, 1-18

Kwan, M.M., & Cheung, P.K., "The knowledge transfer process: From the field studies to technology development," Journal of Database Management, 17(1), 16 – 32 (2006).

Nash, J., "Equilibrium points in n-person games," Proceedings of the National Academy of Science, 36:48-49 (1950)

Prendergast, C., "The provision of incentive in firms," Journal of Economic Literature, Vol. XXXVII, 7-63, (1999).

Pecorino, P., "The effect of group size on public good provision in a repeated game setting," Journal of Public Economics, 72, 121-134 (1999)

Rauch-Hindin, W. B., "A guide to commercial artificial intelligence: Fundamentals and real-world applications," Eagle0wood Cliffs, NJ: Prentice-Hall, (1988)

Semar, W., "Incentive systems in knowledge management to support cooperative distributed forms of creating and acquiring knowledge," Proceeding of the International Conference on Information and Knowledge Engineering, Las Vegas: CSREA Press, 406-411 (2004)

Smith, Vernon L., "Experiments with a decentralized mechanism for public good decisions," The American Economic Review, Vol. 70, No. 4, 584-599, (1980)

Swart, J. and Kinnie, N., "Sharing knowledge in knowledge-intensive firms," Human Resource Management Journal, 13, 2, 60-76 (2003)

Tsai, W., "Knowledge transfer in intraorganizational networks: Effects of network position and absorptive capacity on business unit innovation and performance," Academy of Management Journal, Vol. 44, No. 5, 996–1004 (2001)

Varian, H.R., "System reliability and free riding," (2004)

Wenger, E., "Communities of practice and social learning systems," Organization, 7:2, 225-246, (2000).

Yanow, D., "The languages of "organizational learning": a palimpsest of terms," Proceedings from the Third International Conference on Organizational Learning, June, 1075-1086, (1999)

Student Journalists Acceptance on Collaborative Writing Wikis

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ABSTRACT

The objectives of the study are to identify relevant key intention determinants to Wikis use and to better understand the knowledge creation processes through an investigation of the individual planning and writing patterns. Surprisingly, perceived usefulness (technology utility) was found not significant to intention to use; while image became the strongest determinant to behavioral intention to use. Individual factors such as computer self-efficacy, personal innovativeness with technology were both significant determinants. Open-end survey items collected significant details from individual student journalists about their knowledge creation processes. Implications to Wikis implementation and limitations of the study are discussed.

1. INTRODUCTION

A Wiki is a website that can be edited by anyone. The very successful case Wikipedia, the free encyclopedia, has 13,000 active contributors, working on over 3,800,000 articles in more than 100 languages (Wikipedia, 2006). With the Wikis technology, companies push for corporate collaboration (e.g., Fontana, 2006) and enterprise operation (e.g., Gibbs 2006); while education institutions employ to enhance teaching and learning processes (e.g., Naish, 2006; Raman et al. 2005).

However, Wikis system will not work if no one uses it. This is especially true as Wikis typically is a collaborative tool that requires users to create and enrich the content. "Researching the background of Wikis use indicates that like all new ways to improve on existing services introducing Wikis requires a carefully managed rollout and some real effort," (Gibbs, 2006). It is therefore important to study the Wikis phenomenon to better understand the process in order to provide better guidance to implementation strategies.

Therefore, the objectives of the study are to: (1) to identify relevant key motivators to Wikis system use; and (2) to better understand the knowledge creation processes through posting using Wikis.

The paper is organized as follows. The next section matches motivational variables from prior literature and an analysis of the Wikis phenomenon. Hypotheses are developed to explain effects of the variables toward the intention to use of Wikis systems. Then, research methodology is explained with details in subjects, data collection and data analysis methods. Results of data analysis and model testing are reported. This is followed by a post hoc analysis of the process of use patterns. Implications, limitations and conclusions are discussed at the end.

2. LITERATURE REVIEW

Wiki is described as one of the most promising and rapidly emerging innovations in knowledge management (Gordon 2006). Basically, a Wikis "is a type of website that allows users to add, remove, or otherwise edit and change all content very quickly and easily, sometimes without the need for registration," (Wikipedia, 2006). Wikis is an information resource centralized online database nature and a powerful collaboration tool because of its open editing characteristics (Naish, 2006). While good e-learning is about informing, collaborating and meeting online, Wikis do all these things well (Naish, 2006).

User technology acceptance has been studied considerably in prior IS research (e.g., Legris, Ingham & Collerette 2003; Venkatesh, Morris, Davis & Davis 2003). A survey of prior studies identifies several perspectives on key intention determinants to technology acceptance, including technology utility perspective, social perspective and individual perspective.

Technology Utility Perspective: Perceived usefulness, which refers to the degree to which a person believes that using a particular system would enhance his or her job performance (Davis 1989, p.320), was found to be a key determinants to acceptance, across a variety of technologies, including standard office tools (e.g., Hu, Clark & Ma, 2003); email (e.g., Kettinger & Grover 1997); computer-based training system and rapid application development software (e.g., Bhattacherjee & Premkumar 2004), and mobile multimedia services (e.g., Pagani 2004).

Social Perspective: Wikis provide a transparent platform for users' interaction and information exchange that increase the socialization process, enabling collaboration to generate fast final output (Gordon 2006, ibid). Prior studies found that social determinants, including social influence, social presence and image, affected behavioral intention to technologies. Social influence, defined as the degree to which an individual perceives that important others believe he or she should use a system (Venkatesh et al. 2003, ibid), is a direct determinant of behavioral intention to technology (e.g., Venkatesh et al., ibid), however, it is also found that significant direct effect only appeared in mandatory organizational settings (e.g., Venkatesh & Davis, 2000). Social presence is the degree to which people establish warm and personal connections with each other in a communication setting (Short, William & Christis 1976). On the one hand, social presence / perceived information richness is based on a medium's ability to provide feedback, offer numerous cues, be personalized, and rapidly synthesize complex information (Daft & Lengel, 1986) and empirical studies found that higher perception of system's social presence and feedback results in greater use of the system (Kettinger & Grover, 1997, ibid). However, from the collaborative perspective, reduction in social presence cause users to be more ready to give up their positions in favor of the collective position in the communication setting, hence, cause users to be more uninhibited during discussion (Jessup, Connolly & Galegher, 1990) and cause users to generate more novel arguments and engage in more one-upmanship behavior (Sia, Tan & Wei, 2002). Image is defined as the degree to which use of a system is perceived to enhance one's image or status in one's social system (Moore & Benbasat, 1991) and this the perceived image / status enhancement variable is found to be a significant determinant to attitude towards a system (e.g., Karahanna, Straub & Chervany, 1999); and a significant determinant to perceived usefulness towards a system (e.g., Venkatesh & Davis, 2000, ibid). Identification refers to one's conception of self in terms of the defining features of a self-inclusive category (of the system, in particular, the Wikis online community) that renders the self stereotypically "interchangeable" with other group members, and stereotypically distinct from outsiders (Hogg, 1992). Identification resembles aspects of normative and informational influence (Deutsch & Gerard, 1955), as well as referent power (French & Raven, 1959), and is characterized by the community member's social identity. However, prior studies found that social identity has only indirect significant effect through desire towards intention (Dholakia 2004) but has no significant direct effect on behavioral intention to virtual communities (Bagozzi & Dholakia 2002).

Individual Perspective: Computer self-efficacy reflects an individual's beliefs about his or her capabilities to use computers (Compeau, Higgins & Huff, 1999, p.147) and was found to be a determinant to system acceptance (Compeau et al., 1999, ibid) and a significant anchor to perceived ease of use (Venkatesh 2000). Personal innovativeness with technology represents the degree to which an individual is willing to try out any new information technology (Agarwal & Prasad, 1998). Personal innovativeness with technology influences system usage via their effects on perceived usefulness and perceived ease of use beliefs (Lewis, Agawal & Sambamurthy, 2003) and had significant correlation with usage intention (Agarwal & Prasad, 1998, ibid).

Table 1. Summary of research variables and the corresponding hypotheses

Research Variables	Hypotheses	Source
Perceived Usefulness	H1*: Individual users' perception on the usefulness of Wikis would influence behavioral intention to the use of Wikis.*	Davis (1989)
Social Influence	H2*: Social influence is a direct determinant of behavioral intention to use Wikis.* H3*: Social influence has a positive direct effect on perceived usefulness of an individual user towards Wikis.*	Venkatesh & Davis (2000)
Social Presence	H4*: Social presence is a direct determinant of behavioral intention to use Wikis.* H5*: Social presence has a positive direct effect on perceived usefulness of an individual user towards Wikis.*	Kettinger & Grove (1997)
Image	H6*: Image is a direct determinant of behavioral intention to use Wikis.*	Karahanna et al. (1999); Moore & Benbasat (1991)
Social Identity	H7*: Social identity is a direct determinant of behavioral intention to use Wikis.*	Bagozzi & Dholakia (2002); Dholakia et al. (2004)
Personal Innovativeness with Technology	H8*: Personal innovativeness with technology is a direct determinant of behavioral intention to use Wikis.*	Lewis et al. (2003); Agarwal & Prasad (1997)
Computer Self-efficacy	H9*: Computer self-efficacy is a direct determinant of behavioral intention to use Wikis.*	Compeau et al. (1999)

3. MOTIVATION & HYPOTHESES DEVELOPMENT

This study aims at exploring the key intention determinants of collaborative writing platform Wikis in order to shed light on better strategies to the successful implementation of Wikis. Table 1 summarizes the constructs and the corresponding hypotheses.

4. METHODOLOGY

4.1. Background

Since February 2006, a Student-Written Wiki (named, HKNews) has been setup for the Department of Journalism & Communication at a private local university in Hong Kong. All the students in the department can access to HKNews and participate in the development of this online shared knowledge base by contributing original real everyday life news stories to HKNews. Students enroll in different news writing and editing courses under the undergraduate journalism program and contribute their writing assignments to the shared knowledge base. Finally, the HKNews becomes an updated shared web-based knowledge resource for both the undergraduate students and the general public.

4.2. Subjects

There are in total 526 undergraduate students in the Department of Journalism and Communication. At the end of the academic year 2005-2006, a survey instrument was distributed to all of them through individual course lecturers. 138 (26%)

Table 2. Background of respondents

Demographic Variable	Sample Composition
Gender	Male: 28(20.3) Female: 110 (79.7)
Age	Mean: 21.5
Year of Study	Yr 1: 15 (10.9%) Yr 2: 40 (29.0%) Yr 3: 66 (47.8%) Yr 4: 17 (12.3%)
Computer Experience	Very little: 15 (10.9%) Fair: 75 (54.3%) Good: 45 (32.6%) Expert: 3 (2.2%)
Wikis Experience	Not at all: 7 (5.1%) A little: 38 (27.5%) Fair: 51 (37.0%) Familiar: 41 (29.7%) Very familiar: 1 (0.7%)
General Computer Usage	Rarely: 5 (3.6%) Sometimes: 22 (15.9%) Frequently: 47 (34.1%) Always: 64 (46.4%)
General Internet Usage	Rarely: 5 (3.6%) Sometimes: 15 (10.9%) Frequently: 47 (34.1%) Always: 71 (51.5%)
Visit, read or post articles on HKNews Wikis site last month	Rarely: 57 (41.2%) Sometimes: 47 (34.1%) Frequently: 27 (19.6%) Always: 6 (4.3%) Missing data: 1

questionnaires were completed and returned. The low response rate was partly due to the high absent rate at the last class.

4.3. Methods

The survey instrument was divided into three parts. Part A collected demographic data and usage pattern of the respondents. Part B consisted of 28 statements asking their opinion toward HKNews Wikis system in a seven point Likert's scale where 1 represented strongly disagree and 7 represented strongly agree, except computer self-efficacy which was measured by a ten point scale ranging from not at all confident to totally confident. The 28 statements included eight constructs in total and the items were adopted from various prior studies (see Table 1). Part C consisted of 8 open end questions asking about the process of writing for HKNews. This serves as a post hoc analysis to provide explanation to the use pattern.

5. ANALYSIS AND RESULTS

5.1. Instrument Validity

Construct items have means ranging from 3.36 to 4.93 (standard deviation ranging from 0.89 to 1.38), except computer self-efficacy items ranging from 6.32 to 7.28 (standard deviation ranging from 1.69 to 1.85). Internal construct consistency was evidenced by Cronbach's alpha coefficients ranging from 0.77 to 0.96, where the literature suggests a threshold of 0.7 or above (Nunnally & Berstein, 1994).

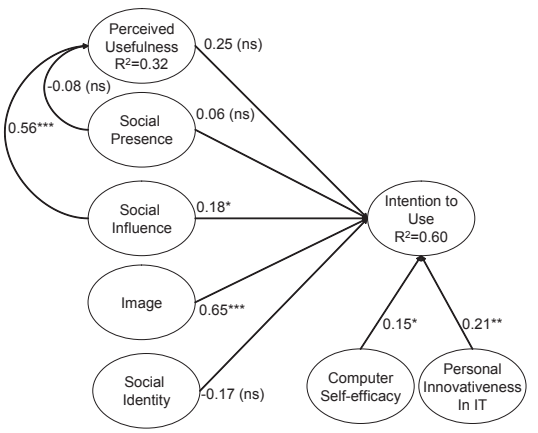
Construct validity of the measurement instrument via discriminant and convergent validity was analyzed. Exploratory factor analysis (using Principal Component extraction method, and Varimax with Kaiser normalization rotation method) found that construct items' factor loadings ranging from 0.69 to 0.91, well above the suggested 0.5 for significant loadings for corresponding component (Hair et al., 2006) while no significant cross-loadings between components were found.

5.2. Model Testing Results

We tested the model with structural equation modeling conducted by LISREL 8.71. The chi-square to degree of freedom ratio was 2.23, satisfied the requirement of being less than 3.0 (Hair et al., 2006). The goodness-of-fit indices, including NNFI, CFI, IFI were all 0.89, close to the suggested level of 0.9 (Hair et al., ibid, 2006). However, GFI has a lower value than suggested (0.71). The limitation of the interpretation of model testing results will be discussed further in later sections of this paper.

The path coefficients were listed in the model testing results diagram below (see Figure 1). Social presence and social influence combined together explaining 32% variance of perceived usefulness (R^2=0.32, for reduced form) while all constructs had a combined effect explaining 60% variance of intention to use (R^2=0.60, for reduced form).

Figure 1. Structural equation modeling testing results



**p<0.05; **p<0.01; ***p<0.001; ns: non-significant*

6. POST HOC ANALYSIS

Respondents were asked to freely express themselves about the use pattern of HKNews at Part C of the questionnaire. All the answer scripts were typed and coded for analysis.

Benefits from Using Wikis: Fewer than half of the respondents expressed a positive attitude from using the system, "lots of reference," "to increase knowledge," "can read others' articles easily," "search for topics or ideas to write." On learning, "convenient for me to find my work," "can check and review (my) own articles at anytime easily," On the system features, "convenient," "user-friendly," "easy to use," "highly access (accessible)," "beautiful layout." A way to publication seems important to the student journalists, "many people can read my writing," "have own record for the public to know." On the other hand, about one-fifth of the respondents, however, showed negative attitude in using the system, "it increases workload," "complicated and a waste of time," and having "poor group pressure (to do so);" and about the system, for example, "it is complex," "difficult to get start and use," "no instructions / instructions not clear enough," "not user friendly," "quite confusing," "speed is low," "not personalized / non-private," while "works are easily deleted by others."

Taking Reference: A significant majority did not read articles before writing their own, because of time constraints, "How come we have time!" "It would affect the planning of my writing," Even they read, they may read only the "topic" or "headline" "focus on the lead of article,"; "to avoid my content of my article (are) the same as the others." Taking references also has benefits "to learn more things about one event," "notice their view point in article and match with mine, so that I can have larger range of opinion,"

How to choose articles? Nearly half of the students do not plan their reading but choose articles at random. Nearly one quarter chooses someone they know; while another quarter chooses someone works better. The reasons for taking references at random because "there are too many articles," "there are so many people on HKNews that I don't know so I just read randomly with no special preference," "I don't know whose working is better than me / especially in different years," just "for interest," "just search the articles which the titles are attractive," "depends on the heading/titles," "I want to read different style of articles," "want to read different people especially from someone I don't know," "to get more detailed information and different angles," "to take a look of the work pattern or what would other choose to write,"

The reasons for them to choose someone they know, such as "I am not interested in reading articles of unknown people," and "I know him/her and realize his/her standard of writing skills."

7. DISCUSSION

Based on prior validated scales, this study examines key intentional determinants of student journalists acceptance to collaborating writing platform Wikis, in which Wikis are used to develop a shared online resources of a specific context. The scale validity is once again confirmed and the model fit is found acceptable. The strength of individual constructs is then measured by their path coefficients. Here follow the discussion of the analysis results.

Technology utility perspective: Surprisingly, perceived usefulness is found non-significant in the overall model, contradictory to most of the prior empirical work in technology acceptance (Legris et al., 2003). However, there may be plausible reasons for the results. In the past, students submit written news articles in hardcopies to instructors. Posting news articles onto Wikis takes students extra time and effort but do not help the writing process. At the beginning stage of the deployment of Wikis, shared resources are not rich enough to create value for students to help the different writing stages in planning, generating ideas, and taking references. While acknowledging the long term benefits in developing such an online shared resource, it is also a fact there is no immediate short term benefits to student journalist users because creating this shared resource changes the work pattern and needs extra time and effort.

Social perspective: student journalist users create a community while using Wikis. Everyone's work becomes transparent to all users. Users interact with each other through the listing of news headlines, news articles, and the profile of individual student journalist. However, this does not mean that all social factors significantly determine individual users' acceptance decision. The model testing finds that social presence and social identity are non-significant to intention to use. Social influence, on the other hand, has a direct significant but weak effect

on intention to use and has a very strong and significant effect on perceived usefulness. Moreover, image is the strongest social factor that significantly affects intention to use. As discussed above, users do not realize the short term value of Wikis at the time being. However, at the time users recognize the technology utility benefits of Wikis, social influence would become a strong and significant determinant which has both a direct and indirect effect on intention to use. Image, as a determinant to acceptance decision has empirical support from prior studies (e.g., Moore & Benbasat 1991). However, it has never become such a strong determinant against all other utility, social and individual factors. Student journalists have a very strong view on image and correlate it to their acceptance decisions. A review of the items used in measure this construct, it is all about how the individual user view their status, image, and prestige positions of using Wikis in the community. To benefit from this finding, management should try the utmost best to realize student journalists' needs for image concern within the community while using Wikis.

Individual perspective: Both computer self-efficacy and personal innovativeness with technology have direct significant effect on intention to use. This can be explained by the fact that Wikis are really new for most student journalists, actually, new to many organizations and individual users. Those early adopters of technology and those have higher confidence on technology use would most probably have a higher intention to use Wikis. A review of the background of student journalists find that more than 60 per cent of them have only fair or little experience to computers, which support the view that student journalists are more aware of the self-assessment of their own resources, computer skills and Wikis experience in acceptance decisions. Management in deployment of such a large scale of collaborative work should consider providing refresher training courses / workshops and easy to approach technical support, probably by volunteer, peer community users.

8. LIMITATIONS

There are several limitations in this study. The study confines to a specific context that journalism undergraduates using Wikis. Moreover, because of the low GFI value, the model testing results have potential limitations and require additional care in interpreting the results though the measurement instrument exhibits both reliability and validity in data analysis. On the other hand, this is the first year the Wiki system fully implemented while students have only limited usage of the system. This would affect how the students value the system. Lastly, future studies shall examine Wikis effect on quality of written work.

9. CONCLUSIONS

To fully utilize Wikis system, users must use it. Wikis depend on the contribution of participants to enrich the content. Probably it would be a vicarious circle that if users do not find rich content, they would not visit the system. There should be more research in the area in order to better understand the cognitive processes of the individual users, the social processes among the community, and the behavioral processes of how individual users use Wikis.

10. REFERENCES

Agarwal, R. and Prasad, J. (1998). A Conceptual and Operational Definition of Personal Innovativeness in the Domain of Information Technology, *Information Systems Research*, 9(2), pp. 204-215.

Bagozzi, R.P. and Dholakia, U.M. (2002). Intentional Social Action in Virtual Communities, *Journal of Interactive Marketing*, 16(2), pp. 2-21.

Bhattacherjee, A. and Premkumar, G. (2004). Understanding Changes in Belief and Attitude Toward Information Technology Usage: A Theoretical Model and Longitudinal Test, *MIS Quarterly*, 28(2), pp. 229-254.

Compeau, D.R., Higgins, C.A. and Huff, S. (1999). Social Cognitive Theory & Individual Reactions to Computing Technology: A Longitudinal Study, *MIS Quarterly*, 23(2), pp. 145-158.

Daft, R. and Lengel, R. (1986). A Proposed Integation Among Organizational Information Requirements, Media Richness and Structural Design, *Management Science*, 32(5), pp. 554-571.

Davis, F.D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology, *MIS Quarterly*, 13(3), pp. 319-339.

Deutsch, M. and Gerard, H.B. (1955). A Study of Normative and Informational Social Influences Upon Individual Judgment, *Journal of Abnormal and Social Psychology*, 51, pp. 629-636.

Dholakia, U.M., Bagozzi, R.P. and Pearo, L.K. (2004). A Social Influence Model of Consumer Participation in Network - and Small-Group-Based Virtual Communities, *International Journal of Research in Marketing*, 21(3), pp. 241.

Fontana, J. (2006). Company to Push Wikis for Corporate Collaboration, *Network World*, 23(17), pp. 30.

French, J.R.J. and Raven, B. (1959). The Base of Social Power, In *Studies in Social Power*, D.Cartwright (Ed.), Ann Arbor, MI: University of Michigan, pp. 150-167.

Gibbs, M. (2006). Customers Make Good Use of Wikis to Combat E-mail Overload, *Network World*, 23(15), pp. 35.

Gordon, C. (2006). Wikis-a Disruptive Innovation, *KM World*, 15(6), pp. 1.

Hair, J.F., Black, B., Babin, B., Anderson, R.E. and Tatham, R.L. (2006). *Multivariate Data Analysis*, Upper Saddle River, N.J.: Pearson Prentice Hall.

Hogg, M.A. (1992). *The Social Psychology of Group Cohesiveness: From Attraction to Social Identity*, New York: NYU Press.

Hu, P.J.H., Clark, T.H.K. and Ma, W.W.K. (2003). Examining Technology Acceptance by School Teachers: A Longitudinal Study, *Information & Management*, 41(2), pp. 227-241.

Jessup, L.M., Connolly, T. and Galegher, J. (1990). The Effects of Anonymity on GDSS Group Process with an Idea-Generating Task, *MIS Quarterly*, 14(3),, pp. 313-321.

Karahanna, E., Straub, D.W. and Chervany, N.L. (1999). Information Technology Adoption Across Time: A Cross-Sectional Comparison of Pre-Adoption and Post-Adoption Beliefs, *MIS Quarterly*, 23(2), pp. 183-213.

Kettinger, W.J. and Grover, V. (1997). The Use of Computer-mediated Communication in an Interorganizational Context, *Decision Sciences*, 28(3), pp. 513-555.

Legris, P., Ingham, J. and Collerette, P. (2003). Why Do People Use Information Technology? A Critical Review of the Technology Acceptance Model, *Information & Management*, 40, pp. 191-204.

Lewis, W., Agarwal, R. and Sambamurthy, V. (2003). Sources of Influence on Beliefs about Information Technology Use: An Empirical Study of Knowledge Workers, *MIS Quarterly*, 27(4), pp. 657.

Moore, G.C. and Benbasat, I. (1991). Development of an Instrument to Measure the Perception of Adopting an Information Technology Innovation, *Information Systems Research*, 2(3), pp. 192-222.

Naish, R. (2006). A Sense of Responsibility, *E.Learning Age*, pp. 12.

Pagani, M. (2004). Determinants of Adoption of Third Generation Mobile Multimedia Services, *Journal of Interactive Marketing*, 18(3), pp. 46-59.

Raman, M., Ryan, T. and Olfman, L. (2005). Designing Knowledge Management Systems for Teaching and Learning with Wiki Technology, *Journal of Information Systems Education*, 16(3), pp. 311-320.

Short, J., Williams, E. and Christie, B. (1976). *The Social Psychology of Telecommunications*, New York: Wiley.

Sia, C.-L., Tan, B.C.Y. and Wei, K.K. (2002). Group Polarization and Computer-Mediated Communication: Effects of Communication Cues, Social Presence, and Anonymity, *Information Systems Research*, 13(1), pp. 70-90.

Venkatesh, V. (2000). Determinants of Perceived Ease of Use: Integrating Control, Intrinsic Motivation, and Emotion into the Technology Acceptance Model, *Information Systems Research*, 11(4), pp. 342-365.

Venkatesh, V. and Davis, F.D. (2000). A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies, *Management Science*, 46(2), pp. 186-204.

Venkatesh, V., Morris, M.G., Davis, G.B. and Davis, F.D. (2003). User Acceptance of Information Technology: Toward a Unified View, *MIS Quarterly*, 27(3), pp. 425-478.

Wikipedia:Wiki (2006, 28 August). Retrieved August 28, 2006 from http://en.wikipedia.org/wiki/Wiki.

Professor SMILE Leads the Way to a New Dawn for Information and Communication Technology Education

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ABSTRACT

Enormous motivation is required from students just to cope with the material, let alone learn from Traditional IT courses. It was not surprising, therefore, to find in four classroom studies in UGRU that only 37% students want to learn IT using traditional methods. Understanding the situation, in spring 2005 UGRU introduced a new ICT program. Still it is not enough. Different students have different styles and strategies of learning. Recognising this fact, we strongly believe that simulations can be an effective counter to many of the aforementioned issues while also providing equal opportunities to men and women in higher education in the Arab World. Professor SMILE (SiMulated Integrated Learning Environment), an intelligent, critical and creative thinker, can help the future generation learn ICT effectively.

1. INTRODUCTION

Teaching and learning in Higher Education in the United Arab Emirates have recently undergone a major paradigmatic shift, from the traditional format to one in which students are actively engaged in their own learning process. This is true for IT as well as other subjects. While core values that are central to Islamic beliefs are retained, the methodology now focuses on teaching curriculums based on thinking, rather than rote memorization.

In spring 2005, the University General Requirements Unit (UGRU) of the United Arab Emirates University (UAEU), replaced the traditional Information Technology (IT) curriculum with a new Information and Communication Technology (ICT) curriculum. Evaluation of the new ICT curriculum, in terms of educational goals, content, teaching methods and assessment, revealed the following facts. The UGRU lecturers find the new ICT curriculum better than the traditional curriculum in all these areas. In particular, it integrates thinking skills into the technologically oriented curriculum. On the other hand, evaluation showed that there still remains much to be done to achieve objectives. There is a widening gap between present and future Information Technology (IT), taught in higher education, and the real use of IT. Educators are confused and students are bewildered by this. We strongly believe that simulations can be an effective way of narrowing this gap. This research paper will also focus on the usage of case-study based intelligent simulation technology in higher education. Particular emphasis would be given to its pioneering implementation within the UAE University's UGRU program.

Professor SMILE[1] is an innovative, intelligent, robust and ubiquitous computer system created to teach ICT to students in higher education. Its implementation is object oriented, and it incorporates a Discrete Event Simulation (DES) shell. Its design also makes it available on internet, mobile systems, and adaptable for the use of disabled persons. It can be used to teach Mathematics, English, Arabic, Science, Engineering and IT courses. It is a versatile system which can be upgraded to teach most of the things a human being can teach.

1.1 Prelude

First let us understand and analyze creativity, communication, collaboration, environment, and the human brain. Perhaps we should begin with a more basic question: what do we mean by creativity? The basis of creativity is achieving something that did not exist previously, breaking down established patterns, seeing things in a new way. But what drives people to think of something new? How does the creative process work? The creative process may manifest itself in different ways. "Chance favors the prepared mind," the famous scientist Louis Pasteur once said. Pathologist Peyton Rouse spoke likewise of "a prepared mind making its own chances." Are we going to prepare our students using new tools of information technology for future and using creative and critical thinking, value of good communication, and habits of collaboration or waiting for the chances[1]?

Several influences have converged to create a new emphasis on the teaching of a thinking skills based IT curriculum around the world. Prominent among these are workplace readiness and the constructivist movement[2]. Although education in the Arab nations was tied to religious fundamentalism during the 20th century and traditional teaching techniques relied primarily on rote learning within a lecturer-centered, religious-oriented context, teaching thinking in IT is not at all antithetical to the Holy Qu'ran. In fact, more than 640[2] verses in the Holy Qu'ran challenge believers to use their minds for critical thinking, problem-solving, creative thinking, and decision-making. In the 21st century, it is particularly important to cultivate these skills to enable our youth to function effectively in their own world as well as in the global community[3]. The new ICT curriculum focuses on critical and creative thinking. Perkins[5] notes six basic priorities for lecturers who actively teach for understanding rather than for memorization. Cognitive research and theory has changed the way many in the education system think about educational practice, including curriculum design, assessment, and learning environments. Greeno, Collins, and Resnick[6] emphasize that the design of learning environments can support cognitive or brain-based learning. Brooks and Brooks[4] describe several of these. For example, students need to be provided with curriculum holistically, emphasizing large concepts, rather than the fragments, or basic skills as building blocks that is typically the current approach[7]. These skills are used intelligently in the new ICT curriculum.

2. REASONS FOR BIRTH OF PROFESSOR SMILE

Some of the reasons for the birth of Professor SMILE are as follows: (i) There is a gap in present and future Information Technology (IT), taught in higher education, and real use of IT. (ii) Educators are confused and students are bewildered about IT programs in higher education. (iii) Traditional IT courses require enormous motivation to go through the material, let alone learn from it. (iv) Serious concerns can be raised regarding gaining relevant knowledge or developing required skills through traditional approach. (v) Different students have different styles and strategies of learning.

It was surprising to find in four classroom studies that not more than 37% students in UGRU want to learn IT using traditional methods. The rise of affordable computers and the internet have made IT learning ubiquitous. Yet much of what is offered under the guise of e-learning completely fails to make use of the essential features of either the computer or the Internet. More often than not the computer is used as little more than a television or a post box. Attempts to address

Table 1. IT students' likes, dislikes, and suggestions about classes, courses, and teachers

Likes/ Dislikes	Art		Business		Science		Total	
	Yes %	No %	Yes %	No %	Yes %	No %	Yes %	No %
I want to use internet instead of books from library for writing my research (papers/projects).	94.87	5.13	100.00	0	80.95	19.05	91.55	8.45
I want to use computer (blackboard programs, etc.) for learning in class not a teacher.	41.03	58.97	36.36	63.64	38.10	61.91	39.44	60.56
I want to take exams by using computer not on paper.	53.85	43.59	54.55	45.46	71.29	28.71	60.56	39.44
I want to study in a government university not in a private university.	69.23	30.77	90.91	9.09	90.48	9.52	78.87	21.13
I want to have higher education only for excellent students.	41.03	58.97	45.46	45.46	42.86	57.15	42.25	57.75
I want to have no exam, only project work, home work and quizzes to promote students to the next class.	61.54	38.46	54.55	45.46	52.38	47.62	57.75	42.25
I want to study to increase my knowledge other than for passing the Examination.	66.67	33.33	72.73	18.18	71.29	28.71	69.01	30.99
I do not like teachers who always ask me to come on time to the class	56.41	41.03	54.55	45.46	42.86	57.14	53.52	46.48
I do not like teachers who always keep me busy in studies whole period.	74.36	23.08	45.46	54.55	52.38	47.62	64.79	35.21
I want to eat and drink in the class while studying.	61.54	38.46	63.64	36.36	57.14	42.86	60.56	39.44
I do not want to come to class on Wednesday.	79.49	17.95	54.55	45.46	61.91	38.10	71.83	28.17
I want to talk with my friends in the class even when my teacher is teaching.	35.90	56.41	27.27	72.73	33.33	61.91	36.62	63.3
I do not like teachers who want me to do more study in class to get good marks but no rest.	43.59	53.85	63.64	36.36	42.86	57.15	47.89	52.11
I like that teacher who wants me to do very little study in class and gives more free time.	48.72	51.28	27.27	72.73	38.10	57.14	43.66	56.34
I feel angry with teachers who give me low marks even my work is poor.	56.41	41.03	63.64	36.36	38.10	57.14	53.52	46.48
I always want good marks in exam whether I study or not.	66.67	33.33	36.36	63.64	42.86	57.14	54.93	45.07
I like Arabic songs and Dances.	56.41	38.46	27.27	72.73	42.86	57.14	49.30	50.70
I want to sing in my free time.	51.28	43.59	54.55	45.46	57.14	42.86	54.93	45.07
I want to dance in my free time.	43.59	51.28	45.46	54.55	33.33	66.67	42.25	57.75
I like to play games (indoor/outdoor) more than studies.	53.85	46.15	36.36	63.64	57.14	42.86	52.11	47.89

this situation by making instruction interactive typically fall short, in part for the same reasons, but also because of a failure to understand what is essential about interactivity[8].

We strongly believe that simulations can be an effective counter to many of the aforementioned issues. In fall 2004, research was conducted by the authors of this paper in classrooms of UAE University to find IT students' likes, dislikes, and suggestions about classes, courses, and teachers. The results are summarized in Table 1.

According to Harvard professor Dr. Howard Gardner in his multiple intelligence theory, students generally exhibit strength and weaknesses across the following types of learning methods: (i) A linguistic learner (excels at words); (ii) A logical learner (excels at numbers); (iii) A spatial learner (excels at visualizing); (iv) A musical learner (excels at music); (v) A kinesthetic learner (excels at physical activity); (vi) An interpersonal learner (excels at relationships); (vii) An intrapersonal learner (excels at working alone); (viii) A naturalistic intelligence; or (ix) An intelligence existential[9]. Our research about learning styles and strategies about UAE University students revealed interesting outcomes. The results are summarized in Table 2. All the earlier reasons are instrumental in the birth of Professor SMILE, an intelligent system to teach ICT to students of higher education. The capabilities of Professor SMILE are enormous, which future generation of learners will appreciate.

3. ARRIVAL OF PROFESSOR SMILE: A NEW INTELLIGENT SYSTEM

The prototype of Professor SMILE was developed using state of the art techniques of software engineering. The system architecture is open and object oriented. It uses rule based (both forward and backward chaining) reasoning at present with a facility to attach neural computing based artificial intelligence and DES modules which have been tested separately.

3.1 Design, Development Stages and Software Engineering Life Cycle

For the development of any simulator there are six main stages. Figure 1 shows a high-level view of the activities required to produce a system in terms of the stages that a system goes through. The development of Professor SMILE has gone through the three stages and the fourth is continuing. We used the classic

Table 2. Learning styles and strategies of some ICT students

How do You want to learn ICT?	Number of Students	% of Students
By words (A linguistic learner)	3	2.57
By Pictures (A spatial learner)	21	17.95
By Doing Step by Step (A logical learner)	20	17.09
By Music (A musical learner)	7	5.98
By Moving or Dancing (A kinesthetic learner)	13	11.11
By working alone (An intrapersonal learner)	24	20.51
By working in a group (An interpersonal learner)	29	24.79
Total	117	100

Figure 1. Design and development stages used for Professor SMILE

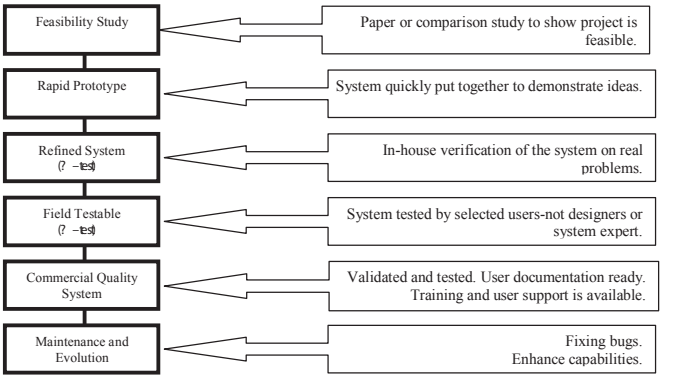
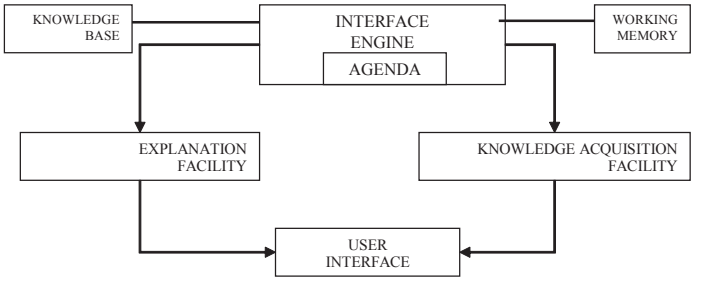


Figure 2. A rule-based expert system mechanism that has been used in design of Professor SMILE



waterfall model for development of software modules to be incorporated with Professor SMILE. In the waterfall model each stage ends with a verification and validation (V & V) activity to minimize any problem in that stage. Also, notice that the iterations go back and forth only one stage at a time. This represents the iterative development between two adjacent stages in order to minimize the cost compared to the higher cost of iterating development over several stages. The main design is "Event Driven. The system is capable of generating "Brain Map" for the problems it encounters.

3.2 Technology

Some of the components are as follows: (i) Visual Basic Version 6.0; (ii) Speech to Text and Text to Speech conversion: SAPI 5.1 (Microsoft); (iii) Use of Agent: CSAgent (Microsoft); and (iv) Expert Systems, Neural Computing , and DES Model. (v) *Computer Systems:* Windows XP, Windows 2000, and Windows NT. (vi) *Portability:* Linux and UNIX after converting VB code to any other language.

3.2.1 Artificial Intelligence (AI) Module

The expert system module of Professor SMILE uses forward and backward chaining in its design. We have a future plan to incorporate neural computing and DES modules with expert system. Figure 2 shows a Rule-based Expert System mechanism. In a rule-based system, the inference engine determines which rule antecedents, if any, are satisfied by the facts. Two general methods of inferencing are commonly used as the problem-solving strategies of expert system: forward chaining and backward chaining[10].

3.3 Future Plan For Professor Smile

We will use Discrete Event Simulation (DES) Model in future. Any addition of a software module to Professor SMILE is very easy because its design philosophy is open software architecture. DES is where a "simulation model" of a system is created using the idea of: "Entity" flow. Some of the features of this model are as follows: (i) It can visualise the concepts/processes involved in designing and writing a program. (ii) It is object orientated visually. (iii) It has simple 2D animation to enhance visualisation of the processes. The area of DES application in academic education is new except for courses in simulation. Professor SMILE is first to use DES as a shell to help students visualize and animate the process flow of program development life cycle (PDLC), the main steps of a general algorithm and writing a program. It can be expanded to cover many other types of process we want to visualize in the academic world.

Another improvement will be application of Neural Networks with existing Rule Based Expert System. The designers of this project have a good expertise in prediction of learner outcome using neural networks. The connectionist approach [which applying neural networks] is based on the supervised or unsupervised learning paradigms [10]. But there are some situations, like in learning environment, where these paradigms cannot be used in isolation because scenario changes continuously. An artificial neural network functions by receiving a set of input facts, processing these facts, and then producing a set of values calculated from these facts[10]. The training of a network is important, which is the major distinction criterion for different neural networks. The neural networks used here are based on two different paradigms; supervised and unsupervised learning paradigms. In our case we are using back-propagation network. McCulloch-Pitts neurons are the basic units of neural networks, shown in Figure 3(a). The basic

Figure 3. (a) An artificial neuron, and (b) a back-propagation Net

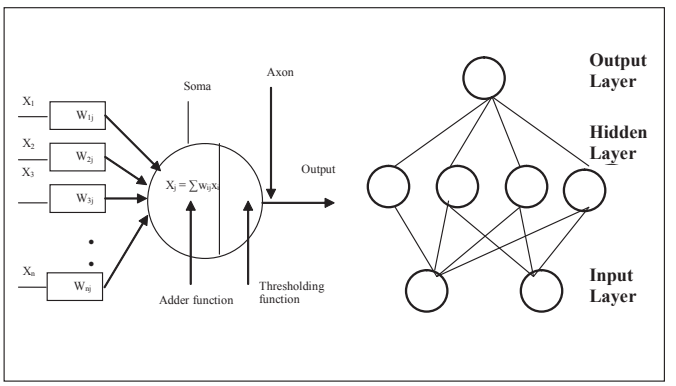
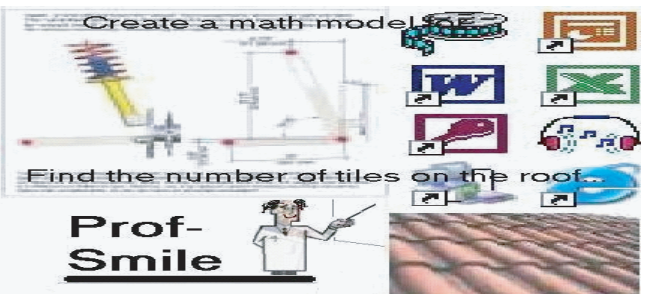


Figure 4. The first screen of Professor SMILE when it is loaded and running



configuration of the neural networks based on the supervised learning paradigm is shown in Figure 3(b).

There are two distinct operations, which take place during the training phase; the first one is the feed forward computation and update of the weights based upon the error of the network's output. Typically each neuron in the network uses the same activation function and threshold value. First, the connection weights between the hidden and output layers are adjusted along with the activation thresholds in the output nodes. In the second state, the connection weights between the input and the hidden layers are adjusted along with the activation thresholds in the hidden layer to reduce error in the output. This error is defined as

$$E_p = 0.5*\sum(t_{pj} - o_{pj})^2 \quad (1)$$

Where E_p is a measure of error on input/output pattern p and $E = \sum E_p$ is the overall measure of error. Here t_{pj} is the value of target output, and o_{pj} is the output value of the network. With hidden units there is a possibility of getting stuck in local minima. The derivatives can be calculated by generalized δ rule. The generalized δ rule works for layered feed forward networks with any number of hidden layers between the input and output layers. The following equation is used in the learning algorithm to calculate the change in weight (ξ) whenever the node (neuron) is an output node. Here, w_{kj} are the weights between the layers.

$$\xi_{pj} = o_{pj}(1 - o_{pj})\Sigma k \xi_{pk} w_{kj} \quad (2)$$

The application of the generalized delta rule involves two phases. During the first phase, called the forward phase, the input is presented to and propagated forward through the network to compute the output value o_{pj} for each output unit. For each processing element, all current outputs are compared with the desired output, and the difference, or error, is computed. The second phase, called the backward phase, involves a backward pass through the network during which the error signal is passed to each unit in the network and the appropriate weight changes are made. Only when these two phases are completed, can the new inputs be presented. Neural networks based on both paradigms were simulated and evaluated for prediction and performance. Our research also concludes that neural networks based on the supervised learning paradigm require a lot of training time, are unstable, very sensitive to tuning parameters, and generally get stuck in local minimas. On the other hand the neural networks based on the unsupervised learning paradigm are significantly faster and are less sensitive to tuning param-

Table 3. Typical examples of the tasks provided by Professor SMILE

Example 1:
What is the number of rectangular roof tiles, to cover the roof area shown in the picture? Assume each rectangular tile is 30cm by 15cm
Case 1 assumes tiles just touch.
Case 2 assume tiles overlap 1cm all the way round its perimeter.
Example 2:
Create a simple math model of the car suspension for a simple two spring two mass damper system.
Example 3:
You work for a telephone company. Your boss has asked you to answer some questions about smart phones. He also wants some information on customers. Do the following Tasks.
a) Your company sells 6 different Smart-Phones. The sales for 2004 are in the Smart-Phones Sales 2004.doc file. Your company wants you to calculate the profit for each model.
a1. Choose the best software to use.
a2. Make sure the information about the Smart-Phones is clear and easy to read.
a3. Calculate the profit that each model is making.
Profit = (Price - Cost)*Number Sold
a4. Save your document as Smart????? Where ????? are the last 5 digits of your id number?
b) The company has decided to sell only 5 different Smart-Phones in the future. Which phone do you think they should STOP selling? Give your reasons.
Example 4:
You are the manager of a new perfume shop, which is about to open. Create a flyer for your shop and also make it into a web page.

Figure 5. (a) User is prompted for the choices of different varieties. (b) User can choose different learning modes. (c) User can become administrator or learn DBA activities. (d) User has a choice of different subjects to study. (e) The choice can be of different areas, learning and testing modes, etc. (f) The systems generated "Brain Map" for number of tiles on roof problem. (g) Professor SMILE provides a possible answer for roof tiles problem. (h) Computer generated "Brain Map" for Smart Phones Scenario

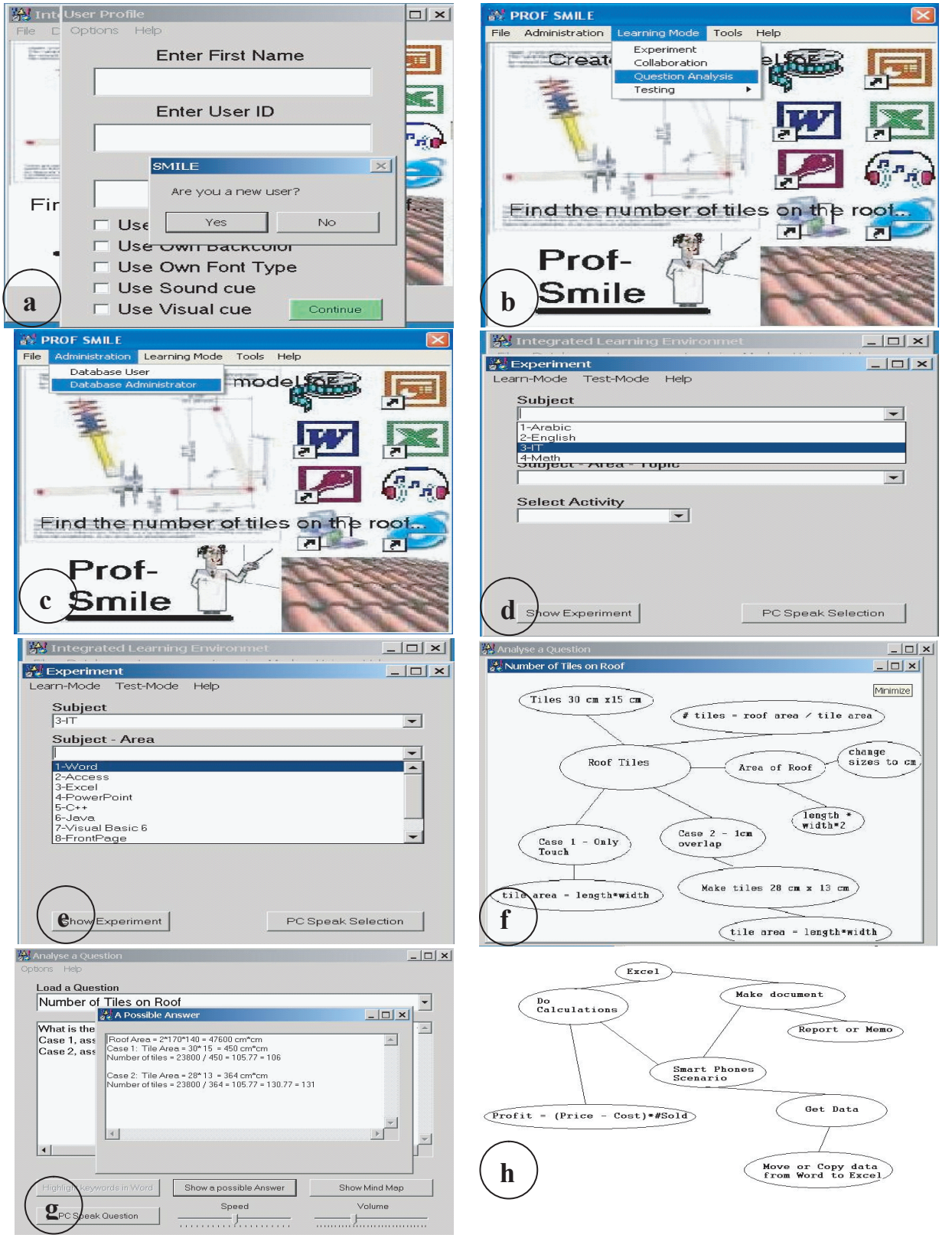
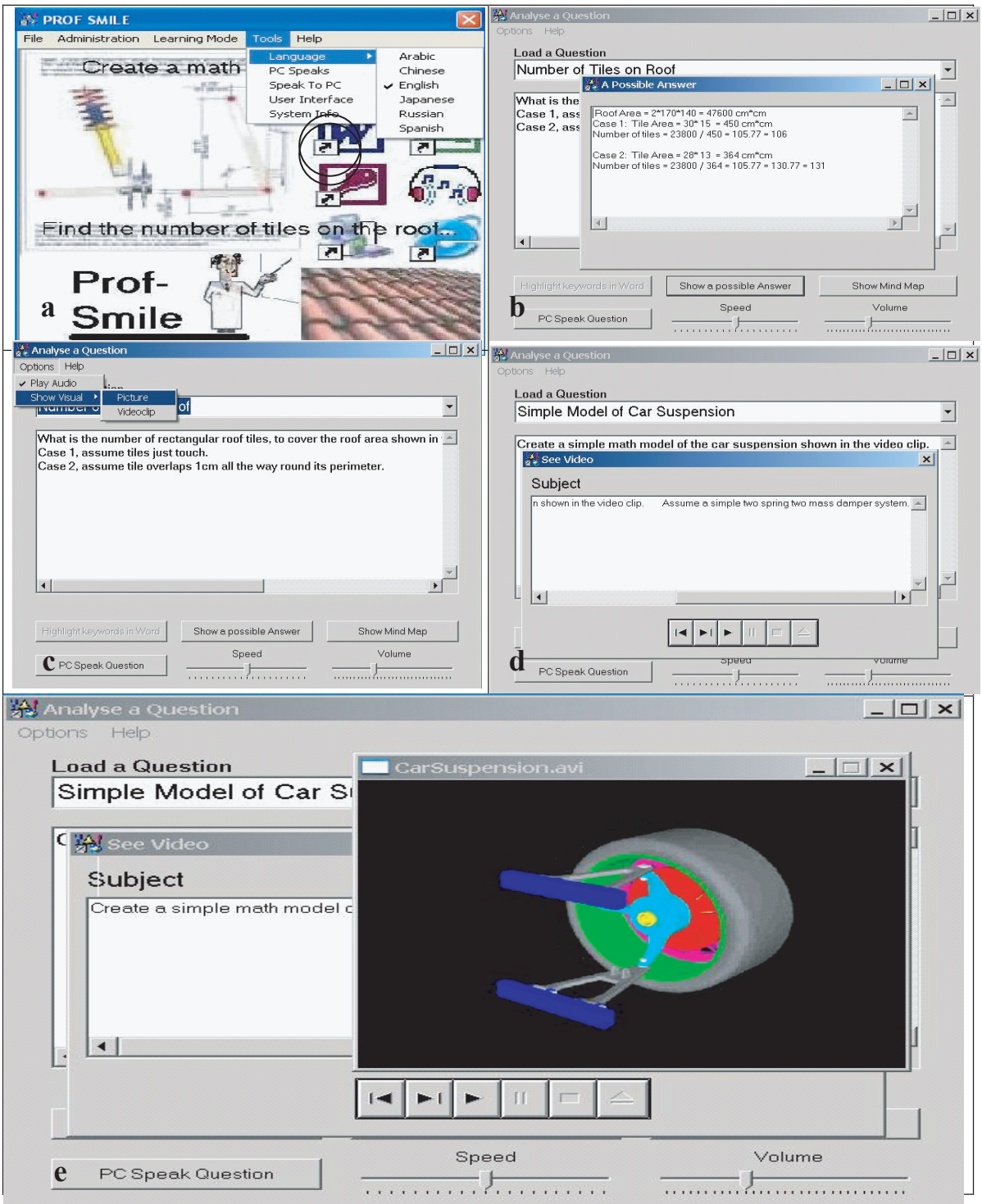


Figure 6. (a) Physically disabled person has a choice of different facilities and options. (b) Calculation of the tiles for a disabled person. (c) Let us analyze the roof tiles problem. (d) Solution of Car Suspension problem. (e) A better method of solving a problem for a disabled person



eters. The neural networks based on both paradigms simultaneously along with feature enhancement on every step provide a much faster, robust solution which is less sensitive to tuning parameters. Neural networks could be easily used for prediction of learning outcomes of any cluster of university students based upon their past performance. The developed and tested neural computing module will also be incorporated with Professor SMILE.

4. TEACHINGS OF PROFESSOR SMILE

4.1 Why Learn from Professor SMILE?

Some of the compelling reasons are as follows: (i) It understands the learning requirements of students. (ii) It is available all the time. (iii) It is intelligent. (iv) It does not show negative human emotions. (v) It does not follow any religion. (vi) Cheaper and less dangerous to simulate than build, buy or operate a real system. (vii) Its software tools provide a highly visual 2D or 3D animated model of your "system". (viii) It provides a tool to play very realistic "what-if" games. (ix) User can see animated flow of various data objects. (x) Various Model Parameters can be modified e.g.: Realistic processing time delays can be used in various objects.

4.2 Learn To Design and Solve Complex Problems with Professor SMILE

Professor SMILE finds it easy to teach the following difficult IT topics using a simple DES (Discrete Event Simulation) model and enhance students' visualization: (i) The Program Development Life Cycle (PDLC); and (ii) the Steps of the General Algorithm.

4.3 Learning Process For Normal Person

The normal person can start learning from Professor SMILE by keying the basic personal information which helps the system to build a user profile. The student profile is used by most of the system modules. Some of the Professor SMILE's interactive screens are shown in figures 4 -6. Some typical examples of the tasks provided by Professor SMILE are shown in Table 3.

4.3 Learning For Physically or Mentally Disabled Person

The system has also been designed keeping in mind the problems faced by physically or mentally disabled persons. They can choose to speak, listen or feel the system. If any touch-coded sign language is available, it can also be incorporated into the system. The physically challenged person has an obvious choice of speaking out his information through microphone. He/She can hear computer-generated output through a speaker or headphones.

CONCLUSION

Our research clearly shows that there is a wide gap between present and future Information Technology (IT), taught in higher education, and real use of IT. It also shows that different students have different styles and strategies for studying IT.

Certain changes were made in the IT curriculum with respect to educational goals, content, teaching methods, and methods of assessment. Regarding teaching methods, lecturers now share the class time with the students, thus engaging them in their learning experience. Generally speaking, the new curriculum has successfully changed from a textbook, lecturer-centered model to a learner-centered model, providing more active student participation in the educational process.

Still it is not enough. The gap has been narrowed but not closed. For example, course content in the new ICT curriculum does not contain all the information needed for students to learn a subject, thereby requiring the students to do their own research to complement the information in their texts. Some areas still need improvement, but the current trend is one that will be consistent with guiding our students to become critical and creative thinkers, able to search out, understand, analyze, and synthesize the information they will need to become world citizens and world leaders.

We strongly believe that simulations can be an effective counter to many of the aforementioned issues. Professor SMILE is an innovative, intelligent, robust and ubiquitous computer system to teach ICT to students in higher education. Its implementation is object oriented and it also incorporates a DES shell which no other working academia project uses at this time. Its design also makes it available on internet, mobile systems and it is ideal for use by disabled people. It can be used to teach Mathematics, English, Arabic, Science, Engineering and IT courses. It is a versatile system, which can be upgraded to teach most things a human being can teach. This model has already been tested with some students to obtain data on what students find difficult to conceptualise and understand in IT. The project is currently continuing. Piloting in other institutions may be a possibility in the future. We are available to help others start similar projects in academia and industry; however, the nature and terms of help would be different for industry and academia. The new ICT is a gift of the UAE University to a new Arab world along with an innovative, intelligent, critical and creative thinker, Professor SMILE, to teach the future generation.

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REFERENCES

[1] U. Larson, Editor, "Cultures of Creativity The Centennial Exhibition of the Nobel Prize", Science History Publications, USA, 2000.

[2] West Virginia Office of School-to-Work., "The history of ReadiSkills", West Virginia Department of Education, USA, 1997.

[3] K.A. Alsuwaidi., *International Journal of Educational Reform,* **Vol. 10, No. 3 / Summer**, pp. 215, 2001.

[4] J.G. Brooks and M.G. Brooks, "In search of understanding: The case for constructivist classrooms.", ASCD Publications, Alexandria, VA, USA, 1993.

[5] D. Perkins, *Education Digest*, **January 1**, 1994.

[6] J.G. Greeno, A. Collins and L.B. Resnick, "Cognition and Learning. In D. C. Berliner & R. C. Calfee (Eds.), Handbook of educational psychology", Macmillan, New York, 1996.

[7] A. Sharma, K.A. Alsuwaidi, C. Hussein and S. Boylan, "A Unique Learning Approach in Information Technology", *16th Information Resources Management Association International Conference*, San Diego, California, USA, 2005.

[8] R.R. Ravaglia, *e-Merging e-Learning Conference 2003,* Abu Dhabi, UAE, September 2003.

[9] H. Gardner, *The Understanding Pathway: Educational Leadership*, **57(3)**, pp. 12-17, 1999.

[10] J. Giarratano and R. Gary, "EXPERT SYSTEMS Principles and Programming", PWS Publishing Company (ITP: An International Thompson Publishing Company), Boston, MA, USA, 1998.

ENDNOTES

1 By the way, similar name Ismail is well known in the Arab world. He was one of the Prophets, (PBUH).

2 In the Holy Qu'ran there are approximately 6236 verses.

An Assessment of Topic Areas Covered in KM Journals (2000–2005)

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ABSTRACT

In recent years, knowledge management (KM) has received increasing attention from researchers and practitioners. In 2005, Peachey, et al. explored the KM literature that appeared in information systems (IS) journals. However, while many KM articles initially appeared in IS journals, KM-specific journals have begun to appear on the scene. This research reviews the literature published in KM-specific journals from 2000 to 2005. Using content analysis, this research explores the literature in KM-specific journals to determine the nature of the body of knowledge in KM. The results indicate that, although the coverage of KM topics within KM-specific journals is fairly evenly distributed, the KM topic of knowledge transfer has been receiving the greatest amount of attention by researchers and practitioners contributing to these journals. Additionally, the comparison of the two bodies of literature (KM and IS journals) shows that there are differences in the coverage of knowledge application.

1. INTRODUCTION

Knowledge management (KM) was first addressed as an identified concept in industries/ functions that were basically selling knowledge (e.g., professional services, pharmaceuticals, and research and development) [3]. Since then it has quickly moved into other industries and now is expected to be adopted in virtually every business unit and function (ibid). Peachey et al. [14] showed evidence of this rapid growth in their 2005 study of KM in the leading information systems (IS) journals. They found that over 2,000 articles were written on the subject from 2000-2004.

Peachey et al. [14] proposed that "understanding the future direction of research in KM requires that we first know what constructs in KM have received the most attention from researchers and where there currently are gaps in the published research." Thus, their study was designed to learn what types of KM articles had been published in the IS journals. To conduct the study, they developed a hybrid framework by combining the KM topics of *knowledge creation*, *storage/retrieval, transfer*, and *application* from Alavi and Leidner [1] with the KM topics of *knowledge generation*, *codification* and *coordination*, *transfer*, and *roles/skills* from Davenport and Prusak [4]. The study found all of the KM framework topics represented in the IS literature, with the KM topic of *knowledge transfer* being addressed more (approx. 42% of the time) than any of the other four KM topics. Peachey et al. [14] suggested that concentrating research on just one or two KM topics could cause an imbalance in KM research as a whole (ibid, p. 68). Given these findings, the purpose of the current study was to extend the research to focus on KM-specific journals.

2. EVOLUTION OF KM-SPECIFIC JOURNALS

With the work of Peachey, et al., we have an idea of the KM topics covered in IS journals. Similarly, Guo and Sheffield [6] identify IS journals as well as management science journals that publish a significant number of KM articles. Recently, KM-specific journals have begun to appear. Although no *official* "KM-specific journal" definition exists, one can be defined as a specialized publication dedicated to KM research and practice [9]. Furthermore, a KM-specific journal's main focus is to advance body of literature in KM by publishing articles only pertaining to KM that may not be published in IS or other discipline-focused journals.

Over the last five years, the number of KM-specific journals has begun to grow. For instance, Schwartz [16] identified a number of outlets "with major aspects of KM as a primary focus" [p. xxiv]. Jennex and Croasdell [9] also identified three journals that "surfaced to address KM research exclusively" [p. ii]: *Knowledge Management Review, The Journal of Knowledge Management, and Knowledge Management Research and Practice*. The evidence suggests the body of knowledge for KM is growing, and as Schwartz suggests "[there is a] compelling need to create a logical structure that maps out the field of knowledge management across its diverse disciplines' [16, p. xxv]."

With the findings of Peachey et al. concerning IS journals, the researchers felt a similar investigation of KM-specific journals would be informative as to the current state of and future development of the KM discipline.

3. RESEARCH QUESTIONS

Given the discussion above, the following research questions were proposed:

RQ1: *What are the dominant KM topics addressed in KM-specific journals?*

RQ2: *Is the KM literature in IS journals different than that being published in KM-specific journals?*

4. LITERATURE REVIEW

In attempting to define knowledge management, Alavi and Leidner reference Von Krogh's [17] definition of knowledge management: "Knowledge management refers to identifying and leveraging the collective knowledge in an organization to help the organization compete" [17, p. 113]. Alavi and Leidner further state that "knowledge management is largely regarded as a process involving various activities" [1, p. 114].

Two frameworks were selected to form a basis for the categorization of topics for this research. First, Alavi and Leider [1] was chosen based on the desire to compare the KM-specific journals with the results of the previous IS journal study [14]. Additionally, this framework is the fourth most often cited article in KM research [8].

Choosing the second framework was more challenging. Rubenstein-Montano et al. [15] examined 26 different knowledge management frameworks published in both academic and practitioner literature. In their review, they noted that "Holsapple and Joshi present the most comprehensive framework in the existing literature and are most closely aligned with the results of this study" [15, p. 10]. Given the strength of this recommendation and Holsapple and Joshi's extensive research in KM, we selected this framework for inclusion in this study.

Alavi and Leidner [1] created a KM framework with four KM categories, or focus topics:

1. knowledge creation
2. knowledge storage/retrieval
3. knowledge transfer
4. knowledge application.

Alavi and Leidner [1] provided extensive definitions of the KM topics. *Knowledge creation* was defined in a manner similar to Nonaka [12, 13] as the continual interplay between tacit and explicit knowledge.

Knowledge storage and retrieval are those activities that an organization engages in to capture and locate knowledge for future use. Additionally, as stated by Davenport and Prusak [4], codification activities that put knowledge in a form that is useable for others are part of storage and retrieval activities.

Knowledge transfer is the process where knowledge flows from one entity to another such as between individuals, groups, organizations, or any combination thereof.

Knowledge application is the focus on use of organizational knowledge for competitive advantage.

Holsapple and Joshi [7] created a framework which consisted of five KM focus topics:

1. Managerial influences
2. Resource influences
3. Environmental influences
4. Activities
5. Learning/projection as outcomes

Holsapple and Joshi's research to produce the framework involved over "31 recognized researchers and practitioners in the KM field" [7, p. 235]. They claim the results of the Delphi panel yielded "a relatively comprehensive framework on which KM research and practice can develop" [7, p. 255]. Bartczak [2] also found the framework to be robust when used as grounding theory for a case study investigation of six military organizations practicing KM.

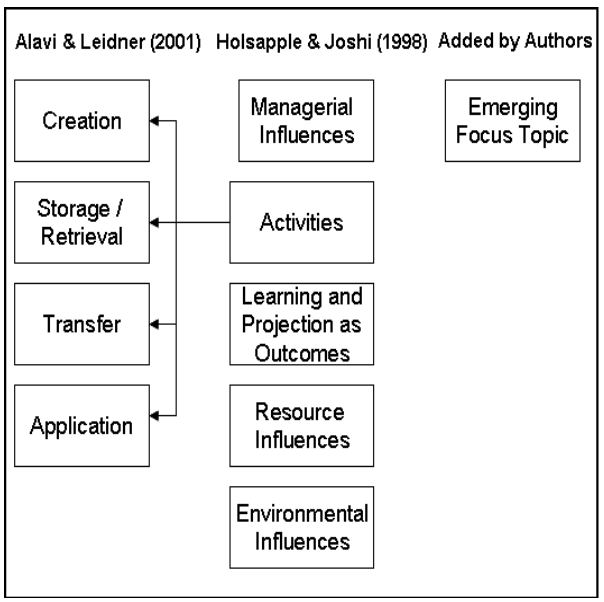
According to Holsapple and Joshi, *managerial influences* are influences that come from those employees within an organization who are in charge of KM functions [7].

Resource influences include the elements of knowledge resources, human resources, and material resources [7]. Each of these resources provides important capabilities for the conduct of KM.

Factors external to an organization that have a direct effect on how KM is conducted are *environmental influences* [7]. The six main factors that comprise *environmental influences* are: competition, fashion, markets, technology, time, and the GEPSE (governmental, economic, political, social, and educational) climate.

Activities are processes that people employ in the conduct of KM within an organization [7]. The four major activities which Holsapple and Joshi identify are acquiring, selecting, internalizing, and using knowledge.

Figure 1. KM topics framework



Learning occurs when an organization attempts to modify its human knowledge resources, and *Projection* is concerned with enhancing an organization's standing within its environment (e.g., its reputation/competencies in the market) [7].

Our challenge was to synthesize those KM topics into an overall framework. In an effort to capture possible *emerging topics* not addressed by the framework, we allowed a placeholder. The final framework is shown in Figure 1.

5. METHODOLOGY

This study used content analysis methodology based on Neuendorf's model [11]. Content analysis allows the researcher to utilize a step-by-step approach for assigning literature (in this case, KM) to a predetermined set of categories. The categories were provided by the model developed in the previous section.

A selection of articles from five KM-specific journals was examined for this study. Of the 469 articles included in these journals, 317 were deemed specifically relevant to this study. The methodology followed the steps highlighted below.

5.1. Theory and Rationale

This first step involved determining "what content will be examined and why." The literature review provided the information for the "what" and "why." The "what" in this review were the articles in the selected journals that reflect research in some aspect of KM. The "why" in this paper was a determination whether there exists a difference in the topic coverage in KM between the two sets of journals (leading IS journals and KM-specific journals).

5.2. Conceptualization

This step focuses on what variables are to be used in the study and their conceptual definitions. The conceptualizations were taken from the comparison work from Peachey et al. [14].

5.3. Operationalizations (Measures)

In order to answer the research question, this study first examined the articles in a manner similar to the study of the KM articles in the leading IS journals [14]. Each KM topic was considered to be an independent operational variable or measure. For an article to be coded in a specific category, specific research into the topic had to be present.

5.4. Coding Schemas

Human coders were used to conduct the research. A detailed code book and code form was created for use by the coders.

5.5. Sampling

The population of interest consisted of articles published in KM-specific journals. To determine what publications could be considered KM-specific journals and which of those journals should be used for the research, four distinct criteria were established. The first criterion was that the journal had to be currently in publication. This criterion did not preclude electronic journals as long as the respective websites were kept current. The second criterion was that KM-specific journals had to be peer-reviewed. The third criterion was that the journals had to specify KM as their primary focus area. The final criterion was that only journal articles published within the last five years, covering the period from January 1, 2000 to September 30, 2005, were coded.

Using these criteria, five KM-specific journals were identified: *Electronic Journal of Knowledge Management*, *Journal of Knowledge Management*, *Knowledge Management Research & Practice, Journal of Knowledge Management Practice* and *International Journal of Knowledge Management.* Due to the small number of journals, it was decided to use a census of the articles rather than sampling a subset.

5.6. Training the Coders

All coders had taken at least one graduate-level KM class and four were trained on coding in person. Each coder was given an eight page instruction sheet that provided detailed descriptions and specific examples of each topic. The fifth

coder was not trained in person but had participated in similar research and was aware of the definitions of the KM topics.

5.7. Coding

Each of the 317 articles was coded by the primary researcher and one of the other four coders, ensuring a minimum of two coders per article. Each coder, with the exception of the primary author, reviewed approximately 64 articles. The coders reviewed each article and scored it in a particular topic category.

5.8. Inter-Coder Reliability

Neuendorf recommends the use of raw percent agreement which she states is "the most popular coefficient in the business and the social and behavioral sciences" [11, p. 148]. However, we selected to employ a more rigorous measure, Krippendorff's alpha-reliability [10], in an effort to eliminate the effects of chance agreements between coders.

5.9. Tabulation and Reporting

For purposes of this research, simple descriptive frequency calculations were employed to answer the research questions.

6. ANALYSIS AND RESULTS

6.1. Reliability

Intercoder reliabilities were calculated for each measure on the criterion of *agreement*. Seven of the eight *percent agreement* (PA) scores across all coders were above .60, and varied from a low of .58 to a high of .77. In her discussion of acceptable levels of inter-coder reliabilities using the more liberal raw percent agreement index, Neuendorf states that coefficients of .90 or greater would be acceptable to all, .80 or greater would be accepted in most situations, while below that there is less agreement [11]. As our Krippendorff's alpha reliability index was more conservative in nature, we believe the reliabilities (.58 - .77) were acceptable for this study. Table 1 outlines these results.

6.2 Findings

The distribution of KM topics across the KM-specific journal articles is shown in Table 2. The body of literature does contain all of the KM topics identified in the KM topic framework developed for this study. Secondly, the body of literature for KM- specific journals reflects a wide dispersion of topics ranging from a low percentage of coverage for the *environmental influences* and *knowledge application* topics to a high percentage of coverage for the *knowledge transfer* topic. In addition, there was one new "emerging" topic discovered during analysis. The emerging topic of *knowledge mapping* was found to be discussed in six percent of the articles reviewed.

Table 1. Intercoder reliability

KM Topic	Overall
Creation	.67
Storage/ Retrieval	.68
Transfer	.58
Application	.73
Managerial Influences	.77
Learning/ Projection as Outcomes	.63
Environmental Influences	.74
Resource Influences	.65

Table 2. KM topic coverage in KM specific journals

Number of articles where topics were observed and the percent of the sample population		
KM Topic	**Num**	**%**
Creation	102	32
Storage and Retrieval	113	36
Transfer	217	68
Application	55	17
Managerial Influences	90	28
Learning/Projection as Outcomes	92	29
Environmental Influences	36	11
Resource Influences	151	48
Emerging KM Topic: Knowledge Mapping	20	6

RQ 1 was answered by tabulating the number of units (i.e., KM-specific journal articles)

that contained each variable (i.e., KM topic). These tabulated numbers were then divided by the total units included in the study. The resulting percentages showed the distribution of KM topics across the KM-specific journal articles.

RQ 2 was answered by comparing the distributions calculated for RQ 1 against the distributions identified by Peachey et al. 413] for the leading IS journals. Since this study included more KM topics than the Peachey study, only the similar categories (i.e., *knowledge creation*, *knowledge storage/retrieval*, *knowledge transfer*, and *knowledge application*) were compared. Additionally, since this research used a simple descriptive frequency calculation method vice the proportional calculation method used in the Peachey study, the data collected from RQ 1 was recalculated using the proportional calculation method to ensure proper comparison.

In this study, if the coder identified an article as addressing a topic, it was coded with a 1 so an article could have from 1 to n for a total score where n is the total number of KM topics addressed in the article. Peachey et al. [14] weighted the coding so that in an article that addressed one topic, the topic would receive a 1. If an article researched two topics, each topic would receive a .5, and so on. The difference between coding methods explains the difference between the percentages shown in Table 2 and those illustrated in Figure 2.

After performing the recalculations we compared the four KM topics side-by-side and determined whether the bodies of KM-specific journals' and the leading IS journals' literature are similar or dissimilar. Figure 2 shows a graphical representation of the results of the two studies.

The results from the comparison of the two distributions showed only small differences. To determine if the differences between groups were significant, we first used a Chi-square test to determine if the distributions as a whole were different. The result was a value of 7.53 with 3 degrees of freedom and was significant at $p=.056$. From this we can infer that there is a significant difference (at $p<.10$) between the populations.

Next we examined the topics between KM journals and IS journals. The proportions were tested for equality by testing if the null hypotheses that the proportion of topic (KM journals) = proportion of topic (IS journals). The topic application showed a significant difference. The topics of *creation, storage* and *retrieval* and *transfer* did not show significant differences. Table 3 shows these results.

Figure 2: Percent of topic areas appearing in KM and IS journals

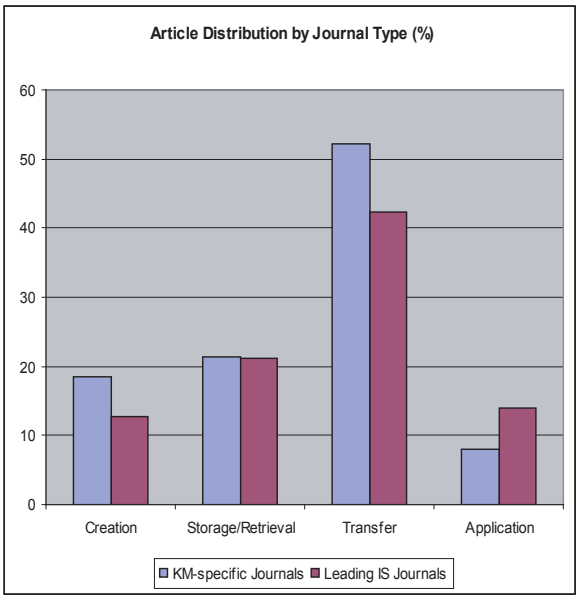


Table 3. Hypothesis tests of equality of topic coverage between KM and IS journals

KM Topic	P Value	Decision
Creation	.184	Do not reject
Storage and Retrieval	.642	Do not reject
Transfer	.316	Do not reject
Application	.04	Reject
Null Ho-Ha=0 and Alternative Ho-Ha≠0		

Table 4. Hypothesis tests of equality of topic coverage in KM Journals

	Storage and Retrieval	Transfer	Application
Creation	.744	**0.00**	**.03**
Storage and Retrieval	NA	**0.00**	**.013**
Transfer	**0.00**	NA	**0.00**
Application	**.013**	**0.00**	NA
Null Ho-Ha=0 and Alternative Ho-Ha≠0			

Lastly, we tested the proportions to determine if there were differences in the amount of coverage in KM journals between KM topics. Each set of proportions was tested to determine if they were the same, i.e. Ho=Ha. All the proportions were statistically different at $p<.05$ with the exception of the difference between the proportion of creation and the proportion storage and retrieval. Table 4 shows the P-values. Significant results are shown in bold.

6.3. Summary

An assessment of the coverage of KM topic areas in KM journals supported the finding that all pre-identified topic areas were covered in KM journals during the years 2000-2005. In addition, a new emerging topic area was identified*: knowledge mapping*. The highest percentage of coverage (68%) was for knowledge transfer, perhaps indicating the high interest in this topic by practitioners as well as researchers.

When the coverage of KM topic areas in KM journals was compared with the coverage in IS journals, a statistically significant difference was found in *application* (greater coverage in IS journals).

When comparing the topic areas from the Alavi and Leidner [1] framework in KM journals, there was a statistically significant difference between all combinations of topics with the exception of *creation* and *storage* and *retrieval*. *Transfer*, which received the most coverage, was followed by the pair of *creation* and *storage/retrieval*. *Application* received the least coverage in KM journals.

7. CONCLUSIONS AND RECOMMENDATIONS

The results from RQ 1 reveal that the body of KM literature in KM-specific journals reflects the KM topics in the KM framework. The fact that *knowledge transfer* was the most frequently identified topic area may well reflect the keen interest in knowledge transfer by many organizational practitioners of KM. However, as stated by Peachey et al., practitioners may find it hard to properly deploy effective KM systems if "the other [KM topics are not] more fully developed" [14]. Another possible explanation for the emphasis on transfer is that the topic may not yet be explored enough to locate other dimensions within the topic. Even though *knowledge transfer* did get significant coverage, discussion of the remaining KM topics was rather evenly distributed. A good example of this even distribution can be found in the KM topics of *knowledge creation (32%)*, *knowledge storage and retrieval (36%)*, *managerial influences (28%)*, *learning and projection as outcomes (29%)*, and *resource influences (48%)*. As for *environmental influences*, the low percentage of coverage (11%) may be indicative of the struggle to "identify and characterize them in a "comprehensive, unified, and organized way" [7, p. 242]. Another possible reason for the lack of coverage may be due to the internal focus many researchers and practitioners are applying to KM.

As for RQ 2, the comparison of KM coverage in KM and IS journals showed a difference in the proportion of articles that address *application* (greater in IS journals). This may be evidence that IS journals are more receptive to KM research that is "applied" with respect to how IS tools and/or theory is used in support of KM efforts.

It must also be noted that, during the process of this research, the KM topic of *knowledge mapping* was found to be discussed in six percent of the articles reviewed. Although other researchers have considered this activity as a subcomponent of broader activities such as knowledge storage [1] and knowledge codification [4], others are addressing it as a separate activity under the KM umbrella.

7.1. FUTURE RESEARCH

The field of KM is in its infancy, and is likely to reflect many changes over the coming years. New journals are coming on line, old ones are evolving their editorial interests, and new areas of investigation are likely to evolve as well. Our first recommendation for future research might involve a time series study that would capture these changes and help to elucidate the changing nature of the field. A second suggestion involves the large number of articles published that address issues in knowledge transfer. It is quite possible that examination of these articles may provide insight into further refinement of the topic.

8. REFERENCES

[1] Alavi, M. and Leidner D. "Review: Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues," *MIS Quarterly*, (25:1), March 2001, pp. 107-136.

[2] Bartczak, S. E. *Identiying Barriers to Knowledge Management in the United States Military*. PhD dissertation, Auburn University, Auburn, AL, 2002.

[3] Davenport, T.H. and Grover, V. "Guest editor's introduction Special Issue: Knowledge Management," *Journal of Management Information Systems,* (18:1), 2001, pp. 3-4.

[4] Davenport, T.H. and Prusak, L. *Working Knowledge*. Boston, MA: Harvard Business School Press, 1998.

[5] DeLong, D. and L. Fahey, "Diagnosing Cultural Barriers to Knowledge Management," *The Academy of Management Executive*, (14:7), 2000, pp. 3-4.

[6] Guo, Z. and Sheffield, J. (2006). A Paradigmatic and Methodological Examination of KM Research: 2000-2004, *Proceedings of the 39th Hawaii Conference on System Sciences, USA*.

[7] Holsapple, C. and Joshi, K.D. "An investigation of factors that influence the management of knowledge in organizations," *Journal of Strategic Information Systems*, (9:2-3)), 2000, pp. 235-261.

[8] Jennex, M.E.. "International Journal of Knowledge Management: Guidelines for Manuscript Submissions," *International Journal of Knowledge Management* (1:1), 2005.

[9] Jennex, M.E. and Croasdell, D. "Editorial Preface: Is Knowledge Management a Discipline?" *International Journal of Knowledge Management*, (1:1), 2005, pp. i-v.

[10] Krippendorf, K. *Content Analysis An Introduction to Its Methodology* (CommText Series). Thousand Oaks, CA, Sage Publications, 1980.

[11] Neuendorf, K.A. *The Content Analysis Guidebook*. Thousand Oaks, CA: Sage Publications, 2002.

[12] Nonaka, I. "A Dynamic Theory of Organizational Knowledge Creation," *Organization Science*, (5:1), February 1994, pp. 14-37.

[13] Nonaka, I., and Takeuchi, H. *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation*. New York, NY: Oxford University Press, 1995.

[14] Peachey, T., Hall, D., and Cegielski, C. "Knowledge Management and the Leading Information Systems Journals: An Analysis of Trends and Gaps in Published Research," *International Journal of Knowledge Management*, (1:3), 2005, pp. 55-69.

[15] Rubenstein-Montano, B., Liebowitz, J., Buchwalter, J., McGaw, D., Newman, B., and Rebeck, K., The Knowledge Management Methodology Team. "A Systems Thinking Framework for Knowledge Management," *Decision Support Systems*, (31:1), 2005, pp. 5-16.

[16] Schwartz, D. *The Encyclopedia of Knowledge Management*. Hershey PA, Idea Group 2006.

[17] Von Krogh, G. "Care in Knowledge Creation," *California Management Review*, (40:3), 1998, pp. 133-153.

On the Definition of Exception Handling Policies for Asynchronous Events in Workflow Processes

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ABSTRACT

Exception handling during the execution of workflow processes is a frequently addressed topic in the literature. One important class of exceptions is those that represent predictable deviations from the normal behavior of the process that can be anticipated at design time. Such 'expected' exceptions are often caused by the occurrence of external events that are asynchronous with respect to the process. The desired exception handling response to these events will often depend on the current state of process execution. One important aspect of this state is the relevant process instance's progress through the process model, which can be expressed in terms of the set of currently executing tasks. In this paper, we present a qualitative discussion on issues relevant to the definition of policies for handling asynchronous, expected exceptions. First, we highlight the requirement for workflow control data to be referenced in the policies if these exceptions are to be handled in a meaningful way. We then demonstrate that the definition of exception handling policies is not a trivial exercise in the context of complex processes, and discuss correctness criteria for these definitions. Finally, we outline a methodology for policy definition to ensure that the policy for each event is complete and consistent with respect to all possible states of process execution for the relevant process model.

INTRODUCTION

Workflow technology is ideal for supporting highly repetitive and predictable processes. However, many processes are faced with the need to deal with exceptional situations that may arise during their execution [4]. Workflows may be affected by different types of exceptions: *system* failures such as hardware and software crashes and *logical* failures or exceptions. Logical failures refer to application-specific exceptional events for which the control and data flow of a workflow is no longer adequate for the process instance [10]. Many logical failures may be *unexpected*, and these must be handled manually on an ad hoc basis by knowledge workers. However, many exceptions are *expected* – the inconsistencies between the business process in the real world and its corresponding workflow representation can be anticipated, even if they might not be frequent [6]. That is, workflows describe the 'normal behavior' of a process whereas expected exceptions model the 'occasional behavior'.

Expected exceptions can be *synchronous* with respect to the flow of work, but most often they are *asynchronous* – that is, they can be raised at an arbitrary stage of the process, potentially during a long-duration activity [6]. This asynchronicity makes it difficult to model exceptions with 'synchronous' constructs like tasks and flows, but since the exceptions are strongly associated with the application domain, they are part of the semantics of the process and so therefore should be incorporated within the process definition [4]. Cancellations of customer orders and car accidents during a rental process are examples of asynchronous events.

In some applications, there may be one standard desired response to the occurrence of such an exception event, regardless of the execution state of the relevant process instance. However, in most real world scenarios, reaction to the events will often depend on the state of the process instance in execution. While there are multiple aspects of the execution state of a process instance, we define 'state' as the 'stage of progression' of the process instance, as expressed through the set of currently executing tasks, for the purposes of this paper.

For example, consider a simple business process for processing customer orders consisting of sequential tasks *Receive Order*, *Approve*, *Pack*, *Dispatch*, and *Bill*. Suppose that the customer may cancel their order, provided that it is not ready for dispatch. Thus, the policy for this exception event consists of two rules: if the customer attempts to cancel the order after the pack activity is complete, the cancellation is to be rejected; and if the customer cancels their order before the pack activity is complete, compensation tasks are to be executed in order to perform a 'semantic undo' of the order.

The focus of this paper is on defining such policies for handling expected exceptions that are based on external events that occur asynchronously with respect to the process. Exceptional situations are usually very complicated [8] and we argue that it is easy to define policies that may produce unintended execution behavior. In the following sections, we present a brief introduction to the basic principles of workflow specification and execution, and then summarize the related work. We then describe the definition of exception handling policies, demonstrate the complexity in reasoning about policies defined over complex process models, and discuss relevant correctness issues. Finally, we outline a methodology for the definition of 'correct' policies with respect to all possible states of process execution. We conclude with an outlook for future research.

WORKFLOW SPECIFICATION AND EXECUTION

Before we can consider exception handling, let us first briefly summarize the basic principles of workflow specification and execution that are required for the subsequent discussion. Before a workflow process can be enacted, it must be specified. The process model describes the order of execution of tasks according to the business policies and resource/temporal constraints. Each task (or activity) is a logical unit of work within a process that may be either manual or automated but performed by a single workflow participant. In this paper, we will adopt graphical process modeling notation whereby rectangles represent forks and synchronizers (concurrent branching constructs) and ovals represent choices and merges (alternative branching constructs). A process *instance* is a particular occurrence of the process, for example, a particular order represents an instance of an order processing workflow.

A *workflow management system* (*WFMS*) is a system that completely defines, manages, and executes workflows. In this paper, we adopt the standard functionality for a WFMS, including states for activity execution, as presented in [14]. During process execution, the WFMS maintains internal *control data* that includes the internal state information associated with the various process and activity instances under execution. There are also two types of data that flows between activities. *Workflow application data* is manipulated directly by the invoked applications. *Workflow relevant data* (also known as '*case data*'), is the only type of application data accessible to the WFMS, and can be thought of as a set of global variables.

RELATED WORK

Exception handling is not a new concept, and has attracted considerable attention in the literature. Many approaches for flexible process enforcement have been proposed. The first approach is to encode the entire workflow process through a set of rules, thereby ensuring complete flexibility. For example [3] and [7] present approaches where the process is described through a set of *Event-Condition-Ac-*

tion (ECA) rules (c.f. [13]). However, while processes encoded through rules enable all predefined behavior to be enforced, it is well known that large sets of rules can interact in unknown ways (e.g. [13]). The importance of verification of the process model before deployment has been emphasized in [12]. Representing the entire process through sets of rules also makes it difficult to visualize the process, which is a drawback when it comes to validation and maintenance. Ultimately, since the process is validated and maintained by business domain experts, the process should be specified in an intuitive way. Therefore, as much of the process logic as possible should be represented in the graphical process model – that is, the entire core process, at a minimum, and ideally the exception handling functionality too.

As already noted, this paper primarily addresses the issue of policy definition for handling expected exceptions that are based on external events that occur asynchronously with respect to the process. (Readers are referred to [9] for a framework to support ad hoc interventions when dealing with unexpected exceptions.) Essentially, there are two approaches for incorporating exceptional cases into a process model – 'exception rules' and 'exception workflows' [11]. The first approach is to implement exceptions through an explicit exception rule base [11]. Each exception is modeled by an ECA rule, where the event describes the occurrence of a potentially exceptional situation, the condition verifies that the occurred event actually corresponds to an exception that must be managed, and the action reacts to the exception [4]. A different approach is presented in [10] where the core process is dynamically modified at run-time based on a set of rules – when exceptional events occur during process execution, the AgentWork system identifies the workflow instances to be adapted, determines the change operations to be applied, and automatically performs the change for those instances.

Alternatively, exceptions can be modeled as workflow processes themselves [11]. This approach is taken in [2], which introduces the notion of Worklets, which are 'an extensible repertoire of self-contained sub-processes and associated selection and exception handling rules'. Choosing the most applicable worklet to execute in response to a particular exception is achieved by evaluating conditions that are associated with each worklet. These conditions are defined using a combination of current data attribute values and the current state of each of the worklets that comprise the process instance. It is noted that the set of states for a worklet-enabled process may be deduced by mining the process log file (c.f. [1]) but that full exploration of the specification of such conditions is yet to be completed.

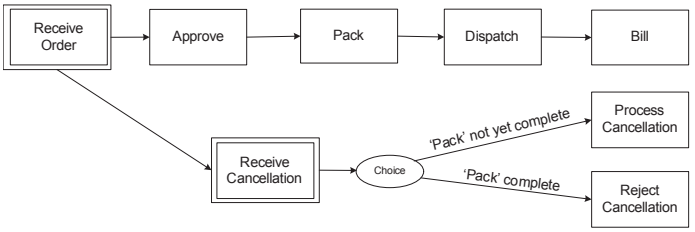
Another approach is to consider the exception handling processes as sub-processes within the core process. In the 'event node approach' discussed in [4], the workflow model includes a particular type of node, called an event node, which is able to observe asynchronous events and to activate its successor in the workflow graph when the event is detected. However, once again, it was noted that upon observation of an event, conditions 'can be used to select, among several exception management alternatives, the most adequate to deal with the current workflow state' [5], and to our knowledge, this issue has not yet been addressed in the literature. The definition of such conditions is the focus of this work.

EXCEPTION HANDLING POLICIES

An *Exception Handling Policy* ('*policy*') can be thought of as a set of ECA rules whereby for each such '*policy rule'* (*PR*), the *Action* is a sub-process ('exception handling fragment' in [6]) that is to be performed on observation of an *Event*, if the process execution state satisfies a particular *Condition*. The process execution state could involve many elements such as resource information and case data values, but for the purposes of this paper, we assume that the 'state' is described only through the set of currently executing tasks. The action may or may not involve terminating currently active tasks for that process instance, as dictated by the business requirements. The impact of the exception on the core process comprises the 'resolution' phase of the exception handling procedure, and while we acknowledge the importance of this phase, we focus our attention on the 'detection' and 'diagnosis' phases only in this paper (c.f. [11]).

While such policies could be defined and enforced through a set of rules, we emphasize that the underlying principles are the same if the exception handling is incorporated into the process model. We will adopt the event node approach for this discussion but it should be noted that these observations are generic and therefore applicable even if a worklet-style approach is adopted. For the sake of illustration, we distinguish a type of activity that assists with process coordination, called an *event listener*, which corresponds with the notion of an event node described in [4]. An event listener is an automated task that automatically completes on detection of a specific event. We emphasize the special role of these tasks in graphical process models by differentiating them with a two-line boundary. Event listeners allow the WFMS to observe relevant events asynchronously from the standard process in execution, enabling an immediate reaction to the event occurrence (following completion of the event listener task). This approach is also attractive because the exception handling functionality is incorporated into the process model but, due to the modular nature of the model, it is trivial to construct a view of the core process (or isolate a particular exception) for visualization purposes. It is also very extensible because the core process does not have to be modified. The example order process, incorporating the exception policy described earlier, is depicted in Figure 1. Observe the different process behavior on observation of the cancellation event according to the current state of the process instance.

Figure 1. Example scenario: Cancellation of customer order



Some of this exception handling process logic can be captured in the process model through the position of the event listeners – they can be placed at appropriate points such that if the event occurs before then, it is not observed by the process instance and therefore no action is taken. However, it will be usually be the case that a decision is (also) required to be made about how to handle the exception based on the workflow control data after it has occurred. To achieve this functionality (using standard modeling constructs, at least), a choice is required to be placed in the process model after the event listener activity to enforce the different PRs, where the choice conditions describe the status of the underlying process instance.

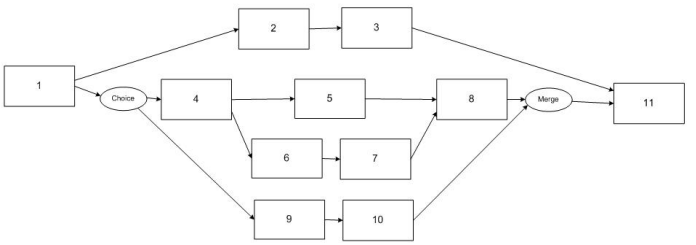
Generally, the conditions for choice constructs in a workflow process are based on case data that is generated during the activities that comprise the process (for example, an insurance application might undertake different treatment depending on whether it has been approved, with this decision being made during the execution of an activity). However, in order to enforce exception handling policies, workflow control data must also be referenced in the choice conditions. As already noted, this is a different type of data, maintained in the workflow log. From a specification point of view, there is no requirement that the choice conditions be defined on workflow relevant data only. We note that this reference to control data may impact on the underlying data model and system design, but we assume that such issues are resolved for the purposes of this paper.

CORRECTNESS ISSUES AND POLICY DEFINITION METHODOLOGY

We now consider the issue of correctness of exception handling policies. Note that we refer here to structural correctness rather than semantic correctness (that is, 'verification' rather than 'validation') since semantic validation depends on the particular application domain and so cannot be automated. We argue that there are two primary correctness criteria for exception handling policies – consistency and completeness. *Consistency* implies that no states have multiple actions defined for them, and *completeness* implies that there is an action defined for every possible execution state. If the exception handling behavior is incorporated into the process model then the choice conditions to be evaluated following the event listener must be mutually exclusive and collectively exhaustive, respectively, to satisfy these properties.

In graphical process models with no branches in the core process, each process instance is executing exactly one task at any point in time, and so these conditions are relatively simple to specify and verify. However, when concurrent branches are introduced into the process model, each process instance may be executing multiple activities at any point in time, and all combinations of these activities must be considered when defining policies. For example, for the process model

Figure 2. Example process model for discussion



depicted in Figure 2, the possible states are: *(1), (2, 4), (3, 4), (2, 5, 6), (2, 5, 7), (2, 8), (3, 5, 6), (3, 5, 7), (3, 8), (2, 9), (2, 10), (3, 9), (3, 10)* and *(11)*.

In general, it is difficult to reason about the correctness of policies when the process contains a large number of activities and choice/split structures. Since a thorough consideration of all possible states for a process instance is a complex task, it is therefore plausible and perhaps even likely that process designers may inadvertently omit one or more states when defining policies. For example, if one PR deals with the case where an event is observed 'before' reaching state *(3, 5, 6)* and another PR deals with the case where an event is observed 'during or after' reaching that state, the required behavior for the case where the instance state is *(2, 5, 6)* is not defined, and so the policy definition is not complete. Note that the intention during specification *may* be that no reaction is required in this case, but a case could be made for requiring the definition of a PR for all such states with a corresponding action of 'No Action', in order to make it explicit that all states were indeed considered during the definition of the policy but that exception handling behavior is not required in particular situations. This requirement for completeness would help to ensure that the exception handling policies are an accurate and complete source of 'process knowledge', making it easier to understand, verify and ultimately maintain the policies.

The consistency of the policy should also be checked to ensure that if an exception event is observed, there is only one possible way of handling the exception. As for completeness, this property is not trivial to check in policies defined on complex processes. For example, a policy that is defined such that an action is performed if an event is observed 'after' state *(2, 4)* and another is performed if an event is observed 'during or before' *(3, 5, 7)* is inconsistent because there is a conflict for state *(3, 5, 6)* – both policies apply in this case, which may or may not have been intended.

In addition to being *complete* and *consistent*, PRs should be defined only for *valid states* of the process instance, otherwise the policy will be unnecessarily complicated with 'noise'. This 'simplicity' can be considered a secondary correctness criterion for exception handling policies. For example, the specification of a PR for *(2, 4, 9)* is also erroneous since this combination of activities is not a valid state due to the choice construct in the process model.

We argue that tools should be provided to either prevent errors from being introduced in the first place or to detect errors in the model before deployment, just as for the specification of the core process model. In the remainder of this section, we briefly propose a systematic method for the specification of policies in line with the former approach.

First, all tasks are assigned unique identifiers, and all instance sub-graphs are generated (c.f. [12]). The set of all possible states is then generated for each instance type, and the union of the sets is the set of possible states for the process model. Clearly, the set of states could be large – the cardinality is dependent on the number of forks in the model, branches for each fork, and activities on each branch. However, all cases must be considered in order to prevent erroneous policies being defined. Also, since this set is a feature of the process model, it can be reused to define policies for an arbitrary number of events, once it has been generated.

The set of states is then partitioned for each policy, with one PR (and action) per partition. We call the set of states in each partition the *scope* of a PR – that is, the set of states of execution for which the action associated with the PR is relevant. Thus, each PR has an event to be observed, a scope, and an action to be performed if the execution state at the time of event occurrence is contained within the set of states comprising the scope.

Once the policies have been defined, the method for enforcing them clearly depends on the exception handling approach that is adopted. However, if only event listeners and other standard workflow modeling constructs are employed, the event listener is immediately followed by a choice construct in the process model, and the scope of the policy corresponds to the choice construct condition that must be satisfied for the relevant sub-process to be executed. That is, each state corresponds to a logical disjunct in the choice condition that must be satisfied for the action associated with the policy to be performed. Upon observation of the event (and completion of the event listener activity), the condition expressions are evaluated using the current control data for the instance. In order to ensure completeness and consistency of the policy definition, every state must be a disjunct of exactly one condition for each exception event. The condition on one of the alternative branches will always be satisfied and the action (sub-process) associated with the relevant policy is then performed.

CONCLUSIONS AND FUTURE WORK

Although workflow exceptions occur infrequently, their handling should be automated whenever possible. In this paper, we discuss the definition of policies to handle expected, asynchronous exception events. The desired reaction in response to these events will often depend on the current state of process execution, and we argue that the definition of exception handling policies for complex processes is a challenging exercise. We have introduced correctness criteria for such policies and outlined a methodology for policy definition to ensure that the policy for each exception event is correct with respect to all possible states of process execution.

In our future work, we will develop a methodology for the automated verification of exception handling policies for any arbitrarily complex workflow model. We will also relax the restriction that state is described only through process instance position (currently executing tasks) and consider case data and other types of workflow control data in policy definition and subsequent verification. Finally, we will consider the development of a software tool to assist with the specification and verification of exception handling policies.

REFERENCES

[1] van der Aalst, W.M.P., van Dongen, B.F., Herbst, J., Maruster, L., Schimm, G. and Weijters, A.J.M.M. (2003) Workflow mining: A survey of issues and approaches. *Data and Knowledge Engineering*, 47(2): 237-267.

[2] Adams, M., ter Hofstede, A. H. M., Edmond, D. and van der Aalst, W.M.P. (2005) Facilitating Flexibility and Dynamic Exception Handling in Workflows through Worklets. *Proc. 17th Conference on Advanced Information Systems Engineering (CAiSE05) Forum*, June 2005, Porto, Portugal.

[3] Bae, J., Bae, H., Kang, S.-H. Kim, Y. (2004) Automatic Control of Workflow Processes Using ECA Rules. *IEEE Transactions on Knowledge and Data Engineering*. Vol 16, No 8.

[4] Casati, F. (1999) A discussion on approaches to handling exceptions in workflows. *SIGGROUP Bull.* 20, 3, 3-4.

[5] Casati, F., Ceri, S., Paraboschi, S., and Pozzi, G. (1999) Specification and implementation of exceptions in workflow management systems, *ACM Transactions on Database Systems (TODS)* 24: 405–451.

[6] Casati, F., Pozzi, G. (1999) Modeling Exception Behaviors in Commercial Workflow Management Systems. *Proc. Fourth IFCIS International Conference on Cooperative Information Systems (CoopIS'99).* Edinburgh, Scotland.

[7] Kappel, G., Rausch-Schott, S., and Retschitzegger, W. (1997) Coordination in Workflow Management Systems - A Rule-Based Approach. In: *Coordination Technology for Collaborative Applications - Organizations, Processes, and Agents*. LNCS, vol. 1364. Springer-Verlag, London, pp. 99-120.

[8] Luo, Z., Sheth, A., Kochut, K., and Miller, J. (2000) Exception handling in workflow systems. *Applied Intelligence*, Volume 13, Number 2, pp. 125-147.

[9] Mourão, H., Antunes, P. (2004) Exception Handling Through a Workflow. *Proc. 12th International Conference on Cooperative Information Systems (CoopIS'04)*: 37-54

[10] Müller, R., Greiner, U., & Rahm, E. (2004). AgentWork: A Workflow-System Supporting Rule-Based Workflow Adaptation, *Data and Knowledge Engineering*, vol. 51, no. 2.

[11] Sadiq, S. and Orlowska, M.E. (2000a) On Capturing Exceptions in Workflow Process Models. *Proc. 4th International Conference on Business Information Systems*. Poznan, Poland.
[12] Sadiq, W. and Orlowska, M.E. (2000b) Analyzing Process Models using Graph Reduction Techniques. *Information Systems*, vol. 25, no. 2, pp. 117-134. Elsevier Science.
[13] Widom, J. and Ceri, S. (1996) Active Database Systems. Morgan Kaufmann Publishers.
[14] Workflow Management Coalition. (1995) *The Workflow Reference Model*, Document Number TC00-1003, Issue 1.1.

The Likelihood of RFID (Radio Frequency Identification) Technology Initiation: The Exploratory Examination

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ABSTRACT

Firms believe that new technologies can change the way we do business similar to the way the Internet has changed commerce. Today, an emerging technology so called RFID (Radio Frequency Identification) would change the way of current business processes between firms and suppliers and customers. This study focuses on contextual variables such as environmental, organizational, and technological dimensions as major determinants of RFID investment intention and moderator effect such as trust and power with partners in the context of supply-wide. Survey was resulted in 250 out of the 90 firms which RFID is already either implemented or is willing to adopt. Uncertainty, organizational size, top management support, IT infrastructure, and tag compatibility influence positively the likelihood of RFID project initiation. In turn, while trust of trading partners moderate between competitor's competition, top management support and the likelihood of RFID project initiation, whereas power of trading partners moderate the relationship between uncertainty, size, top management support and the likelihood of RFID project initiation.

Keywords: IT investment, IT infrastructure, Radio Frequency Identification Systems (RFID), Adoption.

1. INTRODUCTION

During the last decade, the large potential impact of the Internet in firms, especially, supply chain management, was timely important and indispensable in the digital economy (Swaminathan and Tayur, 2003). Collaboration by supply chain partners over Internet can potentially save $223 billion with the reduction in transaction, production, and inventory costs (Keenan and Ante, 2002). Even though many companies adopted the new supply chain systems, each functional department of those companies still requires manual works to initialize or finalize their processes, i.e., for example, manual data entry, manual scanning barcodes, unorganized information results. It implies that firms still require huge intervention of human labor forces to create valuable information; meanwhile, it happens possibly inaccurate data or information from the semi-automatic processes (Scharfeld, 2001).

To solve this problem, a new technology introduced in industries called Radio Frequency Identification (RFID) technology, which stands for a technology that involves tags that emit radio signals and devices called readers that pick up the signal (www.epcglobalinc.org) is going to be a $3 billion market within five years as this sophisticated tracking technology gradually begins replacing its cheaper but still less powerful than the bar code system (http://en.wikipedia.org/wiki/RFID). IDC reported that the investment of RFID has already carried $91.5 million until 2003 and expect the investment to increase $1.3 billion until 2008, and record the annual growth of 70%. Firms expect that the RFID systems will significantly accelerate supply chain productivity, performance and effectiveness throughout and across trading partners (Gramling et al. 2003). In order to start RFID project, firms have to perceive the internal facilitators or barriers as well as supplier relationship. As the previous collaborating systems (i.e., Electronic Data Interchange: EDI) reflected (Son et al., 2005), the role of trading partners' trust and power in collaborating systems make a different result.

Although IT adoption has been researched in various areas, it still remains to the most emerging technology such as RFID for business and supplier relations. With the emergence of RFID, many believed that firm would wary the effect of the significance. However, a few large firms are looking for a better solution for their organizational processes to exchange their information. Numerous studies via EDI, Internet, SCM, or interorganizational value-added network systems have found the effects of adoption and use, organizations are still willing to replace their existing systems with RFID systems for various reasons. Most importantly, RFID reduce considerably human intervention during the operational transactions.

The goal of this study therefore identifies the determinant for the RFID technology and system from a firm itself and shows particularly the trading partner's considerations. Surprisingly, empirical research on RFID adoption in organization has not found positive evidence insofar but also little known about the RFID adoption with partners. We address our research questions in our paper: What are the determinants of RFID project initiation on the firm level? How partners' trust and power moderates between the determinant and RFID project initiation? We explore the determinants and moderators of RFID, offer a conceptual model, and examine the relationship between identified factors and the likelihood of RFID project and trading partners' trust and power effect. We provide literature review in section 2, research model and hypotheses in section 3, research methodology, results, and discussion in section 4, conclusions, implications, and limitation in section 5.

2. LITERATURE REVIEW

2.1 RFID Technology/Systems

Like a bar code, a Radio Frequency tag is a data carrier. While a bar code carries data in a visible symbol and is read at optical or infrared wavelengths, and RFID device (or tag) carries data programmed into a chip and operates at radio frequencies, typically 125 KHz, 13.56 MHz, 2.45GHz and around 900MHz (AIM Inc WP-98/002R2). RFID systems have two different devices, which is actively transmitted called transponder; on the other hand, tags not actively transmit signals to a reader. Radio frequency in reader detects a tag at a remote distance without a necessity of any line, for example, a car that has an authorized tag can pass the entrance parking lot simply. RFID tags have specific data related to the identification of an object. Company will identify the tag attached on an object when a sale occurs, and then the tag will be deactivated after a consumer takes it out. RFID tags consist of a semiconductor chip with memory processing capability and a transmitter connected to an antenna. The tags have a different kind of memory type such as read only, write once, read repeatedly, or write and read together. Furthermore, recent tags have not a chip-called 'chipless tags' instead, these tags have a limitation of data storage, range and data transfer compared with chip-based tags. RFID tags can be divided into chip-based tags and chipless tags. RFID tags will be used mainly for payments, identification, information collecting or a

combination of the above (Intermec, 2003). The reader comprises an antenna and a controller. The controller codes, decodes, checks and stores the data, manages communications with the tags and communicates with the management system. Reader only reads data from the tags whereas an 'interrogator' reads data from the tags and writes data to them. The management system of RFID is the nerve centre for the application and forms part of the FRID user's information technology system. It is responsible for using the data received from and sent to the RFID tags for logistics and commercial management. Readers are also capable of reading all or only relevant parts of the data depending on how the system is programmed (AIM Inc, 2000).

2.2 Innovation and Adoption

Many innovation studies have researched in conceptual issue articles (Downs and Mohr, 1976; Ven de Ven, 1986) as well as empirical studies such as between innovation and performance (Damanpour and Evan, 1984), categorize types of innovations (Damanpour, 1987), and determinants and moderators of innovation (Damanpour, 1991). Damanpour (1991) explains the adoption of innovation that is the generation, development, and implementations of new ideas including a new product or service, a new production process technology, a new structure or administrative systems, a new plan & policy, program etc. Thong notes the Rogers(1983)'s definition of an innovation as "an idea, practice, or object that is perceived as new by an individual or other unit of adoption (p.190)'. Innovation occurs when a new idea is exercised and used across each employees or individuals (Damanpour, 1984), which is caused by not only firms' internal interest but also environmental factors (Damanpour and Evan, 1984), and which is the level of economic and social use of product and process consisting with needs and wants (Utterback, 1971). Innovation theory encompasses adoption, diffusion, and implementation of firms, which look for a better organizational efficiency and effectiveness (Damanpour, 1991). Innovation is a way of method to change organization, which is categorized as major three dimensions: administrative and technical, product and process, and radical and incremental (Damanpour, 1991). Administrative innovation refers to the wide range of changes in administrative core such as organizational structure, administrative processes, and management whereas technical innovation entails products, services, and production process technology that are primarily work activities in organization. Secondly, process innovation, which it improves production process through the new method, machines, or production systems. IS adoption may be included in this category, whereas, production innovation, which it introduces a new product, goods, or service to consumers. Finally, innovation can be realized radically (shock or big bang) or incrementally (gradually or phased approach). The adoption of IT is closely related to technical innovation and process innovation that can bring changes of organization processes or procedures.

Damanpour (1991) introduced 13 organizational determinants of innovation: specialization, functional differentiation, professionalism, formalization, centralization, managerial attitude toward change, managerial tenure, technical knowledge resources, administrative intensity, slack resources, external communication, internal communication, vertical differentiation. Premkumar et al (1994) reveal the most frequent cited factors of innovation such as compatibility, relative advantage, complexity, cost, communicability, divisibility, profitability, social approval, trialability, and observability. Ramamurthy and Premkumar (1995) categorize three dimensional determinant for IT diffusion: innovation factors (compatibility, complexity, cost-effectiveness, relative advantage), organizational factors (top management support, task scope, IS sophistication, championing), organizational learning (elapsed time after IS adoption). Tornatzky and Fleishcer (1990) have provided a considerable underlying dimension of determinant of innovation such as the context of environment, organization, and technology. Their theoretical framework provides a parsimonious view of determinant toward innovation; therefore, many IT researchers have applied their research framework into different type of applications in the various context (Chau and Tam, 1997; Chengalur-Smith and Duchessi, 1999; Chwelos et al., 2001; Forman, 2005; Grover and Goslar, 1993; Iacovou et al., 1995; Khoumbati et al., 2006; Premkumar, Ramamurthy, and Nilakanta, 1994; Rai et al., 1997; Thong, 1999; Zhu and Kreamer, 2005).

Environmental dimension: In early work of innovation, the environment conditions affect a firm to implement or adopt innovation (Mansfield et al. 1977; Utterback, 1971). Specifically, uncertainty in the competitive environment has received considerable attentions in the strategy literature. Milliken (1987) explains that the uncertainty is caused by the lack of information and the perceived inability toward prediction. Perceptions of environmental uncertainty occur when executives are unable to predict future changes in components of the environment or possess an incomplete understanding of the relationships among components of the environment. Much of the theoretical and empirical work on uncertainty has focused on perceptions of uncertainty in the firm's industrial environment (Tosi and Slocum, 1984). Environmental conditions in market are changing constantly through competition. Competitor is a major facilitator to enable a firm to think other strategic options (for example, IT investment) (Kim and Sanders, 2002). The competitor reactions or counter reactions on IT investments may affect the revenue or cost of a firm structure in a long-term base and can justify an IT investment decision making (Garud et al., 1998). In terms of bandwagon effect, bandwagons are not because of its innovation's benefit itself but because of pressure from other firms that have already adopted the innovation (Abrahamson and Rosenkorf, 1993). Abrahamson and Rosenkorf (1993) argued that technological, administrative, or strategic innovation would be adopted with bandwagon way if a firm feels losing competitiveness against competitors. Thus, competitors' pressures a firm to adopt an innovation as good as uncertainty in environmental conditions.

Organizational dimension: Ein-Dor and Segev (1982) introduced ten organizational context variables related to the success of MIS. These variables include organizational maturity, organizational size, organizational structure, organizational time frame, the organizational physiological climate toward MIS, the extra-organizational situation, organizational resources, rank and location of the responsible executive, and the steering committee. Among the ten organizational contexts, they stressed that size is recognized as an important determinant of organizational MIS structure both directly and indirectly. They measures organizational size as three measures: size relative to the relevant industry, number or employees, and total sales. Organizational size is traditionally the most critical factor to management literature (Dewar and Dutton, 1986; Moch and Morse, 1977). However, organizational size also has some controversial points that affect positively or negatively on innovation. Damanpour (1989; 1991) found that there is a positive relationship between organizational size and innovation, however, oppositely, large organization is usually more complex and slow, which make a firm to adapt to change hard and lead implementation slowly (Baker and Cullen, 1993). Many researchers have explained the reason of positive effect as following: economies of scale (Kimberly and Evanisko, 1981), slack resources (Eveland and Tornatzky, 1990), accessible outside resources (Attewell, 1992), and the dependable adoption risks (Hannan and McDowell, 1984), decision agility and prior technology experience (Zhu and Kreamer, 2005). In addition, management in organizational aspect is a critical factor as well. Empirical researches found that top management support has positively associated with IT implementation, success, effectiveness, and diffusion (Ramamurthy and Premkumar, 1995; Thong et al., 1996). Favorable attitude of top management toward innovation affect organizational climate and lead member's behavioral change, since top management has broad view of IT and responsibility of IT strategy, planning objectives, policies, and funding (Thong et al., 1996).

Technological dimension: Bharadwaj (2000) claims that the importance of IT capability of a firm and a firm's IT infrastructure that composes of computer and communication technologies and the shareable technical platforms and databases. In this age, as firms' IT infrastructure span not only entire organizations but also link key supplier and customers in helping its cross-functional processes and cross-selling opportunities. Developing a RFID system may require the current IT infrastructure including enterprise database, network, and operation system would combine seamlessly for the data flow from one application to another and from one part of an organization to another. Taniverdi (2005) asserts standardized IT infrastructure enable firms to span their business processes and provide information and knowledge exchange. Another important factor in technology dimension, current systems VS. New systems should be compatible. Compatibility is conceptualized as consistent existing practices, values, past experience or norms with a new adopting of innovation (Forman, 2005). IT comprises several aspects concerning the compatibility, which should fit with the legacy system, other organizational systems or new one such as hardware, software, and infrastructure, for example, integration of data from different database systems of other organizations, or between interorganizational systems (Ein-Dor and Segev, 1982). Researchers have claimed that those three dimensions (environment, organization, technology) have been consistently found to be important.

3. RESEARCH MODEL AND HYPOTHESES

Based on the literature, we suggest the likelihood RFID project initiation model shown in Figure 1. In this model, we conceptualized as consisting of environmental, organizational, and technological dimensions toward the initiation of RFID project directly and moderating effect of trust and power between firms and trading partners for the initiation of RFID project. Accordingly, we develop and test, firstly, determinants and dependents hypotheses representing: (H1, H2, H3) and, secondly, moderating effects on between the determinants and the likelihood of RFID project initiation representing: (H4, H5).

3.1 Environment

Environmental dimension are categorized as uncertainty and competitors (Miller and Droge, 1986). Uncertainty in this study is defined as the inability to predict product and service from changes in market. As the variety of products and services offer in market, firms are hard to predict market conditions. In addition, depending on the number of competitors and action of competitors, firms tend to pursue strategic options to cope with market conditions (Kim and Saunders, 2002). Concerning the environmental factors with IT&S innovative adoptions, there still be arguments on either a positive impact or not. Grover and Goslar (1993) found significant relationships between environmental uncertainty and the usage of these technologies, vice versa, others who applied the environmental factors in their open system adoption (Chau and Tam, 1997) and CASE tool adoption (Rai and Patnayakuni. 1996) did not find the significance or negative between the market uncertainty and adoption. The findings may be resulted in differently depending on the context, type of applications. The environmental issues including uncertainty and competitors are importantly related to RFID adoption whether firm are willing to invest to preempt the RFID future market such as Wal-Mart or slow because of environment uncertainty. Thus, we suggest the following hypotheses:

H1-1: The relationship between environment uncertainty and the likelihood of RFID project initiation has significantly associated.

H1-2: The relationship between competitor's action and the likelihood of RFID project initiation has significantly associated.

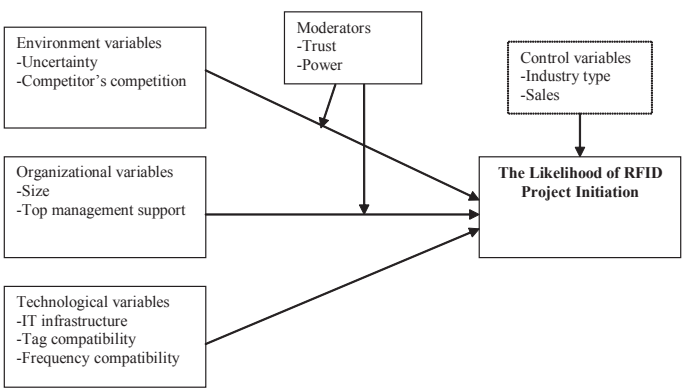
3.2 Organization

Ein-Dor and Segev (1982) posited that organization's size tend to affect organization context. They provide validity of measurement by the number of employees. Organizational size was found as strong determinant of innovation (Damanpour, 1989; 1991). Also, many empirical findings have shown the positive relationship with IT adoption ( ). In terms of RFID, many large firms such as Wal-Mart, Target, and DOD have interested in replacing Bar code systems as RFID as a strategic option. In addition, Damanpour (1991) posits that administrative intensity is one of critical determinant for innovation. Successful adoption of innovation always depends on largely on leadership, support, and coordination of manager. IT innovations always cope with risks of failure caused by the lack of financial support (Ramamurthy and Premkumar, 1995), therefore top management support is essential. In empirical research, top management support has positively associate with adoption, and diffusion (Ramamurthy and Premkumar, 1995, Thong et al., 1996; Wang et al., 2006). Given the potential of RFID to influence the firm's strategic interest and internal operational efficiency as well as its trading partner's relationships, top management will be strongly involvement necessary, need a strong support for initiating RFID project. Hence, we propose:

H2-1: The relationship between organizational size and the likelihood of RFID project initiation has significantly associated.

H2-2: The relationship between top management support and the likelihood of RFID project initiation has significantly associated.

Figure 1. The likelihood of RFID project initiation model



3.3 Technology

IS research has posited that IT infrastructure, IT maturity, and IS sophistication such as IT resource, skill, and expertise is positively associated with IT success, adoption, diffusion, and performance (Grover and Goslar, 1993; Ramamurthy and Premkumar, 1995, Tippins and Sohi, 2003; Taniverdi, 2005). Zhu and Kreamer (2005) show that EDI and Electronic Fund Transfer infrastructure make a firm easy to do Internet business. RFID is essentially necessary from the current IT infrastructure support so that data transactions can be seamlessly overall internal organization as well as external trading partners. In addition, IT compatibility refers to the degree of consistency with the existing legacy systems, procedures, and new systems (Forman, 2005). The more IT innovation compatibility exists, the more likely firms will adopt the new systems (Premkumar et al., 1994). Current state of RFID has lack of standards, which various applications and industries not only pursue different vendors' competing frequencies and protocol but also not even exist yet open systems (AIM inc, 2001). The key components of an RFID system are tag (Asif, 2005) and frequency (AIM Inc, 2001). Choice of tag and frequency wave is also primary importance in determining data transfer rates (AIM Inc, 2001). Thus, type of tag and frequency compatibility would be primary concerns for firms that are likely to adopt the RFID. Here, we propose the following hypotheses:

H3-1: The relationship between IT infrastructure and the likelihood of RFID project initiation has significantly associated.

H3-2: The relationship between types of RFID tag and the likelihood of RFID project initiation has significantly associated.

H3-3: The relationship between types of RFID frequency and the likelihood of RFID project initiation has significantly associated.

3.4 Moderator Effects

Some studies have shown evidence of a positive relationship between trust and power and EDI use and adoption (Hart and Saunders 1997;1998; Son et al., 2005). However, these findings have not discussed major determinants of innovation in theoretical basis that might affect innovation. We assume that the possibility of a moderating effect that affects the effectiveness of innovation adoption and use is consistent with traditional variables for the innovation theory. On the basis of Hart and Saunders (1997)'s study, we induce trust and power possible moderator effects of major innovation determinants on IT adoption. We will examine that trust and power could affect the relationship environmental and organizational dimensions and IT adoption. If these moderating effects exist, firms should focus on possible considerations for the adoption through adjusting the degree of trust and power with trading partners. For example, a new technology in the early stages of a market is influenced by uncertainty as well as by competitors' behavior. Also, it is important to remember that organizational factors are important element of innovation and thus both organizational size and its management support would be crucial to strengthen or weaken the relationship of determinant and IT adoption.

Trust: Hart and Saunders (1997) posit that trust is vital factor in interorganizational relationship. Its trustful relationship facilitate firms to invest their shareable resources rather that behave opportunistic action among other alternatives. Trust explained by Hart and Saunders (1997) is "the behavior of another will confirm to one's expectation and goodwill of another" (p.24) without exploring vulnerability. In terms of firm's trust, which one firms can make another firm perform better and would not make negative result for the firm (Son et al., 2005). Trust may not be build by artificial relation or just long-term trading but "fair dealing" between buyer and supplier in a reciprocal transaction (Hart and Saunders, 1997). In terms of IT systems, IT encourages firms to share information with their partners. Once firms and their partners make a co-investment on IT, its benefit arises from not just coordination but the reduction of uncertainty for the future. Son et al (2005) stress that reciprocal investment draws one party desires to stay relationship firmly into the future. To improve their collaboration through IT, firms first build trustful relationships with their partners. The collaboration based IT and trust enables the

firms to span their business processes and enrich their information sharing with partners. Thus, trust makes a strong relationship to bring co-IT investment and sharing assets and accomplish their strategic and operational outcomes through IT. RFID also needs to share information with between buyer and supplier more enhanced method, even individual customers. The main benefits of RFID exists transaction with suppliers and buyers having accurate information, visible stock data, physical inventory counts such as receiving, picking and shipping, and so on. To achieve this objective, firms need to build RFID into the entire supply chain of transaction and planning systems—of its own plans as well as those of its suppliers and customers. It is strongly necessary of firms to share RFID project plan based on partner's trust. Recently, Zhu et al (2006) study that a moderating variable affects between independent variables and dependent variable, which they incorporate a firm's prior experience of EDI the relationship between the adoption costs and the open-standard EDI adoption. They found that firms that have experienced EDI made a different response toward the Internet based Inter Organizational Systems (IOS). Based on the notion of moderating effect, we infer that the likelihood of RFID project initiation will be differently depending on trust. In this study, we assume that trust would moderate the relationship between environmental factors and organizational factor and RFID project initiation. Hence, we provide the following hypothesis:

H4-1: Trust with trading partners will moderate the relationship between environmental uncertainty and the likelihood of RFID project initiation.

H4-2: Trust with trading partners will moderate the relationship between competitors' competition and the likelihood of RFID project initiation.

H4-3: Trust with trading partners will moderate the relationship between organizational size and the likelihood of RFID project initiation.

H4-4: Trust with trading partners will moderate the relationship between top management support and the likelihood of RFID project initiation.

POWER: Hart and Saunders (1997) posit that power can affect change of a trading partner. A buyer-supplier relationship for adopting a new technology is resistant, hesitant, disobedient, or refuses from the trading partners. In those cases, firms that are more powerful use their power to less powerful partners to listen, and act for their proposal. Hart and Saunders (1997) define power as "the capability of a firm to exert influence on another firm to act in a prescribed manner" (p.24). Thus, using power for partners is a very useful method that adopts EDI (Chwelos et al., 2001). Generally, power depends on a firm's revenue, if a certain buyer generates a supplier's revenue with a large portion, the buyer can have power against the supplier under the condition of other alternatives to be options (Hart and Saunders, 1997). In case, the buyer pushes the supplier to accept its proposal. Vice versus, if the numbers of suppliers are small, unique (Williamson, 1985) or not any alternatives, then, buyers relatively more depend on suppliers, which oppositely decrease the control power for the supplier (Hart and Saunders, 1997). They explain potential power and exercised power, which potential power is a type of influence that is not yet exercised that most likely to influence in EDI adoption when a less powerful firm has already adopted EDI. On the other hand, exercised power is a type of influence in EDI adoption when a less powerful firm has not any EDI with any other trading partners (Hart and Saunders, 1997). Power can be exercised two ways: persuasive and coercive. Persuasive method is that firms that are more powerful give rewards or benefits to their partners in response to their request. Vice versus, coercive method is that firms that are more powerful threat verbally they would stop doing business or actual punishment to the firms that are less powerful unless they don't listen. Power allegedly frequently exercises in industries such as automobile, large retailers like Wal-Mart, Sears etc. (Hart and Saunders, 1997). However, there are not many researches on the moderating effect of power between determinants and dependent variables. Thus, we exploratory test that power will moderate the relationship between environmental factors and organizational factors and RFID project initiation. We suggest the following hypotheses:

H5-1: Power with trading partners will moderate the relationship between environmental uncertainty and the likelihood of RFID project initiation.

H5-2: Power with trading partners will moderate the relationship between competitors' competition and the likelihood of RFID project initiation.

H5-3: Power with trading partners will moderate the relationship between organizational size and the likelihood of RFID project initiation.

H5-4: Power with trading partners will moderate the relationship between top management support and the likelihood of RFID project initiation.

3.5 Control Variables

We consider two control variables to affect our results: Industry type and sales. First, industry type may significantly affect innovation adoption (Zhu et al., 2006), since industry-specific type may specially have interested in RFID adoption such as retailing and logistics, manufacturing, and IT&S software industries, which those industries would expect to achieve a major benefit from the automatic value chain activities. Second, firm size may significantly affect innovation adoption, because large firms may have more slack resource. Douma et al. (2006) assert that sales are a proxy for the size of a firm. Fiss (2006) used an alternative measure such as sales for firm size. Thus, our study set two control variables in our analysis, which variables are various industry type and broad range of sales, may affect our results.

4. RESEARCH METHODOLOGY

4.1 Data Collection

We collected data using survey questionnaire for a wide range of firms and industries from South Korea, in which RFID has either already implemented or being implemented or is plan to adopt RFID. The names and address of ninety firms that have interested in RFID is obtained from LGCNS Company, which is one of biggest IT service companies in South Korea. LGCNS provided the list of potential firms that are planning to adopt RFID for its potential RFID project. We made survey instruments based on IS literature and pretest them for 40 MBA students to ensure the validity of our data. Over two months from early October through late November of 2004, we conducted 250 survey by visit, mail, email, and fax for two or three people simultaneously at a same company (project manager, consulting partner, IS senior executives, task employee, middle managers), who are involved in RFID TFT(Task Force Team) out of 90 firms. They are all involved in RFID project. Before we contact each respondent, we call everyone and explain the purpose of this study, on the other hand, when we visit, we also explain to the respondents about the goal of this study. We collected totally 195 out of 250 surveys from the 90 companies. The response rate is 78%, unusable data is 24, then, 171 used for analysis (response rate: 68.4%). We collected data from various industries such but mainly retail & logistics (40.0%), manufacturer (26.7%) and sales range from over 50 million U.S dollar (15.5%), 1-5 million (30.0%), and 0.5-1 million (32.3%). The plan of RFID adoption will be within one year (42.1%), and 6 month (20.0%), being implemented (7.8%), and already implemented (8.9 %). See Table 1.

4.2 Data Analysis

Instrument Development: To develop the survey instrument, generally accepted instrument development guidelines were followed. Scale items are shown in

Table 1. Statistics of demographic

		Frequency	Percent
Industry	Manufacturing	24	26.7
	Plant & Constructing	7	7.8
	Retail & Logistics	36	40.0
	IS & IT, Software	21	23.3
	Non-profit org	2	2.2
Sales	Less than 0.5 mill	6	6.7
	0.5-1 mill	29	32.3
	1-5 mill	27	30.0
	5-10 mill	9	10.0
	10 -50 mill	5	5.5
	More than 50 mill	14	15.5
Employee	Less than 50	27	30.0
	51-100	33	37.0
	101-300	7	7.8
	301-500	5	5.5
	501-1000	5	5.5
	Over 1,000	13	14.2
Plan of RFID adoption	No plan	4	4.5
	Within 3 years	15	16.7
	Within 1 year	38	42.1
	Within 6 months	18	20.0
	Being implemented	7	7.8
	Already implemented	8	8.9

Table 2. Correlation matrix for likelihood of RFID initiation

Variables	AVE	S.D	ENV_U	CORTR_C	ORG_SZ	TMS	ITINFRA	TG_C	FRE_C	T_TRT	T_PWR	RFID_AD	***Industry***	***Sales***
ENV_U	4.67	.663	1.000											
COPTR_C	5.22	.600	.278**	1.000										
ORG_SZ	2.38	1.68	.087	.302**	1.000									
TMS	4.94	.967	.070	.213**	.088	1.000								
ITINFRA	2.66	.783	-.099	.094	.323**	.193**	1.000							
TG_C	5.22	.783	.118	.004	.090	-.073	-.277**	1.000						
FRE_C	5.29	.627	.124	.040	.032	-.042	-.047	.095	1.000					
T_TRT	5.15	.734	-.140*	.087	.230**	.162*	.039	-.094	-.028	1.000				
T_PWR	4.77	.897	-.024	.197**	.175**	.154*	.127	.043	.007	.037	1.000			
RFID_AD	3.31	1.32	.150**	-.089	.102**	.038	.033	.005	.272**	-.119	.156**	1.000		
Industry	3.45	1.57	-.147*	.080	.155**	-.152*	.226**	-.060	-.069	-.076	-.144*	-.435**	1.000	
Sales	3.12	1.39	.036	.243**	.928**	.150*	.305**	.059	.023	.230**	-.004	.263**		1.000

Note: N=171

*Significant at *p<.05; **p<.01*

ENV_U=Environmental Uncertainty, COPTR_C=Competitor's Competition, FRM_SZ=Firm Size, TMS=Top Management Support, ITINFRA=IT Infrastructure, TG_C=Tag Compatibility, FRE_C=Frequency Compatibility, T_TRT=Trading Partners' Trust, T_PWR=Trading Partners' Power, RFID_AD=Likelihood RFID Adoption, IND=Industry

Appendix A. Many items were derived from earlier work and adapted them to this study. However, scale items for tag and frequency compatibility were newly development. Although many scholars have developed compatibility, there is few for RFID tag and frequency. To measure used in this study is a 7 Likert scale (Strongly disagree =1 or Strongly agree =7) measure of detailed aspects of adoption determinants in IT&S implementation that researchers is likely to adopt. The development of the compatibility of tag and frequency was grounded in the work of ABI Research (2003).

Descriptive Statistics and Correlations: The Pearson Correlation Matrix for the likelihood of RFID initiation was analyzed. The correlation among the independent variables were conducted by the aggregated measure of each variables in Table 2.

Data Reliability and Validity: Table 3 shows the result of reliability test. The reliability analysis is conducted on the 24 items that measured the components for this study. Cronbach's alpha value is showed over 0.6, which the value is recommended as threshold for the exploratory research (Nonnally, 1978). All constructs had higher than 0.60 cutoff alpha values, ranging from 0.6213 to 0.8968.

For convergent validity, items having item-to-total correlation scores lower than 0.4 were dropped from further analysis in Table 4. Factor analysis is used to check discriminant validity. Because each variable was measured by multi-item constructs, factor analysis with Varimax method is conducted to check the unidimensionality among items. Items with factor loading values lower than 0.5 are deleted.

Table 3. Reliability

Variables	Items	Cronbach's Alpha
Environment Uncertainty	2	0.6328
Competitor's competition	3	0.6425
Organizational size		N/A
Top management support	3	0.8851
IT Infrastructure	5	0.8968
Tag compatibility	2	0.7555
Frequency compatibility	3	0.6213
Trust	3	0.8569
Power	3	0.8140

4.3 Regression Analysis

A hierarchical regression analysis tests our hypothesis. For each hypothesis, each dimension of independent variables is run for the dependent variable separately and control variables (industry type and sales) are included in each regression analysis as shown in Table 5. Our model is considered as an aggregated variable, and its correlation is computed. To meet the assumptions of regression analysis, we examined the linearity, constant variance, and normality (Hair et al., 1995). Our model includes industry type and sales as a control variable shown significant positive relationships between two control variables and the likelihood of RFID initiation. Table 5 presents the regression analysis results. In this study, we used a hierarchical regression analysis the following equation model.

Equation:

The Likelihood RFID Adoption =f(Independent variables, Control variables)

$Model1=\alpha_0+\beta_1 ENV\_U+\beta_2\ COPTR\_C+\beta_3 Industry+\beta_4 Sales+\varepsilon$

$Model2=\alpha_0+\beta_1 OS+\beta_2\ TMS+\beta_3 Industry+\beta_4 Sales+\varepsilon$

$Model3=\alpha_0+\beta_1 ITINFRA+\beta_2\ TG\_C+\beta_3 FRE\_C+\beta_4 Industry+\beta_5 Sales+\varepsilon$

The results supported hypotheses 1-1, 2-1, 2-2, 3-1, and 3-2. The likelihood of RFID project initiation is significantly associated with environmental characteristics (uncertainty), organizational characteristics (size, top management support), and technological characteristics (IT infrastructure, tag compatibility), and two control variables (industry type, sales) are also associated positively with the likelihood of RFID project initiation. One environmental characteristics (competitor's competition), and technological characteristics (frequency compatibility) are not significantly related to the likelihood of RFID initiation in Table 5.

Moderating effect is explained as the impact of a predictor variable that has on a criterion variable is rest on the level of a third variable called the moderator (Venkatraman, 1989). It will affect the direction of strength of relationship between independent variables and dependent variables.

Y = f(X, Z, X*Z), X, Z are independent variables, Y is dependent variable, and X*Z is represented as a joint effect. Moderating effect equation set into following way:

$Y=\alpha_0+\alpha_1 X+\alpha_2 Z+\varepsilon$

$Y=\alpha_0+\alpha_1 X+\alpha_2 Z+\alpha_3 X*Z+\varepsilon,$

Table 4. Rotated factor matrixes with Varimax rotation

	Factor1	Factors	Factor3	Factor4	Factor5	Factor6	Factor7	Factor8
ITINFRA1	0.805							
ITINFRA2	0.906							
ITINFRA3	0.835							
ITINFRA4	0.840							
ITINFRA5	0.788							
TMS1		0.891						
TMS2		0.892						
TMS3		0.843						
T_TRT1			0.913					
T_TRT2			0.883					
T_TRT3			0.812					
T_PWR1				0.862				
T_PWR2				0.889				
T_PWR4				0.748				
TG_C 3					0.867			
TG_C4					0.862			
ENV_U1						0.838		
ENV_U2						0.768		
COPTR_C1							0.745	
COPTR_C2							0.726	
COPTR_C3							0.628	
FRE_C2								0.740
FRE_C3								0.629
FRE_C4								0.744
I-gan Value	4.325	2.954	2.545	2.144	1.827	1.500	1.364	1.057
% of Variance	18.022	12.309	10.606	8.935	7.617	6.251	5.682	4.405
Cumulative Variance	18.022	30.332	40.938	49.873	57.486	63.738	69.420	73.825

<Table 5> The Likelihood of RFID Project Initiation

Explanatory variables	Model1 (Environment)	Model2 (Organization)	Model3 (Technology)
ENV_U COPTR_C	.116(2.827**) -.051(-.797)		
OS TMS		.888(5.680**) .265(3.107**)	
ITINFRA TG_C FRE_C			.218(3.464**) .256(4.513**) .030(.505)
Industry Sales	-.374(-5.980**) .164(2.594**)	-.374(-5.980**) .164(2.594**)	-.407(-6.892**) .239(3.911**)
R^2 Adjusted R^2 F-Value	.228 .112 1.710**	.564 .216 16.133**	.563 .101 10.606**

**P<.05, **p<.01*

The moderation effect is supported if the unstandardized coefficient, α3, differs significantly from zero.

Moderating effect equation:

The Likelihood RFID Adoption =f(Independent variables X Moderating variables)

$Model4=\alpha_0+\beta_1 ENV\_U\ \Xi\ Trust+\beta_2\ COPTR\_C\ X\ Trust+\varepsilon$

$Model5=\alpha_0+\beta_1 OS\ \Xi\ Trust+\beta_2\ TMS\ X\ Trust+\varepsilon$

$Model6=\alpha_0+\beta_1 ENV\_U\ X\ Power+\beta_2\ COPTR\_C\ X\ Power+\varepsilon$

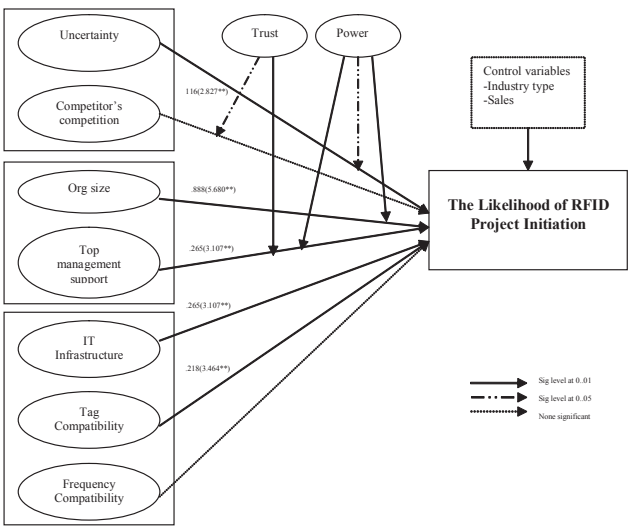
$Model7=\alpha_0+\beta_1 OS\ X\ Power+\beta_2\ TMS\ X\ Power+\varepsilon$

We show the result of our hypotheses in Figure 2.

Table 6. The moderating effects

	Trust	β	R^2	ΔR^2	ΔF	p
Model4	ENV_U COPTR_C	.417 -.509	.237 .242	.002 .013	.459 3.751	.499 .044
Model5	OS TMS	-.643 -2.256	.216 .261	.007 .032	2.213 9.210	.138 .003
	Power	β	R^2	ΔR^2	ΔF	p
Model6	ENV_U COPTR_C	1.233 -1.127	.263 .247	.015 .009	4.476 2.561	.036 .111
Model7	OS TMS	-2.960 -2.252	.473 .304	.154 .068	62.979 21.041	.000 .000

Figure 2. The estimated model



4.4 Result and Discussion

We investigate two-dimensional sides for the likelihood of RFID project initiation. One hand is the determinant effects, on the other hand is the moderating effect on the relationship between determinants and the likelihood of RFID project initiation. The data analysis shows that environmental uncertainty has a major effect on the likelihood of RFID project initiation, whereas competitor's competition is not significantly related. Organizational size and top management support, both, are strongly effect on the likelihood of RFID project initiation, and IT infrastructure and tag compatibility influence positively the likelihood of RFID project initiation, except frequency compatibility is not related. As RFID technology emerges in market, many firms expect the benefits and predict their RFID potential impact on business, then, shows more positive attitude toward the RFID adoption under uncertainty. This result provides support for Grover and Goslar (1993)'s findings which uncertainty is positively related to telecommunication adoption. But, inconsistently, competitor's competition (competitive intensity) does not show a significant relation as good as Grover and Goslar (1993)'s. Organizational size and top management support are consistent with the IS literature. A firm that is a large size is likely to a chance to invest a new IT with enough slack resources (Forman, 2005, Teo et al. 2003; Zhu and Kreamer, 2005). Top management support is always critical factor for adoption innovation in a firm. If the innovation is viewed as a better solution for the firm than the existing system, it is paid attention by top management. Another major determinant affecting of the decision to adopt RFID is IT infrastructure, since the RFID technology should heavily depend on the existing systems. Compatibility of tag and frequency is a peculiar issue for RFID system that should carefully concern not likely other systems. RFID consists of the tag and frequency. Practically, the rate of data transfer is affected by the frequency of the carrier wave. The higher the frequency the higher the data transfer. Depends on the type of tags (passive or active tag), the passive tags are less expensive and unlimited operational lifetime but shorter read ranges, whereas the active tags is higher data transmissions rates, which has the ability to perform well in electromagnetically noisy environments (AIM Inc. White Paper, 2001). Depends on the type of tag and frequency, firms' RFID investment cost and overall organizational effectiveness would be different. RFID is a technological innovation that demands a large portion of IT budget of firms. Most of all, the tag and frequency will affect the future projects that would be extended based on the prior type of tag and frequency. In the context of RFID adoption by firms, the capacity of tag and frequency should be compatible with not only the current organizational process but also current using systems.

The moderating effects are also examined. When trust with trading partners is involved in the relationship between competitor's competition and the likelihood of RFID project initiation, the result changes statistically significance but negatively moderate on the relationship (β: -.509; $p<0.05$). Top management support also is negatively moderated by trading partner's trust (β: -2.256; $p<0.01$). In terms of the trading partner's power, the power moderates positively the relationship between environmental uncertainty and the likelihood of RFID project initiation (β: 1.233; $p<0.05$), whereas the power moderate negatively both relationship between organizational size and top management support (β: -2.960; $p<0.01$; β: -2.252; $p<0.01$). In addition, we show more specific further analysis about power, which a firm has higher power or lower power toward the trading partners. Figure 3 presents the moderating effects of power through graph. The high power group is relatively showing the higher moderating effect than the low power group does. In sum, uncertain business environment, organizational size, and top management support shows that there is moderating effect by firm's power. The moderating effect of trust is negatively engage in competitor's competition and top management support.

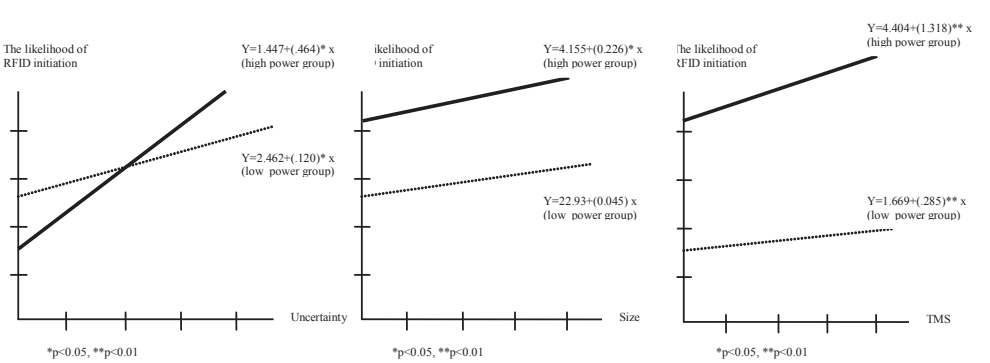
5. CONCLUSIONS

Technology adoption has widely been researching in IT&S areas with innovation theory. This study developed and tested an exploratory model of RFID adoption in early RFID stages. The results support the almost of all hypotheses that are suggested. Three deterministic variables and two moderating variables are important factors in explaining the consideration of RFID project initiation. Environmental uncertainty, organizational size, top management support, IT infrastructure, and tag compatibility have a direct impact on the likelihood of RFID project initiation, whereas the competitor's competition and frequency compatibility have no direct impact on the likelihood of RFID project initiation. In case of moderating effects, trust and power of trading partners show different results on the relationship between determinants and the likelihood of RFID project initiation. Trust moderates the competitor's competition and top management support on the likelihood of RFID project initiation, whereas power moderates the uncertainty, organizational size, and top management support on the likelihood of RFID project initiation. Therefore, the moderating effect supports partially our model.

There is a question why the degree of competition and top management support should be influenced by trust moderator. According to Premkumar and Ramamurthy (1994)'s findings, they found competitive pressure is related to reactive adoption of EDI, whereas top management support is related to proactive adoption of EDI. Those two factors are found evidence of a close relation with their trading partners (Hart and Saunders, 1998). Therefore, we assume trading partner' trust may strength or weaken the determinant and RFID adoption. Indeed, a substantially IT adoption should find more opportunities with trading partners than any other conditions. On the other hand, uncertainty, firm size, and top management support why should be influenced by power moderator. Power is the firm's ability to influence change in another firm that trade. We assume that large firm has more power to their partner than small firms do and top management support would be different depend on its partner's power under the uncertainty. For example, large firm can threaten to quit trading with partners unless the firm adopts RFID. This is why trust and power is as important and is supported as moderator. In sum, the trust and power play an important role for RFID adoption in interorganzaitonal IS system implementation.

The study provides some implications for both practitioners and researchers. In response to practical implications, the study explores the determinants and RFID adoption in early stage of RFID systems. Firms understand not only the benefits of RFID adoption but also the important factors that can facilitate to invest the RFID systems with trading partners. When RFID systems implement, trust and power of trading partners may influence. If the RFID system is not perceived as beneficial to the trading partners, there is no reason for partners to adopt it. The RFID must also be compatible with trading partners' benefits; otherwise, it would be conflict for both firms and trading partners to understand mutual interests. In terms of research implication, although this study is one of the empirical IT&S adoption researches, we explored RFID systems adoption in an early stage with a technological innovation theory.

Figure 3. Power effect between higher power group and lower power group



5. 1 Limitations and Future Research

This study has also some limitations that should be recognized. This study is the perception base of the employees who are involved in RFID task force team, so the results can be showed in a bias way from the side of a firm that has interest in RFID. Therefore, the results of this study should be carefully translated with caution. Second, there exists many other innovation characteristics to IT&S adoptions; we did not include the complete innovative variables that can affect the RFID adoption. Future research can examine other potential variables with other context.

REFERENCES

AIM Inc, Radio Frequency Identification RFID, *White Paper*, Document Version:1.2, 2001-08-23.

Abrahamson, E. and Rosenkorf, L. Institutional and competitive bandwagons: Using mathematical modeling as a tool to explore innovation diffusion. *Academy of Management Review,* 18(3), 1993, 487-517.

Attewell, P. Technology diffusion and organizational learning: The case of business computing. *Organization Science*, Volume 3, 1992, pp. 1-19.

Baker, D. D. and Cullen, J. B. Administrative reorganization and configurational context: The contingent effects of age, size, and change in size. *Academy of Management Journal*, 36(6), 1993, 1251-1277.

Barua, A. and Lee, B. An economic analysis of the introduction of an electronic data interchange system. *Information Systems Research*, 8(4), 1997, 398-422.

Bharadwaj, A.S. (2000), A Resource-Based Perspective on Information Technology Capability And Firm Performance: An Empirical Investigation, *MIS Quarterly*, 24(1), 159-196.

Bruwer P. J. S. A descriptive model of success for computer-based information systems. *Information and Management*, 1984; 7: 63-67.

Chau, P. Y. K. and Tam, K. Y. Factors affecting the adoption of open systems: An exploratory study. MIS Quarterly, 21(1), 1997, 1-24.

Chengalur-Smith, I. and Duchessi, P. The initiation and adoption of client-server technology in organizations. *Information & Management*, 35, 1999, 77-88.

Child, J. (1972), Organizational structure, environment, and performance: the role of strategic choice. *Sociology*, Vol. 6 pp.1-22.

Chwelos, P., Benbasat, I. and Dexter, A. S. Research report: Empirical test of an EDI adoption model. Information Systems Research, 12(3), September 2001, 304-321.

Cooper, R. and Zmud, R. Information technology implementation research: A technological diffusion approach. *Management Science*, 36(2), 1990, 123.

Damanpour, F. Organizational innovation: A meta-analysis of effects of determinants and moderators. *Academy of Management Journal*, 34(3), 1991, 555-590.

Damanpour, F., Szabat, K. A. and Evan, W. M. The relationship between types of innovation and organizational performance. *Journal of Management Studies*, Vol. 26, 1989, pp. 587 – 601.

Dewar, R. D. and Dutton, J. E. The adoption of radical and incremental innovations: An empirical analysis. *Management Science*, 32(11), 1986, 1422-1433.

Dos Santos B.L. and K. P*effers, Rewards to investors in innovative information technology applications: First* movers and early followers in ATMs. *Organization Science*, Vol. 6, No. 3, May-June 1995, 241-259.

Douma, S., George, R, and Kabir, R. Foreign and domestic ownership, business groups, and firm performance: Evidence from a large emerging market. Strategic Management Journal, 27, 2006, 637–657.

Eveland, J.D. and Tornatzky, L.G. The Deployment of Technology, *In The Processes of Technological Innovation*, L. G. Tornatzky and M. Fleischer (Ed.), Lexington Books, Lexington, Massachusetts, 1990, pp. 117-148.

Ein-Dor, P and Segev, E. Organizational context and MIS structure: Some empirical evidence. *MIS Quarterly*, September 1982, 55-68.

Fiss, P. C. Social influence effects and managerial compensation evidence from Germany. Strategic Management Journal, 27, 2006, 1013-1031.

Forman, C, The corporate digital divide: Determinants of internet adoption, *Management Science*, 51(4), April 2005, pp. 641–654.

Garud, R., Kumaraswamy, A. and Nayyar, P. Real options or fool's gold? Perspective makes the difference. *Academy of Management Review,* 23(2), 1998, 212–214.

Gramling, K., Bigornia, A., Gilliam, T. EPC™ Forum Survey. *IBM Business Consulting Services*. Feb 1, 2003.

Grover, V. and Goslar, M. D. The initiation, adoption, and implementation of telecommunications technologies in U.S. organizations. *Journal of Management Information Systems*, 10(1), Summer 1993, 141-163.

Hair, J. F., Anderson, R., Tatham, R. and Black, W. *Multivariate Data Analysis with Readings*, Englewood Cliffs, NJ: Prentice Hall, 1995.

Hannan, T., and J. McDowell. The determinants of technology adoption: The case of the banking firm. *Rand Journal of Economics* 15 , 1984, 328─35.

Hart, P. and Saunders, C. Power and Trust: Critical factors in the adoption and use of electronic data interchange. *Organization Science*, 8(1), 1997, 23-42.

Hart, P. J. and Saunders, C. S. Emerging electronic partnerships: Antecedents and dimensions of EDI use from the supplier's perspective. *Journal of Management Information Systems*, 14(4), Spring 1998, 87-111.

Iacovou, C. L. Benbasat. I. and Dexter, A.S. Electronic data interchange and small organizations: Adoption and impact of technology. *MIS Quarterly*. 19(4), 1995, 465-485.

Intermec White Paper, Understanding the Value of Read/Write RFID Functuionality. 2003.

Jaworski, B. J. and Kohli, A. K. Market orientation: Antecedents and Consequences. Journal of Marketing, 57, 1993, 53-70.

Keenan, F., and Ante, S. The New Teamwork. Business Week. February 18, 2002.

Khoumbati, K., Themistocleous, M. and Irani, Z. Evaluating the adoption of enterprise application integration in health-care organizations. *Journal of Management Information Systems*, 22(4), Spring 2006, 69-108.

Kim, Y. J. and Sanders, G. L. Strategic actions in information technology investment based on real option theory, *Decision Support Systems*, 33, 2002, 1– 11.

Kimberly, J. R. and Evanisko, M. J. Organizational innovation: The influence of individual, organization, and contextual factors on hospital adoption of technological and administrative innovations. Academy of Management Journal, 24(4), 1981, 689-713.

Kwon, T. H. and Zmud, R. W. Unifying the fragmented models of information systems implementation. In R. J. Boland and R. A. Hirschheim (eds), *Critical Issues in Information Systems Research.* New York; John Wiley, 1987, 257-252.

Mansfield, Edwin, Rapoport, John, Romeo, Anthony, Villani, Edmond, Wagner, Samuel and Husic, Frank (1977) The Production and Application of New Industrial Technology (New York, NY: W. W. Norton and Company).

Milliken, F.J. Three types of perceived uncertainty about the environment: state, effect, and response uncertainty. *Academy of Management Review*, 12, 1987, 133-43.

Moch, M. K. and Morse, E. V. Size, centralization and organizational adoption of innovations. *American Sociological Review*, 42(5), 1977, 716-725.

Nunnally, J. C. *Psychometric Theory*, 2d ed. New York: McGraw-Hill. 1978.

O'Callaghan, R., Kaufman, P. J and Konsynski, B. R. Adoption correlates and share effects of electronic data interchange systems in marketing channels, *Journal of Marketing*, 56, 1992, 45-56

Premkumar, G., Ramamurthy, K. and Nilakanta, S. Implementation of electronic data interchange: An innovation diffusion perspective. *Journal of Management Information Systems*, 11(2), Fall 1994, 157-186.

Rajagopal, P. An innovation—diffusion view of implementation of enterprise resource planning (ERP) systems and development of a research model. *Information and Management*, 40, 2002, 87-114.

Rai, A. and Bajwa, Deepinder, S.. An empirical investigation into factors relating to the adoption of executive information systems: An analysis of EIS for collaboration and decision support. *Decision Sciences*, 1997, 28(4), 939-974.

Ramamurthy, K., & Premkumar, G. Determinants and outcomes of electronic data interchange diffusion. *IEEE Transactions on Engineering Management*, 42(4), 1995, 332-351.

Ray, A. and Patnayakuni, R. A structural model for CASE adoption behavior. *Journal of Management Information Systems*, 13(2), 1996, 205-234.

Robertson, T. S.; and Gatignon, H. Competitive effects on technology diffusion. *Journal of Marketing*, Volume 50, 1986, pp. 1-12.

Rogers, E. M. *Diffusion of Innovations*, 3rd ed. New York: Free Press, 1983.

Scharfeld, T.A. An analysis of the fundamental constraints on low cost passive Radio-Frequency Identification system design. *Master of Science Thesis*, MIT: Cambridge, MA.

Son, J., Narasimhan, S. and Riggins, F. J. Effects of relational factors and channel climate on EDI usage in the customer-supplier relationship. *Journal of Management Information Systems*, 22(1), Summer 2005, 321-353.

Swaminathan, J. M., and Tayur, S. R. Models for supply chains in E-business. *Management Science*, 49(10), October, 2003, 1387-1406.

Tanriverdi, H. Information technology relatedness, knowledge management capability, and performance of multibusiness firms. *MIS Quarterly*, 29(2), 2005, 311-334.

Teo, H. H., Wei, K. K. and Benbasat, I. Predicting intention to adopt interorganizational linkages: An institutional perspective. *MIS Quarterly* 27(1), 2003, 19-49.

Thong, J. Y. L. An integrated model of information systems adoption in small businesses. *Journal of Management Information Systems*, 15(4), Spring 1999, 187-214.

Tornatzky, L. G. and Fleischer, M. *The Process of Technological Innovation*. Lexington, MA: Lexington Books, 1990.

Tosi, H. L., and J. W. Slocum. Contingency Theory: Some Suggested Directions. *Journal of Management,* 10(1), 1984, 9–26.

Utterback, J. M. Innovation in industry and the diffusion of technology. Science, 183, 1974, 620-626.

Vankatraman, N. The concept of fit in strategy research: Toward verbal and statistical correspondence. Academy of Management Review, 14(3), 1989, 423-444.

Wang, E.T.G. and Seidmann, A. Electronic data interchange: Competitive externalities and strategic implementation policies. *Management Science*, 41(3), 1995, 401-418.

Wang, E.T.G. Ying, T.C. Jiang, J.J. and Klein, G. Group cohesion in organizational innovation: An empirical examination of ERP implementation. *Information and Software Technology*, Volume 48, Issue 4, 1 April 2006, Pages 235-244.

Williamson, O. E. *The Economic Institutions of Capitalism: Firms, Markets, Relational Contracting*. New York: The Free Press, 1985.

Zhu, K. and Kreamer, K. L. Post-adoption variations in usage and value of E-business by organizations: Cross-country evidence from the retail industry. *Information Systems Research*, 16(1), March 2005, 61-84.

Zhu, K., Kraemer, K. L. Gurbaxani, V. and Xu, S. X. Migration to open-standard interorganizational systems: Network effects, switching costs, and path dependency. MIS Quarterly Vol. 30, August 2006, Special Issue, pp. 515-539.

APPENDIX A
Measurement Items

Constructs	Items	Scale
The likelihood of RFID initiation	Has your firm planned to adopt RFID technology in near future?	1= No plan 2= Within 3 years 3= Within 1 year 4= Within 6 months 5= Being implemented 6= Already implemented
Environmental Uncertainty	Prediction of product preferences change Prediction of the demand of product and service	Jaworski and Kohli (1993) Son et al. (2005) 7-Point Likert Scale
Competitor's Competition	The level of competition in our industry RFID that one competitor can initiate, others can follow readily One hears of a new rival develop/adopt the RFID systems	Adapted from Jaworski and Kohli (1993) Adapted from Reich and Benbasat (1990) 7-Point Likert Scale
Top management support	Top management supports for RFID project Top management willingness to take the (financial and organizational) risk involved in the adoption/development and implementation of RFID Top management's commitment to provide adequate financial and other resources for the development and operation RFID systems	Ramamurthy and Premkumar (1995),
Organizational size	The number of employees	Zhu et al. (2005)
IT infrastructure	IT expertise on RFID IT human professional resources Hardware resources Software resources Network resources	Adapted from Ramamurthy and Premkumar (1995),
Tag Compatibility	Compatibility with tag cost and total RFID systems' budget Compatibility with the existing IT infrastructure	Adapted from Ramamurthy and Premkumar (1995), ABI Research (2003)
Frequency Compatibility	Compatibility with industry characteristics Compatibility with the frequency's competitiveness Compatibility with the standardized frequency	
Trust	Trading partners and our company have a high level of mutual trust Trading partners and our company does fair trading Trading partners stands by its word	Son et al. (2005)
Power	Trading partner has influenced our decision to initiate RFID Trading partner, rather than our company, was the main force for RFID initiation Trading partner has used coercive techniques for initiating RFID project	Adapted from Son et al(2005) Adapted from Hart and Saunders (1997)
Sales	Less than $ 0.5 mill=1, $0.5-1 mill=2, $1-5 mill=3, $5-10 mill=4, $10-50 mill=5, Over $ 50 mill=6.	
Industry type	Manufacturing=1, Financing & Accounting=2, Plant & Constructing=3, Retail & Logistics=4, IT & IS Service=5, Non-profit Org=6.	

Innostructure: Managing Innovation as Business-Critical Infrastructure

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ABSTRACT

The last few years have seen increasing interest in organizational innovation—changing an organization to enhance its ability to sustain innovative thinking and problem solving. Most companies plan to increase spending on innovation this year continuing a five-year trend. However, executives report not being satisfied with the return on investment in innovation. We argue that the wrong metrics are being used because innovation is not being treated as a business-critical infrastructure. We propose a high-level architecture for an infrastructure supporting organizational innovation—the innostructure—and describe how performance of this infrastructure can be monitored and optimized.

INTRODUCTION

In 2004, the former Chairman of the Federal Reserve, Alan Greenspan, observed that the new paradigm of *globalization and innovation* represented a "one-time shift" in national and international economics (Greenspan, 2004). Globalization, the extension of the division of labor and specialization beyond national borders, is driving companies to be competitive in new ways. One response is the acceleration of the pace of innovation. Companies too slow to react to the changing marketplace are out-performed by more agile, sometimes foreign, companies. As a result, chief executives are spending on innovation and are trying to feel their way into an unknown future. According to the Boston Consulting Group (BCG), 74% of companies will increase spending on innovation in 2006, roughly the same as the 72% in 2005 and up from 64% in 2004 (Andrew, 2005), (Andrew, 2006).

However, the BCG studies also report that most executives are not satisfied with the return on investment in innovation spending. Reasons cited for this disappointment include:

1. difficulty in gauging costs and returns
2. development times that are too long
3. lack of coordination within the company
4. not enough insight into customers
5. risk-averse culture in the corporation.

We maintain the primary reason for the disappointment in gauging returns (#1) is that a direct measure of payoff from spending on innovation is not an appropriate assessment measure. We believe innovation should be woven into the fabric of the company itself as a business-critical infrastructure like information technology resources are today. No company today would be considered a serious company if it did not have telephones, fax machines, e-mail, computers, etc. The day is fast approaching when a company without an infrastructure supporting innovation, something we call the *innostructure*, will not be considered a serious company. Such an integration addresses the disappointment in coordination (#3).

History is replete with examples of corporate spending on fads and popular buzzwords enjoying popularity for a few years only to be lost in the rush to the future. We fear interest in innovation will wane accordingly due to the perceived lack of immediate results. This will not only be unfortunate, but a critical mismanagement of something we understand to be a critical business resource—innovation.

Our belief is that innovation is the emergent behavior of the complex adaptive system of humans, information, knowledge, wisdom, and market forces. We propose here the best way to architect the innostructure that supports this innovation is as a scale-free network of collaborators—something we call the *innovation metanetwork*. The metanetwork is an open collaborative system allowing customers and other outside parties to collaborate with company employees, addressing the disappointment in knowing customers (#4).

Constructing the innovation metanetwork as an emergent, scale-free network allows its performance to be monitored, measured, and controlled by objective metrics thereby replacing the troublesome metrics in #1.

WHY THE GLOOM?

The fact that most executives continue to increase spending on innovation while not being satisfied with the results is seemingly a paradox that begs for an explanation. Looking at the studies, we offer that the executives' expectations are misplaced. The executives appear to expect immediate and quantifiable impacts to the corporate bottom line (Andrew, 2006b). We maintain this is not the most effective way to measure corporate innovative effort.

As an illustration, consider what would happen if the CEO of the company wanted to know what the return on investment was in purchasing a new network router. Imagine if it were necessary to measure and report the increase in corporate sales attributable to the new router. It would be easy to show how effective bandwidth might increase and one could point to statistics showing reductions in network latency. Everyone would agree the new router was a good thing to have and no one would argue for its removal.

However, did the router increase corporate profit? The router, its installation, and the metric-gathering cost the company a non-zero amount of money. So to be profitable, does the router have to recoup its own cost in terms of increased sales? If so, how would you determine that an increase in sales would not have happened if the router had not been purchased?

The problem, of course, is there are many more things, other than the new router, that must happen for corporate sales to increase. True, increased network speed, because of the router, may allow a salesperson to respond to more customers and, therefore, close more sales. But because so much else goes into closing the sale, the contribution of the router is obscured.

We think a similar phenomenon is happening with those who are attempting to measure return on investments in innovation spending. The expectation seems to be that a tool will be purchased, someone will use it to produce the next great product, and the company will make a fortune all because it "invested" in the tool. This "eureka" scenario may very well happen, but more likely, and more realistic, is that use of the tool will incrementally improve something in the enterprise which will enable something else to happen, and so on, until ultimately, the effect snowballs to a threshold where a true bottom-line impacting event occurs.

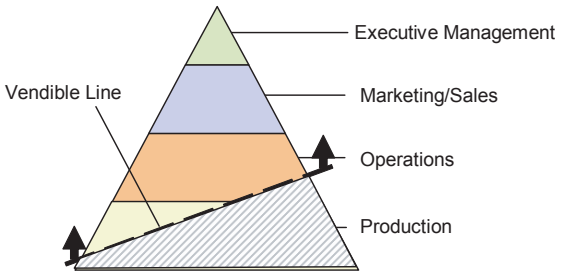
If this is true, the disappointed executives are looking at the wrong metrics. We believe innovation must be infused throughout the organization as a strategic infrastructure component. Therefore, the metrics one uses to measure success of that infrastructure should be oriented toward measuring the infrastructure itself rather than some ultimate application of the infrastructure.

WHY COMPANIES MUST INNOVATE

We begin by modeling an enterprise as a hierarchy shown in Figure 1. This is a visualization we have developed, called the Vendible Model, for in-class discussion of alternative sourcing (Fulbright, 2004)

Enterprises are modeled on the basis of the amount of resources produced internally versus the amount of resources purchased from external entities. The vendible line defines the boundary between internally sourced resources, the strategic regime, and externally sourced resources, the commodity regime.

Figure 1. The Vendible Model depicts the vendible line partitioning an enterprise into a part that cannot be outsourced, called the strategic regime (above the line), and a part that can be outsourced, called the commodity regime (below the line).



Resources of higher strategic value are depicted near the peak and the resources with lower strategic value are near the base. In general, the lower-valued resources get outsourced quicker than the higher-valued resources. This causes the vendible line to sweep upward as commoditization consumes more and more of the enterprise. However, the vendible line never reaches the top because if it did the enterprise would cease to exist. The entire enterprise would have been outsourced. On the other hand, the vendible line never reaches the bottom because no enterprise produces every resource that it needs. Even the smallest company buys something from a supplier be it paperclips, electricity, water, or any other commodity.

Vendible Model analysis shows us something important about enterprises: there is something in any enterprise that will never be outsourced. We call this core set of resources the *strategic kernel* and it represents the very essence of the enterprise itself.

What is contained in the strategic kernel? To answer that, we must first recall the definition of commodity as being a good or service that is traded primarily on the basis of price, and not on differences in quality or features. In other words, commodities are those things that are decidedly *not unique*. Since non-unique resources become commodities and fall below the vendible line, what remains in the enterprise are the resources that make the enterprise unique. The way an enterprise stays unique is to do something that no other enterprise is doing or can do. This is the very definition of *innovation*. The conclusion is not very surprising: companies must innovate to stay ahead of the competition. Leading companies in every industry already invest substantial amounts of resources in research and development departments. However, what is a new response to Greenspan's global economy is how companies will innovate in the future.

Globalization is leveling the playing field and allowing companies all over the world to compete in previously inaccessible markets. Companies are competing against a larger and more diverse group of competitors than ever before. However, something else is happening that is even more important. The time required for the concept-to-product cycle is getting shorter. A few decades ago, a company's new innovation could put it several years ahead of its competition. By the end of the millennium, this lead time had shortened to several months. Globalization, communication technology, information technology, culture, social, and political forces are pushing us into the knowledge age where innovative lead time will be measured in weeks. The large research and development department, that many companies have today, is not likely to respond fast enough for this future marketplace. Companies that do not become leaner, more agile, and continually adaptable will lose out to those companies that do. Being able to *continually* adapt will require companies to distribute its capacity for innovation throughout the company and create a corporate-wide culture of innovation.

To achieve this, a company's innovation quotient must be built into the fabric of the company itself, touching every job, every employee, every department, and every business practice. What we are describing here is the need for a new infrastructure for innovation. We call this the *innostructure*.

We in the industry have seen this kind of thing before. One time relegated to the data processing center, the infusion of IT infrastructure into companies has turned most employees into information workers, and has done so by distributed information resources throughout a company. We expect the same thing to happen to innovation. The infusion of innostructure will turn more and more employees into *innovation workers*.

In Business @ the Speed of Thought: Succeeding in the Digital Economy, Bill Gates makes a strong case for the increased need for IT-savvy thinking to permeate all aspects of business (Gates, 1999). He argues that without it, businesses will not remain competitive and not take advantage of the competitive levers provided by innovative state-of-the-art IT technology. Because we view information management's central role as turning information into knowledge, we see information resource management as the point of the spear leading the way to the innostructure.

THE INNOVATION METANETWORK

There are a number of innovation tools on the market and some companies are already employing these tools. The critical factor companies are lacking is the embedding of innovation tools into a sustaining infrastructure that promotes innovation as a way of doing everyday business. Our proposed innostructure is the *innovation metanetwork.*

We take "metanetwork" to mean a network that is superimposed on another network. Companies today have existing information technology infrastructures so any higher-level organization of resources using this infrastructure as a substrate is a metanetwork. The metanetwork supports innovation by facilitating sharing of knowledge and ideas among collaborators.

Visualizing the innostructure as a metanetwork is important because it leads to the identification of two important properties—a scale-free architecture and emergent behavior. These properties imply specific architectural features that can be constructed and measured empirically. This has the decided advantage of giving companies a metric that can be measured, tracked, and optimized—a control parameter.

At the most fundamental level, the metanetwork is a network of collaborators. Collaborators can communicate with each other about a piece of work, called an *opportunity*. An opportunity is a problem to be solved, an idea to be refined, or any other type of collaborative endeavor. Upon receiving an opportunity, a collaborator can either

- refer the opportunity to another collaborator thought to be able to contribute to the opportunity
- contribute to the opportunity
- respond to and refer the opportunity

How the contribution is made and how the piece of work is manipulated is not of concern here. Collaborators may or may not employ various tools in making a contribution. The key to innovation is the ability to explore alternative possibilities without distracting the work down fruitless paths. The way to achieve this is via an open forum promoting analysis, discussion, various viewpoints, and utilization of others' knowledge. This is the role of the innovation metanetwork.

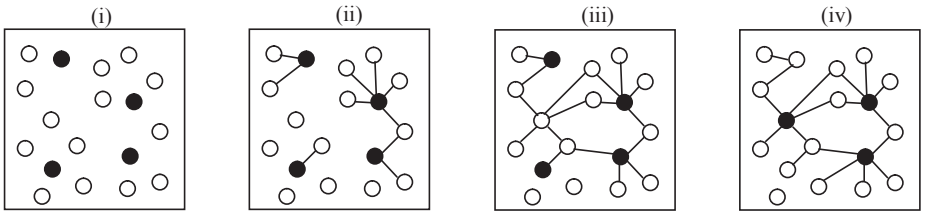
SCALE-FREE NETWORKS

Scale-free networks have proven to be most efficient in promoting information propagation (Barabasi, 2002). This is crucial to support the open and free exchange of ideas in the innovation metanetwork. Scale-free networks are characterized by the existence of a relatively small number of nodes connected to a relatively large number of other nodes. Such highly connected nodes are referred to as *hubs*. An important feature of a scale-free network is the "small-world phenomenon" in which any two nodes in the network are connected together by a small number of links, or "hops."

The airline system is an example of such a network. Cities like Atlanta, Charlotte, and New York are hubs for various airlines. A traveler can get from any departure city to any destination city by taking only one or two flights routed through at least one of the hubs. The Internet is another example of a scale-free network. Internet messages are routed through a relatively small number of switching points arranged in a hierarchy of highly connected hubs, called access points. Because of the small world phenomenon, information can propagate across a scale-free network efficiently.

Another important feature of a scale-free network is its ability to grow to any size without changing the basic architecture or suffering any degradation in information propagation efficiency. Ultimately, the goal of the innovation metanetwork is to develop a collaborative that is highly effective in routing opportunities to the collaborator that can best make a contribution. The hubs in this metanetwork

Figure 2. An efficient, small-world, scale-free collaborative network can be evolved. To seed the process, a set of referrers are initially appointed (i). As the performance of the group is monitored, some appointed referrers will prove to be efficient and others will not (ii). It is likely that individuals not originally appointed will step up and prove themselves to be efficient referrers (iii). Over time, a network of the most efficient referrers will evolve resulting in a maximally efficient, scale-free network (iv).



will be those who are very good at routing an opportunity to the appropriate collaborator. A mistake would be to try to identify these key individuals at the outset. Our proposal is to let the metanetwork self-organize. This can be achieved by appointing, at the outset, a number of referrers to act as the hubs and installing a feedback and monitoring mechanism. Initially, all opportunities will be forwarded to this group who will in turn, refer opportunities to others, and so on. The pattern of opportunity referral and the pattern of contributions across all collaborators will be monitored. A collaborator who refers opportunities resulting in contributions and to a wider range of others will be scored higher than one who never refers opportunities or whose referrals do not result in contributions. Collaborators with higher scores will tend to be sent opportunities first. Over time, the highly effective performers will rise and the under performers will be marginalized. As shown in Figure 2, this results in an optimal scale-free network.

EMERGENT BEHAVIOR

Even though the metanetwork will self-organize, it will be static once the prevailing pattern evolves. Researchers in nonlinear dynamical systems have shown that static systems do not achieve the highest degree of emergent behavior (Langton, 1986) Emergent behavior is the global behavior of a system arising from the complex interaction between the parts of the system and it has been shown that maximal emergent behavior occurs at an intermediate level of system complexity. If the dynamics of the system are tuned downed to a point where interactions are extremely ordered, very little emergent behavior is possible from the static system. Likewise, if the dynamics are tuned to the point of chaos, where interactions are totally random, little emergent behavior is possible. However, when system dynamics are tuned to an ideal intermediate level, between the ordered and chaotic regimes, emergent behavior arises from the system.

Emergent behavior often exceeds the abilities of the individual components and often exhibits qualities that can not be programmed or designed into the components. An emergent system is the classic example of the whole being greater than the some of the parts.

Recent work focuses on modeling human organizations as emergent systems. Following this line of research, we maintain that innovation is an emergent behavior of the complex adaptive system of humans, information, knowledge, and wisdom. Innovation is sometimes the result of individual effort, but more often, the result of collaborative effort and emerges from the contributions of several individuals. Therefore, the innovation metanetwork should promote the highest degree of emergence from the system of collaborators.

To do this, the pattern of referral and contribution that evolves naturally should be retained but not be allowed to remain static. Neither should it be totally randomized. Instead, the prevailing pattern should change slightly and incrementally over time, constantly exploring new routing possibilities. This can be achieved by occasionally routing an opportunity to a collaborator selected at random. This puts an element of chance and randomness into the system and the degree of randomness can be controlled by a single parameter.

What will be observed is that at low values of randomness, the global performance of the innovation metanetwork will be unchanged. As the amount of random routing is increased, emergent properties will be observed until a point where at some value of randomness, the emergent properties will begin to subside. At this point, the randomness will be such that it is beginning to interfere with the operation of the metanetwork. Tuning the randomness factor to values just below this point will keep the emergent behavior of the metanetwork at its maximum.

An emergent metanetwork will have two great benefits. First, the pattern of referrals and contributions will change and improve over time as the system explores and finds better routing solutions. Second, the amount of innovation arising from the collaborators will be higher than one would expect. This will be because instead of acting like a collection of individual innovators, the collective will be acting like a single super-organism achieving greater results than the individuals are capable of separately.

CONCLUSION

We have argued that increasing an organization's innovation quotient—the ability to sustain innovative thinking and problem solving—is a critical business concern and have offered a graphical visualization of one view of this argument, the Vendible Model. Increasing corporate spending patterns over the last several years bear witness to this observation. The troubling finding, however, is that corporate executives are discouraged by the return on investment in this spending. The explanation we offer is that innovation should be built into the fabric of the organization itself as a business infrastructure component. It is simply not possible to purchase a few innovation tools and expect the company's innovative output to measurably increase. Instead, steps must be taken to turn workers into *innovation workers* where innovation is something they do as a routine business practice. To make this vision a reality, we have argued that a communication and collaboration infrastructure be created, called the *innovation metanetwork*, providing the framework supporting innovative work processes. We feel the innovation metanetwork should be built with two critical features in mind: scale-free architecture and emergent behavior. The scale-free architecture will be evolved over time and insure the metanetwork can grow to any size while remaining maximally efficient. The emergent behavior feature will keep the metanetwork from stagnating and insure that it constantly improves itself over time. A fortunate result of this architecture is that it provides two measures for effectiveness that can be monitored and tracked.

REFERENCES

Greenspan, A. (2004). Globalization and Innovation. Conference on Bank Structure and Competition, May 6, 2004. Retrieved July 2006 from the Federal Reserve Web site: http://www.federalreserve.gov/ BoardDocs/ Speeches/2004/200405062/default.htm

Andrew, J.P. (2005). *Innovation 2005*. The Boston Consulting Group, Boston, MA, 2005. Retrieved July 2006 from the BCG Web site: http://www.bcg.com/publications/files/BCG _Innovation_2005_Survey_Report.pdf

Andrew, J.P. (2006). *Innovation 2006*. The Boston Consulting Group, Boston, MA, 2006. Retrieved July 2006 from the BCG Web site Internet site: http://www.bcg.com/publications/files/2006 _Innovation_Survey_report.pdf

Andrew, J.P. (2006b). *Measuring Innovation 2006*. The Boston Consulting Group, Boston, MA, 2006. Retrieved from the BCG Web site: http://www.bcg.com/publications/files/2006_Innovation _Metrics_Survey.pdf

Fulbright, R., Routh, R.L. (2004) How Information Professionals Keep From Being Outsourced or Offshored. *SIGITE -04 Proceedings,* Salt Lake City, UT, 2004.

Gates, W.H. (1999). *Business @ The Speed of Thought,* Warner Books, New York, NY, 1999.
Barabasi, A. (2002). *Linked:How Everything is Connected and What it Means,* Perseus Publishing, Cambridge, MA, 2002.
Langton, C. (1986). Studying Artificial Life with Cellular Automata. *Physica D* 22 (1986).

Quality and Decision Variables: Impact-Focused Taxonomy

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ABSTRACT

This paper presents an inquiry into the applicability of operation qualities identified for data and information to decision variables in general. It posits and demonstrates that they apply equally to data values, information values, elements of knowledge, physical factors in operations, and thus to decision variables used in decision-making to represent them. This approach leads to a universal hierarchical impact-focused taxonomy of decision variables of theoretical and practical importance in analyzing decision situations, their models, and in prioritizing research on decision situations.

Keywords: Quality, data, information, rules of reasoning and proceeding, operation factors, decision variables, universal taxonomy

INTRODUCTION

The theoretical and empirical research on data and information quality conducted for more than a decade and the operations-research approach to quality of factors in operations elucidate that the identified principles apply equally to decision variables in decision-making. On must, however, take a broader than the internal ontological view on quality. The teleological pragmatic viewpoint common in operations management, operations research, management sciences and decision sciences elucidates that the identified principles of operation quality apply to data values, information values, elements of knowledge (rules of reasoning and proceeding), physical factors in operations, and thus to the decision variables, which represent them all.

The presented approach is a purely theoretical one. Consequently, the presented taxonomy claims universal theoretical and rigorous practical validity. Survey-based empirical approaches such as TQM and TDQM are not considered here. They are of high practical value but alas of low scientific validity as they always are situation-specific only.

The main contribution of this paper is a universal hierarchical impact-focused taxonomy of decision variables. The main purpose of this paper is to present this concept for challenge and discussion. For focused reading, key terms in paragraphs are in **bold** font, emphasis in *italics,* highest emphasis underlined, and terms followed by a definition are in ***bold italics***.

A SHORT REVIEW OF LITERATURE

Based on **ontological foundations**, Wand and Wang (1996) proposed four data quality dimensions (complete, unambiguous, meaningful, and correct) that are intrinsic to system design and operations. However, they labeled them intrinsic to data. At the same time, Wang and Strong (1996) using empirical approach identified other about 179+ (later reduced to about 15-20) dimensions of quality mentioned in questionnaires by individuals representing data users or consumers.

Liu and Chi (2002) categorized different approaches to data quality as intuitive, empirical, and theoretical. They concluded, the "*Existing theoretical approaches are limited in their ability to derive a full-fledged measurement model*" and a "*generally accepted model has not yet appeared*" (p. 292). They developed a concept of **evolutional and theory-specific data/information quality** that evolves along the stages of data collection, organization, presentation, and application.

Oliviera, et al. (2005) claimed they presented *"***A formal definition of data quality problems**." The paper identifies and defines 30 specific possible distortions inflicted onto a set of entered data values assumed to be correct and updated. However, their formal definition is limited only to data in databases.

Anchoring the concept of data/information quality in operations research, management science, and decision science, Gackowski (2005) defined a theoretical teleological content-focused framework of ***operation quality requirements*** of data and information values viewed from the perspective of operations management. They pertain to data, information, elements of knowledge (rules of reasoning and proceeding), and any factor of substance.

QUALITY AND OPERATIONS

Point and Frame of Reference, Observer, Assumptions and Postulate

There are two fundamental keywords, '**quality**' and its adjective '**operation**' because it pertains to quality of factors in operations. A reliable theory must refer to a well-defined point of reference, observer, frame of reference, and a yardstick for measuring the results of operations:

Assumption 1a: The **main purpose** of operations is the main ***point of reference*** and it is measurable.

Assumption 1b: The ***observer*** is the decision-maker. Decision makers do not act in the actual reality – a **subject of science and technology**, but in their subjective reality, which is the **subject of phenomenology**. Usually, the two realities overlap only partially: (a) completely, only in structured decision situations, (b) not at all, in fully irrational decision making, and (c) partially, in semi structured decision situations, when part of the model is scientifically and technically sound, and the rest is subjective of unknown validity, hence of unpredictable outcome. Thus, decision situations are complex structures, which might be better handled by **complex analysis** (as defined in mathematics with complex variables, which are pairs of real and imaginary components) and become an extension of the theory of decision-making.

Assumption 1c: The ***frame of reference*** consists of:

- **sn –** a vector of all **states of nature** – independent environmental variables, which are beyond control of decision-makers and of significant materiality or impact on operations; they describe a part of the **circumstances** under which operations occur
- **V** – set of significant (by impact) dependant variables **v** under decision-makers' control,
- An adopted **criterion of effectiveness** of operations, and
- ***Assumption 2*:** Decision-makers employ only **rational** and **rule following** choices as defined by March (1994).

As long all of the above including the assumptions do not change, each variable:

- Is viewed and assessed the same way by rational decision-makers (observers),
- Is bound by the same logic, and
- All principles, to which qualities of operation factors are subject, remain unchanged.

Postulate** of **general relativity of variables: Rational observers view, perceive, and assess the same way all variables, as long the **purpose** and **frame of reference** remain unchanged. Nevertheless, when changes occur, it changes how even objectively identical operation factors and their qualities are seen, perceived, observed, and assessed by decision-makers. This is the **all-pervasive principle of relativity of all variables in informing and in all operations** in general. It employs the analogy of inertial frames in theoretical physics.

A unit of any adopted **measure of results** of operations $\mathbf{M_{RO}}$ may serve as a ***yardstick.*** This is under the assumption that $\mathbf{M_{RO}}$ is a function of the main purpose **P,** all states **s(v) є S(v)** of significant variables **v є V**, and of all significant states of nature denoted by vector **sn,** formally

$\mathbf{M_{RO} = M_{RO}[P, s(v), sn]}$ for all s(v)) є S(v) and v є V
(**Assumption 3**)

For instance in business, income after taxes, retained earnings, return on investment, return on equity, cost effectiveness, etc may measure the results. In public administration, measurable or only observable results can be derived from the entity's mission. In military operations, they may be described by the expected tactical or strategic objectives. For example, when cost effectiveness $\mathbf{C_E(O)}$ of operations **O** matters, then the percentage point of the ratio of the main purpose, **P** divided by the cost **C(O)** of operations **O** over time may serve as a unit of measure. Then formally: $\mathbf{M_{RO} = C_E(O) = 100*P/C(O)}$.

All of the above imply that a relatively complete qualitative cause/effect diagram of operations (known also as a fishbone diagram) is available or can be drawn. Such a diagram tries to identify all factors of significant materiality in the situation, the required actions to implement the decisions made, and/or the results.

Operation quality is defined here by distinct significant states of the factors' qualities (attributes, dimensions) that enable them to play a significant role in operations. If so, they all must be represented by corresponding variables in the decision situation matrix.

These factors can be **factors of substance** and **factors of symbolic nature**. ***Factors of substance*** may the four M's (material, method, machinery, manpower) and others including respective states of their significant qualities. In contrast to factors of substance, ***factors of symbolic nature*** may be data values, information values, and elements of knowledge meant as rules of reasoning and proceeding, again including respective states of their significant qualities. Operations factors may be:

- Already **available** such as any available substance, data, or elements of knowledge, and
- **Not yet available**, to be acquired or as yet even unknown to be recognized – such as any additional substance, information, or element of knowledge.

Operation variables acquire potential **materiality** from the purpose, circumstances and by the adopted criterion of effectiveness of operations. ***Materiality $M(v_x)$ of a specific variable v_x*** **is** defined as the difference in results of operations **RO** using $\mathbf{M_{RO}}$ as their measure when acting with all variables **V** and without the specific variable $\mathbf{v_x}$. Formally:

$M(v_x) = \mathbf{M_{RO}(V) - M_{RO}(V - v_x)}$

Significant materiality or impact on operations is defined by the condition $\mathbf{M(v_x) \geq Min\ (\Delta M_{RO})}$, where $\mathbf{Min\ (\Delta M_{RO})}$ is the threshold of significance expressed as a minimal increment $\mathbf{\Delta M_{RO}}$ **of** the measure of results $\mathbf{M_{RO}}$ the decision-makers care. Each decision variable **v** belonging to their set **V** must meet the following condition. Formally:

$\mathbf{V = E\ [M(v) \geq Min\ (\Delta M_{RO})]}$ for all v є V

After any new variable **ΔV** and its state **ΔS** has been recognized as significant, the previous set of significant variables $\mathbf{V_p}$ and their states $\mathbf{S_p}$ will be updated (augmented or reduced) to their respective current states $\mathbf{S_c}$ of variables $\mathbf{V_c}$. Formally:

$\mathbf{V_c = V_p + \Delta V}$ and $\mathbf{S_c = S_p + \Delta S}$

In general, ***quality requirements QR(v)*** for variables v є V can be represented as a vector of required states of their quality **rs(q(v)) є RS(q(v)),** and all of them can be represented by corresponding decision variables. Formally:

$QR(v) = [\mathbf{rs(q_1(v)), rs(q_2(v)), \ldots rs(q_n(v))}]$ for all q(v) є Q(V), v є V

Universal Taxonomy of Decision Variables

One of the first steps to knowledge is clear distinction of entities (objects, qualities, states, relationships, phenomena, etc) under investigation. One needs a rigorous taxonomy of qualities, their states, and the consequences of their changes. In science, the strongest taxonomy is the binary one. It is natural and logically perfect in accordance to the fundamental principles of thinking.

Most textbooks and empirical studies list under different names a plethora of qualities or dimensions of data/information quality for consideration as stated by Wang and Strong (1996). In operations, certainly one may identify easily hundreds or thousands more qualities. The major question is, however, how to examine those qualities in real life situations, how to focus the attention of the examiners, how to provide them with diagnostic guidelines? Which of them affect the situation results directly or indirectly, which are primary or secondary, necessary or optional, which are not fully attainable and therefore one must learn to act with only some acceptable level of quality. Because many are there, these qualities require a systematic uniform approach to research and their practical diagnostic examination.

In informing, these concerns lead to a universal taxonomy of all known and not-yet known data or information qualities and requirements related to them, which together with research in-progress on interdependencies among them (Gackowski, 2004 and 2006) provides many clues in this regard. The same applies to their taxonomies. Thus by the power of this abstraction one can move from the universal hierarchical impact-focused taxonomy of quality requirements for data and information values (Gackowski, 2005) to an equivalent taxonomy of decision variables in decision-making (see Table 1), which does not yet cover the distinction of their real and imaginary components.

Operation quality of data of information (Gackowski, 2005) identified only **five** direct universally necessary quality requirements, **four** direct secondary quality requirements, when economy of operations matters, and some situation-specific ones, which make them usable. Hence, a variable ***uv*** is usable, if:

uv **≡ (Interpretable** v **Recognizable) ^ Relevant ^ Significantly material ^ Operationally timely available ^ (Actionably credible** v **Actionably reliable) ^ meets all situation-specific necessary quality requirements.**

Similarly, an ***economically usable variable – euv*** must be first usable (**uv** – see above) and then meet the four direct secondary requirements, formally:

euv **≡ uv ^ economically [(interpretable** v **recognizable) ^ available ^ (credible** v **reliable)].**

To facilitate its comprehension it is necessary to reemphasize that in decision-making a variable (whether dependent or independent, deterministic or stochastic, discrete or continues) must represent all its significant states.

The ***universal hierarchical impact-focused taxonomy of sets of significant variables:***

Table 1. Schema of hierarchical impact-focused taxonomy of decision variables

Categories of Decision Variables			
Direct			Indirect
Primary		Secondary	
Universally Necessary	Situation-Specific	……. …….	……. ……. …….
…….	……..		

1. The taxonomy subdivides the universe of **variables V** into **direct** and **indirect** or subordinate variables.
   a. A change from the previous state $\mathbf{s_p}$ to the current state $\mathbf{s_c}$ of ***direct variables*** **s(dv),** where $\mathbf{dv \in DV \subset V}$ immediately affects the decision situation itself, and/or the actions to implement the decisions made, and/or the results of operations, which implies they change the value of the adopted measure of results of operations $\mathbf{\Delta M_{RO}}$, formally: $\mathbf{(s_p(dv) \neq s_c(dv)) \Rightarrow (\Delta M_{RO} \neq 0).}$ If any of the above listed requirements cannot be met, this implication remains valid.
   b. A similar change of states of ***indirect variables*** **s(iv)),** where $\mathbf{iv \in IV \subset V,}$ as the name suggests, only indirectly affects the situation, for it determines or contributes to states of other **indirect variables of a higher order** (closer to the direct ones and at the extreme to **direct variables**). When $\mathbf{s_p}$ and $\mathbf{s_c}$ respectively denote **previous** state **current** state of an indirect or direct variables, and $\mathbf{iv_n}$ and $\mathbf{iv_{n-1}}$ respectively denote **indirect variables** of n^{th} order and **indirect variables** of higher $(n-1)^{th}$ order, for n = 1 indirect variable of 0^{th} order is a direct variable $\mathbf{iv_0 = dv}$. It implies that changes of states of indirect variables of n^{th}-order causes a change of state of the related indirect variables of a higher order $\mathbf{iv_{n-1}}$ or at the extreme of direct variables. Formally: $\mathbf{(s_p(iv_n) \neq s_c(iv_n) \Rightarrow (s_p(iv_{n-1}) \neq s_c(iv_{n-1}))}$. Example: If any of the twenty indirect qualities identified by Gackowski (2006a) as contributing to "actionable credibility" among them definition, variability, bias correctness, precision, and currency cannot be met at least at an acceptable level the concerned variable must be dropped from the decision situation matrix and its definition at least partially redefined.
2. The **direct variables** are subdivided into **direct primary** and **direct secondary** variables. The primary ones are Boolean {true, false}, that is exists or not, a requirement is either met or not.
   a. Changes of states of the ***direct primary variables*** **s(dpv),** where $\mathbf{dpv \in DPV \subset V}$ result always in *qualitative* changes to the decision situations under consideration, which result in adding or eliminating a variable from consideration - labeled $\mathbf{\Delta V.}$ Such changes add or delete entire rows or columns from the matrix that represent the model of a decision situation. When the above requirements of usability cannot be met, again, it requires at least a partial redefinition of the decision situation, which leads to quantitative consequences, as well. Formally: $\mathbf{(s_p(dpv)) \neq s_c(dpv)) \Rightarrow [(V_p \neq V_c) \wedge (\Delta M_{RO} \neq 0)],}$ where $\mathbf{V_c = V_p + \Delta V.}$
   b. Changes to states of the ***direct secondary variables*** **s(dsv),** where $\mathbf{dsv \in DSV \subset V}$ mainly *quantitatively* change the results of operations; hence, they may not necessarily be of significance $\mathbf{(\Delta M_{RO} \geq Min\ (\Delta M_{RO}))}$. Nevertheless, if the subsequent quantitative changes reach a critical point that is, if the current state $\mathbf{s_c \in C(s(dsv))}$ belongs to the set of critical states **C**, they may trigger a qualitative change of situations. Then they become necessary, as well. The secondary variables are mostly of economic nature. If not only effectiveness, but also economy of results matters, the secondary variables also may become necessary, however not universally necessary. Formally: $\mathbf{(s_p(dsv) \neq s_c(dsv)) \Rightarrow [(\Delta M_{RO} \neq 0) \wedge If\ (s_c(dsv) \in C(s(dsv))}$ then also $\mathbf{(V_p \neq V_c)]}$. Example: Usually environmental requirements must be met within a certain prescribed range, of course at cost. However, when the upper lawfully acceptable level has been exceeded, heavy fines may be imposed and even the entire operation suspended.
3. The **direct primary variables** are divided into those of **universal necessity** versus those that are necessary in specific situations, **situation-specific necessary**. Changes to their states are Boolean {true, false} and always redefine the decision situation by adding or deleting entire rows or columns from the decision situation matrix.
   a. The ***direct universal primary variables*** are always necessary. Changes to their states **s(dupv),** where $\mathbf{dupv \in DUPV \subset V}$ add or eliminate them from consideration. Formally: $\mathbf{(s_p(dupv) \neq s_c(dupv)) \Rightarrow (V_p \neq V_c)}$ always redefines the decision situation.
b. The ***direct primary situation-specific variables*** are necessary also. Changes to their states **s(dpssv),** where $\mathbf{dpssv \in DPSSV \subset V}$ also add to or eliminate variables from considerations, however they are not universally necessary only under situation-specific conditions. Formally: **If situation requires** then $\mathbf{(s_p(dpssv) \neq s_c(dpssv)) \Rightarrow (V_p \neq V_c)}$. Example: Restricted availability of information in a competitive situation, otherwise, when available to all, it may lose its advantage, hence materiality).

Research Priorities

Once a universal hierarchical result-determined taxonomy of variables has been defined, it nearly automatically prioritizes the sequence of their diagnostic examination and any corresponding research. These priorities, again, do not yet cover the distinction of the real and imaginary components of variables.

1. ***First priority.*** The variables that represent the **direct universal primary requirements** should be the immediate subject to scrutiny. By the principle of usability (Gackowski, 2005), they must be **interpretable** or **recognizable**, **relevant**, of **significant materiality** of impact, operationally **timely available**, and **actionably credible** or **reliable**. If any of the five requirements is not met, the variable that represents the affected decision factor is out of commission. In addition, in operations, any factor must be **effectively complete** that is be usable together with other usable factors for a task to be accomplished, which gives us the sixth universally necessary requirement. All the above suffice for only effective operations, not necessarily economically effective. It pertains to all-out efforts such as special operations or terror acts, where economy is secondary. All the above requirements, if not met, call for a qualitative redefinition of decision situations. Materiality measures the importance of the variable.
2. ***Second priority***. When economy matters, which is an all-pervasive principle in business, not necessarily in administration or military operations, four additional **direct secondary requirements** play an important role. Then the affected factor (represented by a decision variable) must be **economically interpretable** or **recognizable**, **timely available**, **actionably credible** or **reliable**, and **economically effectively complete** together with its companion factors. Now, the direct secondary requirements are also necessary, however, not universally necessary. Any changes to them, usually cause quantitative changes only, as long, any of them does not reach a critical state (for example, cannot exceed the limits required by law). Then again, it will cause a redefinition of the decision situation.
3. ***Third priority.*** All the rest belongs to **indirect quality requirements**. Depending on the length of the chain of their interdependencies, there are indirect requirements of the first, second, and subsequent orders. This fact again, clearly prioritizes the diagnostic sequence of their examination and respectively any related research about these factors.

Components of the proposed framework and model for research are anchored in basic scientific principles. Hence, they do not require extensive empirical validation except fore coming up with examples to the contrary or other objections with regard to the logic of the model. Then the model may require a revision. The proposed model and framework needs, however, be discussed and challenged.

SUMMARY, CONCLUSIONS, AND LIMITATIONS

A formal definition of operation quality requirements of data and information, and any other factor in operations offers an insight that with no or only some terminological modifications it equally applies to factors of substance. In decision-making, all of them, if only significant, are decision variables. They all are decision variables subject to the same universal hierarchical impact-focused taxonomy. If this taxonomy remains substantially unchallenged, it qualifies as basic research in contrast to applied research of situation-specific limited validity.

Some principles of operation quality by which the quality requirements are governed, and pertain to decision variables may be summarized as follows:

1. **The principle of *relativity* of variables in decision-making.** Quality requirements are determined by the purpose **P** and circumstances of operations described by the vector **sn** of significant states of nature, the criterion of assessment of effectiveness of operations, and the assumption that decision-making is limited to rational and rule following choices (see the Postulate of Relativity).
2. **The principle of *pervasiveness* of materiality of factors.** A factor in operations confers its materiality upon all its qualities and its corresponding necessary task-specific usable companions represented by corresponding decision variables.
3. **The principle of *usability* of factors in operations** (when it meets all the **universally necessary** (**interpretable or recognizable**, of significant **materiality,** operationally timely **available**, and actionably **credible** or actionably **reliable**) and the other **situation-specific necessary quality requirements** that pertain to the corresponding decision variables.

4. **The principle of *degradation* of decision situations by declining usability of factors represented by variables**. If the usability of a factor:
   a. **Is certain**, the decision-maker deals with a **deterministic situation** at least in the area affected by the factor
   b. **Is only probable** (the most likely case), the decision-maker deals with a **stochastic situation** to the same extent as above
   c. **Is not attained,** for instance when not timely available or not actionable reliable/credible, the decision-maker **games** to the same extent. It may be the case even when operations are not triggered, for instance when a threat is ignored.

This first attempt assumes a single main purpose with no conflicting requirements and constraints imposed upon decision makers. The impact-focused taxonomy of decision variables opens the door for research by modeling and simulating decision situations, as systems of state transitions, where the results by whatever adopted measure are a function of states of decision variables. Simulations will facilitate the quest for more complex quantitative dependencies and likely the discovery of other yet unknown interdependencies. Based on a formal theoretical model, research results of simulations conducted under rigorously controlled conditions promise results of a lasting validity when compared with pure empirical studies conducted without such taxonomy. Hence, the presented taxonomy seems to be a theoretical progress and of practical value in analyzing decision situations, decision-making, and the related research.

REFERENCES

Gackowski, Z. J. (2004). "Logical interdependence of data/information quality dimensions—A purpose-focused view on IQ," *Proceedings of the Ninth International Conference on Information Quality (ICIQ-04), Cambridge, Massachusetts*. Retrieved from: http://www.iqconference.org/Documents/IQ Conference 2004/Papers/LogicalInterdependence.pdf

Gackowski, Z. J. (2005b). "Operations quality of information: Teleological operations research-based approach, call for discussion". *Proceedings of the 10th Anniversary International Conference on Information Quality—ICIQ-05* at Massachusetts Institute of Technology (MIT), Cambridge, MA. Retrieved from http://www.iqconference.org/ICIQ/iqdownload.aspx?ICIQYear=2005&File=OperationsQualityofDatanInfo.pdf

Gackowski, Z. J., (2006a). "Quality of informing: Credibility - Provisional Model of Functional Dependencies"**,** *Proceedings of the 2006 Informing Science and IT Education Joint Conference.* Salford, UK – June 25-28, retrieved from http://proceedings.informingscience.org/InSITE2006/ProcGack194.pdf

Gackowski, Z. J. (2006b). "Redefining Information Quality and its Measuring: The Operations Management Approach". Accepted for the *Proceedings of the 11th International Conference on Information Quality—ICIQ-06* at Massachusetts Institute of Technology (MIT), Cambridge, MA.

Liu, L., Chi, L. N., (2002). "Evolutional Data Quality: A Theory-Specific View," *Proceedings of the Seventh International Conference on Information Quality (ICIQ-02), Cambridge, Massachusetts*.

March, J. G., "A Primer on Decision Making – How Decisions Happen". Free Press, New York, NY, 1994.

Oliviera, P., Rodrigues, F., Henriques P., (2005). "A formal definition of Data quality problems," *Proceedings of the 10th Anniversary International Conference on Information Quality—ICIQ-05* at Massachusetts Institute of Technology (MIT), Cambridge, MA. Retrieved from http://www.iqconference.org/ICIQ/iqdownload.aspx?ICIQYear=2005&File=AFormalDefinitionofDQProblems.pdf

Liu, L., Chi, L. N., "Evolutional Data Quality: A Theory-Specific View," *Proceedings of the Seventh International Conference on Information Quality (ICIQ-02), Cambridge, Massachusetts*.

Wand, Y., and Wang, R. Y., (1996). "Anchoring Data Quality Dimensions in Ontological Foundations," *Communications of the ACM*, 39(11), 1996, pp. 86-95.

Wang, R. Y., and Strong, D. M., (1996). "Beyond Accuracy: What Data Quality Means to Data Consumers", *Journal of Management Information Systems (JMIS)*, 12(4), 1996, pp. 5-34.

Teaching Online Information Systems Courses with Virtual Machines

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ABSTRACT

This paper considers the issues on setting up online computer labs for teaching the information systems courses that require intense hands-on practice. Due to limited technical support, budget, and space, it is always a challenge for a small university to implement online teaching for courses in the information systems curriculum. Often, faculty members in a small university need to be involved in the construction and management of online computer labs in addition to their normal teaching and research workload. The virtual machine technology can be used to ease some of the burdens of online computer lab construction and management.

1. INTRODUCTION

As the Internet technology advances, more and more courses are taught online now. Many academic fields have developed effective solutions for online teaching and learning. Generally, for courses with no lab activities, such as some of the courses in English, history, and education, the implementation of online courses are relatively easy. Many commercial learning management system (LMS) software packages such as WebCT are available to support this type of courses. Instructors post lecture notes, images, and assignments on a WebCT. Students read the online course content or download the files and read the materials off-line. LMS can also be used as knowledge management such as grading, hosting discussion groups, and presenting multimedia course content (Itmazi and Megías, 2005). For many information systems courses, this way of online teaching is not adequate because hands-on practice is a very important part of the curriculum.

Using the virtual machine technology can effectively overcome many difficulties for online hands-on practice. The Virtual machine technology can be used to create online computer labs that meet the requirements of teaching and hands-on practice. Two popular virtual machine software packages are VMware and Microsoft Virtual Server. The virtual machine technology has been used in computer technology certification training (Lammle & Tedder, 2003). When purchasing training materials, virtual machines are provided to simulate underlying IT products for learners to perform hands-on practice off-line. For the off-line use of the virtual machine technology to teach technology-based courses, the author can only find one report by Correia and Watson (2006) who used the software VMware to create 60 virtual computers for teaching computer network courses. The use of the virtual machine technology in constructing online computer labs is still in its early stage. There are few publications available.

This paper will first discuss the difficulties for teaching information systems courses online. Then, it will describe the virtual machine technology and how it can be used to support the teaching and hands-on practice for some information systems courses. This paper will provide some information about the advantages of using the virtual machine technology and possible hands-on activities that can be accomplished by using the virtual machine technology. It will also discuss some design and management issues. The last topic to be covered in this paper is about students' responses to the online information systems courses.

2. DIFFICULTIES IN PERFORMING HANDS-ON PRACTICE ONLINE

Unlike students in other fields, our information systems students have to play the roles of system administrators, network managers, and database administrators. It is inevitable that they will learn through mistakes made in operating systems, networks, and database management systems. An online information systems course needs an online computer teaching lab to support these hands-on activities. Some difficulties encountered in developing this kind of online computer lab are:

- Setting up fully functioning online computer labs requires sophisticated skills and experience in developing remote access services, enforcing security measures, and creating a highly interactive Web site. Often, the labs are built on the client-server architecture with a highly secured remote access mechanism. To better support the needs of students and faculty members, lab technicians should also be knowledgeable about the course content and should be able to update the online computer labs according to the current IT trend. Faculty members also need to fully understand the technologies used in the online lab.
- It is expensive to create and manage online computer labs. In our information systems curriculum, many of the courses require some lab activities on IT products. The requirements for hardware and software are different for different courses. It is difficult for small universities to cover every course with different technology requirements. The labor cost is also a great concern. Many small universities do not have the budget to support an experienced technical support team or hire consulting companies for constructing and managing the labs.
- It requires great effort to manage online computer teaching labs. The course content in the information systems curriculum is changing rapidly. The course content is often updated every semester. It takes a group of technicians to frequently redesign and update the online computer labs. Many small universities may not have dedicated computer service staff for daily maintenance of these computer labs. It is a nightmare for a small computer service department to handle so many different technologies and to update these technologies so frequently.
- Technical support is another difficult area. Many of our students are new to the lab facilities. They have little experience on using the hardware and software in the lab. Even worse, students in some information systems courses such as network management and database administration have to be given the system administrator' privilege in order to perform server-side operations. From time to time, students crash the operating systems, networks, or databases because of wrong configurations or other mistakes. When technical problems occur, it is difficult to get technical support due to lack of detailed information about students' projects and the shortage of technicians on campus.

Because of these difficulties, many hands-on based information systems courses are not fully online. Some of the online information systems courses require students to purchase the necessary technologies for hands-on practice. Many of our students cannot afford to purchase all the required hardware and software. Even if some students are able to purchase all the hardware and software for their classes, they may configure them differently; which may cause problems that prevent them from conducting some of the hands-on activities.

3. SOLUTION

As described above, many small universities have limited budget, limited technical support, and high demand for lab resources. Among the possible solutions for dealing with the challenge, the virtual machine technology provides a low cost, secure, and manageable solution. Virtual machines use software to accomplish the functionalities of hardware devices. On a physical computer, multiple virtual machines can be created and each can be installed with a different operating system and application software. These virtual machines can run concurrently

(Nathaniel Martinez, 2004). Originally, virtual machines are used to construct a testing environment for software and hardware consolidation. The technology reduces security risks and enables developers to quickly reconfigure computer systems for different testing tasks without the fear of destabilizing the systems for other users. For us, such a technology can be used to overcome the difficulties in developing an online computer teaching lab. The following are some of the advantages of the virtual machine technology when used for teaching online information systems courses.

- Affordability: Since multiple virtual computers can run concurrently on a single physical computer, it significantly reduces the cost and lab space. Even a small university can afford virtual machines.
- Flexibility: These virtual computers can communicate with each other through a virtual network created on the same physical computer. More importantly, virtual computers can be accessed through the Internet so that students can remotely access the online computer lab from anywhere and at any time. A virtual computer allows the lab developer to experiment with various lab configurations for different information systems courses in a fast and easy way. It is a great platform for the frequently updated computer labs.
- Manageability: The maintenance of virtual computers is relatively easy. You do not need to maintain network cables, power cords, and many other hardware devices. If a virtual computer crashes, you do not need to reinstall all the software. Instead, you can create a new virtual computer in a few minutes and link the newly created virtual computer to an existing backup of the virtual hard drive.
- Security: The virtual machine technology provides a much securer solution for teaching online courses. Students do not need to have the administrator's privilege for the physical computers. All they need is the administrator's privilege for the virtual computers. In such a way, students can only experiment with their own virtual network system and they have less chance to damage the university's network.

With the advantages mentioned above, the virtual machine technology is promising for teaching information systems courses.

For online use of the virtual machine technology, you may need another virtual technology, Virtual Private Network (VPN). Instead of using a physical network such as leased phone lines from a telephone company, VPN uses virtual connections to communicate with remote computers through the Internet. More information about VPN can be found in the book by Snader (2005). The following are some advantages of VPN.

- VPN allows students to log on to the online computer lab from anywhere and at any time through the Internet.
- VPN can be configured to allow students to log on to the online computer lab without directly working on the university's internal network. This greatly reduces the network's security risks.
- VPN provides the broadband Internet compatibility which is essential for GUI based hands-on practice.
- The cost of the VPN software is minimal. Operating systems such as Windows Server 2003 includes the VPN utility.

On the other hand, the virtual machine technology is not perfect for everything; the following are the restrictions that we may encounter when developing this kind of online computer lab.

- Due to the fact that multiple virtual computers are sharing the same physical computer, the performance of virtual computers in general is slower than that of a physical computer itself. This is not a serous problem for our lab activities since most of the lab projects are small projects when compared with the real enterprise level projects.
- Usually, for GUI based hands-on practice, we need a broadband Internet connection. Fortunately, most of our students have a broadband connection at home. For those who do not have broadband connections, they can go to a public library, or local community college campus to access the Internet.

In the next section, I will briefly describe how the virtual machine technology is used to support teaching and hands-on practice for various courses in the information systems curriculum on our campuses.

4. DESIGN OF COMPUTER LAB FOR ONLINE TEACHING

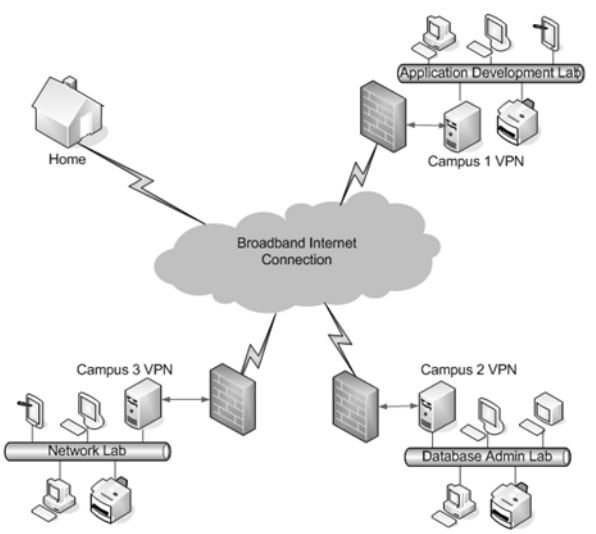
With the virtual machine technology, we are ready to develop an online computer lab for teaching various information systems courses that require intense hands-on practice. In this section, we will investigate how the virtual machines are used for supporting multiple information systems courses concurrently.

The first task is to investigate the requirements by the information systems courses. The courses that require hands-on practice can be classified into the following categories.

- The courses such as networking and system administration must allow students to have an administrator's privilege. Students will need to install and configure a network or operating system as part of their hands-on practice. No other courses should share the same computers with these courses since after reconfiguration, students of other courses may lose all their work or even are unable to log on to the computer system. The virtual machine technology is the best solution for this type of course.
- Students in the courses such as database administration or other application administration related courses must have the administrator's privilege for database servers and application servers so that they can perform the server-side administration tasks. The courses using various servers may share the same physical computer since the reconfiguration of one server normally has minimal impact on the other servers.
- In an information systems curriculum, courses related to application development and programming languages normally require a secure and stable physical computer as the server. The application development courses such as Database Application Development should not share the same server that also supports the Database Administration course since the reconfiguration of the database server can wipe out the database content created by the students in the application development course or prevent the students from other courses to log on to the database server. The virtual machine technology is a good platform for hosting the servers for application development courses on different virtual computers.

As mentioned earlier, the performance of virtual computers is a major concern. Due to limited budget, purchasing more powerful computers is often not an option for many small universities. One of the possible design options is to distribute the computing tasks to multiple less powerful computers. We can do that at different levels. First, let each physical PC host three or four virtual computers. In such a way, twenty PCs can host sixty to eighty virtual computers. Each virtual computer can handle a specific task. Next, to reduce network bottlenecks, we can distribute the VPN servers to multiple locations. As an example, consider our university which has three small campuses and each of them has the limited computer resources. To meet the needs of teaching and hands-on practice, a distributed computer lab can be constructed with three small labs, one on each campus. In such a case, we

Figure 1. Distributed online computer lab



can set up one VPN server for each campus. Each campus will host a computer lab that can support a certain type of courses. For example, the first lab can be used to support the network administration related courses, the second one can be used to support the database administration related courses, and the third one can be used to support the application development courses. The following figure demonstrates the design of the distributed online computer lab.

In Figure 1, the client computers such as students' home computers or notebook computers need to be configured so that they are able to remotely access the VPN servers. Based on the class enrollment, each VPN server has the local accounts for these students so that they can log on to the VPN server. Through the VPN server, the students can access each individual physical computer in the lab for hands-on practice. Each individual physical computer does not have to be an up-to-date powerful PC; a low-end Pentium IV PC has enough power to handle the hands-on practice for the information systems courses. Even the older Pentium III computers can get the job done if they are equipped with adequate memory for running the virtual computers.

5. EVALUATION OF ONLINE COMPUTER LAB

Our online computer lab has been used for two semesters. Is it a satisfactory solution in supporting online hands-on practice for information systems courses? We are also interested in what makes students take the online courses supported by the virtual technology and their reaction to this type of online courses. The response from students can be used as a guideline for further improvement.

At first, we were not sure whether it is doable to teach courses that require intense hands-on practice online, especially, to teach the information systems courses that require operations on the server side. To be on the safe side, we offered two sessions for each course, one session was a traditional face-to-face class, and the other one was a complete online class. The same instructor taught both sessions and the same teaching materials were used for both sessions. To give the students in the face-to-face class a chance to experience the online computer lab, we also permit them to use the online computer lab for their hands-on practice. Similarly, the students in the online session can participate in the face-to-face class and use the computer lab on campus. Initially, 42% of the students chose the face-to-face session and 58% of them chose the online session. At beginning of the semester, a survey was conducted to collect information about the students' background on taking online courses and the reasons that made them choose the online session over the face-to-face session, and vice versa. For the online session, the responses to some of the survey questions are listed in Table 1.

According to the survey results, the reasons for students to choose an online session are mainly due to the considerations of their job schedules, family activities, and class schedules. The students can take advantage of an online course to resolve the time conflicts. As indicated by the survey, 95% of the students have some knowledge or familiar with the course content and therefore they have confidence that they can handle the course work on their own. Other significant findings are: 100% of the students can access the Internet through their home computers and 95% of them have broadband Internet connections; 94% of the students use Windows XP Professional to access remote servers and 100% of the students can use their computers for online chatting and connecting to the VPN servers. A majority of these students are part time students. Only a small percentage of the students do not have the broadband Internet connection which is necessary for performing the hands-on practice using an online computer lab. For these students, we have arranged them to go to the nearest college campus to access the online computer lab. On the other hand, we are also interested in why some students chose the face-to-face session over the online session. The survey results for the face-to-face session are listed in Table 2.

The survey results indicate that the main reasons for a student to choose face-to-face are that they like to interact with instructors and classmates and they like to work in the campus computer labs which have better technical support and performance. Among these students, only about half of them have some previous knowledge about the course content, significantly less than those of the online session. A significant finding is that 83% percent of the students have taken other online courses. They come back to take the face-to-face class; this indicates that they are not satisfied with those online courses.

We have followed the same group of students for both sessions for two semesters. The average grades including exam and assignment scores for both sessions have no significant difference by the t-test with the significant level 0.05. About 5.8% of the students in the online session withdrew from the online class while no one withdrew from the face-to-face class. There is a significant change in the enrollment. Initially, 58% of the students enrolled in the online session and 42% of the students enrolled in the face-to-face session. At beginning, some of the students in the online session showed up in the face-to-face session whenever they could attend. On the other hand, some of the students in the face-to-face session used the online computer labs to complete their assignments at home. Now, for the coming semester in Fall 2006, only 16% of the students enrolled in the face-to-face session and 84% of the students registered for the online session. These are the same group students. What has caused such a dramatic change? One thing has to do with the students' confidence towards the online courses supported by the online computer labs. In order to find out how these students' learning

Table 1. Online session survey results

Question	Answer	Percentage
What are your reasons for enrolling in an online class? (Check all that apply.)	Want to have an experience about online classes.	5%
	Online classes do not conflict with my job schedule.	82%
	Online classes allow me to take care of my family.	57%
	The class I preferred was cancelled.	0%
	My preferred class is offered at an inconvenient time.	18%
	Online classes require less study time.	0%
Have you taken an online class before?	No, it is the first time for me.	35%
	Yes, I have taken an online class before.	65%
What is your enrollment status?	Full-time (12 or more credit hours).	18%
	Part-time (less than 12 credit hours)	82%
From where do you log on to the course Web page? (Check all that apply.)	Home computer	100%
	Work computer	53%
	Campus computer	18%
	Public library	0%
What types of Internet connections do you use to access the online course materials? (Check all that apply.)	DSL	29%
	Cable	53%
	Dial-up	5%
	WAN or LAN	29%
What types of operating systems do you use to access the online materials? (Check all that apply.)	Windows XP Professional	94%
	Widows XP Home	29%
	Unix or Linux	5%
	Mac OS	12%
Are you able to handle the following tasks with your computer? (Check all that apply.)	Online chat	100%
	Video conferencing	35%
	VOIP	12%
	VPN	100%
How much do you know about the course content?	Have no knowledge about the course content.	5%
	Have some knowledge about the course content.	89%
	I am familiar with the course content.	6%

Table 2. Face-to-face session survey results

Question	Answer	Percentage of Response
What are your reasons for enrolling in a face-to-face class? (Check all that apply.)	I am not sure about the quality of an online class.	10%
	I did not know there is an online session.	6%
	I do not have a high speed Internet connection.	8%
	I do not have adequate computer equipments.	9%
	I can interact with my instructor and classmates.	83%
	I like to work in a computer lab on campus.	75%
How much do you know about the course content?	Have no knowledge about the course content.	50%
	Have some knowledge about the course content.	50%
	I am familiar with the course content.	0%
Have you taken an online class before?	No, I have not taken an online class before.	17%
	Yes, I have taken an online class before.	83%
What is your enrollment status?	Full-time (12 or more credit hours).	34%
	Part-time (less than 12 credit hours)	66%

behavior changes with time, we need to collect more data from the same group of students over time for longitudinal analysis which will provide us with more convincing conclusions.

6. CONCLUSION

This paper has discussed the issues related to the application of the virtual machine technology in developing online computer labs for hands-on practice. The virtual machine technology can be used to overcome many difficulties in performing hands-on practice online. Virtual machines provide an efficient solution to constructing an online computer lab so that the technology-based courses requiring hands-on practice can be completely taught online. The results of the analysis indicate that the students have gained confidence towards the online lab-based courses, and more and more students on our campuses are in favor of the online courses.

REFERENCES

Itmazi, J. A., & Megías, M. G. (2005). *Survey: Comparison and evaluation studies of learning content management systems.* Retrieved May 7, 2006, from http://scholar.google.com/url?sa=U&q=http://moodle.org/file.php/5/moddata/forum

Lammle, T., & Tedder, W. D. (2003). *CCNA virtual lab, platinum edition (Exam 640-801)*. Alameda, CA: Sybex.

Correia, E., & Watson, R. (2006). VMware as a practical learning tool. In N. Sarkar (Ed.), *Tools for teaching computer networking and hardware concepts*. (pp. 338-354). Hershey, PA: Idea Group, Inc.

Nathaniel Martinez (2004). *Microsoft Virtual Server 2005 and the virtualization server market opportunity (Digital)*. Framingham, MA: IDC.

Snader, J. C. (2005). *VPNs Illustrated : Tunnels, VPNs, and IPsec*. Boston, MA: Addison-Wesley Professional.

Reinventing Gantt's Chart

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INTRODUCTION

The "Gantt Chart" has been a key tool in project management and industrial engineering since the early twentieth century. Even today the Gantt chart along with the relatively modern "spreadsheet" are still the most commonly used and well understood tools for analyzing and presenting project schedules and progress thereon. However today's Gantt, while similar in basic concept to the original Gantt chart, has evolved considerably in terms of appearance and functionality.

This article researches the Gantt chart both looking back and forward. It is appropriate to present this research at this time on the one hundredth anniversary of the original Gantt chart. The article follows the Gantt chart's evolution, and then looks forward to hyperlinked web based "earned value enabled" Gantt charts emerging in the twenty first century.

THE ORIGINAL GANTT CHART

Henry Laurence Gantt (1861-1919) was a mechanical engineer and management consultant. He formulated his Gantt charts early in 20th century, about 100 years ago. The charts were used as a visual tool to show scheduled and actual progress of tasks, types of work, and individuals. Now a commonplace project management tool, it was an innovation of great importance then. Gantt studied in great detail the order and types of tasks in industrial work, and his studies initially focused on Navy ship construction during WWI. He formulated "The Task Idea", and a couple years later presented it in Chapter VII of his book (Gantt, 1910). His "task" had a well defined procedure for carrying out the steps thereof, metrics to ensure proper completion of the task, metrics for approximate resources used to perform that type of task, and bonuses or some other type of motivation for a worker to complete the task in a timely and quality manner. Even today some of these components of tasks are not quantified in our construction of schedules. His definition of a schedule was a series of ordered tasks charted on a calendar.

Gantt charts had visual task bars and they outlined the sequence and duration of project tasks. His original charts were organized by person, and also showed work type ("piece" or "day" work), absence, termination, promotion, and bonus situations. One of Gantt's main areas of study was worker motivation, hence the inclusion of that additional type of information on his charts. An original chart from his book (Gantt, 1910 and 1919) is shown in Figure 1, which compares the same time period in 1909 and 1910. Gantt charts were later used on large U.S. domestic construction projects like the Hoover Dam started in 1931.

With the advent of WWII, the growing complexities of projects and a shrinking war-time labor supply demanded new organizational structures. Complex network diagrams called PERT charts and the critical path method were introduced and combined with Gantt charts, giving managers greater control over very large and extremely complex projects (such as military weapon systems) where tasks were highly interdependent. Later his charts were used on large peace time projects such as the U.S. interstate highway system started in 1956.

A typical Gantt chart of this era is shown in Figure 2. Here each task is represented as a horizontal bar and is a time-line view of the tasks. Now each task may have one or more resources assigned thereto. This chart is a bar graph where the length of each bar designates the start and finish dates for each task. Each task is typically labeled with its ID (or WBS code) and description.

In the early 1990s link lines (as shown in Figure 2) were added to these task bars depicting dependencies between tasks. Today there are many variations of the basic Gantt chart where more information is added in task ID area or in the graphic area with the bars. In the graphic area there may be: use of color, precedence

Figure 1. Original Gantt chart

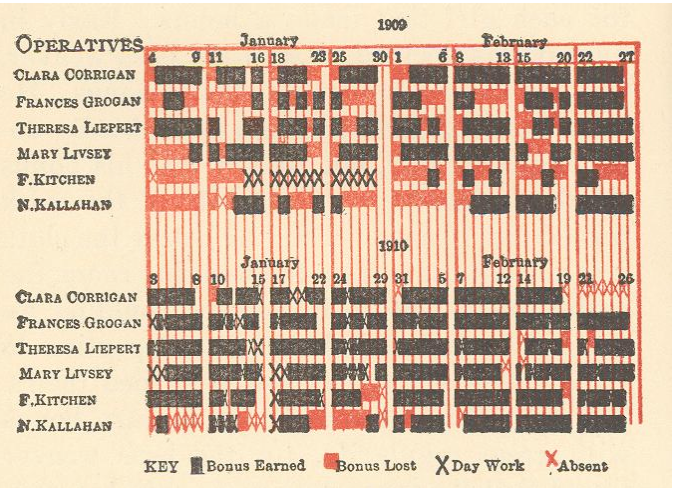


Figure 2. Classical Gantt chart

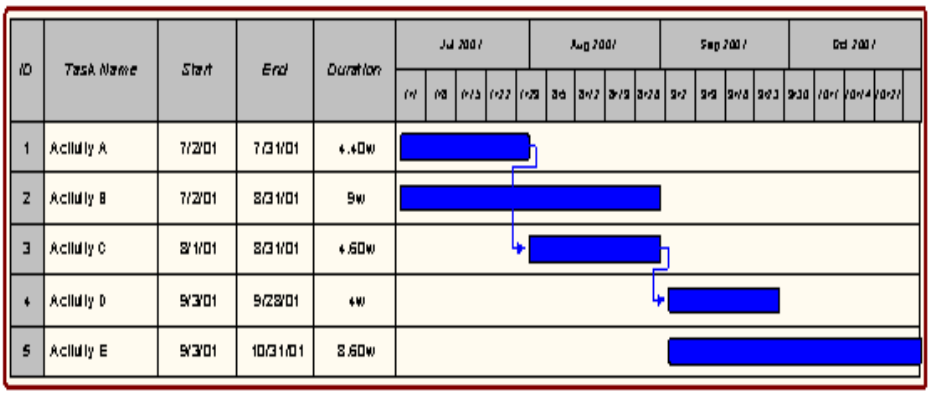


Figure 3. Modern Gantt chart (Kidasa Software, www.kidasa.com)

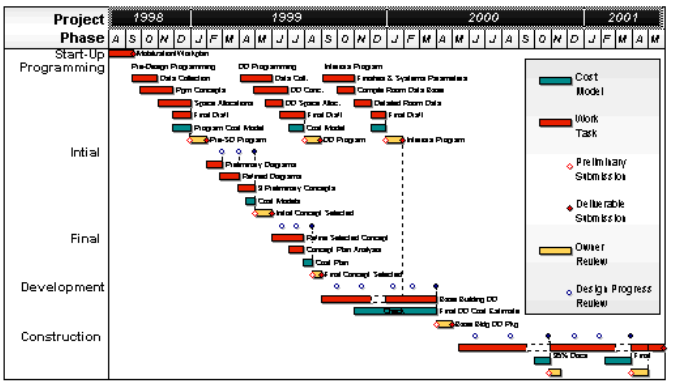
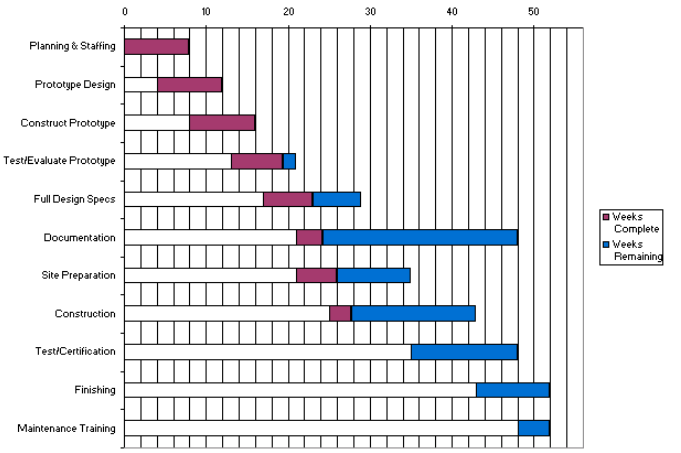


Figure 4. Project info in spreadsheet

Project Plan and Progress - Week 30

Task	Start Week	Weeks	% Complete	Weeks Complete	Weeks Remaining
Planning & Staffing	0	8	100	8	0
Prototype Design	4	8	100	8	0
Construct Prototype	8	8	100	8	0
Test/Evaluate Prototype	13	8	80	6.4	1.6
Full Design Specs	17	12	50	6	6
Documentation	21	27	12	3.24	23.76
Site Preparation	21	14	36	5.04	8.96
Construction	25	18	15	2.7	15.3
Test/Certification	35	13	0	0	13
Finishing	43	9	0	0	9
Maintenance Training	48	4	0	0	4

Figure 5. Gantt chart from spreadsheet



relations, shading in the bars to show percent completions of the tasks; coloring or other notation of the bars to show tasks on the critical path, and milestones (zero length event markers). In the task ID area there may be a WBS hierarchy, phasing, envelopes, or other information about the tasks in additional columns. Figure 3 is an example of a Gantt chart with other such information.

However even the modern Gantt chart is not without some problems in regard to the representation of a project schedule and the progress thereon:

- It portrays an even distribution of both planned and actual effort from the start of a task to the end of that task (particularly when per-cent complete shading of the bars is used).
- It is not generally interactive, and does not respond to user actions (i.e. mouse clicks) to change the content, level of detail, or perspective of the information displayed
- It is not immediately apparent what tasks may be in trouble in regard to schedule or cost parameters
- It does not show true schedule variances (i.e. EVA schedule metrics)
- It does not show cost information (planned, actual, and EVA variances)

MANAGEMENT AND TECHNOLOGY ADVANCES

In the last twenty years or so a number of management and technology advances have occurred many of which have been applied to the basic Gantt chart. These advances remove some of the problems previously itemized and also provide other utility. Such management and technology advances include electronic spreadsheets, relational database management systems (RDBMS), earned value analysis (EVA), management by exception, management "dashboards", client/server computing, hypertext, and the Internet/WWW.

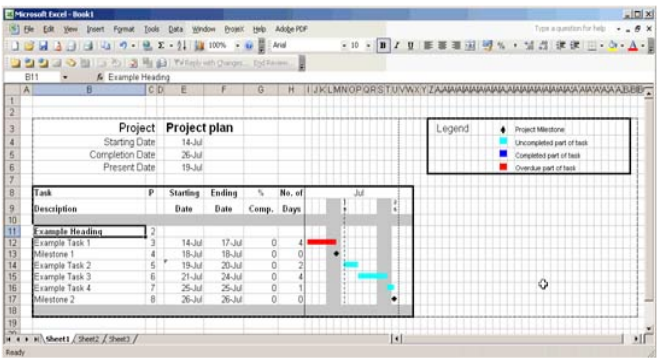
The most commonly used computer software for project management (and business in general) is the spreadsheet program. Spreadsheets are easy to learn, easy to use, inexpensive, generally available, and adaptable to most project management tasks. Consider the project planning and progress information shown in the spreadsheet of Figure 4; the last two columns are calculated columns. A graphical representation in the form of a classical Gantt Chart can also be created from the spreadsheet data in the first three columns using the "charting" capability in most modern spreadsheet programs (such as Microsoft Excel). In addition one can also use the columns for "weeks completed" and "weeks remaining" to draw a Gantt Chart showing progress as illustrated in Figure 5.

The Excel chart wizard was used to create Figure 5 with the columns for "task", "start week", "weeks complete", and "weeks remaining"; the first part of each bar was made the same color as the chart background (the chart may be shown in black and white here, but the "completed' and "remaining" parts of each bar are a different color).

There are also spreadsheet "add-ons" available from a number of vendors to facilitate Gantt chart creation; one such add on is illustrated in Figure 6.

Today internet based Gantt charts are starting to be used. These are typically created using hypertext markup language (HTML) tables and cascading style sheets (CSS) as is the example in Figure 7 from the FiveAndDime system. This variation of the basic Gantt chart is a "Cost Based Gantt Chart" where "bars" are

Figure 6. Gantt chart using an Excel add-on



represented as a series of cost numbers for each time period of each task. This provides for a non-linear distribution of cost (and resources) across the time span for the task and allows one to quickly see at a glance both the time for a task and the cost distribution (cash flow).

EARNED VALUE ANALYSIS

"Earned Value" (EV) is a value (usually expressed in currency) of the work accomplished up to a point in time based upon the planned (or budgeted) value for that work. The original U.S. government's term for earned value is "Budgeted Cost of Work Performed" (BCWP). Earned value terminology was originally

Figure 7. Cost-based Gantt chart as Web table (www.fiveanddime.biz)

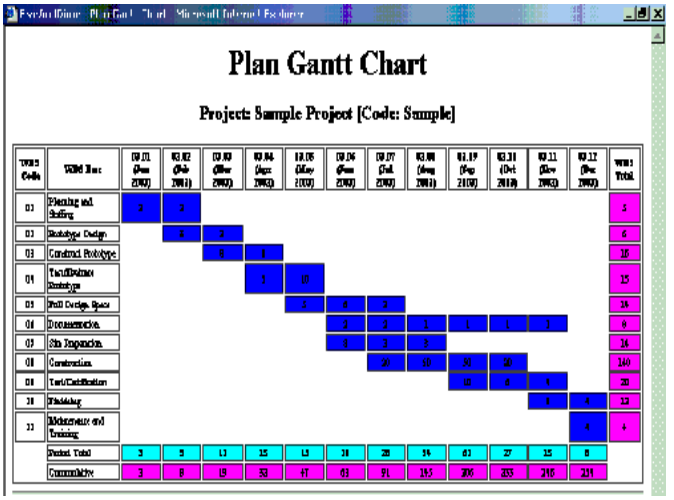
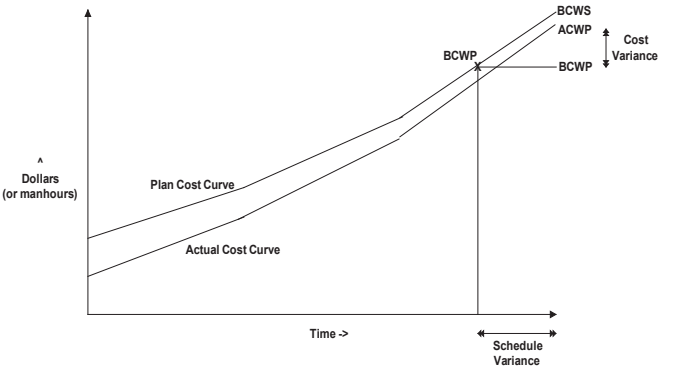


Figure 8. Graphical EV analysis



formalized in US DoD (Department of Defense) standard 7000.2. The ANSI standard (ANSI/EIA-748-1998) on Earned Value Management Systems (EVMS) was approved in May of 1998 and later adopted by the DoD. Other governments and organizations have adopted similar standards for earned value such as the Canadian General Standards Board (CGSB 187.1-93 November1993).

EVA (or EVM – Earned Value Management) is a "progress versus plan" based metric to evaluate the true performance of a project in terms of both cost deviation and schedule deviation. It also provides a quantitative basis for estimating actual completion time and actual cost at completion; EVA can provide an early warning of project time and/or cost problems as early as 15 percent into the project (Fleming, 1998).

In EVA the three key terms and definitions are:

BCWS – budgeted cost of work scheduled (the cumulative planned cost) as of a certain point in time
ACWP – the cumulative actual cost of work done as of a certain point in time
BCWP – this is the "earned value" and is determined from the product of the budgeted cost of each work packet times the percent complete of each work packet as of a certain point in time

Variances between the three values BCWS (planned cost), BCWP (earned value), and actual cost (ACWP) yield the earned value metrics. There are earned value metrics available for both cost and schedule variances. The basic cost metrics are:

Cost Variance (Dollars) = BCWP - ACWP
Cost Variance (%) = (BCWP - ACWP) * 100/BCWP
Cost Performance Index (CPI) = BCWP/ACWP
Estimated Cost at Completion (EAC) = ACWP + (BAC - BCWP)/CPI
Or in its simpler form EAC = BAC/CPI

Where BAC is the budget at completion, ACWP is a "sunk cost", and (BAC - BCWP) is the estimated remaining work. The CPI is also called the "cost efficiency factor"; and values less than one indicate that the project is costing more than planned, or that one is getting CPI of a dollar for each one dollar spent. This is good prediction formula if one expects that future performance will be similar to past performance. There are several other (EAC) formulas, and the most appropriate depends upon project type, whether past performance is a good indicator of future performance, and when in the project the EAC is calculated (Christensen, 1995). For a complete discussion of EVA cost formulas and methods is referred to the following references: Brandon, 2006; Webb, 2003.

The basic schedule metrics are:

Schedule Variance (Dollars) = BCWP - BCWS
Schedule Variance (Months) = (BCWP - BCWS)/(Planned Cost for Month)
Schedule Variance (%) = (BCWP – BCWS) * 100/BCWS
Schedule Performance Index (SPI) = BCWP/BCWS
Estimated Time to Complete (ETTC) = ATE + ((OD – (ATE * SPI))/SPI
Or in a simpler form ETTC = OD/SPI

Where ATE is the actual calendar time already expended and OD is the original duration. The SPI is also called the "schedule efficiency factor"; and values less than one indicate that the project is taking more time than planned.

The EV can be projected onto the planned cost (BCWS) curve to graphically show deviations. This is illustrated in Figure 8 (Brandon, 2006), which shows the planned cost and actual cost curves for a project analysis for the example here through July. The schedule variance in time is also shown in that figure along the time axis.

There are also other formulas which can be used for ETTC, and some may be better as a project draws closer to completion. In addition there are EAC formulas that use both the CPI and SPI; for a complete discussion of EVA schedule formulas and methods is referred to the following references: Brandon, 2006; Webb, 2003.

EVA uses a percent complete for each work packet to calculate an earned value for each packet. This value requires knowledge of the planned cost and the percent complete; it does not require knowledge of the actual cost. Thus EVA schedule variances can be calculated without any knowledge of actual costs. For some projects or some organizations, the determination of actual costs may not be practical in an accurate and/or timely manner. However, EVA can still be performed partially without any actual cost data including the SPI and estimated time to complete.

For many projects most of the cost is labor, and that being the case there are several ways that one can expedite the gathering of actual cost information or approximating cost information. One effective EVA method is to represent cost in terms of person-hours instead of currency (Brandon, 1998). All of the EVA formulas still apply there is just a change to the dimension. This often provides sufficient accuracy for project control purposes, even where there is considerable variation between pay rates on the project team. Even non-labor costs can be converted back into equivalent person-hours using a standard average overall labor rate. This has another advantage for the project manager, since it focuses his attention on the matters that he can control (Brandon, 2006).

EVA AND GANTT CHARTS

Traditional project progress reporting of schedule progress (as represented in classical Gantt charts) cost is neither as accurate or as effective in the early identification of problems, nor in projecting time to complete as is EVA. However EVA can be integrated into modern Gantt charts to overcome these shortfalls. Some modern software programs are capable of such a combination to present a more complete picture of project performance; an example of such a presentation is shown in Figure 9.

Figure 9. EVA on Gantt (Kidasa Software, www.kidasa.com)

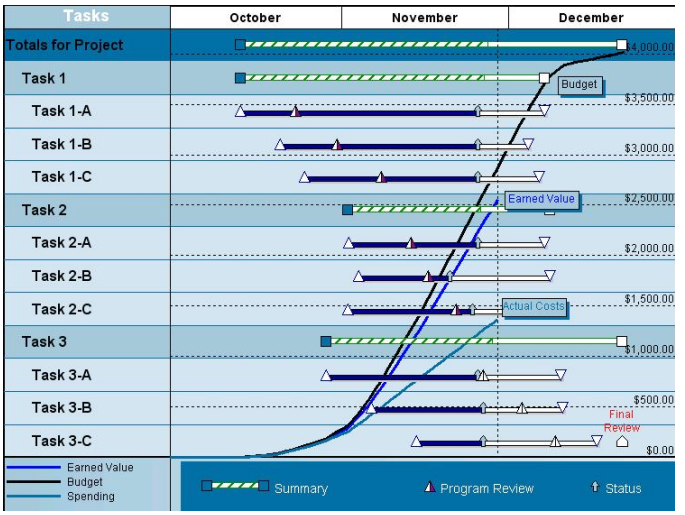
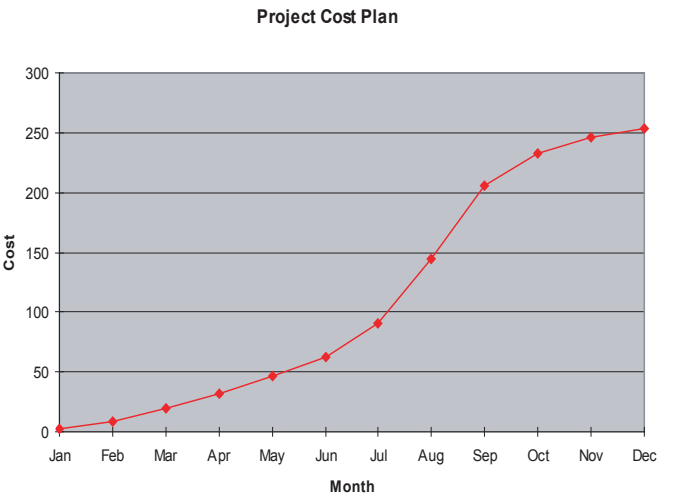


Figure 12. Project cost plan graph



To illustrate how effective a combination of EVA and Gantt analysis can be, we will revisit a brief case study from an earlier publication (Brandon 1998, 1999).

For this example, the WBS consists of two levels, zero and one; and this is shown graphically in Figure 10 for level zero. Each level zero WBS item is further broken down into sub tasks at level 1; for example the breakdown of the "Test Prototype" task is shown in Figure 13.

The "cost plan" is shown in Figure 11 as a spreadsheet rolled up to the top level (level 0) of the WBS; this is also illustrated graphically in Figure 12.

A "bottom-up" estimation method is used to develop the cost plan, where there is another spreadsheet which shows the estimated cost and schedule for associated the level one work packets as shown in Figure 13 (for one of the level zero items – Test/Evaluate Protoype).

As the project progresses, actual costs are incurred by the effort expended in each work packet. These costs along with the percent complete of each work packet are collected each week work for this case study. This information is typically shown superimposed on the Gantt chart as percent complete numbers inside of the bars or shading a portion of each bar in an amount proportionate to the percent complete value. An example of this Gantt chart is shown in Figure 14. Figure 15 is an example of the planned and actual cost in currency (dollars) thru July for this case study. For most organizations these two types of displays are presented to management to report project performance as of a point in time. In that figure the planned cost curve is marked using the diamond symbols, and the actual cost curve is shown with the triangle symbols.

Figure 10. Example WBS (Level Zero)

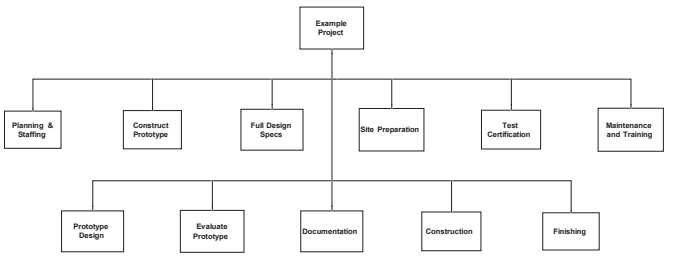


Figure 11. Project cost plan in spreadsheet

Project Cost Plan

	Ja	Fe	Ma	Ap	Ma	Jn	Jl	Au	Se	Oc	No	De	Total
Planning & Staffing	3	2											5
Prototype Design		3	3										6
Construct Prototype			8	8									16
Evaluate Prototype				5	10								15
Full Design Specs					5	6	3						14
Documentation						2	2	1	1	1	1		8
Site Preparation						8	3	3					14
Construction							20	50	50	20			140
Test/Certification									10	6	4		20
Finishing											8	4	12
Maintenance Training												4	4
Monthly Cost	3	5	11	13	15	16	28	54	61	27	13	8	254
Cumulative	3	8	19	32	47	63	91	145	206	233	246	254	

Figure 13. Cost plan for prototype

Test/Evaluate Prototype

	A	M	J	J	A	S	O	N	D	Plan
Test Screens	3									3
Test Reports	2									2
Test Processing		2								2
Audit Trail Verify		4								4
Destructive Testing		4								4
Monthly Plan	5	10	0	0	0	0	0	0	0	15

Figure 14. Case study Gantt chart

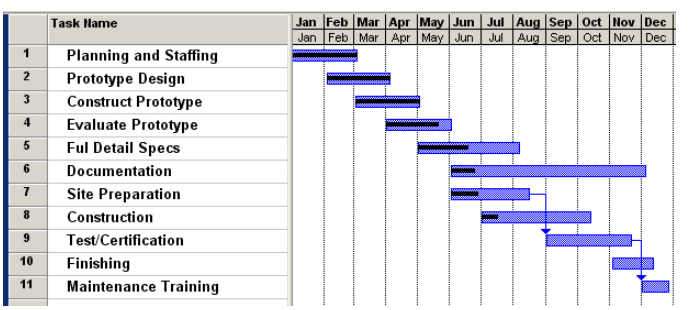
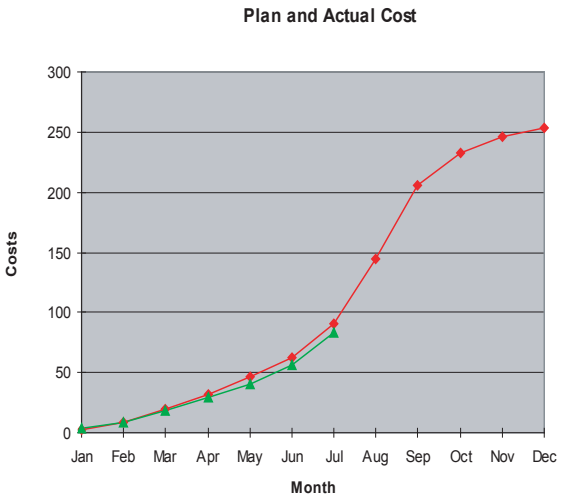


Figure 15. Planned and actual cost plan graph



The problem with these usual methods is that they do not provide a clear quantitative picture of the true project status, nor do they provide a quantitative means for extrapolating project cost to complete or completion date. For the example project here, consider the Gantt chart above (which also shows the task percent complete as dark bars stripes inside the bars) and the actual cost versus budget graph. The project is not over budget (actual cost of $83,000 versus planned cost of $91,000), however it is hard to determine if it is on schedule or not. Actually this project is well behind schedule and is over-spent as the forthcoming earned value analysis will show.

For this case study, Figure 16 shows the EVA calculation through July. Note that the calculation of EV does not involve actual costs, but is simply the product of the percent complete and the planned cost.

Percent complete is determined for each work packet and then EV is calculated for each packet. The total project earned value at a point in time is determined by a WBS rollup of the EV values. A WBS rollup example is shown in Figure 17, for the level one tasks corresponding to the level zero item of "test/evaluate prototype".

In the example project herein, the schedule variance is -0.67 months (behind schedule) and the cost variance is -10,000 dollars (over spent). The estimated time to complete is 15 months instead of the 12 months planned, and the estimated cost to complete is 289,000 instead of 254,000. The calculation of these numbers for our example using the previous formulas is implemented in the spreadsheet of Figure 18.

Figure 16. EV calculations in spreadsheet

	Earned Value – Thru July										
	J	F	M	A	M	J	J	…	Plan	% C	EV
Planning & Staffing	3	2							5	100	5
Prototype Design		3	3						6	100	6
Construct Prototype			8	8					16	100	16
Evaluate Prototype				5	10				15	80	12
Full Design Specs					5	6	3		14	50	7
Documentation						2	2		8	12	0.96
Site Preparation						8	3		14	36	5.04
Construction							20		140	15	21
Test/Certification									20	0	0
Finishing									12	0	0
Maintenance Training									4	0	0
Monthly Plan	3	5	11	13	15	16	28	…	254		73
Cumulative	3	8	19	32	47	63	91	…			
Monthly Actual	4	4	10	11	12	15	27	0	83		
Cum. Actual	4	8	18	29	41	56	83				

Figure 17. EV calculation for prototype activities

	Ap	Ma	…	Plan	% C	Value
Test Plan Devel.	3			3	100	3
Unit Testing	2			2	100	2
Full Testing		4		4	100	4
Destructive Testing		4		4	50	2
Test Documentation		2		2	50	1
Monthly Plan	5	10	0	15	80	12

Figure 18. EV variance calculations in spreadsheet

Schedule Variances	
Budgeted Cost of Work Scheduled (BCWS)	**91**
Budgeted Cost of Work Performed (BCWP, EV)	**73**
Schedule Variance (Dollars)	**-18**
Schedule Variance (Months)	**-0.67**
Schedule Efficiency Factor	**0.8**
Estimated Time to Complete (Months)	**15**
Cost Variances	
Actual cost of Work Performed (ACWP)	**83**
Budgeted Cost of Work Performed (BCWP, EV)	**73**
Cost Variance (Dollars)	**-10**
Cost Variance (Percent)	**-3.9**
Cost Efficiency Factor	**0.88**
Estimated Cost at Completion	**289**

INTERACTIVE WEB GANTT IMPLEMENTATION

Modern project management methods and modern information technology are now being integrated to produce "super-charged" Gantt charts. Figure 19 shows a display from the web based FiveAndDime system for this case study showing EVA calculations (as well as percent complete and cost data) with a familiar spreadsheet

Figure 19. EVA display in Gantt table (www.fiveanddime.biz)

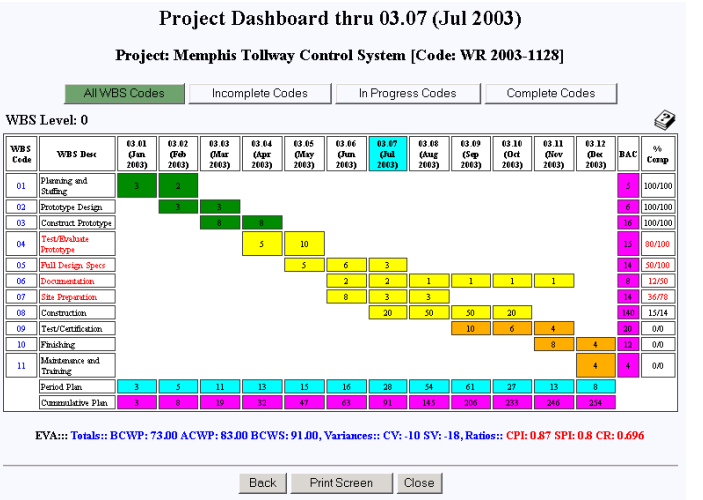
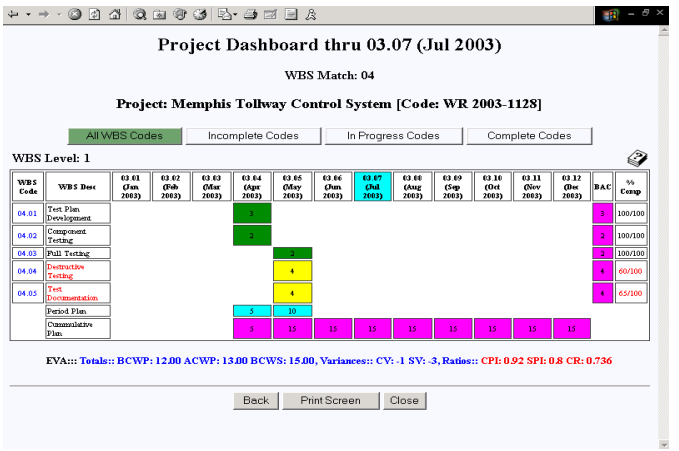


Figure 20. EVA drill down (www.fiveanddime.biz)



type Gantt chart format. Such web based systems make project information available anywhere in the world on any device that supports a standard web browser (without any custom client configuration necessity whatsoever) - even on modern PDA's and cell phones. Some emerging 21st century software is also now based on "open source software" to drastically reduce the cost involved with software licenses. For example, FiveAndDime is based on the open source "LAMP" stack (Linux, Apache, MySQL, and PHP).

In figure 19, the color in the Gantt chart bars is green for completed tasks, yellow for tasks in progress, and orange for tasks not yet started. The last column for percent complete shows a ratio where the numerator is the rolled up percent complete and the denominator is the percent complete that should have been obtained as of the reporting date; the value of that ratio is actually the EVA SPI for that task. WBS codes that have either the CPI or SPI below unity are displayed in red.

EVA greatly facilitates "management by exception". When there is a problem with a project as indicated by CPI and/or SPI less than unity, one can "drill down" in the earned value analysis to lower levels of the WBS. For example if the overall project index(s) is below unity, then one can select the level zero WBS codes that have their index(s) below unity; and then so on to the next level (level one for the case study herein).

Modern Gantt charts can also support this drill down capability and some software systems allow a PM to drill down interactively. Figure 20 is a screen shot from FiveAndDime showing a drill down from level zero to level one. This was accomplished by clicking on a particular WBS code (Evaluate Prototype) on the level zero display (Figure 19, where WBS codes with a CPI or SPI below unity are shown in red).

CONCLUSION

The Gantt chart has undergone many and significant changes since its introduction a century ago. Today's Gantt charts include earned value analysis so that effective performance management can be accomplished. Which of the new presentation formats available may be a matter of personal preference, however the interactive web based products have numerous clear advantages such as "drill down" capability. Even though Henry Gantt may not initially recognize the 21st century web enabled Gantt chart, the basic concepts and visualization he introduced have still been preserved.

REFERENCES

Anbari, F. (2003), "Earned Value Project Management Method and Extensions", Project Management Journal, Vol. 34, No. 4, December

Brandon, D. (2006), Project Management for Modern Information Systems, Idea Group Publishers, Hershey, PA [ISBN: 1-59140-693-5]

Brandon, D. (2004), "Project Performance Measurement", Chapter Thirty Four in The Wiley Guide to Managing Projects, edited by Morris and Pinto, John Wiley & Sons [ISBN: 0-471-23302-1]

Brandon, D. (1999), "Implementing Earned Value Easily and Effectively", Chapter in Essentials of Project Control, Project Management Institute Press, [ISBN: 1-880410-64-8], pp 113 – 124

Brandon, D. (1998), "Implementing Earned Value Easily and Effectively", Project Management Journal, Vol. 29, No. 2, June

Christensen, D. and Ferens, D. (1995), "Using Earned Value for Performance Measurement on Software Projects", Acquisition Review Quarterly, Spring, 155 – 171

Christensen, D., et al. (1995), "A Review of Estimate at Completion Research", Journal of Cost Analysis, Spring

Fleming, Q and Koppelman, J. (1998), "Earned Value Project Management, A Powerful Tool for Software Projects", CROSSTALK, The Journal of Defense Software Engineering, July, 19 – 23

Gantt, H. (1910), Work, Wages and Profit, *The Engineering Magazine*, NY

Gantt, H. (1919), Work, Wages and Profit, 2nd Edition, *The Engineering Magazine*, NY

Webb, A. (2003), Using Earned Value, Gower Publishing, [ISBN: 0-566-08533 X]

Military Physicians' Assessments of a Mobile Medical Information System: A Longitudinal Study

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ABSTRACT

This paper sets out to investigate military physicians' perceptions and usage regarding a mobile medical information system during their military service in the Finnish Defence Forces. Longitudinal data were gathered in September and December of 2005, and April 2006 by three semi-structured surveys. The military physicians (n=31) had positive perceptions of the mobile medical system, and had used it in their daily military training. But the perceived usefulness, in the terms of effectiveness and usefulness of the system, had declined significantly in April 2006. The same trend has also been found in their perception of ease of use, in the aspect of "easy doing what I want to do". The changes of the physicians' assessments and beliefs toward the system are explained. Insights of the findings and implications for system improvement are discussed.

Keywords: mobile medical information system, usefulness, ease of use, military physicians, longitudinal study

1. INTRODUCTION

Health information technology has been adopted by military medicine in different environments and for different purposes[1]. One early adopter is the U.S. Military that is, thanks to its large resources, in the forefront of development. For example, the U.S. army medical staff has been equipped with a point-of-care handheld assistant BMIS-T (implemented on Hewlett-Packard iPAQ Pocket PCs) based on Microsoft Windows Mobile software[2]. This mobile system can help the military medics in a critical part of their job—tracking medical information on the troops under their care. The system also helps medics to make quicker and more accurate diagnoses and treatment decisions, as well as helps them to reduce the paperwork when treated personnel are moved to e.g., military hospitals. Another new electronic system, a logistic tracking system by Intermec mobile computing, lowered U.S. military drug costs by $389 million in year 2004[3]. Very recently, 3M has developed and installed an RFID-based system[4] to the U.S. Army to track medical records at the US facility in Ford Hood, Texas. These examples have shown that mobile technology is playing an increasingly important role in supporting military medicine.

However, these systems are in use in a very large organisation with massive resources. Smaller national defence forces (e.g. Finland) have generally allocated fewer resources to implement health information technologies. There are systems developed originally for civilian purposes, which could improve the efficiency of military medicine without the development cost of a tailored system. In this paper we present some insights that we have obtained from a longitudinal study by investigating the adoption and usage of a mobile medical information system among thirty one physicians during their military service in the Finnish Defence Forces from September 2005 to April 2006.The research was designed to detect the changes of the physicians' perceptions of the system, i.e. usefulness and ease of use over the time. The structure of the paper is arranged as follows: In the next section, we briefly review the relevant literature. The research method is discussed in Section 3. Results are reported in Section 4, followed by discussion and conclusion at the end of the paper.

2. LITERATURE

2.1 Theoretical Background

Users' perceptions of and intentions to adopt an information system (IS) and the rate of diffusion and penetration of technology within and across organizations are two important foci of IS research (e.g. Straub et al., 1995). Well-accepted theories, for examples, the Technology Acceptance Model (Davis et al., 1989), the UTAUT (Unified Theory of Acceptance and Use of Technology) (Venkatesh et al., 2003) have provided good explanations of the adoption and usage of technology in different socio-technical contexts. The conclusions of many studies based on these theoretical approaches have indicated that perceived usefulness and perceived ease of use are two fundamental factors determining a user's acceptance of technology. These theories have recently been applied to explain user adoption of mobile technology (e.g. Pedersen and Nysveen, 2003; Han 2005). Perceived usefulness and ease of use of a specific mobile system are also found to be important determinants of technology adoption behaviour.

There are two temporal dimensions of adoption behaviour. One is pre-adoption or initial adoption behaviour (initial adoption, first-time usage and possible rejection at the pre-implementation stage). The other is post-adoption or post-implementation behaviour, (sustained continuous usage, and discontinued usage). In the two dimensions, users usually have different beliefs regarding the technology (Karahanna et al., 1999). As users gain more experience of a system, their beliefs and attitude towards the system might change. Such changes have major impacts on human behaviour regarding continuous system usage (Bhattacherjee and Premkumar, 2004).

2.2 A Mobile Medical Information System

The mobile medical information system, investigated in this research is a set of medical information and knowledge databases. It contains doctors' handbook, the EBMG (available in both, English and Finnish) with Cochrane abstracts, pharmacology database Pharmaca Fennica with a wireless update service for a complete medicine price list, the international diagnosis code guide (ICD-10) in Finnish, a laboratory guide by the Helsinki University Hospital, an emergency care guide issued by the Meilahti Hospital, a medical dictionary of over 57,000 terms, and a comprehensive database over health-care related addresses and contact information (pharmacies, hospitals, health centres). The content of the system is generated by an XML (eXtensible Mark-up Language) database. The system functions in most mobile devices operated by different systems, e.g., Symbian, Palm OS, and Windows CE. The device most commonly used as a platform in Finland is the Nokia Communicator (9210, 9300, and 9500). The mobile medical system is delivered on a 256 MB memory card, and is self-installing, containing the search engine, user interface programs, and core databases. Currently, an update of the system is available and is delivered on memory cards. In the near future,

the system will be able to update itself partly or completely through the wireless networks. The price list, part of the Pharmaca Fennica (the pharmacopoeia) is already able to update itself through the wireless data link provided by the mobile device. The databases have been updated to include a drug interaction database originally developed by the Karolinska Institute, Sweden.

3. RESEARCH METHOD

Theories of user technology acceptance can contribute greatly to understanding user behaviour regarding technology. These theories have served as the theoretical background and generated some important concepts that we have focused on in this study. A "practice-driven" approach has been adopted to design our research due to the fact that in the early stages of studies, of an exploratory nature (like our study), it is better to conduct studies in a natural setting, rather than from a pre-established theoretical perspective (Sharker et al., 2003, Zmud, 1998).

A longitudinal study was carried out from the autumn 2005 to the spring 2006. On September 6, 2005, with support from Pfizer Finland Ltd. and Duodecim Publishing Ltd, thirty one physicians, later in this paper called military physicians, (including some medical students) undergoing their military service in the Finnish Defence Forces, were given a Nokia Communicator 9210 equipped with a mobile medical information system. After the first user training session of the system[5] (on the same day they got the system), we distributed our first, semi-structured, questionnaire to collect their demographic information and to investigate their initial perceptions of perceived usefulness and ease of use of the system. The structured measurements were borrowed from previous established research with changes in wording to make them appropriate for the mobile medical information system and the military medicine context. In December 2005, after the military physicians had used the mobile medical system for a time of approximately three months, we conducted the second survey, to study the use of the system and the opinions regarding the system being used for military purposes in the field conditions. Nineteen valuable answers were returned. In the spring 2006, these physicians were relocated to different garrisons to continue their military service. In April 2006, the third survey that had a similar structure and questions with the previous surveys was distributed. Twenty-one physicians responded the survey.

The data analysis was primarily descriptive in nature. Frequencies and some central tendencies were calculated to illustrate physicians in the military service, their usage, and assessments towards the mobile medical information system. Potential differences in their behaviour over the three points in time were tested by ANOVA (Sig. < 0.05). The Scheffé test was used for *post hoc* tests.

4. RESULTS

4.1 Demographic Information of the Study Group

Of the thirty one participants, twenty-three have graduated and have become qualified physicians, eight are still medical students. Among the 31 participants, one has earned a doctoral degree in medicine, and two have, or will, become qualified pharmacists. The gender distribution was 30 male and one female. The mean age of the group was 25.19 years, the youngest being 20 and the oldest 28. Among the participants, twenty-two have never used a Nokia Communicator (any models) prior to the first survey, eight indicated prior usage. Seven have used the mobile medical information system before; among them, two have used it for 1 year (one of the two was the female physician in the group), two have used it for some months, and 3 have tried for a few hours.

In order to know whether the participants were familiar with the contents of the databases in the mobile medical information system, we also collected information regarding the usage of Terveysportti[6], the Finnish health care portal in the Internet in the first survey. Excluding 6 missing answers, all have used it ranging from 7 months to 5 years. They have used it for education/learning purpose (n=30), for patient consultation (n=21), and for completing their specialisation knowledge (n=8).

In general, this group was young, male–dominated, and familiar with the contents of the mobile medical system.

Table 1. Usefulness of the mobile medical information system

Perceived Usefulness	Mean			F	Sig. (p<0.05)
	Sep./05 (n=31)	Dec./06 (n=19)	Apr./06 (n=21)		
Improve medical knowledge	3.97	3.68	3.62	1.18	0.313
Enhance effectiveness in the field conditions	4.34	3.94 (n=18)	3.38	7.29	0.001
Improve my ability to make good decisions	3.83	3.74	3.33	2.25	0.114
Useful	4.58	4.32	3.38	14.25	0.000

4.2 Perceived Usefulness of the Mobile Medical Information System

The military physicians' perceived usefulness of the system was studied from four aspects: (i) using the system improves my medical knowledge; (ii) using the system enhances my effectiveness to do clinical work in the field conditions; (iii) using the system improves my ability to make good decisions; and (iv) I find the system useful for me. The military physicians' evaluation was measured using a five point scale, ranging from (1) strongly disagree to (5) strongly agree.

The perceived usefulness of the system, after a period of actual usage, was still positive in general (mean value > 3), but with a clearly declining trend (Table 1) across the study period. The *F*-ratios for the analysis of variance on the aspects of effectiveness and usefulness were significant at the 5% level ($F_{effectiveness} = 7.29$, df =2, 65, $p<0.05$; $F_{useful} = 14.25$, df=2, 68, $p<0.05$). Consequently, the Scheffé Test was used to compare pairs of the means in order to assess where the differences lie. It was found that at the 5% level of significance, the assessment of effectiveness of the system in April 2006 (M=3.38) was significantly lower than those in September 2005 (M=4.34), but the means of that in September and in December 2005 did not differ from each other. The evaluation of the usefulness of the system in April 2006 (M=3.38) was also significantly lower than those in September (M= 4.58) and in December (M= 4.32), but that the means of those of the two times in 2005 did not differ from each other. A very important insight we obtain from the results is that military physicians have gradually found that the system is not very useful in their military training. As they have obtained more experience from their actual usage in the different working environments, they have evaluated the usefulness of the system quite differently from their initial hype of the system. There are several reasons. Firstly, it might be due to the differences between the civilian and military medicine. The mobile medical system is designed for civilian physicians (see Han 2005, Harkke, 2006), the contents of the system lacks of a focus on military medicine. The longer time they worked in the field conditions, the higher demand for the contents specifically suited for military medicine would be raised, and the more limitations of the current contents would be shown. The second reason may due to the fact that military physicians used the system in the tough field conditions. The weather was cold and humid during the study period. Therefore, the natural environment gave rise to the high requirements on the physical robustness of the mobile device. The Nokia communicator is not very suitable to be used in such conditions (Han et al., 2006; Tétard et al., 2006). The drawbacks of the physical device may shed a shadow on the usefulness of the system. The third reason goes to the limitation of the mobile medical system itself. As a standalone system, it contains only the medical knowledge and information, but lacks of integration with other important systems which contain some crucial information, e.g. soldiers' health records. The last reason may be the possible effect of the changing working environment from the field conditions to the garrisons after December 2005. In the different garrisons these physicians can't access to the Internet, but they have other traditional databases which are accessible, i.e. books, CDs. The possible increasing usage of the traditional databases may also lead to less use of the mobile medical system in their daily work, thus, decreased positive perceptions of it in terms of effectiveness and usefulness.

4.3 Perceived Ease of Use of the Mobile Medical Information System

The military physicians were asked to indicate their perceived ease of use of the system. Questions about four aspects were asked: (1) learning to operate the system is easy for me; (2) I find it easy to get the mobile medical system to do what I need to do; (3) It is easy for me to become skilful in using the system; and (iv) I find the system easy to use. The evaluation was measured using a five point scale, ranging from (1) strongly disagree to (5) strongly agree.

The military physicians' perceived ease of use of the mobile medical system was positive in general with most of the mean value> 4 at the three points of time (Table 2). It is interesting to notice that the evaluation has displayed an increased trend from September to December 2005, but declined afterwards, especially the aspect of "easy doing what I need to do". The *F*-ratio for the analysis of vari-

Table 2 Ease of use of the mobile medical information system

Perceived Ease of Use	Mean			F	Sig. (p<0.05)
	Sep./05 (n=31)	Dec./06 (n=19)	Apr./06 (n=21)		
Easy learning to use	4.65	4.84	4.52	1.85	0.165
Easy doing what I need to do	4.19	4.47	3.57	5.45	0.006
Easy to become skilful	4.42	4.53	4.19	1.16	0.320
Easy to use	4.32	4.42	4.05	1.38	0.258

ance was significant at the 5% level ($F = 5.45$, df = 2, 68, $p < 0.05$). The post hoc Scheffé test showed that the difference lied between the evaluations of December 2005 with that of April 2006. The changing working environment may be one of the reasons to explain the differences. In a comparison with the accessibility of the traditional databases (books, CDs), it might be not easy enough to use the mobile medical system.

4.4 Usage Behaviour

4.4.1 Usage Intention

In the first survey in September 2005, the military physicians' behavioural intention towards the system was also measured by asking, if they think they will use it in the future. There was one negative answer that indicated that the person would not use the system, several neutral responses (n=7) that indicated insecurity about the future use. Twenty-three (74.2%, n=31) military physicians expressed clear interest in using the system in the future.

4.4.2 Self-Reported Actual Usage

In the second and third survey we carried out in December 2005 and April 2006, we investigated the real usage of the mobile medical information system, in terms of usage frequency (Table 3), and volume of use during a period of one week (Table 4). The possible differences of the usage frequency and volume over the study period were performed by paired T-tests; neither of the results was statistically significant. Table 3 has shown that majority of the group have used the system on weekly basis. Two physicians have reported that they did not use it at all from the dataset in April 2006. A declined trend of usage volume was also found. As showed in Table 4, 14 physicians in April 2006, compared to 10 in December 2005 have used it less than half an hour per week. A possible explanation may go to the fact that as their hand-on experience of using the system grew, their speed to find information increased, thus, they spent less time on using it. Another explanation is the possible negative effect from their declining perceptions of usefulness of the system. Physicians do not use a system if it is not useful for their work (Jayasuriya, 1998). The third explanation may also go to the changing working environment across the study period. The increasing use of other databases would decrease the usage of the mobile medical system in terms of usage frequency and usage volume.

Table 3. Usage frequency

	Usage Frequency	
	Dec. 2005 (n=19)	Apr. 2006 (n=20)
I don't use it at all	0	2
About once a month	4	3
About once a week	4	4
Several times a week	7	8
About once a day	3	2
Several times a day	1	1

Table 4. Usage volume

	Usage Volume	
	Dec.2005 (n=19)	Apri.2006 (n=20)
< 0.5 hours	10	14
0.5-0.9 hours	6	5
1.0-1.9 hours	2	1
2.0-2.9 hours	1	0
3.0 or more hours	0	0

5. DISCUSSION

This paper investigates military physicians' perceptions on and usage of a mobile medical information system in the Finnish Defence Forces. The findings from the longitudinal study have provided us with important insights and implications.

The Military physicians have positive perceptions of the usefulness and ease use of the system, but with a declining degree, in some aspects significantly. They have used the system on a weekly basis and spent mostly less than a half an hour using it. The reasons for usage patterns presented above may give some implications for system improvement: (i) more contents of military medicine should be included into the system, such as major trauma handling, pain relief, detoxication and cleansing of chemical/radiation injury in a combat situation; hygiene, epidemiology, prevention of infectious disease outbreaks while soldiers are living under rough conditions (in field and out of casern); and some peculiarities of "military health"-mass vaccinations, epidemiology, skin disease, and occupation safety/risk issues specific for military in casern/barracks; (ii) more attention has to be paid to the mobile device which is adopted to implement the system. Measurements to increase its physical robustness in the field are required; (iii) possible integration of the system with other crucial health databases will enhance its effectiveness and usefulness for military physicians working in the field; (iv) it seems that military physicians perceptions and usage behaviour towards the system could be significantly influenced by the changing working environment. When they were not in the field they could use other information resources. The mobile system is seen primarily as a supplement to, rather than a substitute for, traditional medical databases which are delivered from wired internet, PC-based tools or in printed books.

The results from the longitudinal study and the three datasets have convinced us that such a mobile medical system is needed by military physicians, especially in the beginning of the study as well as in field conditions. However, the result from the last dataset has shown some significantly different evaluations. This may imply that in order to encourage the usage of the mobile medical system, we have to be sensitive to the physicians' working environment. In other words, the organization should strategically implement the system to the "mobile" military physicians, not to those who are stable at different garrisons.

6. CONCLUSION

This study has helped us understand how military physicians adopted a mobile medical information system during their military service, while also providing some indications of the actual usage patterns and some belief and behavioural differences across time. There seems to be a need for the kind of mobile medical system for military purposes, but some significant improvements have to be made to the civilian systems to make them fit the needs of military training and in order to increase the usage in the future.

A longitudinal study has given us the opportunity to detect more insights of the research phenomenon and also helped to reveal more important effects, such as changed working environments and temporal effects on human technology adoption behaviors.

The research reported here could be seen as a study reflecting the military physicians' reactions to mobile technology in general and the mobile medical information system in particular. Since the military physicians have used the system in their work practice, both in the field and in the garrisons, their appreciation of the system may be considered as a solid basis for future system development.

7. REFERENCES

Bhattacherjee, A. and Premkumar, G. (2004) 'Understanding changes in belief and attitude toward information technology usage: a theoretical model and longitudinal test', *MIS Quarterly*, Vol. 28, No. 2, pp.229–254.

Davis, F.D., Bagozzi, R.P. and Warshaw, P.R. (1989) 'User acceptance of computer technology: a comparison of two theoretical models', *Management Science*, Vol. 35, No. 8, pp.982–1003.

Han, S.(2005): "Understanding user adoption of mobile technology: focusing on physicians in Finland", Doctoral Dissertation, Turku Centre for Computer Sciences, Åbo Akademi University, second edition ,June 2005.

Han, S., Tétard, F., Harkke,V., and Collan, M. (2006): Usability evaluation of a mobile medical information system for military physicians, Proceedings of the 40th Hawaii International Conference on System Sciences (HICSS).

Harkke, V. (2006): "Knowledge freedom for medical professionals-an evaluation study of a mobile information system for physicians in Finland", Doctoral Dissertation, Turku Centre for Computer Sciences, Åbo Akademi University, 2006.

Jayasuriya, R. (1998) 'Determinants of microcomputer technology use: implications for education and training of health staff', International Journal of Medical Informatics, Vol. 50, pp.187–194.

Karahanna, E., Straub, D.W. and Chervany, N.L. (1999) 'Information technology adoption across time: a cross-sectional comparison of pre-adoption and post-adoption beliefs', *MIS Quarterly*, Vol. 23, No. 2, pp.183–213.

Pedersen, P. and Nysveen, H. (2003) 'Usefulness and self-expressiveness: extending TAM to explain the adoption of a mobile parking services', *The 16th Beld eCommerce Conference*, June 9–11, 2003, Bled, Slovenia.

Skarker, S., Urbaczwski, A. and Wells, J.D. (2003) 'Understanding hybrid wireless device use and adoption: an integrative framework based on an exploratory study', *The 36th HICSS*, January 6–9, Big Island, Hawaii.

Straub, D.W., Limayem, M., and Karahanna, E. (1995) 'Measuring System Usage: Implications for IS Theory Testing', *Management Science*, Vol.41, No.8, pp.1328-1342.

Tétard, F, Han, S., Collan, M., and Harkke,V. (2006): Smart phone as a medium to access medical information: a field study of military physicians, Proceedings of Helsinki Mobility Roundtable 2006, June 1-2, Helsinki, Finland

Venkatesh, V., Morris, M.G., Davis, G.B. and Davis, F.D. (2003) 'User acceptance of information technology: toward a unified view', *MIS Quarterly*, Vol. 27, No. 3, pp.425–478.

Zmud, R.W. (1998) 'Conducting and publishing practice-driven research', in: T.J. Larsen, L. Levine and J.I. DeGross (Eds) *Information Systems: Current Issues and Future Changes*, Laxenburg: International Federation of Information Processing, pp.21–33.

ENDNOTES

1 http://www.military-medical-technology.com/ [accessed on 19 Jan. 2006]

2 http://download.microsoft.com/documents/customerevidence/6640_BMIS_T.doc [accessed on 19 Jan. 2006]

3 http://epsfiles.intermec.com/eps_files/eps_articles/DMLSS_article_web.pdf [retrieved on 3 Aug. 2006]

4 http://www.eweek.com/article2/0,1895,1994160,00.asp [Retrieved 3.8.2006]

5 The military physicians were given a two-hour introduction to the mobile device and the mobile medical information system.

6 www.terveysportti.fi

XML in a Data Warehouse Design: Performance Evaluation Utilizing Geological Data

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ABSTRACT

The structure of XML data presents challenges when determining efficient ways to map it to a relational data warehouse. One of these challenges is the presence of multi-valued child elements. Translating multi-valued XML elements to a relational data warehouse may require the consideration of non-traditional approaches to the design of the data warehouse. Traditionally, the star schema has been the design of choice for data warehouses. However, the semi-structured nature of XML data may make the use of alternatives, such as the snowflake schema, more efficient. This paper presents the implementation details of methods for preserving XML data in a relational data warehouse that are based on the star and snowflake design schemas and compares the methods quantitatively and qualitatively for geological data sets.

Keywords: XML, data warehouse, star schema, snowflake schema, relational database, geological data

1. INTRODUCTION

Extensible Markup Language (XML) has become the accepted standard for exchanging data over the Internet [1]. As more organizations choose to collaborate and share information on the Web, the demand to access and mine XML data is dramatically increasing which in turn is resulting in the need to utilize design methodologies for effective storage and retrieval or warehousing of the XML information.

Many research projects, as well as software corporations (such as, Oracle [2], Microsoft [3], and IBM [4]), have initiated techniques and various methods for creating, storing, and retrieving XML information [5][6], including a variety of proposed methodologies for translating XML data to a relational environment [7]. Several published works cite the need to store XML data in a file system or a relational database environment, as well as address some of the difficulties that arise from the differences between the structure and semantics of XML data and that of relational data [8][9].

As noted by Shanmugasundaram, native XML databases do not have the "sophisticated storage and query capability already provided by existing relational database systems" and "do not allow users to query seamlessly across XML documents and other data stored in relational database systems" [10]. Two complications presented by XML data have been identified as recursion and multi-valued (or set-valued) elements [11].

In a relational data warehouse, the main issue in storing XML data is the potential inability to extract all the information necessary from the XML document and definition to develop a data warehouse design that accurately represents the XML data [12]. Another problem is the differences in "expressive power" of the relationships presented in an XML document's definition [13]. The source of these issues is the semi-structured nature of XML.

The presented research work addresses design issues of storing multi-valued XML data with many-to-many relationships, which results in multiple associations within a relational data warehouse. Two alternative methodologies for preserving this type of XML data are evaluated. Both methods involve decomposing the XML elements and storing their values in a relational table within the data warehouse. The first proposed alternative makes use of the snowflake schema in the design of the data warehouse tables, while the second alternative utilizes the traditional star schema. The details of the implementation of these alternative methods, along with quantitative and qualitative comparisons of the methods are described.

The paper is divided into the following descriptive sections. Background information on XML and the relational paradigm are given in sections 2 and 3 respectively, with XML storage and mapping in a relational environment considered in section 4. The alternative methodologies and the comparative study are described in section 5, followed by more specific information about the implementation processes in section 6. The testing results from running SQL queries against each method's data tables are given in section 7, with section 8 providing the conclusions of the research.

2. XML CHARACTERISTICS

XML is a text-based language with user-defined tags that preserve the semantics and relative context of information. The tags add flexibility to XML documents and semantic representation. XML has become the preferred language for exchanging data over the Web for two reasons. It is based on a standard and, therefore, vendor-neutral, and since it is text-based, XML can be viewed within any text editor [1]. In order to allow the consumer of an XML document to verify its validity, a document type can be used in conjunction with the document to define the allowable structures.

The three basic methods for storing XML documents are as a flat file, XML database, and relational database [14]. The flat file approach allows for the access of a specific XML document through the traditional file system hierarchy. The XML database approach involves the "direct access to XML documents and fragments of documents, and the ability to query across those documents and fragments" [14]. The relational database approach is more complex and involves decomposing (shredding) the XML document and storing element values in table fields. Of the three approaches for storing and accessing XML data, only the relational database allows for the creation of complex queries, can be integrated with other relational data, and provides mechanisms for transaction management and recovery [14].

3. RELATIONAL PARADIGM

Relational database, introduced by E. F. Codd in 1970 [15], is presented by collections of tables (or relations) that contain data items with similar properties (or attributes). In a table, each column corresponds to one of the attributes, and each row (or tuple) represents a piece of data (or record) containing those attributes. Data warehouses, which typically contain historical data or facts and are structured specifically for querying and reporting, can take advantage of the structure of relational database for design and implementation. However, because the data is historical or factual and unlikely to change, data warehouses tend to be denormalized and the data treated as read-only [15].

Two common schemas used for a data warehouse are the star and snowflake [16]. The star schema contains a single fact table that holds factual data (typically transactions) surrounded by multiple dimension tables that contain reference data (i.e., components that comprise each fact or transaction) [15]. The fact table consists

of a unique primary key for each fact, a foreign key reference to the primary key from each of the dimension tables, and optional measure data (such as quantity). The star schema models a many-to-one relationship between the fact table and each of the dimension tables.

The snowflake schema allows dimension tables from a star schema to be "organized into a hierarchy by normalizing them" [16]. This schema, therefore, allows for multi-valued attributes associated with a dimension table to be modeled using additional, hierarchical tables. However, because a data warehouse can contain an enormous number of records, performing joins between numerous tables can be costly in terms of query response time.

Typically, the star schema is used to represent the multi-dimensional data warehouse model and is better suited for querying, over the snowflake schema, because the data is denormalized [17]. The more normalized snowflake schema, while providing advantages when maintaining the data [17], requires additional table joins for queries that access the normalized data and can, therefore, increase the query response time [18].

4. STORING XML DATA IN RELATIONAL TABLES

There are three basic techniques to decompose (or shred) XML data for storage in relational tables: no decomposition, partial decomposition, and total decomposition [19][20]. They are differentiated by the extent to which the XML data is decomposed and by the way that XML is stored in relational tables. The decompositions into relational tables generally fall into two categories: those that start with an XML document and those that do not. Each approach varies in the number of relational tables that are created and in the structural information and element values that are captured.

The no decomposition approach (document-centric) involves storing the entire XML document as text in a flat file or relational table's field (e.g., as a character large object-CLOB) [20]. In partial decomposition, XML data is selected, decomposed, and stored in tables to allow quick access to specific data through SQL queries [19]. Total decomposition (data-centric) involves decomposing the entire XML document and storing its elements' and attributes' values in table fields. The third approach fully exploits the query power of relational databases, but is a complex implementation due to the differences in structure between XML documents and relational tables, and cardinality uncertainties inherent in XML schemas.

A schema-based approach for storing XML data in a relational data warehouse proposed by Golfarelli starts by translating an XML document into a graph and an algorithm applied to the graph to create an attribute tree from which a data warehouse conceptual design is developed. Golfarelli's method, unlike other methods, emphasizes the determination and evaluation of relationship cardinalities within the graph. These cardinalities show a to-one or to-many relationship between elements and their child elements (or sub-elements) [13].

Because of their structure, XML documents benefit from either the partial or total decomposition for storing XML information in a relational data warehouse. Both methods can handle multi-valued sub-elements in XML format using Golfarelli's methodology for to-one and to-many associations.

5. DATA WAREHOUSE DESIGN METHODOLOGIES

The focus of the proposed methodologies is on the problem of how to best capture multi-valued XML data within the confines of a relational data warehouse. Because of the inherent structure of a data warehouse, the fact table often contains a very large number of records, which means that performing table joins between the fact and dimension tables can be costly in terms of query response times. This is one reason why the denormalized star schema is generally the preferred design for a data warehouse.

The first methodology decomposes non-multi-valued elements and stores their values in data warehouse dimension table fields similar to Golfarelli's approach. However, instead of dropping multi-valued child or sub-elements altogether, the method is modified in order to capture the multi-valued sub-element data by storing the data in XML format within a field. Because the multi-valued elements are not decomposed, no table hierarchies are created and the star schema is maintained.

The second proposed alternative uses a variation of the star schema that includes additional hierarchical tables, thus creating a snowflake schema. This method, like the star schema, fully decomposes the XML data and captures its element values in the data warehouse tables and makes use of an additional table to hold the decomposed multi-valued element data. The additional table is then linked via a foreign-key field to the dimension table that holds the parent element data; thus creating a one-to-many relationship between the dimension table and the added table creating a normalized snowflake.

6. IMPLEMENTATION PROCESS

The following subsections summarize the implementation process for the two proposed design methods, including the XML data chosen for translation and storage, the design of the data warehouses, and the queries applied to the data tables.

6.1 Geological XML Data

To evaluate the performance of XML in the design of a data warehouse, the initial testing has been completed with text-based geological XML data to provide the foundation for future expansion to support more complex semi-structured data. The implementation process utilized the U.S. Geological Survey's (USGS) website [21] for historical XML data available in their earthquake advisories. The historical earthquake data consists of the date and time or origin, geographic coordinates (latitude and longitude), depth, magnitude, station used for the magnitude measurement, region, and additional magnitudes. A sample data format for an earthquake is presented below with the field names and data examples separated by :=.

Date:= 1/1/2004
Origin Time (UTC) (HH:MM:SS):=20:59:31.9
Latitude:= 8.310 S
Longitude:= 115.788 E
Depth:= 45
Magnitude:= 5.8
Station No. Used:= 119
Region:= Bali, Indonesia
Additional Magnitudes (Formula/Value/Station):= Mw/5.8/GS, Mw/5.8/HRV, mb/5.5/GS, Ms/5.4/GS

The earthquake data from 2000-2005 were converted to a modified XML earthquake advisory format and grouped by month resulting in 72 XML documents. To populate the data warehouses with a sufficient amount of data to show query access time differences between the methodologies, the data within the 72 documents (i.e., 6 years worth of data) was quadrupled to create over 100 years of data.

6.2 Implementation of the Data Warehouse Design

A fact table within the data warehouse consists of all of the data associated with an earthquake advisory, including the data for the advisory in which the event is reported as well as the event data. The following data items provided a complete earthquake advisory record or fact:

- Advisory title
- Advisory publish date
- Event date
- Event latitude, longitude, and depth
- Event region
- Event magnitudes (one or more)
- Magnitude source
- Magnitude formula
- Magnitude value

The design for each data warehouse as shown in Figures 1 and 2 includes a single fact table and dimension tables to hold the event advisory data. Time data is represented in a separate dimension table. The fact table contains foreign keys for the publish date and event date that refer to the time dimension table's primary key.

A separate dimension table is used to hold the publisher name. Using a separate dimension table avoids unnecessary duplication and leaves room to include advisories published by other organizations in the future. A separate dimension table is also used to hold the advisory title and link for the same reasons. The fact table contains foreign keys that link it to the publisher and advisory dimension tables.

Figure 1. Star schema data warehouse logical schema

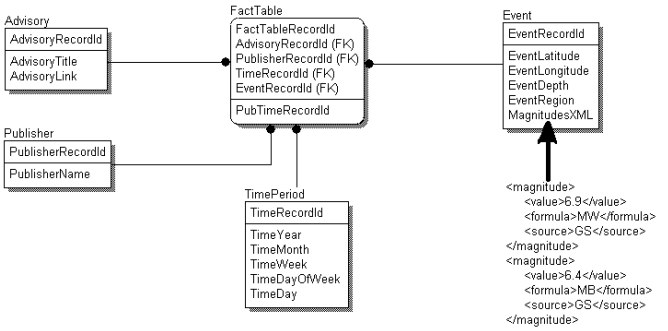
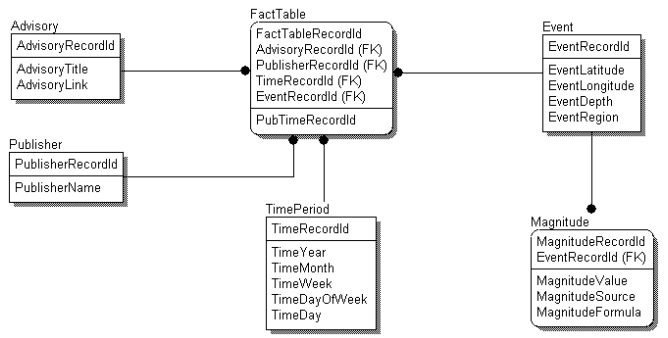


Figure 2. Snowflake schema data warehouse logical schema



The event region, latitude, longitude, and depth are represented in their own dimension table and the unique identifier included as a foreign key in the fact table. Magnitude data is stored differently for the two methods. The star schema method stores magnitude data in XML format for each event as presented in Figure 1. This means that the magnitude data is maintained in the original XML document format and stored as text within a table field called the Event table.

The snowflake schema method uses a separate, hierarchical table to store the multi-valued magnitude data. This means that each magnitude is maintained in a separate row with the source, formula, and value each contained within a column. In addition to the general structure of the snowflake schema's fact and dimension tables, Figure 2 shows the multi-valued XML data broken down into individual fields and records, and stored in a separate table. The table contains a foreign key reference to the primary key of the dimension table, which holds the parent element data.

6.3 Queries

Queries used to compare response times between the two methods are representative of the types of queries that might actually be applied to the earthquake advisory data in the real world. The queries are also designed to test the technique each method uses to store the multi-valued magnitude data. These queries, in a business language format, are:

1. Retrieve all earthquake event records
2. Retrieve a single earthquake event record for a given date and region
3. Retrieve all earthquake event records that had a magnitude >= 7
4. Retrieve earthquake event records that had a magnitude equal to the maximum magnitude across all records
5. Retrieve the average magnitude over all earthquake event records

The goal when translating these queries to SQL is to extract the information with a single query to the data warehouse, when possible. Multiple queries, however, are necessary in some cases. The SQL queries for the star schema method, where magnitude data is stored as XML for each event, involved using an extraction function applied to the XML text in order to retrieve each individual element's data value. Because there may be multiple magnitude source, magnitude formula, and magnitude value nodes for each event, these nodes must be accessed via a subscript. In addition, because the number of subscripts necessary to access the source, magnitude, and value nodes for each record varies, queries use the maximum number of subscripts and require additional processing to filter any null values returned. The SQL queries for the snowflake schema require an additional join of the Magnitude table.

7. RESULTS

The data tables for the two data warehouses were created using Oracle 10g [2] server with a dual Xeon processor. All queries were executed five times and the average of the five runs taken as the representative response time for that query.

In addition, indices were created in an attempt to maximize query response times. An index was created for each table's primary key and functional indexes were created for magnitude values within each data warehouse. The response times for Queries 1, 2, and 3 for the Star Schema and Snowflake Schema methods show less than an order of magnitude difference, while the Query 4 and 5 response times for the two methods show several orders of magnitude difference. The variations between the two sets of queries are a result of the differing query complexities caused by the manner in which the multi-valued XML data is stored and, therefore, must be accessed in the two methods. Queries 1, 2, and 3 involve either no or

Figure 3. Response times (milliseconds) for queries without calculations or aggregations

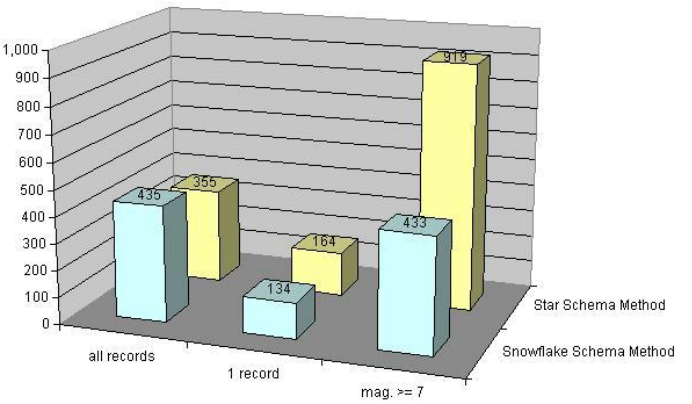


Figure 4. Response times (milliseconds) for queries with calculations or aggregations

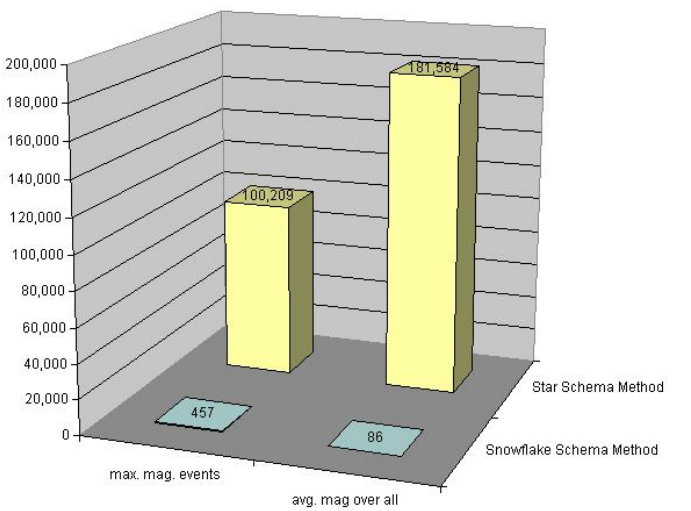
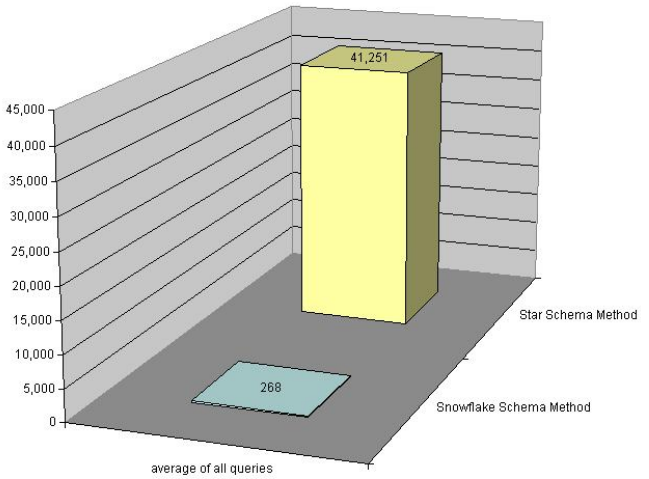


Figure 5. Response time average over all queries (milliseconds)



simple filtering, while Queries 4 and 5 involve calculations or aggregations of the multi-valued magnitude data, which is stored differently in the Star Schema and Snowflake Schema methods.

The response times (Figure 3) for Query 1 (retrieve all records) show that the Snowflake Schema is slightly slower than the Star Schema. Although the query for the Star Schema makes use of an XML extraction function, which is built into Oracle, to extract the magnitude data, the Snowflake Schema method actually takes slightly longer (435 vs. 355 ms for the Star Schema method). This is most likely due to the increased time it takes to join records, which is greater for the Snowflake Schema method because it has an extra table.

The response times for Query 2 (retrieve a single specific record) show that both the Star Schema and Snowflake Schema methods are comparably efficient at retrieving a single record (164 ms for the Star Schema method vs. 134 ms for the Snowflake Schema method). Even though the Snowflake Schema method requires the extra join for Query 2, the criteria for retrieving the single record translates into a much faster execution plan that filters for the search criteria before scans on the hierarchical table are performed.

The response times for Query 3 (retrieve all records that have a magnitude >= 7) show the Snowflake Schema method to be almost twice as fast as the Star Schema method (433 vs. 919 ms for the Star Schema method). The query for the Star Schema requires a comparison for each of the multi-valued XML elements, which adds extra filter criteria. The Snowflake Schema method, however, can take advantage of the relational database's built-in ability to join and filter.

Queries 4 and 5 (Figure 4), which involve aggregations of the multi-valued magnitude data, have response times that show differences between the Star Schema and Snowflake Schema methods that are several orders of magnitude in size.

The response times for Query 4 (retrieve all records with the maximum magnitude) show that the Snowflake Schema method is much faster than the Star Schema (457 vs. 100,209 ms for the Star Schema method). Response times for Query 5 (retrieve the average magnitude of all records) also show the Snowflake Schema method to be faster (86 vs. 181,584 ms for the Star Schema method).

Like Query 3, Queries 4 and 5 require access to and extraction of the multi-valued magnitude data. With the Star Schema method, Queries 4 and 5 must access the XML elements twice, once to perform a calculation or summation and a second time to perform an aggregation. Because of the need to extract the XML text elements in the Star Schema method, Queries 4 and 5 become cumbersome, while the Snowflake Schema method, again, takes advantage of the relational database's built-in ability to join and filter.

The response time averages for all 5 queries (Figure 5) show that the snowflake schema method demonstrates a response time average that is 153 times faster than that of the star schema method. These results demonstrate that in this case, where the XML documents contain multi-valued magnitude data, the decomposition of the magnitude data into a snowflake schema is advantageous over attempting to maintain the traditional star schema.

8. CONCLUSIONS

A comparison of the methods from a quantitative standpoint, based on the query response times, shows that the snowflake schema method is consistently faster, and markedly faster in most cases, than the star schema. The star schema method has some response times that are comparable to the snowflake schema method. However, queries that require calculations (e.g., sum) or aggregations (e.g., average) of data values stored as XML demonstrated much slower response times with the star schema.

A comparison of the two methods from a qualitative standpoint, based on the experiences gained from implementing the methods, also shows that the snowflake schema method is preferable over the star schema. The star schema method required the use of a subscript when accessing multi-valued elements within the XML data. In addition, the star schema method required additional filtering when accessing a variable number of multi-valued elements and post-query processing when performing aggregates. The snowflake schema method required only one query and did not require filtering or post-query processing.

The implementation in this research has demonstrated that when storing multi-valued XML data, the snowflake schema demonstrates faster query response times than the star schema and may, therefore, be preferred over the star schema in cases involving the storage of semi-structured XML data. Finally, the type of data and the access methods necessary to retrieve the data should be an important consideration when making decisions regarding the design of a data warehouse.

9. REFERENCES

[1] http://www.w3.org/XML/Core/#Publications
[2] http://www.oracle.com/index.html
[3] http://www.microsoft.com/
[4] http://www.ibm.com/us/
[5] Kanne, C. and Moerkotte, G. Efficient Storage of XML Data. Proceedings of ICDE (San Diego CA, March 2000), 198.
[6] Eisenberg, A. and Melton, J. SQL/XML Is Making Good Progress. SIGMOD Record 31, 2 (June 2002), 101-108.
[7] Florescu, D. and Kossman, D. Storing and Querying XML Data Using an RDBMS. Bulletin of the Technical Committee on Data Engineering 22, 3 (September 1999), 27-34.
[8] Kanne, C. and Moerkotte, G. Efficient Storage of XML Data. Proceedings of ICDE (San Diego CA, March 2000), 198.
[9] Tian, F., DeWitt, D., and Zhang, C. The Design and Performance Evaluation of Alternative XML Storage. SIGMOD Record 31, 1 (March 2002), 5-17.
[10] Shanmugasundaram, J., Krishnamurthy, R., and Tatarinov, I. A General Technique for Querying XML Documents Using a Relational Database System. SIGMOD Record 30, 3 (September 2001), 20-26.
[11] Shanmugasundaram, J., et al. Relational Databases for Querying XML Documents: Limitations and Opportunities. Proceedings of the 25th VLDB Conference (September, 1999), 302.
[12] Xylem, L. A Dynamic Warehouse for XML Data of the Web. Bulletin of the Technical Committee on Data Engineering 24, 2 (June 2001), 40-47.
[13] Golfarelli, M., Rizzi, S. and Vrdoljak, B. Data Warehouse Design from XML Sources. Proceedings of the 4th ACM International Workshop on Data Warehousing and OLAP (November, 2001), 40-47.
[14] Graves, M. Designing XML Databases. Prentice Hall, Upper Saddle River, NJ, 2002.
[15] Connolly, T. and Begg, C. Data Systems: A Practical Approach to Design, Implementation, and Management. 2nd ed., Addison-Wesley, New York, 1999.
[16] Elmasri, R. and Navathe, S. Fundamentals of Database Systems. 3rd ed., Addison-Wesley, New York, 2000.
[17] Chaudhuri, S. and Dayal, U. An Overview of Data Warehousing and OLAP Technology. SIGMOD Record, 26, 1 (1997), 517-526.
[18] Seyed-Abbassi, B. Designing an Optimized Data Warehouse for Data Mining. Proceedings of the 5th World Multiconference on Systemics, Cybernetics and Informatics (July, 2001), 214-219.
[19] Appelquist, D. XML and SQL: Developing Web Applications. Addison-Wesley, Boston, MA, 2002.

[20] Quin, L. Open Source XML Database Toolkit. Wiley Computer Publishing, New York, 2000.

[21] http://neic.usgs.gov/neis/epic/epic_global.html or http://eqint.cr.usgs.gov/neic/cgi-bin/epic/epic.cgi?SEARCHMETHOD=1&FILEFORMAT=4&SEARCHRANGE=HH&SYEAR=2000&SMONTH=&SDAY=&EYEAR=2005&EMONTH=&EDAY=&LMAG=1&UMAG=9.9&NDEP1=&NDEP2=&IO1=&IO2=&SLAT2=0.0&SLAT1=0.0&SLON2=0.0&SLON1=0.0&CLAT=0.0&CLON=0.0&CRAD=0&SUBMIT=Submit+Search

Adoption of CRM in Higher Education

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ABSTRACT

This study examines the adoption factors for deployment of customer relationship management (CRM) in higher education institutions. While CRM is widespread in the corporate sector, its usage has been limited in higher education. With the rising service expectations, universities have to realign their strategies to serve students across their entire student life cycle. We used the case study approach to examine factors critical to CRM adoption in the higher education sector. The study is exploratory in nature, representing one of the first efforts to study CRM adoption in universities and colleges. Our findings suggest that groups with a clear understanding of student life cycle will be more likely to adopt CRM. We propose that a fit between the choice of CRM goal - strategic versus transactional CRM - and organizational factors will help determine the continuous adoption of CRM by higher education users.

INTRODUCTION

Customer relationship management (CRM) involves the deployment of strategies, processes, and technologies to strengthen a firm's relationships with customers throughout their life cycle – from marketing and sales, to post-sale service (Winer, 2001). While CRM is a widespread concept in the corporate world, it is a relatively new phenomenon in the higher education sector (Grant and Anderson, 2002).

In this paper, we examine the factors affecting the adoption of CRM technology in the higher education sector. Through a case study of a Midwest university, we intend to address three research questions: (1) What characteristics of an institution contribute to the adoption of CRM technology? (2) What factors influence adoption decisions? (3) What strategies can be applied to increase the success of CRM adoption in higher education institutions?

We use the innovation diffusion theory (IDT) (Rogers, 1995) and the unified theory of acceptance and use of technology (UTAUT) (Venkatesh et al., 2003) to guide data collection and analysis for this case study. This paper starts with a review of CRM research, its implications for colleges and universities, and research on IDT and UTAUT. It then presents the research methodology and data collection procedures. The paper concludes with a discussion of contribution of this research. Findings from this study will help us gain a better understanding of the specific needs of the higher education sector for CRM deployment.

LITERATURE REVIEW

Customer Relationship Management

CRM is an enterprise-wide initiative which focuses on developing and leveraging an in-depth view of customers across enterprise applications and business units. It promises to provide seamless integration of multiple business areas that touch the customer – marketing, sales, customer service and field support - through integration of people, process and technology (Satish et al., 2002). It is a combination of business processes and technology that seeks to understand a company's customers from the perspective of who they are, what they do, and what they like (Ryals and Knox, 2001). Along with other enterprise systems, such as enterprise resource planning (ERP) systems, companies are adopting CRM technologies to strengthen customer interactions and shifting their focus from business efficiency to business effectiveness (Sheng, 2002).

CRM in Higher Education

Higher education institutions are "student centric" organizations that encompass a wide range of student outreach and counseling activities such as admissions, academic advising, job placement and more.

While CRM usage is widespread in the corporate sector, higher education is far behind with CRM implementation (Grant and Anderson, 2002). Universities and colleges may benefit from CRM by improving student-facing processes (Chen and Ching, 2005), personalizing communications with students (Karimi et al., 2001), sharing information among departments (Chen and Ching, 2005), and increasing student retention and satisfaction (Bradshaw and Brash, 2001).

Student Life Cycle

Significant changes in the expectation of students, contribute to the relevance of relationship management strategy (Conant, 2002). While it might seem counter-intuitive to view students as customers, changes in the higher education sector necessitate this shift in thinking. Viewed from the CRM lens, the concept of customer life cycle can be mapped to the stages that a student progresses through when considering and using the services of a learning institution to form the student life cycle. Within a student life cycle, a student progresses though the following stages:

Suspect→ Prospect→ Applicant→ Admitted → Enrollee→Alumni

- Suspect: A suspect is any student who might be a potential candidate for the school.
- Prospect: A prospective student is at the information gathering and opinion forming stage.
- Applicant: A student is an applicant when he/she makes the decision to join the institution.
- Admitted: A student is admitted when the college makes a decision to accept the student.
- Enrollee: This is the stage where students become a part of the institution.
- Alumni: At this stage, students who are satisfied with their academic experience will develop long-term loyalty to their alma mater.

In view of corporate CRM activities, college student enrollment management activities of converting suspects to the admitted represent the marketing components of CRM; the conversion of admitted students to enrollees represent the component of sales; and the continuous enrollment and participation as alumni represent the retention and support components. However, student life cycle involves more complex interactions especially during the retention phase as academic programs, advising, and student life play critical role in student retention (Tinto, 2005).

Innovation Diffusion Theory (IDT)

IDT by Rogers (1995) emphasizes diffusion life cycle and addresses the differences in the pre- and post-adoption attitudes and beliefs. The innovation decision process leading to institutionalization of usage (Karahanna et al., 1999) may be conceptualized as a sequence of steps through which an individual passes from initial knowledge of an innovation (information), to forming a favorable or unfavorable attitude towards it (persuasion), to a decision to adopt or reject it (decision), to put the innovation to use (implementation), and to finally seeking reinforcement of the adoption decision made (confirmation) (Rogers, 1995). The IDT framework as highlighted below could enable us to examine CRM adoption through different stages of innovation life cycle.

Information→ Persuasion→Decision→Implementation→ Confirmation

Unified Theory of Use and Acceptance of Technology (UTUAT)
In addition to IDT, we used UTUAT framework which takes a more comprehensive view of technology adoption in an organization. The decision by a company to deploy a CRM system is in essence a technology adoption issue. Venkatesh et al (2005) present the unified theory of use and acceptance of technology (UTUAT) by integrating eight prominent but fragmented research models concerning user acceptance and usage of new technology. Unified theory identifies four determinants of user acceptance and usage behavior: (1) performance expectancy, (2) effort expectancy, (3) social influence, and (4) facilitating conditions. We used UTUAT to help us structure our research constructs and facilitate data collection.

RESEARCH METHODOLOGY

Because of the exploratory nature of this research, we used the case study method to examine CRM adoption in a single organization, a Midwest university. According to Lee (1989), case study method is well suited for exploratory studies where the sample sizes are relatively small. The case study method is particularly appropriate when the research and theory are at their early formative stage (Benbasat et al., 1987). According to Yin (1984), a single-case study approach is most useful when the phenomenon of interest, in this instance, user adoption factors and usage patterns, can not be clearly separated from the social, technological and organizational context in which they appear.

The case study strategy consists of defining the study focus, construction of framework to guide data collections, interviews, data collection and case analysis (Pick and Roberts, 2004). In our study, the unit of analysis is a department within a single institution. We included 37 members in nine departments/colleges. These groups provide a range of CRM adoption scenarios across different stages of student life cycle.

Data Collection Procedure
We used multiple sources of evidence to support the construct validity, including: structured email questionnaire, statement of business cases and other documents as appropriate. Internal validity has been ensured by constructing a detailed research framework with detailed steps. Reliability was addressed by adopting detailed case study protocol that documents the scheduling, interview procedures, recording, and follow-up questionnaire. The procedures for data collection involve the following steps:

Table 1. Participating departments

Department/ College	Number of Users	Adoption life cycle stage	Pre/post Adoption	Stage in student life cycle
Enrollment Management	6	Confirmation	Post-Adoption	Suspect, Prospect & Applicant
College A Admissions	5	Decision	Post-Adoption	Prospect
College E	6	Confirmation	Post-Adoption	Prospect & Applicant
College B	5	Decision	Pre-Adoption	Prospect, Applicant, Enrollee & Alumni
College D	3	Implementation	Post-Adoption	Prospect, Applicant, Enrollee & Alumni
College C	4	Implementation	Post-Adoption	Applicant & Enrollee
Student Affairs	3	Confirmation	Post-Adoption	Applicant & Enrollee
Financial Aid	2	Decision	Pre-Adoption	Applicant & Enrollee
College A Advising	3	Persuasion	Pre-Adoption	Enrollee

For each department, the research team conducted semi-structured interviews with the key decision maker and one or more users. Two parallel sets of interview questions were used for departments in the pre- or post-adoption stage, respectively. Based on IT diffusion adoption life cycle (Rogers, 1995), departments at a persuasion or decision phases were categorized as pre-adoption and those identified in the decision, confirmation and implementation phases were categorized as post adoption (Rogers, 1995).

An email survey questionnaire was sent to the interviewees, approximately two days after the interview. The questionnaire items were adapted from the UTUAT study (Venkatesh et al., 2003). Due to the small sample size, we only used the survey results to supplement interviews.

Participating Units
Users in nine departments participated in this study. Table 1 presents the diverse range of scenarios of CRM adoption at this institution. Each group of users is categorized based on the stage in adoption life cycle, pre- or post-adoption, and targeting students in terms of student life cycle.

FINDINGS

Research Case: Profile of the Target Institution
Our case study focuses on a Midwestern university which has metropolitan and suburban campuses. The university now supports well over 23,000 students and over 3000 faculty and staff. At the time of the study, the university had installed an enterprise CRM system (Enterprise CRM) as a part of enterprise resource planning (ERP) package, an Enrollment Management CRM (EM CRM), and two standalone CRM applications for two different colleges (College CRM). Therefore, the findings discussed below represent a diverse set of choices for CRM technology.

At the enterprise level, the IT department has deployed one-to-one communication module of the enterprise CRM package. For example, offices of student affairs utilize online marketing tools of the Enterprise CRM package to maintain an active relationship with enrolled students, particularly students at risk. The enrollment management division has recently adopted an EM CRM, niche software designed

Table 2. CRM grid

GOAL	ORGANIZATION: Centralized	ORGANIZATION: Decentralized
Strategic CRM	Process Characteristics: Redefine existing processes and emphasize long-term relationship building with students Impact on student life cycle: Services students across the entire or significant portion of student life cycle Organizational Dependency: Service provider to other organizational units Role: CRM users and champion(s) Example: Enrollment Management	Process Characteristics: Redefine existing processes and emphasize long-term relationship building with students Impact on student life cycle: Services several stages of the student life cycle Organizational Dependency: Standalone organizational unit Role: CRM users Example: College E, College D
Transactional CRM	Process Characteristics: Automation of existing processes. Short-term and tactical in nature Impact on student life cycle: Services limited activities or a single stage of the student life cycle Organizational Dependency: Service provider to other organizational units Role: CRM users and champion(s) Example: Student Affairs, Financial Aid	Process Characteristics: Automation of existing processes. Short term and tactical in nature Impact on student life cycle :Services limited activities or a single stage of the student life cycle Organizational Dependency: Standalone organizational unit Role: CRM users Example: College C, College A Advising,

specifically for the higher education sector, to manage student recruitment funnel (from suspect to admitted stages of the student life cycle). The College CRM tools are either in-house applications or standalone systems designed to support admissions process, which are either used alone or in conjunction with Enterprise CRM. For example, College A's admissions office used enterprise CRM and its own email application to target prospects for open house and other recruiting events.

Group Segmentation: A CRM Grid

Based on our initial assessment of the user departments and groups, we conceptualized a framework to synthesize and segment the participating groups. As shown in Table 2, this CRM Grid segments the participating units according to the nature of their organizational responsibility and structure (centralized versus decentralized) and the goal of CRM adoption (strategic or transactional).

Organization

Organization defines the structure of the division/college/department in this university. An organization can be either centralized or decentralized in terms of its ownership of CRM process. Centralized units are service providers to other departments or colleges. They support and collaborate with other colleges on core business processes like recruitment, student affairs, and alumni relations. In most cases, they were the owners of enterprise-wide CRM process and technology solutions. Their role was not only as users of the system but as champions as well. Decentralized units are colleges and schools that are autonomous administrative units. These colleges have their own departments to take care of recruiting, admissions, and student and alumni relations. Since this university did not mandate the usage of an Enterprise or EM CRM application, CRM adoption is voluntary and based on needs. Decentralized units have resources to build or buy their own CRM systems. They were mainly CRM users who would rely on vendors or centralized departments to support the backend operations and data integration.

Goal

Goal defines the purpose for using CRM application in this university. Strategic CRM is long-term in nature and requires user departments to redefine their existing process. The CRM scope is broadly defined and users who viewed CRM as a strategic tool catered to all or most part of the student life cycle. CRM was seen as an important competitive advantage and was used to strengthen relationship with students. Transactional CRM is short-term and tactical in nature. It supports automation of existing process and requires little or no process changes. The main aim of using CRM for transactional purpose was cost reduction and improvement of efficiency. CRM did not redefine their current operations and was used to support only narrowly defined activities involved in one particular stage of student life cycle.

Examples

Using the CRM grid, we identified four groups of CRM users. An example for each group is provided below.

- Strategic-Centralized: Enrollment Management is a centralized division that handles the recruiting and admissions operations for the university. At the time of our study, the group had just implemented a new EM CRM suite to centralize interaction points with prospective students from suspects to the admitted. The new system helped them create communication plan around the early stages of student life cycle and enabled recruiters to customize their recruiting strategies based on segmentation.
- Strategic-Decentralized: College E is a well-established college which manages most of its own operations like recruitment, admissions and student retention. The college decided to invest in its own CRM suite because it had some unique steps in recruitment process and the college staff felt that the current IS support did not meet their needs. The usage of the new CRM suite helped them streamline their student-related processes and freed up the staff's time to focus on face-to-face interactions with students.
- Transactional-Centralized: Student Affairs manages all activities pertaining to student retention such as housing. They work with other colleges to streamline their student retention activities. At the time of the study, the group was collaborating with Information Services department to champion the usage of Enterprise CRM in other colleges. Within its own departments, they used it to streamline their existing communication operations, including online newsletter and event planning.
- Transactional-Decentralized: Admissions office in College A is responsible for graduate student recruitment. This college used the Enterprise CRM system to streamline its existing operations around event planning. Prior to using the Enterprise CRM systems, the college's admissions office communicated with students via postal letters, radio ads, and web banners. College A decided to use CRM to reduce costs and to personalize communications with prospective students.

OBSERVATIONS

Our study yielded a set of key criteria for adoptions of CRM technology as expectation (UTUAT, 2003).

Benefit Expectation

While CRM as a terminology was new to some user groups, most of them were using the technology in one way or another. One common factor that we found in all users, irrespective of their stage in the adoption life cycle, was the perceived or actual benefit of using CRM. An individual's perception of benefits attained through CRM influenced the group's decision to use it. For some of the users, the benefit was CRM's ability to have more personalized communication with the students, for others, cost saving was an important benefit.

Effort Expectancy

Effort expectancy is defined as the degree of use associated with the use of the system (Venkatesh et al., 2003) We found this to be a factor in many groups who decided against using Enterprise CRM, despite the fact that Enterprise CRM was available at no cost. Users expressed strong reactions to the effort required them to build new business processes into their existing operation. It was a decisive factor in two groups who decided to purchase their own CRM applications. Both groups perceived the existing Enterprise CRM system to be inadequate for strategic CRM and felt that it made their job more difficult.

Training Expectation

Training was seen as an important adoption factor among all users. Even users who were comfortable with technology expressed their desire to get trained prior to using the existing Enterprise CRM system. We found that training helped individuals who were initially intimidated by the system.

Collaboration and Support Expectation

Level of available support, especially from the university's IS staff, was seen as another important factor. We found that there was no social pressure to use the system, but all users wanted to be able to call for help when needed. Though the university had independent departments or units, they had to rely on IS staff for data integration, expert advise and hardware support. Most users felt that establishing a good relationship with the support groups helped them use CRM more effectively.

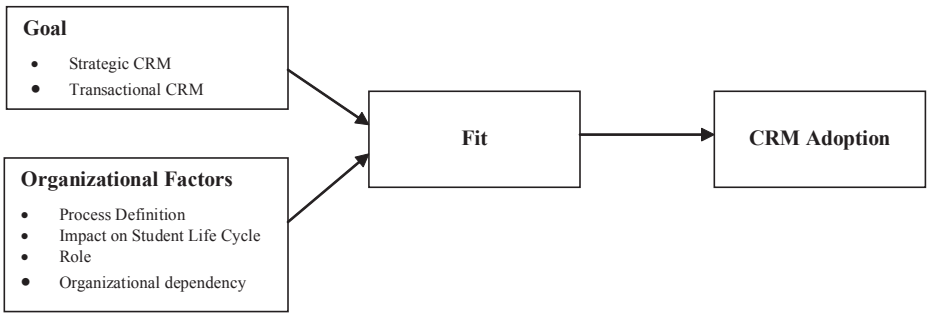
PROPOSITION

Based on our exploratory case study, we have postulated a CRM adoption model for the higher education sector (Figure 1). While there are many user acceptance models available, we believe that these models provide an overall perspective of user adoption which is not suitable to address the divergent needs and complex nature of the higher education sector. As we discussed earlier, departments within higher education have varied needs based on their goals and organizational factors. An appropriate fit between these two factors facilitates CRM adoption

This study uses the perspective that fit is a theoretically defined match between two related variables (Venkataraman, 1989) namely goal and organizational factors. Alexander and Randolf (1985) emphasize that fit, within a technology system context, exists when the organizational structure matches the required technology system. They have used this fit model as a predictor of performance.

Viewed from that perspective, our model proposes that the fit will be determined by the right combination of CRM goal (strategic or transactional) and organiza-

Figure 1. CRM fit model



tional factors (process definition, organizational role and dependency). A match between these two variables will enhance fit thereby facilitating successful adoption. More specifically,

- An organizational unit with a clear concept of student life cycle is more likely to achieve long-term benefits from a CRM initiative. An organization with a tactical view about CRM can also benefit by focusing on automating specific activities or a single stage of student life cycle.
- Organizations with centralized responsibilities play a champion role in promoting CRM usage. An appropriate fit of these factors will help determine successful adoption. However, misfit occurs when the CRM concept and technology is promoted for process redesign while the organization aims only for transactional CRM, or when a transactional CRM is promoted to an organization focusing on broadly defined interaction process. Such gaps will result in rejection or early termination of CRM technology. While long-term adoption is preferred, short-term adoption can also contribute to strengthening an institution's interactions with students.

IMPLICATIONS AND NEXT STEPS

This case study has identified approaches to the adoption of CRM in the higher education sector. The conceptual model contributes to a better understanding of determining a CRM fit based on organizational factors and CRM goal. As more universities adopt CRM, determining an appropriate fit can facilitate successful deployment of CRM. This research will help to expand the understanding on adoption factors in this sector. Despite the comprehensiveness of the proposed research model, we acknowledge some limitations which call for additional research. This project is a single case study and while it was well triangulated, future studies should expand the scope to include multiple cases and an empirical test of the proposed conceptual model through a survey study.

REFERENCES

1. Alexander, J. W., and Randolf, W. A. (1985). The Fit between Technology and Structure as a Predictor of Performance in Nursing Subunits, *Academy of Management Journal*, 28(4), 144-153.
2. Benbasat, I., Goldstein, K. D., and Mead, M. (1987). The Case Research Strategy in Studies of Information Systems, *MIS Quarterly*, 9, 369-386.
3. Bradshaw, I., and Brash, C. (2001). Management Customer Relationships in the e-Business World" *International Journal of Retail and Distribution Management*, 29(12), 520-530.
4. Chen, J., and Ching, R. K. H (2005). An Examination of the Effects of CRM Practices on CRM Effectiveness and Business Performance, *Proceedings of the Eleventh Americas Conference on Information Systems*, August 11- 14, Omaha, NE, USA, 179-188.
5. Conant, R. (2002). Relationship Management in Higher Education Information Technology, *ECAR*, 13, 1-12.
6. Grant, G., and Anderson, G. (2002). *Web Portals and Higher Education*, Wiley Company, USA.
7. Karahanna, E., Detmar, S., and Chervany, N. (1999). Information Technology Adoption across Time: A Cross-Section Comparison of Pre-Adoption Beliefs and Post-adoption Beliefs, *MIS Quarterly*, 23(2), 183-213.
8. Karimi, J., Somers, T., and Gupta, Y. (2001). Impact of Information Technology Management Practices on Customer Service, *Journal of Management Information Systems*, 17(4), 125-158.
9. Lee, S. A. (1989). A Scientific Methodology for MIS Case Studies, *MIS Quarterly*, 12(2), 33-50.
10. Pick, J., and Roberts, G. (2004). Case Study Analysis of Corporate Decision-Making for Cell Phone Deployment, *Proceedings of Americas Conference on Information Systems,* 1-10.
11. Rogers, E. (1995). *Diffusion of Innovations*, 4th edition, New York, New York: Free Press.
12. Ryals, L., and Knox, S. (2001). Cross Functional Issues In the Implementation of Relationship Marketing Through Customer Relationship Management, *European Management Journal*, 9(3), 534-542.
13. Satish, S., Pan, L. S., and Raman, K. S. (2002). Customer Relationship Management (CRM) Network: A New Approach to Studying CRM, *Proceedings of the Eighth Americas Conference on Information Systems*, 545-553.
14. Sheng, P. Y. (2002). A Business Model and Framework for Electronic Customer Relationship Management, *Proceedings of the Eight Americas Conference on Information Systems*, 539-544.
15. Tinto, V. (2005). Epilogue: moving from theory to action. In A. Seidman ed., *College Student Retention: Formula for Student Success*, 317-334. Westport, CT: ACE/Praeger.
16. Venkataraman, N. (1989). The Concept of Fit in Strategy Research: Toward Verbal and Statistical Correspondence, *The Academy of Management Review,* 14(3), 423-444.
17. Venkatesh, V., Morris, M., Davis, G., and Davis, F. (2003). User Acceptance of Information Technology: Toward a Unified View, *MIS Quarterly*, 27(3), 425-478.
18. Winer, R. (2001). A framework for customer relationship management, *California Management Review*, 43(4), 89-105.
19. Yin, R. K. (1984). *Case Study Research: Design and Methods*, Sage Publications, Beverly Hills, California.

The Open Catalogue of Manuscripts in the Malatestiana Library: Balance and Perspectives

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ABSTRACT
The reasons for the project of a special information system for manuscripts' cataloguing and publication is first explained. The features of the Open Catalogue of manuscripts in the Malatestiana Library, which is the first example of implementation for that information system, are soon after described. The evolution of the system during last years and a balance of the activities involving students, researchers and general users are then reported. At last the developments and future applications for the open catalogue are drafted.

Keywords: manuscript, paleography, catalogue, Web, database, information system.

INTRODUCTION
Many experiences laying on the Internet have been carried out in Paleography during last years and many changes were introduced in the discipline's methods. Furthermore, especially planned information systems have been more and more used and everyday work and study processes of the discipline were consequently influenced.

The proposal of the Open Catalogue of manuscripts takes its place among the studies introducing innovation in Paleography research and study with the ICT and aims at the creation of connections with information sciences (i.e., IS, IT and ICT disciplines).

What Is Changed In Paleography Research Methods And Instruments?
ICT radically changed the approach scholars had with manuscripts for at least two reasons:

a) the way manuscripts were analyzed,
b) the medium scientist could adopt to share the results of their work,

in the first case it has to be noted that before the Internet researchers had to personally study manuscripts in archives or libraries; secondly they published the results of their research only by means of printed catalogues (before the use of web sites).

During last years the spreading of networking communication techniques produced relevant effects on the sharing of knowledge and information within the community of paleographers. First of all the Web was used to publish the images reproducing manuscripts pages, but it increased also the number of on line historical magazines, the collections of bibliographies, the use of on line databases etc. (Cartelli and others, 2001).

The above considerations and the proposals coming from newly defined disciplines like informing science (Cohen, 1999), led the authors to the definition of a special information system called "Open Catalogue". This system, which is described in the following section, has been adopted and carried out from the staff of the Malatestiana Library, an ancient Italian library hosting a consistent number of manuscripts.

CATALOGUES OF MANUSCRIPTS AND THE OPEN CATALOGUE
The history of manuscript cataloguing began between 17th and 18th century and notwithstanding the great work made by paleographers in these centuries an enormous amount of manuscripts still remains uncatalogued, if not unknown.

The main trouble with the study of old, handwritten books can be summarized as follows:

a) people simply don't know of manuscripts' existence (with respect to texts, where bibliographies and Internet resources make relatively easy to find a printed book, the same doesn't happen for manuscripts),
b) every manuscript is a unique book (i.e., there are no duplicates for it). Even if the text in two manuscripts is the same, as in the case of a model and its copy, they are never equal; two books can in fact be different for scripting style, physical appearance and even text, because a handwritten copy always contains some changes with respect to its source.

As a consequence the creation of a catalogue of manuscripts is a really difficult task, it requires a deep competence in a lot of fields, from philology to history, from history of art to paleography, from literature to library science.

In the authors' opinion time has come for a radical change in catalogue publishing. First of all the Internet can make available great part of the manuscript heritage all over the world (i.e., a good example for the new way of catalogues' publishing can be found in the choice of CDF in Germany, reported from Overgaauw, 2001); furthermore it is possible to give scholars new and more powerful tools to improve their work and let them create *Open Catalogues* (i.e., catalogues in progress, constantly changing with the continuous contribution of new information).

The Open Catalogue of Manuscripts
When the structure of the Open Catalogue was hypothesized two separated environments were planned (Cartelli & Palma, 2002): a former one where researchers and scholars had the scientific liability of the materials to be published and a latter one where people could occasionally or systematically obtain information (i.e., it couldn't be used to produce new data).

The above separation affected the way users could access the system and led to three different and separated access levels:

a. system and scientific administrator level; one or more persons with the scientific responsibility of the catalogue, who can enable researchers and scholars to access and manage the materials to be published (they can also manage the data produced by everyone),
b. scholars and researchers level; allowed people who can insert, modify, delete and display the materials to be published (manuscripts' descriptions, notes, images etc.),
c. general users level, where only the answers to specific queries can be obtained (i.e., the descriptions and images of manuscripts, bibliographies, notes etc.).

As regards the structure of the Open Catalogue it was based on five sections, to be intended in a flexible manner (i.e., the presence of each section depends on

the resources the library will have at its disposal and on the different solutions it will adopt for them) (Cartelli & Palma, 2003):

a) the first section is devoted to documents explaining the history of the library and its manuscripts;
b) the bibliography ordered by shelfmark and, eventually, alphabetically and chronologically, is housed in the second section;
c) in the third section the descriptions of the manuscripts, i.e. previous printed catalogues or ancient handwritten catalogues (suitably digitized) and new descriptions (according to nationally/internatio-nally defined standards) are stored;
d) the fourth section contains the images of the highest number of manuscripts in the library (possibly all);
e) the fifth and last section is made of a communication subsystem including electronic blackboards, chats, forums and special Web solutions granting the easier acquisition, writing and editing of texts among the members of a selected community of scholars interested in the materials in the library.

MALATESTIANA LIBRARY AND THE OPEN CATALOGUE OF MANUSCRIPTS

In the *Malatestiana libraria*, designed and built in the mid-15th century by Malatesta Novello, Lord of Cesena, 343 manuscripts, which give witness to his tastes and cultural inclinations, are housed. Malatesta Novello enriched the ancient volumes (about fifty) of the Franciscan convent with an invaluable collection of manuscripts which were especially copied and illuminated, and with codices which were purchased, received in donation, dedicated, or already part of his family's patrimony.

Further manuscripts come from the collection of Giovanni di Marco, the physician of Malatesta Novello (53 codices), from the choral books of the Cathedral (7 books), from the books of the Franciscan convent (8 books), from the Piana Library (59 manuscripts, which were the private library of Pope Pius VII), from the town library (12 manuscripts collected from dissolved religious houses in 19th century).

The staff of Malatestiana Library decided to adopt the idea of the open Catalogue and decided to find the resources for building it, mostly because it looked interesting and useful to have a *catalogue in progress*. The advantages of this choice were both immediate and evident:

- the possibility of proceeding in a programmed and gradual manner;
- the ability to retrieve all the information already acquired even in a partial and non-final form;
- the opportunity to extend the research to ancient sources that were difficult to access;
- the increase in the interactive updating of the information available by qualified specialists and scholars.

The web site for the Open Catalogue of manuscripts in the Malatestiana Library can be accessed from the portal of the Forlì-Cesena county (http://www.malatestiana.it/manoscritti/). The database accompanying the site was autonomously constructed with a personalized wwwisis 5.0 application.

The catalogue is made of four parts:

- the first part credits people working to the project and its carrying out,
- the second section contains general texts on the Library and the manuscript collections (i.e., the history of the library, Cesena humanistic culture, the scriptorium, the illumination, the collections etc.). First of all classical texts suitably digitized have been put on line, now special works and degree theses are adding to the former ones together with descriptions of the Library coming from foreign visitors,
- the third part lets users access manuscripts according to shelfmark, author and title. For each codex the description and the bibliography are reported. A program for a regular updating and retrieval of recent and previous bibliography, according to the resources of the Malatestiana Library and its goals has been planned. At the end of October 2006 every user will find the reproductions of 42 codices, although the Library staff plans to offer a complete reproduction of all the manuscripts;
- the fourth section plays a fundamental role in this project hosting users' requests, opinions and articles. Here, scholars or persons interested in the Library's manuscript collection can contribute with their observations, as well as publish their contributions online. Recently this section was enriched with two special functionalities: a) collaborative bibliography, by which everyone entrusted with the access to the section can insert his/her personal bibliographical records in the page, b) works in progress on two manuscripts, by which a community of study and research is granted the permission of accessing all the texts in the area.

The open catalogue neither excludes nor acts as a supplement to printed work, which is always possible and even desirable, because this has a particular type of diffusion and is permanent by nature. Instead, the open catalogue is updated constantly by the Library staff, particularly by those who are involved in manuscript preservation. It is their duty to actively administrate the site and to promote research even encouraging interested specialists to provide critical contributions.

CONCLUSION AND FUTURE TRENDS

Main remarks on the work carried out from Malatestiana staff during last three years is reported below:

- institutional librarians coordinated the work in the library and in the site and produced descriptions and bibliographies for the manuscripts,
- continuous contacts were kept with public and private institutions and with scholars interested in the study of manuscripts in the Malatestiana library,
- young and highly qualified people (i.e., people coming from special humanistic studies) was involved in the production of manuscripts' descriptions and other texts.

Furthermore, the use of web technologies contributed in changing the way of studying and working in paleography by introducing social-constructivist elements in everyday activities. Examples of communities of learning and of communities of practices based on ICT use were in fact detected.

At last it has to be noted the presence of factors influencing knowledge construction and development both on individual and social bases.

REFERENCES

Cartelli, A., Miglio, L. & Palma, M. (2001). New Technologies and New Paradigms in Historical Research. *Informing Science*, Vol 4, 2, pp. 61-66.

Cartelli, A., & Palma, M. (2002). *Towards the Project of an Open Catalogue of Manuscripts*. In (E. Cohen & E. Boyd ed.s) *Proceedings of the Informing Science + Education Conference*, (Cork, 19-21 June 2002), retrieved on line on Sep 28, 2006 at http://proceedings.informingscience.org/IS2002Proceedings/papers/Carte188Towar.pdf.

Cartelli, A., & Palma, M. (2003). The Open Catalogue of Manuscripts Between Paleographic Research and Didactic Application. In (M. Khosrow-Pour ed.) *Proceedings of IRMA 2003 International Conference, Information Technology and Organizations: Trends, Issues, Challenges, and Solutions*, , pp. 51-54. Hershey (PA): Idea Group Publishing.

CDF (Committee of the Deutsche Forschungsgemeinschaft) (2001). *Neue Konzepte der Handschriftenerschliessung. Informationsysteme zur Erforschung des Mittelalters und der Frühen Neuzeit.* Available on line on Se 28, 2006, at http://www.dfg.de/foerder/biblio/download/handschriften.pdf.

Cohen, E. (1999). Reconceptualizing Information Systems as a Field of The Transdiscipline Informing Science: From Ugly Ducking to Swan. *Journal of Computing and Information Technology*. 7 (3), 213-219

Overgaauw, E. A. (2001). Neue Konzepte der Hanschriftenerschliessung in Deutschland. *Gazette du livre médiéval*, 38, pp. 49-54.

Towards Early Consideration of Non-Functional Requirements at the Business Process Level

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ABSTRACT

Non-functional (or quality) requirements are one of the key issues that need to be addressed during the development of any software system. Experience has shown that as the alignment of business processes and the supporting information systems become increasingly close and robust, early consideration of non-functional aspects is needed to considerably reduce subsequent rework. In this paper, we present a method based on quality models and related checklists for integrated treatment of non-functional requirements in a measurable and testable way at the business process level. The benefit of such an early quality consideration consists of closer and more robust alignment between business processes and supporting information systems by providing early conflict solution, easier design derivation, and continuous traceability up to the strategic goals. This will lead to less rework effort during development or maintenance and thus to more flexible business support.

1. INTRODUCTION

In today's enterprises, business strategy, business processes, and business information systems are closely intertwined and are typically not considered separately any more [Allw05] (see also Figure 1). While business processes support the achievement of the underlying strategy, information systems support or even enable successful implementation of these processes. The mapping between business processes and information systems supporting these processes should thus be as close as possible [EmMa95] and as robust as possible [SmFi03] to allow rapid adaptation to any change, especially to organizational changes. Therefore, business processes have become an important source for requirements in information systems (here we use "information systems" in a very broad sense, ranging from one-function services to complex workflow implementations), independently of how the information system is implemented.

Nevertheless, present approaches used in industry typically address only the alignment of business processes and functional (system) requirements, while often neglecting non-functional aspects. Only few companies such as, e.g., [YYOI05] are going to annotate business processes with quality requirements.

In the majority of cases, however, even if non-functional (or quality) requirements (called NFRs) were identified as crucial with regard to the success of a product or project [CNYM99] [DKK+05], they are considered for the first time when the development of the supporting information systems starts – if at all. The Fraunhofer IESE NFR approach [KDP+05] is an example of such a system-targeted NFR elicitation method (see Figure 1).

However, especially for modern implementation strategies, the earliest possible consideration of non-functional requirements is needed to support some important decisions. In the Model Driven Architecture [OMG06], for instance, business processes are considered as parts of the computer independent models (which describe in an abstract manner *what* the system should support) and are used to derive platform (in)dependent models that describe *how* to build the system in a technology (in)dependent manner. Neglecting efficiency requirements in these models, for instance, may cause costly rework because these requirements typically have a great influence on the system architecture.

By contrast, the vision of Business Process Management Systems aims at executing business process descriptions without any additional development effort [SmFi03]. Instead of developing software to support the processes from scratch, an execution engine should be able to perform the processes (as workflows), integrating existing functionality based on service-oriented platforms. In this sophisticated vision, which – of course – still requires that many challenges are solved, business processes will be the only specification a system has to fulfill. This makes an upfront handling of NFRs during process modeling in a measurable and testable manner indispensable. Otherwise, services could only be selected based on their functionality, which might not be sufficient for achieving the intended business process support.

With our currently still evolving method presented in this paper, we thus intend to specify NFRs in a measurable form already at the business process level. We consider NFRs at this level as any required quality of the elements involved in a process needed to assure the process goals achievement. In this context, the often mentioned measurability is crucial, as NFRs such as "The function should be efficient" leave the developers to image what "efficient" might be. This, in turn bears the risk of failing the business goals, even if "efficiency" is explicitly considered as an important requirement.

While the motivation above has shown that NFRs are also needed on the level of business processes, the question of which quality aspects are important at this level and how they influence each other remains. Furthermore, the assurance of their measurability is also an open issue. The key concepts of our method presented in this paper therefore primarily focus on these questions.

As benefits of our approach, we expect from the business point of view:

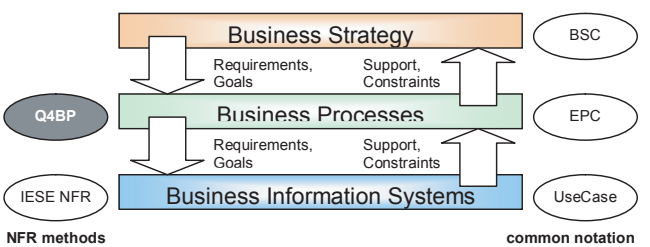
- being able to check whether the strategic goals can be successfully operationalized with the available resources
- less costly rework due to early requirements conflict resolution
- business processes that also fit best to quality needs.

From the IT perspective, we furthermore expect:

- closer alignment due to clearer dependencies on system requirements
- better traceability up to the strategic goals by bridging the gap between these goals and system qualities using NFRs on the business process level.

The remainder of this paper is structured as follows. In section 2 we present some related work. Section 3 briefly explains the basic concepts of our method, while

Figure 1. Requirements on different business levels



its application process is described in section 4. The paper closes with a summary and outlook in section 5.

2. RELATED WORK

Figure 1 depicts, according to [Oest95], how the three business levels (strategy, processes, and information systems) influence each other. Furthermore, common methods and notations are shown (to the left and to the right). Based on the business strategy goals that can be exemplarily specified using the Balanced Scorecard (BSC) [KaNo92], appropriate business processes, which could be specified with Event Driven Process Chains (EPC) [KeNS92], for instance, are derived. These processes are then used themselves to derive requirements for the supporting information systems, e.g., in terms of UseCases.

Publications such as [SmFi03] have identified this alignment of business processes and information systems as a key research aspect, referring to the vision statement that "business processes should be directly and immediately executable – no software development is needed". This emphasizes and underpins the notion of integrating additional requirements, especially quality issues.

Regarding the close and robust alignment of business processes and information systems, key research has already been done [RoSE04] [EtRo05]. All these publications however, solely address and cover the functional aspects, or cover the non-functional aspects in a very generic and not measurable manner [SoWa05], denoting them as soft-goals or organizational goals. Approaches for goal modeling (see [Lams04]) are important to support the expression of quality goals on the strategy level. These quality goals can then serve as a basis or rationale for expressing NFRs on the business process level and, finally, on the information system level. Therefore, the systematic derivation and analysis of NFRs on the business process level with regard to the strategic goals will be important work to be done. However, this is beyond the scope of this paper.

Methodologies addressing system NFRs and change guidance are available [ChNY96], [DKK+05], but do not specifically address the business process level and thus lack the potential support.

A consideration of business process qualities is part of process performance management [WWDV06] [BuGe04]. Performance management defines business relevant indicators, checks if the performed processes really fulfill them, and helps to identify room for improvement. While these indicators are requirements for the processes derived from the strategy (e.g., time and costs), requirements for the resources that are involved in the process execution (e.g., security or capacity constraints for systems, data or employees) are still missing. However, the resources need such requirements in order to be able to provide the required quality.

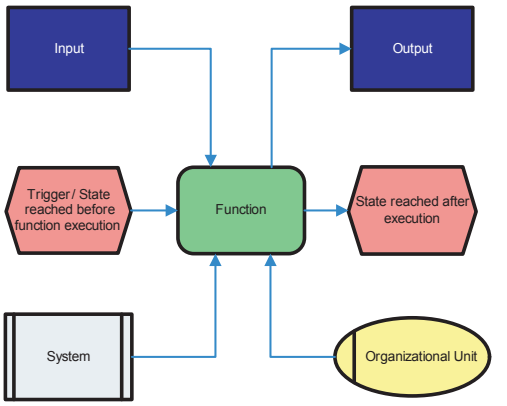
One of the key related research approaches regarding systematic NFR elicitation (the Fraunhofer IESE NFR Method) has been described in numerous publications, as for instance [DKK+05] [KDP+05] [DKKP03] [KeKD03]. By default, this work addresses only NFRs on the system level and is thus not directly applicable to the business process level, where other qualities might be important. Even if some qualities are overlapping on both levels, they are not identical or may even be completely inadequate (e.g., maintainability). However, parts of this work, such as the usage of quality models, checklist-based elicitation, and striving for measurable requirements, are the key fundament on which we have developed our methodology.

3. CONCEPTS OF NON-FUNCTIONAL REQUIREMENTS AT THE BUSINESS PROCESS LEVEL

In this chapter, we present a methodology called Quality Requirements for Business Processes "Q4BP" to address NFRs in a measurable and integrated manner already at the business process level. The goal from the IT perspective is to facilitate easier derivation of information systems from business process models. The goal from the business perspective is to build processes that address the strategic goals in a more suitable manner.

In order to keep our explanations simple, we here focus on enhancements of the notation of EPC. The reasons are that EPCs are widely used in industry and are easy to understand both for IT experts and for business experts. Furthermore, EPCs include all relevant concepts for business process modeling [Allw05] and are thus an appropriate notation for showing the possibilities of our approach. As our approach is intended to work with every business process notation, our future work will address other notations, especially those that are directly executable.

Figure 2. Main elements of EPC



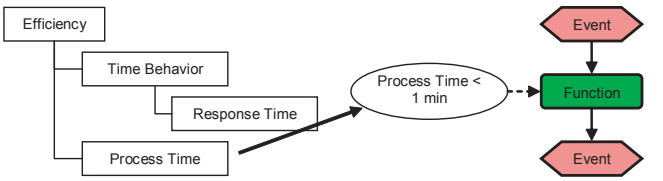
An (extended) EPC typically depicts (see Figure 2) in which order business functions are performed, which states exist before and after each function execution, which organizational units are responsible for a function execution, which information system is used, and which inputs and outputs (in terms of material or data) are handled. EPCs allow specifying business processes on different levels of abstraction and systematically refining them. Furthermore, business rules can be attached. However, this does not refer to NFRs, as business rules are a kind of functional requirement in terms such as "If invoice amount is greater than 1000 $, allow a discount of 10%".

However, in the same manner, our method recommends enriching the process model elements with suitable NFRs derived from an overall quality model for business processes (which is still evolving). This quality model consists of many quality attributes concerning process elements (function, system, data, organization, etc.) that are hierarchically organized. On the top level, the most important attributes are efficiency, reliability, security, usability, and manageability (a subset from ISO 9126 [ISO03] that is modified according to its suitability to business processes). When assigning a value to a quality attribute associated metric, it becomes an NFR. In Figure 3, an excerpt from the quality model (on the left hand side) and an exemplary assignment to a business process element (on the right hand side) are shown.

In order to address the goal of eliciting measurable and testable NFRs, we refined the quality attributes (according to GQM [BaCR94]) in the same manner as the Fraunhofer IESE NFR Method, until a measurable level was reached.

Besides the hierarchical organization, the quality attributes within the model are classified according to the business process elements where attaching them makes sense (see table in Figure 3). Here, "Process time" is considered as a relevant attribute for "Process" and "Function", but not for other process elements. In

Figure 3. Excerpt from the quality model and exemplary usage



	Process	Function	System	Organization	Data or Material
Process time	X	X			
Response time			X		

contrast, "Response time" is only of interest for the "System" that supports the function. Of course, there exist dependencies between quality attributes on the business process level and on the information system level. These dependencies are also handled in our approach (see section 4). Nevertheless, the major part of the requirements for the information system level should not be attached to business processes at this stage but later when development starts. The reason is that we do not want to harm the business orientation by adding too much implementation relevant information. In general, only qualities regarding the process execution and the involved resources are of interest, while internal system qualities such as maintainability are neglected.

The identification of all important quality attributes for business processes is still a part of our current research. Until then, the relevant issues for a specific project have to be gathered using the method described in section 4.

4. APPLYING THE Q4BP METHOD

The procedure for applying our method is a specialization of the Fraunhofer IESE NFR method mentioned in the related work section. It is based on a set of experience-based artifacts, which are tailored to project-specific ones. Figure 4 depicts the main steps and artifacts when applying the method.

In a first step, for each business process modeling project, our reference quality model, which is a structured set of all possible quality attributes for business processes is taken and tailored (including extensions) to the specific needs of the project. This tailoring includes a discussion about the quality attributes that are relevant for the business processes and how these attributes are hierarchically organized or dependent. The tailoring stops when a metric for each attribute can be defined (e.g., minutes for "Process Time"). If quality attributes were found during the tailoring that do not exist in the current experience-based reference quality model, they are added after the tailoring to the experience-based model, too.

The quality model developed is then used to derive checklists that guide the systematic elicitation and specification of measurable NFRs for the business processes. For each high-level quality attribute, all related measurable attributes from a lower level are listed and mapped to the process elements they should be attached to. A section within the checklist might then be, for instance, "Efficiency of functions: Define for each function how long it should take (process time)."

Elicitation and specification require the business process models and enrich them with all non-functional aspects needed to achieve the intended business goals. So far, this procedure is quite similar to the proven Fraunhofer IESE NFR Method.

However, we strive for an easier-to-use method that does not need to be tailored every time it is applied. We assume that the tailoring and the improvement cycle are only needed as long as our reference quality model does not contain all relevant quality attributes concerning business processes. Because of the limited space available to issues described in a business process model, we expect our model to be almost complete one day, so that no individual tailoring will be necessary any more. Then, the reference checklists can be used directly to elicit the NFRs for business processes. Until then, we consider this methodology as a research support to finding all relevant attributes and their dependencies.

One important issue when eliciting requirements is the early detection and resolution of conflicts. As requirements conflicts often lead to change rework during system development, it makes sense to handle them during an earlier phase, in particular on the business process level. Problems can thus be solved business-like and not with regard to technical decisions.

Avoiding conflicts requires the consideration of each possible requirement dependency. Besides trivial dependencies between efficiency requirements, which are already handled in some current performance management approaches [BuGe04], other quality attributes may also affect each other. The reference checklists that contain clues about such dependencies and their underlying quality models are thus a helpful tool to avoid specifying processes that will not work as intended.

In this paper, we distinguish two types of conflicts: conflicts due to vertical and conflicts due to horizontal dependencies. The first type of conflict might occur when (sub-)processes are further refined and an NFR of the upper element conflicts with (the sum of) the lower ones. An example from the "efficiency" area is when the sub-functions including waiting time take more time than the upper process is allowed to take. In this case, either the process has to be performed in another way, reorganizing the sub-functions, or the requirements for the upper process have to be specified less restrictively. At this point, it becomes obvious that non-functional and functional requirements (also in business processes) influence each other. That is why our approach aims at the integrated handling of NFRs within business processes.

The second type of conflict arises from the relationships between different requirements, e.g., between efficiency and security issues: Encryption typically affects the response time of a system, whereas authentification affects the time needed to perform a function that is limited to authorized access. Considering this at the business process level might, for instance, lead to a process where authentification is realized once at its beginning using the system support of single-sign-on.

Besides the dependencies between different kinds of quality attributes attached to one process (element), there might also be relationships between requirements attached to different elements. Figure 5 shows, for instance, that requirements concerning data privacy may influence access control for functions, or the personality traits of the assigned employees. In the other direction, constraints regarding personnel or technical capacities might also influence functions and processes, e.g., inexperienced personnel might have higher requirements regarding the time needed to perform a function.

When business processes are enriched with conflictless NFRs, a helpful starting point for system development is given. The NFRs related to "System" elements are precise enough to adopt them directly during system development. As "Organizational units", "Functions", and "Data/Material" elements also influence the "System", the requirements attached to them also have to be considered for the information system to be developed. Here, we will establish in future work clear dependencies that allow translating them into requirements of the information system level. For instance, the privacy requirement from Figure 5 could lead to a system level requirement describing where the employee data have to be stored and how they should be encrypted.

The method presented in this paper was applied in a large information system company that uses business processes as a substantial element for their requirements specifications. First, we tailored models for efficiency and reliability by brainstorming which related attributes are important in business environments and how they could be measured. We found out that some attributes were very technical and thus appropriate for the information system, while others concerned the underlying processes.

Based on the developed models, we derived checklists by defining elicitation instructions that clearly depicted to which process element an NFR should be attached, how it should be measured, and which conflicts have to be checked and

Figure 4. Applying the Q4BP method

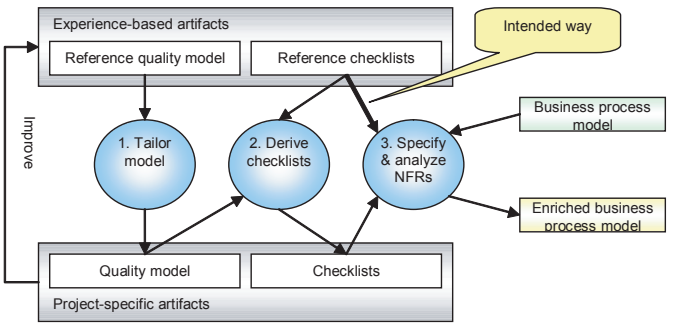
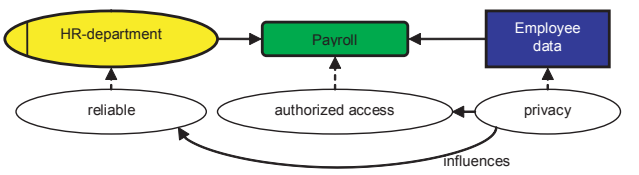


Figure 5. Dependencies between requirements attached to process elements



resolved if necessary. This checklist was then finally used to elicit concrete NFRs for an exemplary business process description. As the elicitation itself required little effort, we expect our method to be a suitable instrument for assuring the required process quality right from the beginning of any information system project.

5. SUMMARY AND OUTLOOK

In summary, our method explicitly addresses the problems of neglecting NFRs in business process and information system alignment as well as those of eliciting imprecise NFRs (e.g., "The process should be efficient"). Furthermore, conflicts between requirements that might lead to unintended process results can be identified and solved early in a business-like and not in a system-oriented manner.

From a business point of view, we see further benefits in being able to check whether or not the strategic goals will be successfully operationalized with the available resources. From an IT perspective, requirements or even design decisions for the system to be built can be derived more easily. The quality requirements defined on the business process level also allow selecting suitable software solutions by better comparing competitors (or their services). Finally, the hierarchical refinement of business processes and the attached NFRs facilitate the assurance that the overall process requirements are guaranteed even if each function is implemented by another system.

As one of our first future work projects, we will extend our method to other business process notations, especially to those that are executable. In this context we strive to build a business process meta model enriched with the relevant quality attributes.

Another important research topic is the identification of dependencies up to strategy goals and down to real information system requirements in order to provide continuous traceability and effective conflict resolution.

In parallel, our general method, the underlying quality model, and the related checklists have to be continuously evaluated and improved. Therefore, we will use our method in industry projects and academic case studies.

With regard to the vision of executable business processes in which "no software development is needed" [SmFi03], NFRs should be paid special attention. To support this vision, we strive to analyze how the identified business process quality requirements can be integrated, automatically assured, and evaluated in a formal and readable notation (such as BPEL [Juri04]).

6. REFERENCES

[Allw05] T. Allweyer: Geschäftsprozessmanagement – Strategie, Entwurf, Implementierung, Controlling. W3L-Verlag, Herdecke, Germany. 2005

[BaCR94] V. Basili, C. Caldiera, D. Rombach: Goal Question Metric Paradigmn. In: Encyclopedia of Software Engineering, Volume 1. John Wiley & Sons, 1994, pp. 582-532

[BuGe04] F. Buytendijk, L. Geishecker: Corporate Performance Management: Connecting the Dots. Garnter Inc., Stamford 2004

[ChNY96] L. Chung, B.A. Nixon, E. Yu: "Dealing with change: An approach using non-functional requirements", Requirements Engineering, Springer, London, 1996, 1 (4), pp. 238-260

[CNYM99] L. Chung, B.A. Nixon, E. You, J. Mylopoulos: Non Functional Requirements in Software Engineering, Kluwer Academic Publishers, Boston, 1999

[DKK+05] J. Doerr, D. Kerkow, T. Koenig, T. Olsson, T. Suzuki: "Non-Functional Requirements in Industry – Three Case Studies Adopting an Experience-based NFR Method", 13th IEEE International Conference on Requirements Engineering (RE 2005), pp. 373-384

[DKKP03] J. Doerr, D. Kerkow, A. von Knethen, B. Paech: „Eliciting Effiency Requirements with Use Cases", 9th International Workshop on Requirements Engineering, Foundation for Software Quality, Klagenfurt/Velden, 2003, pp. 23-32

[EmMa95] K. El Emam, N.H. Madhavji: "Measuring the success of requirements engineering processes", Proceedings of the Second IEEE International Symposium on Requirement Engineering, IEEE Computer Society, Washington, 1995, pp. 204-211

[EtRo05] A. Etien, C. Rolland: "Measuring the fitness relationship", Requirements Engineering, Springer, London, 2005, 10 (3), pp. 184-197

[ISO03] ISO/IEC 9126-x:2003(E) : Software Engineering - Product Quality

[Juri04] M. B. Juric: Business process Execution Language from Web Services. Packt Publishing, Birmingham, 2004

[KaNo92] R.S. Kaplan, D.P. Norton: The Balanced Scorecard Measures That Drive Performance. In: Harvard Business Review 1992, pp. 72-79

[KDP+05] D. Kerkow, J. Doerr, B. Paech, T. Olsson, T. Koenig: "Elicitation and Documentation of Non-Functional Requirements for Sociotechnical Systems", in: Requirements Engineering for Sociotechical Systems, J. Mate and A. Silva, Information Science Publishing, Hershey, 2005, pp. 284-302

[KeKD03] D. Kerkow, K. Kohler, J. Doerr: „Usability and Other Quality Aspects Derived from Use Cases", in: Proceedings of forUSE 2003, International Conference on Usage-Centered Design, Ampersand Press, Rowley, 2003, pp. 135-154

[KeNS92] G. Keller, M. Nüttgens, A.W. Scheer: Semantische Prozessmodellierung auf der Grundlage Ereignisgesteuerter Prozessketten (EPK). In: Veröffentlichungen des Instituts für Wirtschaftsinformation, Saarbrücken, 1992, pp. 89 (in german)

[Lams04] A. van Lamsweerde: "Goal-Oriented Requirements Engineering: A Roundtrip from Research to Practice", in: Proceedings of the 12th IEEE International Requirements Engineering Conference, IEEE Computer Society, Washington, 2004, pp. 4-7

[Oest95] H. Österle: Business Engineering, Prozess- und Systementwicklung. Springer, Berlin, 1995

[OMG06] Object Management Group: The Model Driven Architecture. http://www.omg.org/mda

[RoSE04] C. Rolland, C. Salinesi, A. Etien: "Eliciting gaps in requirements change", Requirements Engineering, Springer, London, 2004, 9 (1), pp. 1-15

[SmFi03] H. Smith, P. Fingar: Business process management – The Third Wave, Meghan Kiffer Press, Tampa, 2003

[SoWa05] P. Soffer, Y. Wand: "On the notion of soft-goals in business process modeling", Business Process Management Journal, Vol 11 No 6, 2005

[WWDV06] P. Willaert, J. Willems, D. Deschoolmeester, S. Viane: Process Performance Measurement: Identifying KPI's that link process performance to company strategy. In: International Resources Management Association (IRMA) Conference 2006

[YYOI05] R. Yamamoto, K. Yamamoto, K. Ohashi, J. Inomata: Development of a Business Process Modeling Methodology and a Tool for Sharing Business Processes. In: Proceedings of the 12th Asia-Pacific Software Engineering Conference, IEEE, 2005

Presenting Technical Drawings on Mobile Handhelds

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ABSTRACT

Due to the spread of mobile handheld devices, new application fields like technical maintenance and mechanical inspections open up to their use. Yet, to fully benefit from their modern technical capabilities, standard interaction techniques need to be revised and new ways of accessing the abundance of technical documentation on the handheld need to be conceived. However, the display of technical illustrations on its tiny screen is still a difficult task. In this paper, we discuss an approach specifically conceived for technical drawings that aims at overcoming this difficulty. To underline its practicability, we also present our software prototype that incorporates this approach by utilizing the technical potentials of the standardized vector graphics format SVG.

INTRODUCTION

A meaningful and comprehensive technical documentation is essential for error-free, smooth operations in many industrial applications. It contains all relevant technical information on a product and is the basis for communication between different branches like design, production, assembly and maintenance, for example during the process of building complex machinery. Aside from part lists, procedures and manuals, the major part of technical documentations comprises drawings and schematics.

Technical drawings fall into one of several categories depending on their intended usage. The main distinction is between production drawings and assembly drawings. The former is used during design and production, whereas the latter is used in assembling and maintenance work. Therefore, production drawings generally focus on single component details like dimensions and surface finish, while assembly drawings depict dependencies between parts and subassemblies like relative position and attachment points. Unlike artist conceptions, technical drawings are subject to defined rules and norms regarding e.g. symbols, perspective, and line styles [ISO02].

Today, paper drawings have become all but extinct. Widespread use of Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM) methods mean more and more drawings are available and are used throughout all stages of the production process in electronic form. This has the added benefit that illustrations for specific purposes can be derived from a single parent drawing. In this paper, we specifically focus on illustrations required for maintenance work. Servicing machinery in fixed installations, e.g. in power plants, is necessarily performed on-site, thus the service technician needs to bring the required documentation with him. Consequently, the bulk and weight of (potentially multi-part) printed manuals is rather undesirable.

Because of this, combined with the fact that mobile devices like PDA handhelds are becoming more and more common, there exist several projects that seek to utilize these devices as portable "e-handbooks" or even augmented reality (AR) applications, both for assembly [ART06] and maintenance [NPF+04, FR+06] tasks. One assumption for this paper, however, is the use of commonplace mobile devices instead of special viewing hardware or smart environments required for AR approaches. In practice, this constraint might often be based on availability and cost considerations. This inevitably leads to all the problems and technical limitations that such devices struggle with. We found that most comparable approaches concentrate on a single specific aspect, like pipe flow visualization [NPF+04], rather than addressing these in principle.

Therefore in the next section, these principal challenges of are briefly rehashed. In the two sections following thereafter, we present basic concepts that can be used to present technical drawings efficiently on small devices. These sections discuss concepts and techniques for presenting assembly drawings and circuit schematics, respectively, as typically used during maintenance tasks. In the last section we give some concluding remarks.

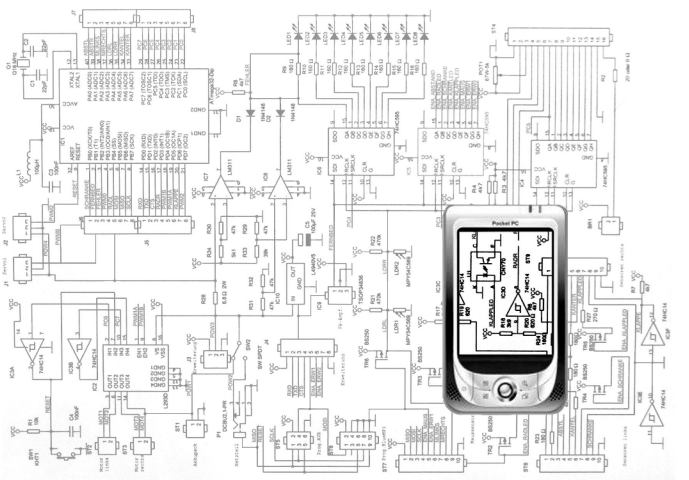
PROBLEM ANALYSIS

The constriction on run-of-the-mill mobile devices like PDA has some important ramifications. Aside from data security issues, limitations in storage and processing capability mean it is generally not feasible to employ a CAD-Viewer on the device, i.e. use CAD data directly. Therefore, some set of views suitable for a given task at hand must be pre-selected and converted into static illustrations. Even more importantly, due to the small size of typical handhelds, the available screen space is also very limited. The challenge in integrating even static technical illustrations in such an environment becomes apparent when the resolution of a typical PDA is contrasted to the resolution of a medium-sized circuit schematic:

The straightforward solution to the above challenge, scaling the illustration down to the size of the PDA screen, leads to unacceptable results. There would be indiscernible tiny or cluttered details, possibly further distorted by scaling artefacts. Therefore, the adaptation must consider the semantics of the technical drawing in order to select a subset of information to be displayed. This provided, there are basically two ways to solve the screen space problem:

- The display can be limited to show only a certain part of the entire technical drawing that fits the PDA screen, thus sacrificing the completeness of

Figure 1. Comparison of the screen resolution of a typical PDA (320x240 pixels) to the resolution of a medium-sized circuit schematic (1742x1275 pixels)



the representation but preserving its detailed depiction. The degree of this limitation can easily be chosen from several levels of segmentation that are appropriate for technical drawings -- like "Complete", "Functional Modules", "Sub-Modules" and "Individual Parts".
- A number of individual objects can be merged into new "compound objects" that take up less screen space, thus sacrificing the in-depth-depiction of all objects but preserving the completeness of the overall structure. This approach can also easily be graded into several levels of detail.

In combination, it is possible to gain results that are optimized with respect to both, completeness and depth, according to the demands of the task at hand that the user needs to carry out upon the drawing.

There are two principal choices for the graphics format used in these approaches: raster images (bitmaps), or vector graphics. The advantage in using bitmaps is that there are numerous established formats and out-of-the-box viewing software available. However, bitmaps have no notion whatsoever about the structure of the depicted content if they are not annotated with external metadata [FR+06]. They also suffer heavily from scaling artifacts, e.g. when originally thin lines are scaled down to sub-pixel width and are thus vanishing.

Vector graphics like the predominant SVG[1] standard, on the other hand, build on graphical primitives like rectangles and circles, and group these to form more complex shapes. Therefore vector formats do exhibit some inherent notion of structure that can be utilized in different levels of segmentation. Moreover, vector graphics are defined by means of geometric coordinates independent of pixel sizes and thus can be arbitrarily scaled without loss of quality. These advantages make vector graphics a much better choice as the basis for technical illustrations. As a matter of fact, many CAD packages provide an option to export selected views as SVG files.

In the following two sections we will discuss ways to use both approaches outlined above efficiently and using SVG drawings, for two typical use cases.

CONCEPTS FOR PRESENTING ASSEMBLY DRAWINGS

A maintenance technician typically needs assembly drawings at the work site to determine the best sequence of dismantling machinery in question, to locate parts that must accessed or attachment bolts of those to be removed, and detail information on components disassembled for repair. Finally, the technician needs to discern the correct alignment of components upon reassembly. Therefore, the visual representations by a mobile "e-manual" need to address all these different aspects.

Technical drawings for a given unit comprise a hierarchy of single component drawings, subassembly drawings and the general drawing. These drawing types already implement three levels of segmentation as postulated in the previous section. The general drawing will depict a complete overview of the entire machinery (likely with some simplifications), whereas subassembly and component drawings will sacrifice the completeness for subsequently more details locally.

However, these drawings may still require adaptation to fit small PDA screens, and to communicate certain aspects of the task at hand more efficiently. The visibility and perceptibility of relevant objects is essential for intent-based visualizations [SF91]. This is especially an issue when typical step-by-step, automatically generated assembly instructions [AP+03, HP+04] are created from a single (or few) available input images. It must therefore be possible to modify an existing base illustration to:

- Accentuate important parts/components in the illustration, or in reverse, subduing the component's context.
- Hide from the drawing parts irrelevant in the current context, or that occlude relevant geometry. This is especially important since the viewpoint cannot be changed in 2D graphics to resolve occlusions.
- Show details within their context. Very small parts like fastening screws are only drawn in conjunction with larger components, but may become indiscernible small if drawn to scale, especially when considering typical PDA screen diagonals. These parts should be displayed in an enlarged detail view.
- Explode the view to show the relative position and alignment of several parts with respect to each other. Explosion views are also used to show the direction in which parts must be pulled off/put back during assembly [AP+03]. This may require the addition of subsidiary lines for clarity.
- Label the illustration, e.g. for cross-referencing the illustration with additional information, e.g. part lists, or to link labeled view elements with additional audio outputs [FR+06].

In the following paragraphs, concepts to realize the above bullets using SVG are discussed. These concepts have been implemented in a software prototype deployable on Windows Mobile-based PDA.

The SVG format allows to hierarchically group vector primitives with the <g>…</g> tag, to assign a group common display attributes (color, line width etc.), and to assign a reference id to enable reuse of the defined geometry [Jac03]. It also allows embedding content from other SVG files into a composed drawing. Usually, grouping occurs according to graphical criteria, e.g. all background gradients or all lines with the same style. However, this ordering is not mandatory.

Instead, we propose a new concept where the groups are defined according to semantic criteria. First, all vector primitives constituting specific components are grouped together. Since groups can contain subgroups, the logical structure of machinery (single parts grouped into subassemblies grouped into main assemblies) can be reflected in the structure of the SVG file. It is also possible to define several graphical levels of detail for individual components in the same way. Any SVG file, e.g. from a CAD export, can be re-sorted using authoring tool developed for this purpose (Figure 2 (a)). Using these prepared SVG files as input to the "e-manual" application on a PDA, the above features can be supported efficiently.

Accentuation of single components is done by modifying their rendering attributes, e.g. through fill color, line thickness, or explicitly drawing the (usually invisible) bounding box in case of small objects (Figure 2 (b)). Technically, the SVG vector primitives associated with the component group have their corresponding attributes modified before they are passed on to the render engine. Thus, our concept keeps rendering of the content independent of the semantics required to identify the accentuated elements. Our software uses a task model to define the necessary semantics and to control the parameterization of the renderer [FR+06].

Information hiding can be achieved in a variety of ways. If a component should be removed from the illustration in its entirety, its associated geometry simply is not passed to the renderer at all (Figure 2 (b)). Another approach is to render the component geometry first, before all other components. Since SVG renderer by definition overwrite already drawn elements with later ones, this results the hidden component being pushed into the background. Like accentuation, the required semantics for both approaches are defined in the task model.

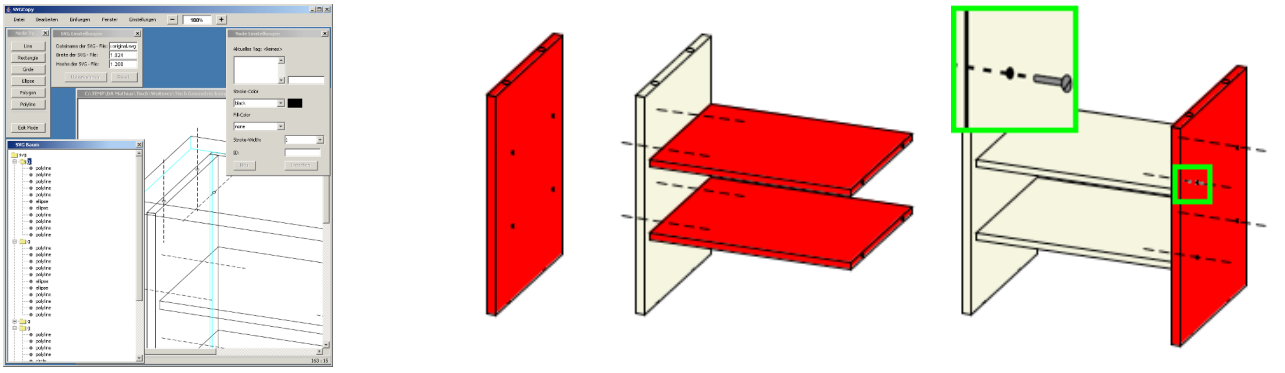
Information hiding can also be used as interactive tool [BS+94]. We implemented an "X-Ray lens" that modifies the representation to a wire-frame rendition within the lens area. It is a powerful new concept that allows a user to interactively examine regions of an illustration, revealing geometry otherwise hidden in the default view (Figure 3(a)). It is also usable on any SVG file even if no semantics from a task model are available. Technically, a temporal copy of all primitives within the lens area is created with the fill color attribute removed from the render attribute list. Note that if a primitive is only partially covered by the lens, it is split into two or more temporal primitives as needed to confine the modification to the lens area. The modified primitives are then substituted for the original ones when passed to the renderer.

Detail-in-overview displays can be implemented using SVG's viewport mechanism [Jac03]. For this, a rectangular region is defined around the part of interest. A viewport with appropriate scaling is defined and positioned on the display area. Then, all geometry within the defined region of interest is rendered into the viewport. The necessary scaling and clipping is done automatically by the SVG renderer (Figure 2 (b), right).

Explosion views can be created by displacing adjacent components so that these do no longer overlap. An automatic approach proposed in [AP+03] determines the displacement direction that affords the least distance by evaluating the bounding boxes of all affected components. However, to allow more complex displacements, in our prototype displacement vectors and subsidiary lines are defined explicitly. This information is stored to the SVG file using the XML namespace mechanism, enabling standard SVG agents to ignore it and still display the unexploded view correctly. Our prototype, on the other hand, uses an extension-aware SVG agent that decodes this information. Figure 3 (b) shows an example of an assembly instruction encoded as a single explosion view.

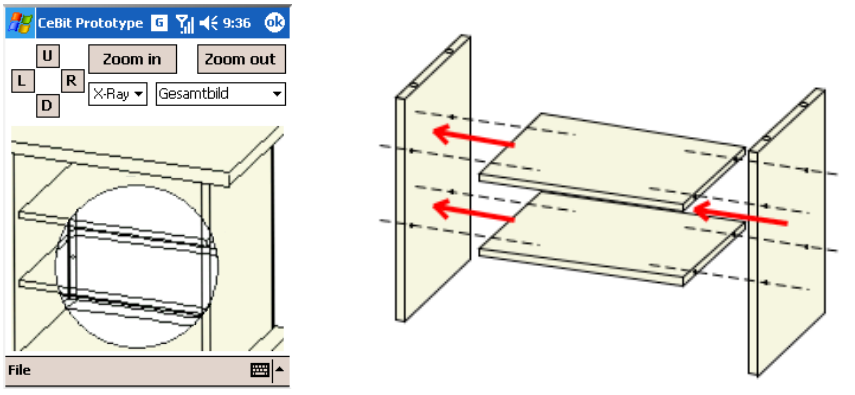
Labeling is an important aspect of technical illustrations [Tuf97], although the labeling problem has proven to be NP-complete [MS97]. Labeling in our pro-

Figure 2. Authoring tool for editing SVG group/symbol tag structures of input files (a), example for a step-by-step assembly instruction generated from a single input image using accentuation, information hiding, and detail-in-overview (b).



a *b*

Figure 3. Screenshot of the "X-Ray lens" used to reveal hidden geometry (a), generated explosion view with additional geometry (subsidiary lines) shown (b).



a *b*

totype is therefore either static, i.e. done by the content author or, if a WLAN connection is available, using a labeling service as described in [FL+06]. In both cases, textual labels are directly supported by SVG, so no extension of the renderer is needed.

CONCEPTS FOR PRESENTING STRUCTURES

In contrast to assembly drawings, structure representations like piping diagrams or technical process flows usually focus upon displaying the functional dependencies between different parts or modules. While the individual parts themselves can be represented by one of the techniques described in the above section, the depiction of their relationship to one another adds to the difficulty of bringing such structure representations to the limited screen of a handheld device. Approaches to overcome (or at least lessen) this problem, can again be derived from the two principal strategies –segmenting the structure or decreasing their depth. This section discusses these approaches specifically for circuit schematics in the context of electrical engineering, but the underlying principles can easily be adapted for structures from other technical fields as well.

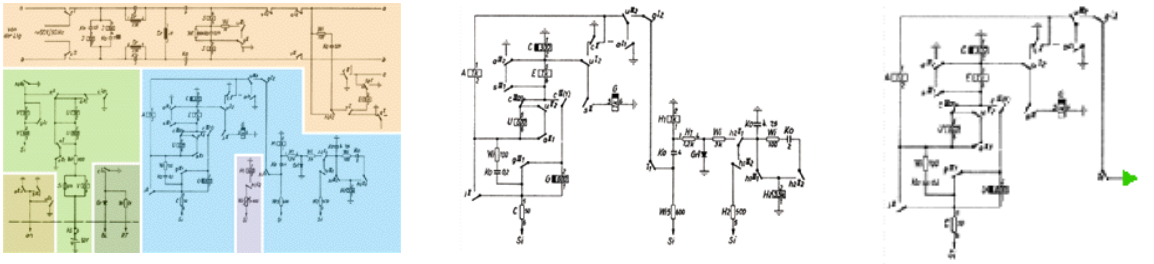
Segmentation can at first be used to partition the circuit schematic into its disjoint parts. These can be extracted and then displayed independently (see Figure 4 (a) and (b)) or combined into a new schematic as needed. This allows to reduce the content of the illustration to only those segments that are ultimately required for the task at hand. When there are no disjoint parts or further simplification of an extracted segment is needed, a folding method can be employed that hides additional subsections of the circuit drawing (exemplified in Figure 4 (b) and (c)).

Depth reduction uses on the other hand means of abstracting certain parts of a complex schematic. This is usually done by repeatedly combining several low-level parts into one high-level "compound part" that represents the merged elements as a functional block. This is common practice in electrical engineering where functional groups of parts are integrated into a single IC or circuit board to ease its repair and its interchangeability with updated, newer hardware.

Both of the presented methods suit the typical tasks that an electrical engineer needs to carry out upon a schematic very well. Thus, the aggregation of "low-level" components to reduce the depth of the schematic serves well in an overview that shows the main structure of the entire circuit. And segmentation and folding of the circuit are good ways to focus upon a certain section of the schematic. This is very helpful when measuring sections need to be identified or functional modules and individual parts must be located.

While the above ideas for reducing the visual complexity of circuit diagrams seem quite elementary and uncomplicated at first, their technical implementation is not. Especially the automated segmentation and abstraction of a schematic representation pose algorithmically complex tasks. Their realization is based upon a semantic annotation of the SVG geometry that basically models the topology of the described circuit. Unfortunately, our graphics format of choice – SVG – is only of limited use for their implementation. Since a standard SVG-file [Jac03] does not hold any information about the topology of the structure it contains, e.g. which geometric primitives are connected with each other by which (poly-)lines, an automatic processing of the above methods would be impossible. Yet, there have been first attempts to provide SVG with additional topological features that allow to exactly grasp the notion of geometric structures that are connected to one

Figure 4. A circuit schematic that is segmented into its disjoint sections (a), an already larger view of the light blue section only (b) and the even larger depiction of the same light blue section with one hidden part at the green arrow head (c).



a *b* *c*

another [TMM00, KMS04]. While these non-standard extensions will be simply ignored by a standard SVG-viewer, a customized SVG-viewer can take advantage of the additional topology information in the SVG-files and use it for the automatic deduction of possible folding points or unconnected circuits. Furthermore, the topology information also permits to run a final compaction step, for example to further compress the image or to adjust the image to a certain aspect ratio of the screen. Since the compaction of a given two-dimensional layout is NP-complete [SP82], heuristics or approximation algorithms may need to be employed to run the compaction in acceptable time [SL89, Wol84].

If, for certain reasons, one must not extend the SVG standard, an authoring tool can be used to manually annotate the schematic in SVG format with the needed information. Both, the segmentation into its connected parts or the selection of meaningful folding points, can be modeled directly in SVG via the <g>…</g> tag described in the previous section. Since the other parts of the proposed electronic handbook besides the circuit schematics need to be authored too (written text, photographs, video-tutorials, etc.), such an authoring tool for annotating circuit schematics can easily be plugged into the existing workflow and its toolset. While this requires an additional amount of effort on the side of the content provider, it guarantees the compatibility to all standard SVG-viewers. An example for both, our authoring tool and our client software using a standard SVG-viewing component can be seen in Figure 5.

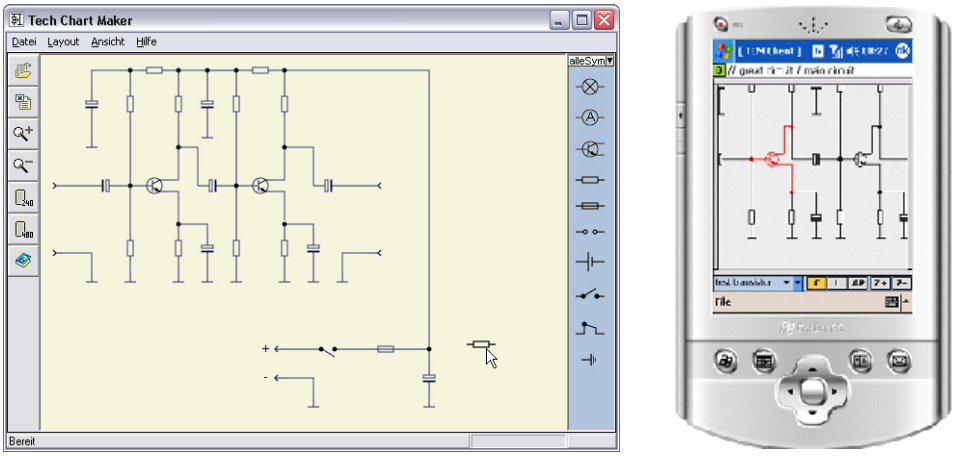
Independently of the way in which such a screen-optimized circuit schematic is generated (manually with an authoring tool or automatically from a topology description), the above presented methods usually behave quite well for ordinary schematics. Yet, one has to bear in mind that if one tries to handle extremely large and highly connected circuit diagrams, a suitable reduction of its visual complexity might be hard or even impossible to obtain. Fortunately, since most of the complex functional blocks of a circuit are already integrated into higher-level parts like ICs or circuit boards, our experiences show that overly complex schematics occur only rarely in real world maintenance applications.

SUMMARY

As one can easily see from the above sections, providing CAD-derived illustrations for mobile handheld devices is an ambitious goal that gets increasingly difficult with the amount of automation involved. Especially the reduction of complex drawings to fit the small screen space of today's mobile devices poses a challenging problem. Yet, it is encouraging to see that already the basic techniques presented in this paper combined with the technical possibilities of a state-of-the-art vector graphics format like SVG show promising results. Also, the possibility to shift complexity issues and issues of standard conformity between the authoring process and the interactive mobile client allows the adaptation to a wide range of technical architectures and content creation workflows. In this paper, we have shown both – powerful authoring tools and prototypes of smart mobile clients that utilize their respective strategies to circumvent technical incompatibilities as well as runtime and screen bottlenecks.

Our ideas to further this study focus on additional automation possibilities using topologically annotated illustrations. Because describing the topology using a graph structure seems to lead towards unexpected benefits like the possibility to use a simple breadth-first-search to easily determine connected components or graph drawing algorithms for further optimization of the layout. Additionally,

Figure 5. Our authoring tool for creating and annotating circuit schematics in SVG (a) and the accompanying client software displaying an example circuit with a highlighted transistor using the standard conform SVG-component SVG.Net (b).



a *b*

an evaluation of the proposed techniques and their acceptance by maintenance workers in different scenarios needs to be realized.

REFERENCES

[AP+03] M. Agrawala; D. Phan; J. Heiser; J. Haymaker; J. Klingner: Designing Effective Step-By-Step Assembly Instructions; Proc. of ACM SIGGRAPH 2003, S. 828-837

[ART06] ARTESAS. *Advanced Augmented Reality Technologies for Industrial Service Applications*. http://www.artesas.de, 2006.

[BS+94] E. A. Bier, M. C. Stone, T. Baudel, W. Buxton, K. Fishkin: *A Taxonomy of See-Through Tools*. ACM Proceedings of CHI '94 (Boston, MA, April 24-28), S. 358-364, 1994.

[FL+06] G. Fuchs, M. Luboschik, K. Hartmann, K. Ali, H. Schumann, Th. Strothotte: *Adaptive Labeling for Interactive Mobile Information Systems*, 2006.

[FR+06] G. Fuchs, D. Reichart, H. Schumann, P. Forbrig. *Maintenance Support - Case Study for a Multimodal Mobile User Interface*. IS&T/SPIE's 16th Annual Symposium Electronic Imaging, Jan. 2006.

[HP+04] J. Heiser, D. Phan, M. Agrawala, B. Tversky, P. Hanrahan: Identification and Validation of Cognitive Design Principles for Automated Generation of Assembly Instructions; Advanced Visual Interfaces 2004, S. 311-319

[ISO02] ISO Standardization Committee. *ISO Standards Handbook Vol.1+2*, 4th Edition, 2002.

[Jac03] D. Jackson (Editor). *Scalable Vector Graphics (SVG) 1.1 Specification*. W3C Recommendation, 14 January 2003.

[KMS04] M. Klima, P. Halabala, P. Slavik. *Semantic information visualization*. CODATA Workshop Prague, 2004.

[MS91] J. Marks and S. Shieber. *The Computational Complexity of Cartographic Label Placement*. Technical Report TR-05-91, Center for Research in Computing Technology, Harvard University, 1991.

[NPF+04] W. Narzt, G. Pomberger, A. Ferscha, D. Kolb, R. Müller, J. Wieghardt, R. Bidner, H. Hörtner, C. Lindinger. *PARIS - Personal Augmented Reality Information System.* 2nd ACM International Conference on Mobile Systems, Applications and Services, June 2004.

[SF91] D. Seligmann, S. Feiner. *Automated generation of intent-based 3D Illustrations*. Proceedings of ACM SIGGRAPH, p. 123-132, 1991.

[SL89] H. Shin, C.-Y. Lo. *An Efficient Two-Dimensional Layout Compaction Algorithm*. Proceedings of the 26th ACM/IEEE Conference on Design Automation, p.290-295, 1989.

[SP82] S. Sastry, A. Parker. *The Complexity of Two-Dimensional Compaction of VLSI Layout*. Proceedings of ICCC-82, p.402-406, Sept. 1982.

[TMM00] J.J. Tirtowidjojo, K. Marriott, B. Meyer. *Extending SVG with Constraints*. In Proceedings of the 6th Australian World Wide Web Conference, 2000.

[Tuf97] E. R. Tufte. *Visual Explanations: Images and Quantitatives, Evidence and Narrative*. Graphics Press, Cheshire, Connecticut, 1997.

[Wol84] W. Wolf. Two-Dimensional Compaction Strategies, PhD Thesis, Department of Electrical Engineering, Stanford University, 1984.

ENDNOTE

[1] Scalable Vector Graphics, a W3C recommendation for XML-based vector graphics [Jac03].

An Evolutionary Framework for Strategies of Spatial Technologies: Case Study Analysis

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ABSTRACT

An evolutionary framework is presented for spatial information technologies in business. The framework has the three dimensions of extent spatial applications are customer-facing, the extent geography influences the business, and the extent of presence of spatially-enabled web integration platform versus traditional spatial platform. The evolution of the framework over time is towards more customer-facing, greater extent of geography in the business, and greater extent of spatially-enabled web integration platforms. The framework is tested by interviews of eighteen case study companies that vary in size and industry. Case study methodology is utilized. The research question asks whether strategic spatial focus is related to one or more of the framework dimensions. Results indicate that greater strategic focus of a company is associated with increases of spatially-enabled web integration platforms, but not with extent of geography in the business or with the extent spatial applications are customer-facing. The findings are compared to literature on frameworks of classifying spatially-enabled firms.

Keywords: Spatial technologies, strategic, framework, case study.

1. INTRODUCTION

Spatial technologies and geographic information systems (GIS) grew up in government (Longley et al., 2005), but have moved rapidly in recent years into the business sector (Francica, 2005). A few studies focusing on business spatial uses have emphasized the strategic aspects. The framework of Ghosal (1987) has been useful to understand IT strategy, and was extended to GIS in business (Murphy 1996). Ghosal pointed to three areas of strategic goals: efficiency in current operations, managing risks, and learning, innovating, and adapting. All the areas carry over to GIS strategies (Murphy 1996). Likewise, Ghosal's three areas of IT strategic tools (economies of scale, economies of scope, and exploiting factor differences) can apply also as GIS strategic tools (Murphy 1996.) A contributor to the goal of learning, innovating, and adapting is "organizational memory and learning" (Ghosal 1995). For spatial applications, GIS mapping and analysis can consolidate memory visually, reduce the complexity, and make learning easier. GIS can help an organization achieve its vision and strategic goals (Tomlinson 2003).

Use of these technologies is growing rapidly, including in the business sector. Daratech estimates that the market of core software and services for GIS was $1.7 billion in 2003 (Daratech 2004), while Longley et al. (2005) estimate the total worldwide expenditure on GIS and related activities is $15-20 billion.

The trend for spatial technologies in business has been to extend them from traditional GIS systems to enterprise-wide systems that run on web-based architectures (Sonnen and Morris 2005; Guerrero, 2005). A traditional GIS system refers to powerful desktops or client-servers running GIS commercial software. It has powerful functionality and requires geographic and GIS expertise to develop. The enterprise-wide systems tend to run under spatial web services architecture, which consists of servers connected to the web that provide spatial applications to web-connected clients. Also, enterprise servers such as those from ERP, CRM, and Business Intelligence can be connected to this web architecture. For instance SAS, a leading business intelligence vendor, has achieved tight integration of its server-based software to the server versions of ESRI's GIS software (Barnes 2005).

The objectives of this research are the following: (1) develop a conceptual framework of the evolution of spatial technologies in business, that takes into account how customer-facing the application is, how geographical the industry or firm is, and the extent the industry or firm uses a spatially-enabled, enterprise-wide integration platform, (2) analyze eighteen case studies of businesses and classify the cases in the framework, (3) analyze how strategic are the spatial applications for the case companies, and (4) answer the research question of whether the level of spatial strategy of firms is associated with dimensions of the framework.

The paper's *Research Question* is as follows: Is the extent that a company is strategic in its spatial technologies in year 2005 associated with one or more of the three dimensions in the evolutionary framework: the extent applications are customer-facing, extent the firm is geographic in its business, and/or extent the firm uses a spatially-enabled, enterprise-wide web integration platform.

The study is exploratory and utilizes qualitative, case-study methodology. Its goal is to raise issues of emerging spatial technologies for business and to gain understanding through exploratory analysis of case studies. The study is not intended to be statistically significant or to confirm research questions based on a large sample.

2. METHODOLOGY

The methodology for this research is case study (Yin 1993, Yin 1994). The case study strategy consists of definition of the study focus, framework construction, interviews, data collection, and case analysis. Case studies are often used to deepen insight into enterprises and their decision-making processes, sometimes more so than can be done with large sample surveys (Yin 1994). Case study investigation often has small sample sizes (Yin 1994). The present case study sample was determined by selecting eighteen firms, each in a different industry that is known to utilize GIS (see Table 1**).** The sample of firms is not randomly chosen, but is a convenience sample**.** Five of the industries were ones with high spatial technology use (oil and gas, utilities, retail, environmental services, and transportation) and seven were ones with moderate spatial technology use (banking, health care, marketing/advertising, newspapers, publishing, consulting, and consumer services). The firms were selected to have different size categories (6 large, 3 medium, 2 small), ownership structures (3 are private, 8 public), and corporate structures. The range of firms is broad in order to encompass a variety of spatial and strategic factors and to demonstrate a range of firms for the evolutionary framework. For each firm, the protocol is to interview the manager or executive responsible for spatial technologies. For one firm, that responsibility was split evenly between GIS technology and GIS marketing so both managers were included in the interview. The interviews utilized a standard interview protocol and set of general questions. They were transcribed in writing and tape recorded if permission was granted. The interview transcripts were sent to the interviewees for factual corrections. Secondary materials on spatial technologies in the firms were requested, and provided by most firms. They consisted of company reports, postings, and writeups. In addition, secondary business materials were obtained from company websites and standard business information services (Dun and Bradstreet 2005; Hoover's, 2005; Standard and Poors, 2005).

Responses to specific items on the interview protocol were used to position the company in the framework, in particular extent spatial is customer-facing; extent spatially-enabled, enterprise-wide web integration platform; and extent of geog-

Table 1. Sample of firms for case studies

Name or description	*Industry*	*Size*
Global Integrated Oil (description)	Oil and Gas	large
Kaiser Permanente	Heath Care	large
Large Credit Bank (description)	Banking	large
Large Commercial Bank (description)	Banking	large
Rand McNally	Publishing	large
Southern Company	Utilities	large
Sears Roebuck	Retail	large
URS	Environmental, Planning	large
Norwich Union	Insurance	large
Lamar Advertising Company	Marketing/Advertising	medium
Arizona Republic	Newspapers	medium
Western Exterminator	Environmental Services	medium
Bay State Health	Hospitals, healthcare	medium
Sperry Van Ness	Commercial real estate	medium
Prudential Preferred Realty	Residential real estate	medium
Engineering Systems	Consulting	small
Motion-Based Technologies	Consumer Services	small
MapGistics	Consulting for Hospitals and Healthcare	small

raphy in the business. The latter refers to how important geographically-based products and services are in the firm.

3. EVOLUTIONARY FRAMEWORK OF SPATIAL TECHNOLOGIES

This section proposes an evolutionary framework that takes into account three key dimensions. Since GIS and spatial technologies are new to the business research few frameworks or theories have been proposed to account for their evolution and growth (Hackbarth and Mennecke 2005; Jarupathirun and Zahedi 2005).

A prior "geo-business application model" (Hackbarth and Mennecke, 2005) categorized geo-business applications by three dimensions: (1) type of agents (virtual, digital, physical), (2) type of products (virtual, digital, physical), and (3) type of processes (virtual, digital, physical). This model focuses on these virtual typologies, but does not take any account of the organization. The unit of analysis is the application. Another study considered a model of web-based spatial decision making where a variety of expectations led to perceived goal commitment and perceived task-technology fit, leading in turn to performance measures of spatial decision support systems (Jarupathirun and Zahedi 2005). The present paper's framework recognizes the whole industry or firm as the unit of analysis. No prior firm-level or industry-level conceptual models have appeared in the research literature for spatial technologies.

The present evolutionary model was developed by consultation with industry experts and by scrutiny of industry literature (Tomlinson 2003, Barnes 2005, Guerrero 2005, Maguire 2005, Reed 2005, Sonnen and Morris 2005) and several academic sources (Francica 2005, Lopez 2005). The model is a theoretical one that is based on three model dimensions that were repeatedly emphasized by the experts and the literature. The dimensions are: (1) extent that spatial applications are customer-facing, (2) extent that geography is part of the industry or business, and (3) extent that the industry or business utilizes a spatially-enabled enterprise-wide integration platform. The configuration of them into a three-dimensional space for categorization was the original work of the author, but was suggested by a three-dimensional categorization model for location-based-systems (Hackbarth and Mennecke 2005). There are numerous 2-D and 3-D categorization models in the IT field. The first dimension consists of the extent that spatial applications in the industry or company are directed towards a user base that is predominantly customers (i.e. customer-facing) versus spatial applications that are directed towards internal users. Internal users include executives, managers, marketing specialists, middle-level analysts, operations personnel, sales force, and field workers. Spatial applications at outsourcing providers that are closely associated with a firm are considered "internal," rather than customer-facing.

The extent of geography as part of the business refers to whether the major business products and processes relate closely to geography. An example of an industry closely linked to geography is transportation, for which the key processes of moving goods and services are inherently tied to geography; another example is the utility industry, for which the products of energy, purified water, and essential materials are provided through geographical network routing of transmission lines, pipelines, and specialized transport vehicles. Real estate is another obvious example, with land as its central element. On the other hand, the legal services industry has slight linkage with geography for its essential products and processes. Another less geographically-tied industry is financial services, since its vital products and services are not usually strongly linked to geography. In between in spatial intensity are industries such as health care, banking, metals manufacturing, and pharmaceuticals.

The extent that an industry or business utilizes a spatially-enabled web integration platform refers to whether it is based on "traditional" desktop or client-server spatial applications or is mostly based on the web-based and location-based enterprise architecture that consists of web servers, content servers, the web, thin and thick clients (Barnes 2005, Guerrero 2005, Lopez 2005, Maguire 2005, Sonnen and Morris 2005). Sometimes spatially-enabled portable mobile devices are included in this architecture by GPS and/or wireless links. In between are mixed architectures, in which industries for companies depend substantially on a mixture of the traditional technical GIS platform and the emerging web- and location-based integration platform.

The changes in the evolutionary framework over time are shown circa 1995 in Figure 1, and in 2005 in Figure 2. Figure 1 only shows two dimensions, since the spatially-enabled web integration platform was not present, but only the traditional desktop or client-server. Geography-tied industries such as transportation and utilities are shown with higher values on the x axis while ones with much less spatial linkage such as steel and private hospitals have low values. On the y axis, industries that are not customer-facing in spatial technologies include pest management and oil and gas, while industries such as real estate are moderately customer-facing, but no industries in the mid 90s are highly spatially customer-facing. The deficit of high customer-facing is because map delivery was still cumbersome, bandwidths were not high enough for effective interactive mapping, and businesses mostly had not yet recognized the benefits of providing maps and spatial analysis to customers.

In 2005, the complexion of industry distributions changed, and the web integration platform appeared, so it is added to the framework as the z dimension. Compared to 1995, there are only moderate changes in some industries with respect to ex-

Figure 1. Evolutionary framework of industry categories by two spatial dimensions, 1995

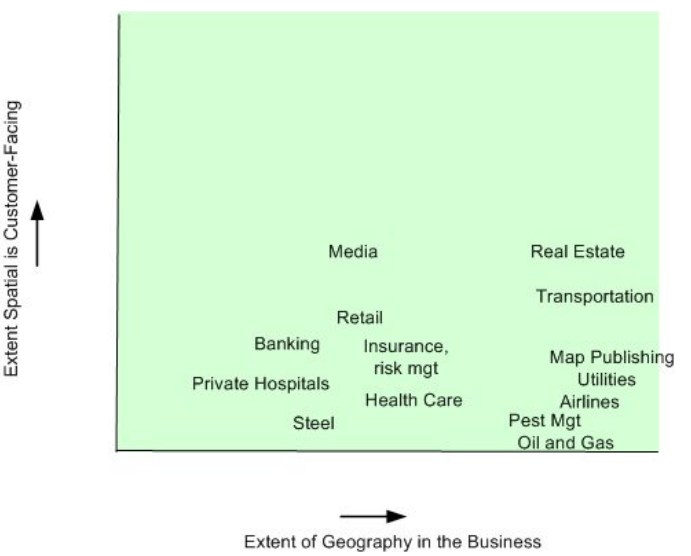


Figure 2. Evolutionary framework of industry categories by three spatial dimensions, 2005

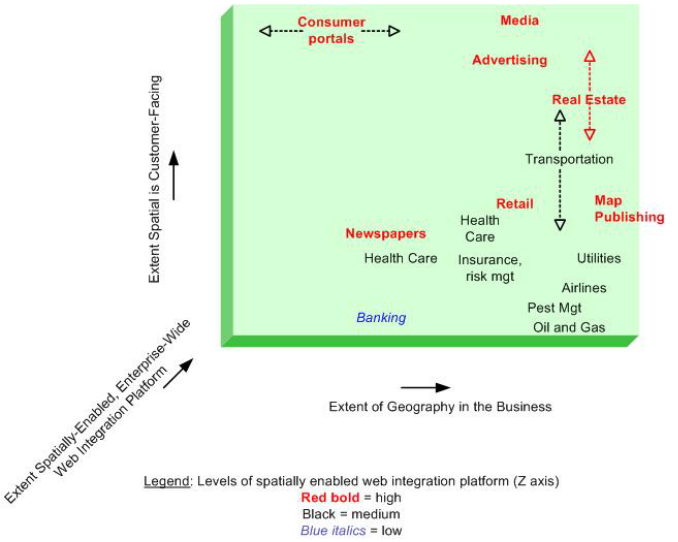
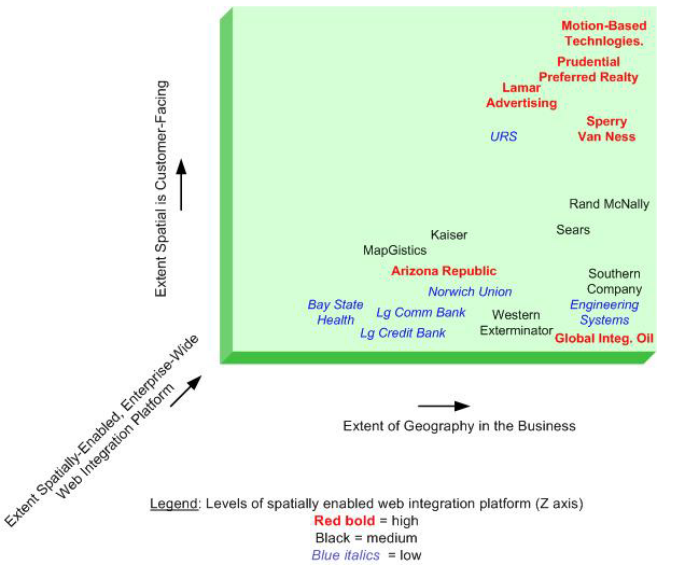


Figure 3. Evolutionary framework of industry categories by industry cases, 2005



tent of geography in the business. These changes arose because some industries became more geographical. For instance, as banks consolidated and covered larger territories, some of their geographical-based functions, such as real estate and marketing, gained in importance. Likewise for private healthcare, the larger chains created through mergers and acquisitions resulted in more prominence for geography, such as in national marketing planning and competitive siting of hospitals and clinics. On the y-axis of extent customer-facing, there were substantial changes in some industries due to fast, web-based delivery of enhanced map products in real-time. An example is real estate, where increasingly multimedia and map enhancements occurred. This is typified by a product such as Realtor.Com, which is very customer-facing with real-time nationwide maps and multimedia. An industry not present in 1995 but strong today is consumer portals with products such as Google Map and Earth, Microsoft MSN, Yahoo Maps, and Amazon A9, that deliver detailed maps on a worldwide basis. At the low end of customer-facing, some industries remain from 1995 such as metals manufacturing and pest management, for which consumers are not demanding interactive spatial interfaces and the firms are not providing them. Some industries such as transportation have become more customer-facing in certain functions such as automated vehicle navigation (AVN) and marketing, but remain internally focused in design, manufacturing, and other areas.

In the z-axis dimension of extent spatially-enabled web integration platform, industries such as consumer portals, media, and real estate lead the way, with continual, powerful, and appealing delivery of maps and spatial analysis to customers. Industries that have mostly not adopted the web- based platforms include banks, steel, and pest management. These industries have not seen sufficient benefits in spatial applications to justify the high costs of upgrading from desktop/client-server to web-based enterprise platforms.

This evolutionary framework can be expected to change further, since spatial technologies are currently in a phase of rapid advancement in business, due to reduced costs and more realization of the competitive importance of the benefits (Sonnen and Morris 2005, Francica 2005). The framework can be useful to managers who conduct mid- to long-range planning of their spatial architecture and applications. This paper now turns to eighteen case studies of businesses that use spatial technologies. Based on case analysis, each firm will be placed on the 2005 evolutionary framework, and the extent each business has identified spatial applications as strategic will be compared to the three factors of the framework.

3.1 Summary of Findings

The detailed findings for each case study firm cannot be included in this paper, due to space limitations. The summaries of the individual cases are available by request from the author. This findings section contains a summary to the results as they pertain to the research question. The case study firms vary on the three dimensions of the evolutionary framework, as shown in Figure 3. Size of firm has no consistent association with position in the framework, which implies that barriers to entry are low for spatial technologies in business. The extent applications are customer-facing relates to type of industry. Consumer services, billboard advertising, newspapers, and retail are industries that serve large numbers of customers. By contrast, the oil and utilities industries are more proprietary about retaining geographic information. Furthermore, post 9-11, those industries have been restricted by government policy from making publicly available certain types of spatial information, such as detailed maps of their network configurations and loads. The giant Credit Bank is in the early process of shifting from centralized service of customers with credit needs that are not spatially-based to serving emerging retail customers who often need spatial displays, but the bank's traditional habits are not spatially-oriented. The pest industry has not yet offered spatial displays to its customers, who don't seem ready to use it.

Regarding the extent of geography in businesses, it is keyed closely to industry characteristics. Those with the largest geographical component come from oil and gas, utilities, GIS consulting, and consumer services, while geography is less important for banking and newspapers.

3.2 The Research Question

The research question can be answered based on the case study results, which are summarized in Table 2. Detailed description of each case appears in Pick (2006). It is evident that strategic level is not related to extent of customer facing. In comparing the extent the eighteen firms are spatially strategic to the adoption of spatially-enabled enterprise-wide web integration platforms, they are highly associated for this sample. Five of the six firms that adopted web-based, enterprise-wide platforms have high to very high strategic levels for spatial technologies, whereas six firms in the traditional client-server mode have predominantly low (five out of six) strategic levels for their spatial technologies. The six firms in the middle level of spatially-enabled enterprise-wide web integration platform have medium to high strategic levels (4 medium, 2 high) for spatial. The Research Question is supported for the positive association of strategic level and spatially-enabled, enterprise-wide web integration platform.

4. DISCUSSION AND CONCLUSION

Spatial technologies have expanded rapidly in the business world. Uses are evolving, supported by spatially-enabled, enterprise-wide web integration platform. Sometimes location-based-service capabilities are added. As costs lowered, more

Table 2. Case study sample – Company Name/Description, Industry, and Size (strategic level refers to strategic level of spatial technology in the business. Note: the colors in the last two columns refer to spatial strategic level, blue=high or very high,, white=medium, and yellow=low)*

Name or description	*Size*	*Customer-Facing*	*Platform*	*Strategic Level**
Global Integrated Oil	large	Very low	Web-based, Enterprise-wide	very high
Kaiser Permanente	large	medium	Intermediate. Mostly traditional, client-server	medium
Large Credit Bank	large	very low	Traditional client-server	low
Large Commercial Bank	Large	low	Traditional client-server	low
Rand McNally	large	medium	Intermediate. Client-server, Enterprise-wide, moving to web	high
Southern Company	large	very low	Intermediate. Client-server, Enterprise-wide, moving to web	high
Sears Roebuck	large	medium	Intermediate. Client-server, Enterprise-wide, moving to web	high
URS	large	medium	Traditional, client-server	medium
Norwich Union	large	medium	Traditional, client-server	low
Lamar Advertising Co.	medium	high	Web-based, Enterprise-wide, moving to more functionality	high
Arizona Republic	medium	medium	Web-based, Enterprise-wide, limited to circulation and advertising	high
Western Exterminator	medium	low	Intermediate. Commercial web services	medium
Bay State Health	medium	low	Traditional client-server	low
Sperry Van Ness	medium	high	Web-based, Enterprise-wide	medium
Prudential Preferred Realty	medium	high	Web-based, Enterprise-wide	high
Engineering Systems	small	low	Traditional Client-sever	low
Motion-Based Technologies	small	very high	Web-based, Enterprise-wide	very high
MapGistics	small	low	Intermediate. Is partly web-based enterprise-wide	high

profitable uses were discovered. The present research proposes an evolutionary 3-dimensional framework for industry and firm applications of spatial technologies having three dimensions. The extent of customer-facing spatial applications has steadily expanded over time towards greater customer-facing. This is due both to the convenience and user-friendliness of the new technologies as well as to broader user bases. The extent geography is associated with the business has grown slowly, as the structure of industries altered or new industries emerged. An example is the web-portal industry sector, which emerged in the last eight to ten years and in 2005 took a giant step towards the general-public consumer with such offerings as Google Earth and Microsoft Virtual Earth. For established industries such as banking, the trend towards mergers and acquisitions can broaden the geography of the firm and make spatial applications more important.

Eighteen case studies were conducted of firms from different industries and size categories. Applications of spatial technologies are varied, but have advanced for all the firms as cost reductions and newer software and systems have made the technologies more beneficial and profitable.

The research question is supported by the positive association in 2005 of firm's spatial strategic level with spatially-enabled, enterprise-wide web integration platform. No association was evident between strategic level and customer-facing spatial application, nor between strategic level and extent of geography in the business.

The implications of the research are that a firm should evaluate its industry and determine how suitable it is to spatial technologies, as well as how much competitive advantage the technologies offer. Firms should consider deploying spatial applications on platforms that are web-enabled, as long as it can rationalize the investment from a cost-benefit standpoint. It should plan in the long term to evolve the applications to enterprise-wide. Some firms such as Motion-Based in this study have been able to leap-frog directly to full web-based enterprise spatial platforms and take the lead in market niches. Of course that increases risk and requires understanding of customer markets.

The research is exploratory. Future research can test the framework and the research question with a large sample survey that would statistically evaluate the preliminary findings reported here. This would lead to a more robust organizing framework. The research might be further strengthened by interviewing or surveying varied levels of employees in each firm, to assess each firm's responses from a variety of organizational perspectives.

Managers in businesses should consider what opportunities are present to improve productivity, lower costs, and strengthen strategic positioning through spatial technologies and GIS.

REFERENCES

Barnes, Scottie (2005) Beyond the niche. Geospatial Solutions, May 1.

Brail, R.K. and R.E. Klosterman (Eds.) (2001) Planning Support Systems, ESRI Press, Redlands, California.

Daratech (2004) Geographic Information Systems Markets and Opportunities. Daratech Inc., Cambridge, Massachusetts.

Dun and Bradstreet (2005). Dun and Bradstreet Small Business Solutions. Dun and Bradstreet, New York.

Francica, J.L. (2005). GIS and the future in business IT. In Geographic Information Systems in Business (Pick, J. Ed.), pp. 358-372, Idea Group Publishing, Hershey, Pennsylvania.

Ghosal, S. (1987). Global Strategy: an Organizing Framework. Strategic Management J., 8, 425-440.

Guerrero, I. (2005). Emerging technologies in the geospatial industry." In Proceedings of the Annual Conference of the Geospatial Information and Technology Association, GITA: Aurora, Colorado.

Hackbarth, G. and B. Mennecke (2005). Strategic positioning of location applications for Geo-Business. In Geographic Information Systems in Business (Pick, J. Ed.), pp. 198-235, Idea Group Publishing, Hershey, Pennsylvania.

Hoover's (2005). Hoover's Online. Hoover's Inc., Austin, Texas. Available at www.hoovers.com.

Huxhold, W.E. and A.G. Levinsohn (1995). Managing Geographic Information System Projects. Oxford University Press, New York.

Jarupathirun, S., and F. Zahedi (2005). Exploring the influence of perceptual factors in the success of web-based spatial DSS. Decision Support Systems. Article in press.

Longley, P.A., M.F. Goodchild, D.J. Maguire, and D.W. Rhind (2005) Geographic Information Systems and Science. John Wiley and Sons, New York.

Lopez, X.R. (2005). Location-based services. In Telegeoinformatics: Location-Based Computing and Services (Hassan, K. and A. Hammad, Eds.), Chapter 6, pp. 171-188, CRC Press, Boca Raton, Florida.

Maguire, D.J. (2005). Enterprise geographic information servers: a new information system architecture. In Proceedings of the Annual Conference of the Geospatial Information and Technology Association (GITA), GITA: Aurora, Colorado.

Murphy, L.D. (1996). Competing in space: the strategic roles of geographic information systems. In Proceedings of the Association for Information Systems, AIS, Atlanta, Georgia.

Pick, J.B. (2006). A Case-Study Analysis of Costs and Benefits of Geographic Information Systems: Relationships to Firm Size and Strategy. In Proceedings of the Twelfth Americas Conference on Information Systems, AIS, Atlanta, Georgia.

Reed, C. (2005). The spatial web. White paper, available at www.opengis.org, Open Geospatial Consortium, Wayland, Massachusetts.

Sonnen, D. and H. Morris. (2005). ESRI: extending GIS to enterprise applications. White paper, February, International Data Corporation, Framingham, Massachusetts.

Standard and Poors (2005). Stock Reports. Short Hills, Standard&Poors, McGraw-Hill, New York.

Tomlinson, R. (2003). Thinking About GIS: Geographic Information System Planning for Managers. ESRI Press, Redlands, California.

Yin, R.K. (1994). Case Study Research: Design and Methods. Second Edition. SAGE Publications, Thousand Oaks, California.

An Integrated Sugarcane Phenology and an Optimization Approach to Set Plant and Harvest Schedules Within a Mill Region

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ABSTRACT

As a result of separated planning between rain-fed sugarcane growers and sugar mills in Northeastern Thailand, the supply of sugarcane to the mills were fluctuated. This situation led both sugarcane farmers and sugar plants to produce below their profit maximization level. During the harvest season, the quantity of sugarcane harvested did not match the capacity level of the mills. Hence, the supply of sugarcane was under capacity in the early and late harvest season, but it was over capacity in the middle of the season. This problem portrayed the loss of the mills to operate under capacity and the loss of farmers when the cut-to-crush time exceeded 15 hours as a result of the over supply of the sugarcane on that particular day. This problem, however, could be solved through the supply chain management using the database management, sugarcane phenology modeling such as the DSSAT-CANEGRO and a heuristic method. The database was used to record land information, climate zones, soil structures, land sizes, and farm management. The information, then, was fed into the CANEGRO, which combined weather data, genetic characters, management strategies, and soil data in order to simulate expected outputs. The results of these simulations were used in heuristic programming to identify varieties, plant and harvest date for a particular sugarcane plot so that the capacity of a sugar processing plant was optimized as well as the farmer's revenue. The simulated maximum quantity of sugar that could be produced was 810 million kilograms; it was obtained from the start of the harvest season on January 6 until the end of November 9. The simulated result using the purposive algorithm was greater than the average of simulated randomly grown sugarcane by 243 million kilograms. Moreover, the results of the simulated randomly grown sugarcane depicted that the supply of sugar exceeded the capacity by 4 times and under it by 20 times on the average.

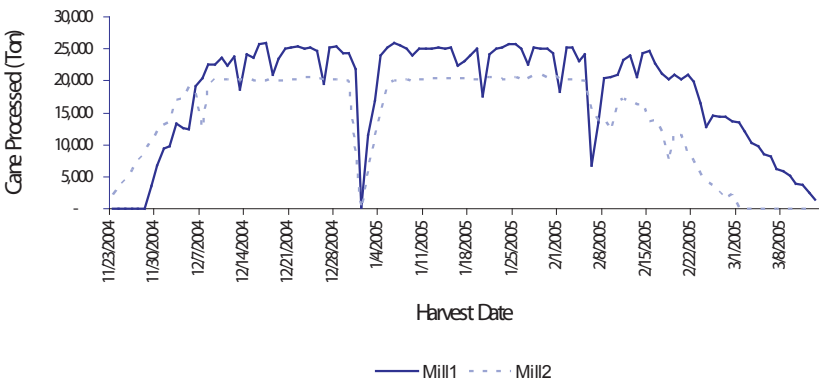
Keywords: Supply Chain Management, Heuristic, Sugar Industry, Quantitative Analysis, CANEGRO

INTRODUCTION

In recent years, sugar exporters have been competing fiercely in driving down their cost or pushing up their productivity. Severals engage in quest for better management. Hence, researchers have been conducting research for clearer vision on this matter. Most of them have concluded that collaboration between cane growers and sugar mills would pave the way to their ultimate goals. This collaboration plan is known as supply chain management. The collaboration will enable planners to set harvesting dates which will give optimum benefits to the sugar industry as a whole. Moreover, it possesses promising future application in marketing, transportation and warehouse management, etc. However, the road to this promising future has not been neatly paved.

In the Thai sugar industry, the unpaved road is traditionally adopted. Most of the Thai cane is rainfed, and the plant date is naturally fixed by the mother of nature. Also, growers' copycat habit leads them to grow the same variety of cane. Combining the two events, the sugarcane inevitably ripens at the same period. This incident triggers a big road block as shown in Fig. 1. The amounts of cane supplied to mills are under crushing capacity at the beginning and at the end of the harvest season while they are over capacity in the middle of the season. The under capacity operation causes high per unit fixed cost for mills while the over capacity one prolongs cut-to-crush delay which leads to lower recoverable sugar yield. From an interview with growers, the cut-to-crush delay sometimes lasts four days, and that portrays an unnecessary loss of 60 kg. per ton.

Figure 1. Tons of sugar produced daily in the 2004/2005 harvest season



Solutions for this phenomenon are as follows: First, exploiting genotypes of cane varieties is needed. Varieties of cane may differ in their mature characteristics or ripening time. As suggested by Gilbert et al.(2004), some varieties are early season mature; some are mid, and some are late season mature. Hence, a certain combination of varieties will enable capacity and yield optimization. Second, enhancing the ability to predict sugar yield is to be conducted. This element is a consequence of the first one. If a variety selection is a preferred method to solve this problem, an accurate yield forecast is needed so that decision makers can decide harvest schedules accordingly. Third, a mathematical tool to lay out estimated yield into a collaboration plan is to be applied. Because the plan involves numbers of participatory growers, together with daily yield prediction, the problem can be unimaginary large. Therefore, decision makers need a mathematical tool to sort it out.

LITERATURE REVIEW

Engineering/management researchers have been trying to combine yield estimation and mathematical programming to smooth out this problem for years. Their mathematical concepts are rather more advanced while they are still struggling with yield prediction. Whan, Scott and Jefferson (1978) were among very first researchers who dealt with the application of cane yield prediction. Their predicted methodology was a quadratic equation which was a function of cane age, years of crop cycles and cross products between cane age and years of crop cycles. Although they attempted to imitate a pattern of real cane yield over time, their method did not cover crucial factors such as weather distribution. Years later, Hahn and Ribeiro (1999) suggested a daily planning of the transportation of sugar cane to mills which minimized cost and waiting time. Although it was a big leap forward for the cane industry, they assumed the amount of ripening cane was known and given. Cane growers were free to make decisions regarding pant dates, varieties, and the amount of land to grow. Therefore, the situation ended up as the Thai case. Their solution seemed to fix the waiting time, but the growers were not able to harvest at their possible optimal level.

Another study by Higgins et al. (1998) portrays a close concept to this study. They obtained a monthly average yield from historical data of each region to set up a harvest schedule. Although they demonstrated an elegant framework, using monthly average data implicitly assumed the same weather distribution across the year. Recently Jiao, Higgins and Prestwidge(2005) have proposed a combination of statistical and optimization approaches to resolve harvest schedule problems. They divided cane varieties into groups of early, middle and late mature varieties. Then, they estimated the sugar content of cane(CCS) as a polynomial function of number of weeks after the harvest season started. Finally, they applied a linear programming to optimize the predicted CCS under respective constraints. Similar to Higgins et al., Jiao, Higgins and Prestwidge assumed the same weather pattern across the year.

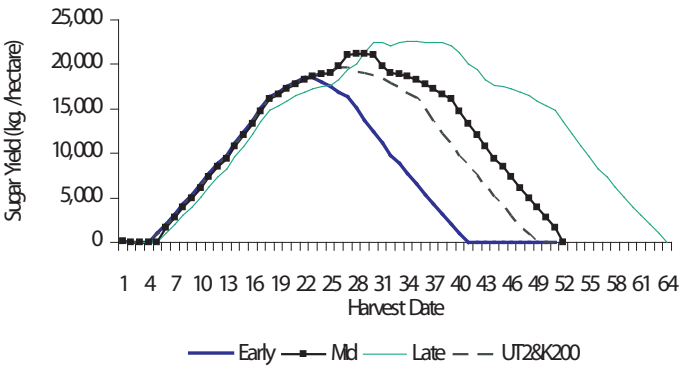
Plant phenologists have long been working on sugar yield estimation paralleled to the groups stated earlier. They successfully develop the state of art software programs for yield prediction. Two programs that have been widely used in cane industries are APSIM and DSSAT-CANEGRO. The two take similar approaches in dividing cane development into certain stages. Each stage differs in requirements of crucial factors such as solar radiation, water, temperature, nutrients, etc. A simulating process is created to imitate the development of plant growth in each stage. Hence, the program considers each important factor and each land plot separately and carefully. Although the simulated result possesses a promising future, it has not been applied for a group management. Rather, a single farm management is more commonly exploited.

To solve the problem of uneven cane supply and sugar mills' crushing capacity, we propose an integration of plant phenology programming and a heuristic approach. The details of this integration will be stated in the next section.

PLANT PHENOLOGY

Firstly, cane yield is simulated by the use of the DSSAT-CANEGRO. Due to the unavailable genetics coefficient for Thai cane except for UT2&K200, genetics of three varieties bundled with the DSSAT package, N14, NCo376, and GEOFF'S FAV were used. The coefficients were modified so that they could represent early, mid, and late season maturity. Degree-days(degree of highest temperature accumulated) from emergence to the harvest maturity of NCo376, N14, and GEOFF'S FAV were changed to 8.5, 7.0 and 6.5 thousand °C which represented late, mid and early season maturity consecutively. And the coefficient of UT2&K200 were obtained from Jintrawet et al.(1997).

Figure 2. Simulated results of 4 varieties on Chaiyaphum loamy sand planted in March



In this study, the management was assumed to be the same across the board and was constructed according to normal practice for Thai cane. The studied sugar mill is a mill located in Khon Kaen province. Growers who supplied cane to this mill, are in the provinces of Khon Kaen, Chaiyaphum and Loei. Therefore, weather distributions were separately created from the distribution of these provinces. There are two types of typical soil structures in these provinces, loamy sand and sandy clay. Combining the three weather stations together with the two types of soil, the studied areas were, then, classified into six different regions. As for planting periods, normal planting periods were around February, March and October. In summary, the simulated case was classified into 4 varieties, 6 regions, and 3 planting date. Therefore, it summed up to 72 different cases.

The examples of simulated yields were shown in Fig. 2. These yields were created from 4 varieties, planted in March on Chaiyaphum loamy sand. As indicated in Fig. 2, graphs of cane yield were crisscrossing. One interpretation is that each variety is to be harvested at a different date. If the harvest before period of 23 is needed, the early season mature variety should be chosen. Whilst, the period of 25, the UT&K200 will give more yields, and for the mid season mature variety, it is suitable for harvesting at the period of 27. Additionally, the harvesting beyond the period of 27, the late season mature should be selected.

INTEGRATION INTO A MATHEMATICAL PROGRAMMING MODEL FOR OPTIMIZATION

After predicted yields were obtained, we applied heuristic Algorithm to set plant and harvest dates which would give the highest amount of total sugar. The objective function of maximizing group outputs takes the following form:

$$\text{Max } Z = \sum_{s=1}^{n}\sum_{t=1}^{n}\sum_{k=1}^{4}\sum_{j=1}^{6}\sum_{i=1}^{3} Q_{ijkt} A_{ijkt} B_s$$

where Z is total sugar produced, Q_{ijkt} is the sugar yield from cane planted at period i in region j with variety k and harvested during period t, A_{ijkt} is the amount of land where cane was planted at period i in region j with variety k and harvested during period t, and B_s is the binary number which equals to 1 when it is harvested in the season and 0 otherwise

I	set of planting dates and $i \in I$, i equals to 1 to 3
J	set of regions and $j \in J$, j equals 1 to 6
K	set of varieties and $k \in K$, k equals 1 to 4
T	set of harvest dates and $t \in T$
S	set of harvest seasons and $s \in S$

Constraints

1. $\sum_{t=1}^{n}\sum_{k=1}^{4}\sum_{j=1}^{6}\sum_{i=1}^{3} A_{ijkt} \le L_j, \forall\, i \in I, \forall\, j \in J, \forall\, k \in K, \forall\, t \in T, s \in S$

   The first constraint ensured that sum of Area j which planted Variety k at Time i would not exceeds its maximum level. The total land available for the studied mill is 48 thousand hectares. Due to limitation of the detailed data, we assumed each region has equal amount of land, L_j equals to 8 thousand hectares.

2. $\sum_{k=1}^{4}\sum_{j=1}^{6}\sum_{i=1}^{3} Q_{ijkt} A_{ijkt} \le CAP_t, \quad \forall\, i \in I, \forall\, j \in J, \forall\, k \in K, t \in T, s \in S$

   This constraint is to say that the total amount of cane being harvested did not exceed crushing capacity, CAP_t.

3. The amount of land used were positive numbers.
   $A_{ijkt} \ge 0, \quad i \in I,\ j \in J,\ k \in K,\ t \in T,\ s \in S$

4. Only one harvest season was selected for a particular year. The interpretation is that the harvest season was to be continuous. Hence, the process would go on until the running out of land.

   $\sum_{s=1}^{n} B_s = 1, \forall\, s \in S$

SIMULATION MODEL

We constructed a heuristic algorithm to optimize the objective function. The detailed logic of the algorithm is described as follow:

1. Given 72 different cases simulated yield from the DSSAT-CANEGRO, the optimization model would start its first scenario, s = 1, by beginning the harvest season on t = 1.
2. First, it would search for the best sugar yield per hectare during that period, and fill up capacity with the best yield up to the amount of land available. Nonetheless, if after the harvesting best yield, the supply of cane was still insufficient to fill up the mill's capacity, the algorithm would search for the next best. The process would go on until the capacity was sufficiently filled. Then, the program would move on to the next harvest date and so on.
3. The filling up process went on until the amount of land subsided to zero. Then, the iteration process would start the next scenario s = 2 meaning the harvest season had begun on t = 2 and Step 2 was repeated. The process went on until $s = n$.

The optimization process is described by using the following pseudo codes.

Algorithm

```
SET each land = Maximum of land
SET capacity for each period equals to its maximum capacity
FOR each starting the harvesting season date
  FOR each harvesting time
    DO
      FOR each region
        FOR each variety
          FOR each planting period
            Obtain 'Current_Solution' from the result of DSSAT
            IF Current_Solution is an improvement over Best_Solution check
                if the solution is feasible (there is some land available for
                growing sugarcane and there is some capacity left to be filled
                up) THEN Best_Solution = Current_Solution
            ENDIF
          REPEAT
        REPEAT
      REPEAT
        Calculate sugar_produced which will be produced by land available
        IF sugar_produced is less than capacity THEN
        UPDATE capacity needed to be filled
        SET land available to grow next t equal to 0
        ELSEIF sugar_produced is greater than capacity THEN
        calculate land available for the next t and set capacity needed to be
            filled equal to 0
    UNTIL land_available = 0 or capacity_be_filled = 0
    RESET capacity and capacity_be_filled to initial value
    UPDATE total_sugar_accumulated
  REPEAT
  RESET total_sugar_accumulated = 0 and land_available to its maximum
      initial value
REPEAT
```

At the end of each scenario, the total amount of sugar is calculated. Then, these summation sugar yields were compared in order to retrieve an optimum solution from these calculated yields.

SIMULATING RESULTS

The result of comparison total simulated yields as shown in Fig. 3 suggested that the harvest season should start on January 6 and end on November 19 with an optimum sugar yield of 813 million kg.

Also, the proposed algorithm recommended a harvest schedule. The example of the schedule is shown in Table 1. It shows that, from January 6 until March 2,

Figure 3. Total simulated yields for each harvest season

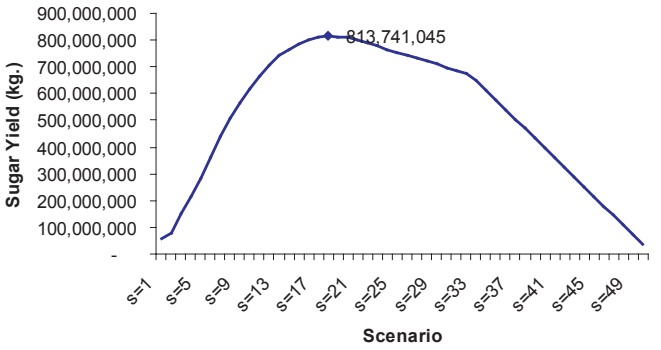


Table 1. Recommended harvest schedule

Harvest Date	Harvest Area (Hectare)	Variety	Plant Date	Region
Jan 6	1,582.0	UT2&K200	February	Chaiyaphum Loamy Clay
Jan 20	1,510.0	UT2&K200	February	Chaiyaphum Loamy Clay
Feb 3	1,458.0	UT2&K200	February	Chaiyaphum Loamy Clay
Feb 17	1,416.0	UT2&K200	February	Chaiyaphum Loamy Clay
Mar 2	1,416.0	UT2&K200	February	Chaiyaphum Loamy Clay
Mar 16	618.0	Mid Season	February	Chaiyaphum Loamy Clay
	810.0	Mid Season	February	Chaiyahum Sandy Loam
Mar 30	1,443.0	Mid Season	February	Chaiyahum Sandy Loam
Apr 13	1,443.0	Mid Season	February	Chaiyahum Sandy Loam
Apr 27	1,417.0	Late Season	February	Chaiyahum Sandy Loam
May 11	1,381.0	Late Season	February	Chaiyahum Sandy Loam
May 25	1,338.0	Late Season	February	Chaiyahum Sandy Loam
Jun 8	168.0	Late Season	February	Chaiyahum Sandy Loam
	2,178.0	Late Season	February	Chaiyahum Sandy Loam
Jun 22	2,476.0	Late Season	February	Chaiyahum Sandy Loam

Table 2. Recommended plant dates, areas, and varieties for each region

Region	Variety	Area (Hectares)	Planting Date
Chaiyaphum Sandy Loam	Mid season	3,696.0	February
	Late season	4,304.0	February
Total		8,000.0	
Loei Sandy Loam	Late season	7,226.0	February
	Late season	774.0	March
Total		8,000.0	
Khon Kaen Sandy Loam	Late season	8,000.0	February
Chaiyaphum Loamy Clay	UT2&K200	7,382.0	February
	Mid season	618.0	February
Total		8,000.0	
Loei Loamy Clay	Late season	8,000.0	February
Khon Kaen Loamy Clay	Late season	8,000.0	February

UT2&K200 planted on Chaiyaphum loamy clay in February should have been harvested with the amount of land indicated in the table. Whilst, from March 16 to April 13, the mid season variety grown on Chaiyaphum loamy clay and sandy loam should have been harvested. Next, the late season on Chaiyaphum sandy loam should have been harvested from April 12 to June 22.

According to the recommended planting schedule, the late season variety planted in February was recommended to grow on Chaiyaphum sandy loam, Loei sandy loam, Khon Kaen sandy loam, Loei loamy clay and Khon Kaen loamy clay for amount of land stated in Table 2. The mid season variety planted in February was recommended to grow on Chaiyaphum sandy loam and loamy clay. Finally, UT2&K200 planted in February was recommended to grow on Chaiyaphum loamy clay.

Because the result from optimization is a simulated one, its benefits are not known unless the model is supplied with the real world data. To show a potential benefit of this framework, we created 25 randomly grown scenarios. For each scenario, cane growers were to select a variety, the plant date and the amount of land on their own wishes and to harvest their canes when it was ripe. All 25 random scenarios showed lower total sugar yields, with an average of 570 million kg. The average randomly grown was 243 million kg. less than the former. Moreover, the result of these random scenarios showed uneven supply of cane which exceeded the sugar mill's capacity by an average of 4 times and was lower than the capacity by an average of 20 times.

CONCLUSIONS

The contribution of this research is to combine plant phenology with an optimization technique in solving supply chain management problems. Although the Thai cane industry will not be able to adopt this framework at this moment, we intend to illustrate a promising future application of the two fascinating tools which will lead to enhancing productivity of the industry as a whole. To get on track of this paved road, farmers' database is essential to the task. The mill needs to know the location, the amount of land, soil structures and the farm management style of each individual farmer. This information, then, will be fed to the optimization program to retrieve recommendations of plant dates, varieties and harvest dates.

REFERENCES

Jintrawet, A., Laoharisiwong, S., & Lairuengroeng, C. (1997, July) *Developing and Testing Plant Phenology Modeling for Thai cane*. The Thailand Research Fund.

Gilbert, R. A., Shine, J. M. Jr., Miller, J. D., Rice, R. W., & Rainbolt, C. R. (2004). *Maturity Curves and Harvest Schedule Recommendations for CP Sugarcane Varieties*. Retrieved March 10, 2006 from http://edis.ifas.ufl.edu.

Hahn, M. H. & Ribeiro, R. V.(1999). Heuristic Guided Simulator for the Operational Planning of the Transport of Sugar Cane. *The Journal of the Operational Research Society*, *50*(5), 451-459.

Higgins A. J., Muchow, R. C.,Rudd A. V., & Ford A. W. (1998). Optimizing Harvest date in Sugar Production: A Case Study for the Mossman Mill Region in Australia I: Development of Operations Research Model and Solution. *Field Crops Research*, *57*, 153-162.

Jiao, Z., Higgins, A. J., & Prestwidge, D. B. (2005). An Integrated Statistical and Optimization Approach to Increasing Sugar Production within A Mill Region. *Computers and Electronics in Agriculture*, *48*, 170-181.

Whan, B. M., Scott, C. H., & Jefferson, T. R. (1978). A Stochastic Model of Sugarcane Crop Rotation. *The Journal of the Operational Research Society*, *29*(4), 341-348.

Towards a Data Warehouse-Based Approach to Support Healthcare Knowledge Development and Sharing*

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ABSTRACT

In the past, much effort of healthcare decision support systems were focused on the data acquisition and storage, in order to allow the use of this data at some later point in time. Medical data was used in static manner, for analytical purposes, in order to verify the undertaken decisions. Due to the massive economical impact of today's health system, great changes in medical treatments are notable. Apart of the humanitarian and healing nature of medicine, this industry is becoming more and more business like. The exploitation of evidence-based guidelines becomes a priority concern, as the awareness of the importance of knowledge management rises.

Consequently, interoperability between medical information systems is becoming a necessity in modern health care. Under strong security measures, health care organisations are striking to unite and share their (partly very high sensitive) data assets in order to achieve a wider knowledge base and to provide a matured decision support service for the decision makers. Ontological integration of the very complex and heterogeneous medical data structures is a challenging task. Our objective is to point out the advantages of the deployment of a federated data warehouse approach for the integration of the wide range of different medical data sources and for distribution of evidence-based clinical knowledge, to support clinical decision makers, primarily clinicians at the point of care.

Keywords: data warehouse, clinical decision support systems, evidence-based medicine, knowledge management, wrapper, mediator, ontological integration

1. INTRODUCTION

Despite the scientific and technological development progress over the recent years in the healthcare delivery, a significant portion of the decision-making information on the treatment of a patient's illness is still based on unstructured information or even hand-written notation. Furthermore, patient records are distributed over many different locations, instead of being available when required at the point of care.

We propose a data warehouse (DWH) based approach, in order to enhance the process of clinical knowledge management, which is a prerequisite for a successful clinical decision support. The benefits of such a solution are:

- The most recent medical knowledge can be provided, in order to take treatment decisions, i.e. enabling the practice of evidence-based medicine. Due to the huge data volumes, a DWH approach is required for the production of evidence-based knowledge.
- Clinical business management can perform the desired knowledge-oriented strategic decision making, planning and management of the healthcare enterprise. The financial resources can be used more efficiently through the implementation of DWH-based clinical pathways. Henceforth, clinical business management is then enabled to negotiate appropriate care contracts based on accurate knowledge on resource utilization.
- Clinical DWH, which gathers all available data related to the patients, treatments and drugs they received, will represent an ideal knowledge base for research purposes.

The addressed issues are very demanding and comprehensive. In this paper we confine ourselves to handle one aspect – the goal of our paper is to point out the advantages of the deployment of DWH for integration of wide range of different data sources and for distribution of evidence-based clinical knowledge to support clinical decision makers.

The contribution of our work is to propose a DWH based, ontologically focused integration model for integration of heterogeneous health care data sources, which could even include external data suppliers or some third-party stakeholders' web services.

The remainder of the paper is organized as follows: in section 2, we present a short introduction into the concepts of DWH facilitating evidence-based medicine. An integrated health care information system, built upon a federated DWH is described in details in section 3. Section 4 outlines the advantages of the application of DWH technology for the support of care givers at the point of care via a case study. Section 5 deals with related work and finally, we conclude the paper in section 6.

2. DATA WAREHOUSE FACILITATING EVIDENCE-BASED MEDICINE

As discussed in related work [5], the business success of an organisation is highly dependable on the proactive use of information which is stored in its operational systems. A DWH integrates the relevant information, originating from the diverse internal and external data sources. Data in a DWH is prepared for users with different analytical and software skills, and consequently, having different types of requirements. A DWH should not only respond to pure reporting and data analysis requests but also support high-level users to track business trends, improve strategic decisions and enhance forecasting.

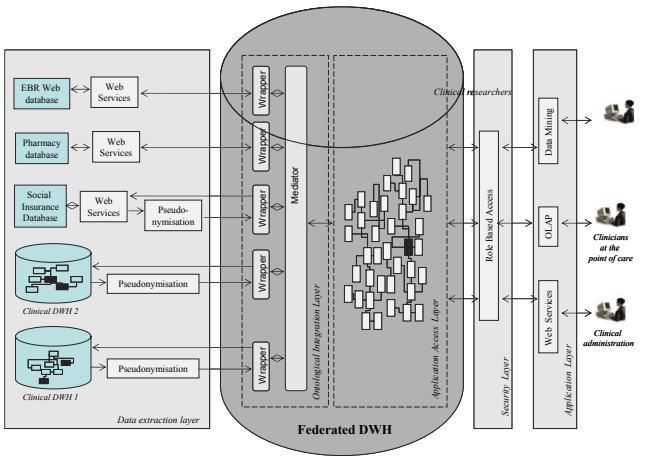
David Sackett [11] defines evidence-based medicine (EBM) as the conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients. Published clinical evidence is not necessarily sufficient for providing integrated support to care givers. EBM complements existing clinical decision making process with the most accurate and most efficient research evidence. Application of EBM concepts speeds up the transfer of clinical research findings into practice, leading to cost reduction and to the improvement of the healthcare process as the whole.

Both medical institutions and health insurance companies are primarily interested in increasing the patient healing rate and in reducing treatment costs. The right use of data warehousing in the area of EBM could prove as economically highly advantageous (in the long term) by the avoidance of duplications of examinations, by the automation of routine tasks and by the simplification of accounting and administrative procedures.

3. FEDERATED DWH MODEL FOR INTEGRATION OF MEDICAL INFORMATION SYSTEMS

During the last few years, healthcare organizations are confronted with massive knowledge processing challenges primarily caused by the increasing amount and

Figure 1. Medical federated DWH integration workflow



complexity of medical data. DWH offer a comprehensive support for gathering, analyzing and presenting medical data.

The system complexity, the heterogeneity of health care data sources, massive volumes of medical data and high number of concurrent users are the main reasons for the use of federated DWH integration model. As shown in Figure 1, the central point of such an integrated system is a federated DWH where all participants have access to and where the user's conceptual view is preserved.

In related work [10], we discussed the advantages of the federated approach against the centralized approach, in the aspects of cost-effectiveness, security and usability. A federated approach [1], [3] is required, when several independent organisations share their data for mutual purposes, but do not allow any physical copy of their data to be created in any external system. Most often, they demand to maintain full control of the access to their data. Highly confidential healthcare records are a typical example of such data. In case of interoperability in the health care domain, a federated DWH is therefore always a preferred solution.

3.1. Participators of DWH Federation

In our DWH model, the different medical treatment domains, i.e. the social insurance domain, the pharmaceutical domain and the evidence-based guidelines repository are participating in one federation. The existence of the federation is invisible to the users of the source systems.

The clinical DWH contains data which originates from a wide variety of data sources, such as:

- clinical data (patient, pharmaceutical, medical treatment, length of stay),
- administrative data (staff skills, overtime, nursing care hours),
- financial data (i.e. treatment costs, staff salaries, accounting)
- organizational data (facilities, equipment, room occupation)

The health insurance company stores information about patient encounters, treatments, therapies and drug prescriptions it supports. It communicates with the federation via web services.

Both clinical DWHs and the health insurance transfer their sensitive data to the federation, in case of a federated query. We assume that depersonalisation and pseudonymisation techniques are used to protect the confidentiality of patient data, as described in related work [2],[4],[10],[15],[16].

The pharmaceutical sector provides the federation with drug information such as medication description, packaging size, pharma-id number, indication group, pharmaceutical form (pills, juice etc.), and medication fee. In an analogous way to the insurance company, it uses web services to provide the federation with the necessary data.

The evidence-based rules repository is a collection of most accurate and most efficient research evidence. Through the web services, it provides the federation "on demand" with the best fitting guidelines for a given patient and given disease.

Since only a "single version of evidence" and a unique interpretation of the joined data should exist, it is necessary to have a unique singular common federated schema. For building the conceptual model of the federated DWH, just data relevant for further analyses and reporting are considered. In this phase, business users (from the domain of clinical/social insurance management) have to specify the respective sensitivity levels of data. The data modeller incorporates the specified privacy restrictions into the resulting logical data model.

3.2. Ontological Integration

The essential part of the integration of logical schemas of the underlying DWHs as well as of the data structures originating on the diverse participating legacy systems (such as relational or XML databases), is the ontological integration layer, as shown in the model depicted in Figure 1. Our model includes wrappers and mediator, which are two main architectural components of a mediated query system.

Wrappers encapsulate local data sources and export their functionalities and the metadata stored therein. They accept queries in a certain language and return metadata in a united form [12],[13]. The wrapper keeps locally the data schema for the specific data source it deals with. By integrating wrappers, we can cope with technical heterogeneities among local systems, without having to modify them.

The mediator [12], [13] handles the global queries from the application layer, unfold them into sub-queries and disperse these sub-queries to the relevant local data sources via their wrappers. The local results will be returned from wrappers; the mediator finally combines and presents the result to the client. Hence, the mediator will keep the global data schema and the mapping between global and local schemas. To maintain the dynamic mapping between local and global schemas, an ontological-based mediator/wrapper is one of the interesting problem solving approaches [13].

Figure 2 shows an example of how a user's query is handled by the wrappers and the mediator, from the query submission to the presentation of the result. On receiving the SQL query, the system performs the following:

1. DWH-Application invokes the mediator.

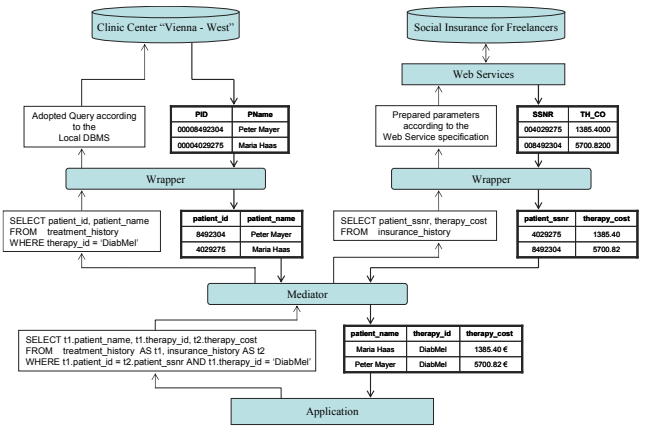
Query unfolding:

2. The mediator resolves the submitted query into partial queries, according to the exported schemas previously exposed by the wrappers. It determines which wrappers are relevant to the correspondent sub-queries.
3. The mediator passes the sub-queries to the affected wrappers.
4. A wrapper receives its sub-query and translates it into the format so that it can be understood by the underlying data source (database, web service etc.).
5. The wrapper forwards the adapted sub-query to the local DBMS or to the responsible Web Service for execution.

Query answering:

6. A wrapper retrieves answer data set, translates it into its exported schema.
7. The wrapper passes its answer data set to the mediator.

Figure 2. Mediated query system in health care environment



8. The mediator integrates partial query results into one answer set, transforms and formats it, so that it can be processed by the application.
9. The mediator passes the answer set to the application, so that it can be presented to the user.

The users of a federated DWH are not aware of the fact, that the data they are querying may be distributed across the network. Through data mining tools, web services, ad-hoc queries and predefined reports (OLAP tools), users are able to analyse data, as if they were physically stored in a centralised DWH. A role-based access model [14] guaranties that each user get access only to those data, which are necessary for the performing of his (her) tasks.

4. CASE STUDY: DWH SUPPORTING CLINICIAN AT THE POINT OF CARE

To illustrate the described DWH-based approach we present a case study, in which we suppose that the emergency room clinician is querying the federated DWH (as described in chapter 3) while examining the patient. The following scenario, which has not yet been implemented, builds the starting point of our case study: The diabetes patient, suffering from a progressive liver disease is complaining about itchy rash on her hands. Since the attending physician is not familiar with the patient's medical history and needs to handle quickly, he(she) is using federated DWH facilitating EBM, to find the most efficient therapy, which does not conflict with the patient's ongoing diabetes and liver disease treatment.

The clinician is using an OLAP tool, which is set up on the federation logical data model (LDM). One small but representative part of this model is shown in Figure 3. (In this paper, we are not handling data mining or web services based data retrieval. This is a part of an ongoing project and will be published in our future work.) Dashed arrows show the data flow between underlying data sources and resulting tables. Since the federation exists only on a virtual level, data are physically stored in their originating sources but queried and presented through the federation model.

The clinician is querying the patient's healthcare record, containing all the existing anamnesis/diagnostic data and all the patient's treatments in the past. Further, he(she) is interested in the patient's overall health condition (allergies and medication incompatibilities) as well as the personal data (age, weight, family predisposition to some diseases etc.). In addition, the clinician has to find out what kind of therapies will be covered by the patient's social insurance. Finally, he(she) is aiming at finding the treatment which proved to be the most effective under the given conditions.

The answering procedure takes place in two phases:

1. The user (the clinician) is querying the federated DWH by providing only the patient's name and the corresponding social insurance number. In the first step, the mediator sends queries containing these two parameters to all relevant participating sources (in this case study, these are: clinical DWHs, pharmacy and social insurance company). The aim of this step is to retrieve all patient data, which might be interesting as input for the second step, namely querying EBG database.
   Responsible wrappers return the corresponding data to the mediator, which in sequel joins them and produces a result data set.
2. In the second step, the resulting data set (containing patient's age, blood pressure, blood type, diseases history, list of received treatments and medications, social insurance categorisation etc.) is used as input parameter for the querying of the evidence-based guidelines database. The mediator forwards a new query to the EBG- database wrapper and retrieves the final data set.

Figure 3. Extract from federated DWH LDM with belonging data sources

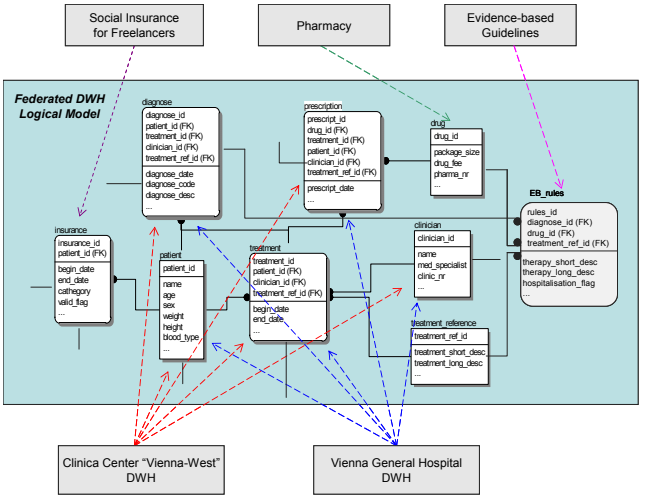
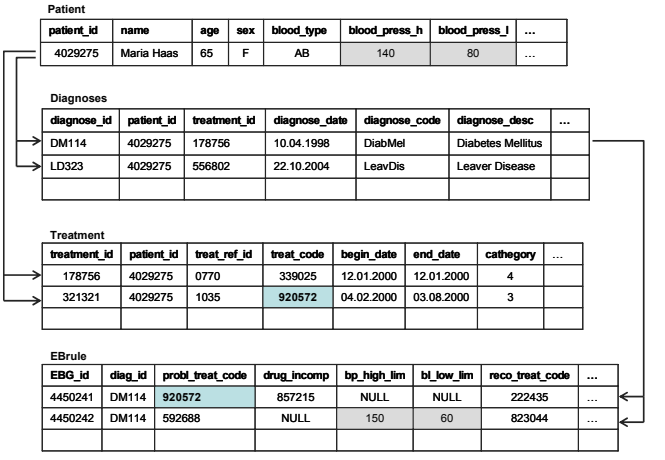


Figure 4. A part of tables involved into finding of the best fitting evidence-based rule for a given patient and given diseases



Patient

patient_id	name	age	sex	blood_type	blood_press_h	blood_press_l	...
4029275	Maria Haas	65	F	AB	140	80	...

Diagnoses

diagnose_id	patient_id	treatment_id	diagnose_date	diagnose_code	diagnose_desc	...
DM114	4029275	178756	10.04.1998	DiabMel	Diabetes Mellitus	
LD323	4029275	556802	22.10.2004	LeavDis	Leaver Disease	

Treatment

treatment_id	patient_id	treat_ref_id	treat_code	begin_date	end_date	cathegory	...
178756	4029275	0770	339025	12.01.2000	12.01.2000	4	
321321	4029275	1035	920572	04.02.2000	03.08.2000	3	

EBrule

EBG_id	diag_id	probl_treat_code	drug_incomp	bp_high_lim	bl_low_lim	reco_treat_code	...
4450241	DM114	920572	857215	NULL	NULL	222435	...
4450242	DM114	592688	NULL	150	60	823044	...

As shown in Figure 4, some of the existing treatment rules are disqualified due to medication or treatment incompatibilities. Since the proposed treatments must be adjusted to the patient's health risks, parameters like blood pressure may play the determining role in the treatment verification process. Nevertheless, the scope of a patient's social insurance contract (refers to treatment categorization) is significant for the determination of applicable treatment.

In our example, the evidence-based guideline with identification: EBG_id = '4450241' is not applicable, for the reasons of treatment incompatibility. Namely, in the past, Mrs. Haas has received a treatment with treatment_code = '920572', which is listed as problem treatment for this guideline.

The evidence-based guideline with identification: EBG_id = '4450242' is the best fitting guideline for Mrs. Haas's medical condition, so it is forwarded to the federated DWH.

In the last step, an OLAP tool presents the result to the clinician in an understandable and illustrative way.

5. RELATED WORK

Abidi et al. describe in [6] an Integrated Clinical Evidence System designed to augment the typical literature–based clinical evidence with additional technology-mediated clinical evidence. They propose a technology-enriched strategy to exploit advance computer technologies – knowledge management, data mining, case-based reasoning strategies and internet technology – within traditional evidence based medicine systems to derive all-encompassing clinical evidence derived from heterogeneous clinical evidence modalities.

The four steps in incorporating the best available research evidence in decision making is the subject of the research project in [9]. The authors formulate the following steps: asking answerable questions; accessing the best information; appraising the information for validity and relevance; and applying the information to patient care. Further, they state that applying evidence-based medicine to individual patients requires drawing up a balance sheet of benefits and harms based on research and

individual patient data. Wu et al. state in [8] that growing evidence indicates that the integration of clinical decision support into the computer-based patient record can decrease medical errors, enhance patient safety, decrease unwanted practice variation and improve patient outcomes. Clinical Pathways are the subject of research of Roeder et al., at the DRG Research Group at the Universitätsklinikum Münster [7]. They investigated 8 different international DRG-systems on the basis of data from cardiac surgery and concluded that the Australian AR-DRG-system excellently matches levels of complexity. Thus it provides a good basis for the German R-DRG-system, which will serve for the reimbursement of all in-patient cases, according to the German Ministry of Health.

A self-medication information system, which proposes to patients information and services on mild clinical signs and associated treatments, is illustrated in [17]. Given the simplified patient's electronic health record as input, an ontology is used to infer the right treatment proposal out of the self-medication knowledge base.

Integrating the Healthcare Enterprise (IHE) [18] is an initiative designed to stimulate the integration of the information systems that support modern healthcare institutions. It defines a technical framework for the implementation of established messaging standards to achieve specific clinical goals. The Cross-Enterprise Document Sharing (XDS) provides a general mechanism for sharing of documents between different healthcare enterprises. The main difference between IHE and our approach is that it does not facilitate statistical and in-depth analysis of clinical data, nor it offers pattern recognition capabilities.

6. CONCLUSION

The collaboration project for evidence-based medicine described in this paper merges data originating in a pharmacy database, a social insurance company database and diverse clinical DWHs. Our universal, simple and flexible common conceptual model enables potential future integrations of other health care organisations to be done seamlessly and with a minimum effort.

In this paper we showed, that a federated clinical DWH that facilitates evidence-based medicine is a reliable and powerful platform for production and dissemination of clinical knowledge. Knowledge originating from evidence-based medicine represents a valuable resource for healthcare policy makers. Integration of knowledge management into clinical decision support system enables strategic decision making for both clinical business management and for the caregivers at the point of care, which results in a better service for the patient, the medical personal and administrative staff.

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REFERENCES

[1] Sheth A.P., Larson J.A.: "Federated Database Systems for Managing Distributed, Heterogeneous, and Autonomous Databases", *ACM Computing Surveys*, Vol. 22 (3), ACM Press, New York, USA, 1990, pp. 183-236.

[2] Clifton C., Doan A.H., Elmagarmid A., Kantarcioğlu M., Schadow G., Suciu D., Vaidya J.: "Privacy-Preserving Data Integration and Sharing", *Proceedings of the 9th ACM SIGMOD Workshop on Research Issues in Data Mining and Knowledge Discovery (DMKD 2004)*, ACM Press, New York, USA, 2004, pp. 19-26

[3] Jindal R., Acharya A.: "Federated Data warehouse Architecture", Wipro Technologies white paper, 2004, http://hosteddocs.ittoolbox.com/Federated%20data%20Warehouse%20Architecture.pdf

[4] Kalra D., Singleton P., Ingram D., Milan J., MacKay J., Detmer D., Rector A., "Security and Confidentiality Approach for the Clinical E-Science Framework (CLEF)", HealthGrid 2004 Conference, *Methods of Information in Medicine*, Vol. 44 (2), 2005, pp. 193-197

[5] Stolba N., Tjoa A M.: *An Approach towards the Fulfilment of Security Requirements for Decision Support Systems in the Field of Evidence-Based Healthcare*, Knowledge Rights - Legal, Societal and Related Technological Aspects (KnowRight2006), Vienna, Austria, Austrian Computer Society, pp. 51-59, February 2006.

[6] Abidi S.S.R., Abidi S.R., "A Case of Supplementing Evidence Base Medicine with Inductive Clinical Knowledge: Towards Technology Enriched Integrated Clinical Evidence System", 14th IEEE Symposium on Computer-Based Medical Systems, (CBMS'2001), 26-27 July 2001, Bethesda (USA).

[7] Roeden N. et al., "Clinical Pathways", Medizincontrolling/DRG Research Group, Universitätsklinikum Münster, http://drg.unimuenster.de/de/behandlungspfade/cpathways_reisebericht.html

[8] Wu R., Peters W., Morgan M.W., "The next generation of clinical decision support: linking evidence to best practice", J Healthc Inf Manag 2002 Fall;16(4):50-5.

[9] Craig J.C., Irwing L.M., Stockler M.R., "Evidence-based medicine: useful tools for decision making", The Medical Journal of Australia [http://www.mja.com.au], MJA 2001; 174:248-253M. Young, The Techincal Writers Handbook. Mill Valley, CA: University Science, 1989.

[10] Stolba N., Banek M. and Tjoa A M., "The Security Issue of Federated Data Warehouse in the Area of Evidence-Based Medicine", ARES 2006, The First International Conference on Availability, Reliability and Security, April 20-22 2006, Vienna

[11] Sackett D.L., Rosenberg W.M.C., Gray J.A.M., Haynes R.B., Richardson W.S., "Evidence-Based Medicine: what it is and what it isn't". *British Medical Journal (BMJ)*, Vol. 312 (7032), 1996, pp. 71-72

[12] Beneventano D., Bergamaschi S., Guerra F., Vincini M.: "Synthesizing an Integrated [15] Ontology", IEEE Internet Computing Magazine, September-October 2003,42-51.

[13] Beneventano D., Bergamaschi S.: "Semantic Search Engines based on Data Integration Systems", In Semantic Web: Theory, Tools and Applications (Ed. Jorge Cardoso), Idea Group Publishing, 2006.

[14] Stolba N., Tjoa A M.: *An Approach towards the Fulfilment of Security Requirements for Decision Support Systems in the Field of Evidence-Based Healthcare*, Knowledge Rights - Legal, Societal and Related Technological Aspects (KnowRight2006), Vienna, Austria, Austrian Computer Sociaty, pp. 51-59, February 2006

[15] Pommerening K., Reng M., "Secondary Use of the Electronic Health Record via Pseudonymisation", *Medical and Care Compunetics 1*, Studies in Health Technology and Informatics, Vol. 103, IOS Press, Amsterdam, The Netherlands, 2004; pp. 441 - 446.

[16] Priebe T., Pernul G., "A Pragmatic Approach to Conceptual Modeling of OLAP Security", *Proceedings of the 20th International Conference on Conceptual Modeling (ER 2001)*, Lecture Notes in Computer Science, Vol. 2224, Springer Verlag, Berlin-Heidelberg, Germany, pp. 311-324.

[17] Curé, O.: *Ontology Interaction with a Patient Electronic Health Record*. In: Proc. Symp. Computer-Based Medical Systems (CBMS'05). IEEE Computer Society (2005) 323-32.

[18] IHE, http://www.ihe.net/Technical_Framework/, published on June 9, 2006, last checked on December 28, 2006.

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End User Computing and End User Development: Exploring Definitions for the 21st Century

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ABSTRACT

As end user computing continues to impact on businesses around the world, students in the fields of business and management need to be aware of how EUC and EUD impact on their future careers. This paper examines the plethora of definitions from the last 25 years of literature from a student and academic perspective and looks at how students have made attempts towards the development of clearer definitions for the future.

INTRODUCTION

End user computing (EUC) is a theoretical issue which came to prominence in the early 1980s with the introduction of personal computers (PCs) and has now become prolific throughout business due to the decreased cost of the available PCs and the introduction of "easy-to-use" software application generators such as the Microsoft ® Office Suite and the more freely available Open Source software. End user computing has been defined in many ways however the most often used definition is one which incorporates the facts that end user computing involves the interaction of managers, professionals and operational level users with application software within their own working departments (Torkzadeh & Doll, 1993).

A review of the literature has identified that much research over the past 25 years has been particularly in the areas of end-user satisfaction with information systems (not necessarily end-user developed), end-user computing in terms of the general use of computers, the development of spreadsheet applications by end-users, and the identification of who end-users are and the organisational areas which are affected by end-users (Rockart & Flannery, 1983; Brancheau & Brown, 1993; Powell & Moore, 2002). There has also been significant research published on the issues that impact on end-user development but little regarding how this can be addressed in the current technological environment.

Over this 25 year period there has been a significant change in the available technology (hardware and software), the introduction of technology into education increasing the computer literacy of the users and a change in the information technology culture within organisations (Rockart & Flannery, 1983; Brancheau & Brown, 1993; McBride & Wood-Harper, 2002). However, the changes in technology and use of technology do not appear to have been reflected in the ways that end user computing and end user development are defined. This paper explores the definitions developed in the past literature and works towards the development of a more concise and relevant definition for the future which reflects these changes.

BACKGROUND

The first papers relating to End-user Computing (EUC) were published in the late 1970s (McLean, 1979 and Codasyl report, 1979, as cited in Cotterman & Kumar, 1989). In the 1970s computing was identified with mainframe computers and end-user computing appeared to relate to one of three types of computer use: indirect use (where computing tasks were undertaken for the requester), intermediate use (where instructions were given by the person requesting the information as to the format the information would take) and direct use (where information was retrieved by the user using a terminal).

The introduction of PCs in the early 1980s lead to EUC being reported as '…a rapidly growing and irreversible phenomenon' (Alavi & Weiss, 1985, p6). The research into EUC has lead to a number of differing definitions being developed dependent upon the researcher's experience and how they classified end-users.

DEFINING END USERS

Rockart and Flannery (1983) identified that in order to understand EUC it is necessary to know who the users are, where they work and what they do. As part of this they developed six classifications of end-users dependent upon their function within the organisation. These classifications were:

- Non-programming end-user: have access to computerised data through simple menus or structured instructions
- Command level end-user: access data on their own terms. They are classified as being willing to learn just enough about the software to obtain the data required
- End-user programmers: develop applications for use by themselves and others in their department. They are able to undertake some programming using command and procedural languages.
- Functional support personnel: actively support end-users from within their own department. These persons have a sophisticated understanding of the software being used in the organisation.
- End-user computing support personnel: most commonly a formal support centre who have good general knowledge of most programming techniques.
- Data processing programmers: uses who are the most knowledgeable within an organisation of the end-user programming tools being utilised. (Rockart & Flannery, 1983)

The first three of these classifications relate primarily to non-information systems specialists who either: (1) use computers in their daily business to obtain information; (2) can use more complicated commands to filter information to obtain relevant and complex results and (3) use computer language (coding) to develop software applications for their own use (or for the use of others in their department). The remaining classifications relate to the classification of support personnel who are available to develop applications for users or to assist the users in their development and/or use of software applications. These classifications expanded upon those defined by the Codasyl report (1979, as cited in Cotterman & Kumar, 1979) by being more prescriptive with their definition of how the end-users interacted with the technology. Early researchers (eg Rockart & Flannery, 1983) reported on a producer/consumer dichotomy when it came to describing end-users whilst other researchers (Leithseier & Wetherbe, 1985 as cited in Cotterman & Kumar, 1989) reported on the comparison between the end-user operator and the end-user developer.

Leithseier and Wetherbe (1986) amended their research to include a third component, that of the amount of control that the manager or user has over the computer resources. According to Amoroso (1988) end users are defined as those that develop applications according to their needs in an environment where they have access to personal computers, data and support resources. This definition did not take into account the research of Leithseier and Wetherbe (1985, 1986) or Rockart and Flannery (1983) which outlined specific categories of end users and the tasks that they performed.

Cotterman and Kumar (1989) developed a taxonomy of end-users based upon this research. It was already apparent at this early stage in the research into end-user

computing that some end-users (ie non-Information Systems trained users) were undertaking some application development. It was identified in their paper that it is imperative to understand who the users are to ensure that each class of user is treated appropriately and that the relevant training, education and management approaches are used to assist them in their daily tasks. The development of the user cube taxonomy was undertaken using a morphological analysis technique, identifying known variables and parameters from current literature, developing an orthogonal structure and then testing the taxonomy by using the previous classifications of end users to see if they fit in the new structure (Cotterman & Kumar, 1989).

The User Cube has been recently reviewed in an attempt to operationalise the taxonomy and assist in the classification of todays, more knowledgeable, end users (Govindarajulu, 2003). This review determined that the User Cube was an excellent starting point for the classification of users by using the dimensions of operator, developer and controller. It also highlighted that the users did not necessarily fall neatly into one of the three dimensions but that there could be much overlap between the dimensions leading to the inevitable 'power user' who is conversant in all of the dimensions.

DEFINING END USER COMPUTING

Davis and Olson (1985, cited in Amoroso, 1988, p50) defined EUC 'as the capability of users to directly control their own applications and computing needs.' Amoroso (1988, p50) identified that 'end-user computing has further been described as an alternative development approach in which the user can avoid the traditional development complexities, time delays, and communication problems'.

In the early 1990s, Brancheau and Brown (1993, p439) reviewed the previous 10 years of research into end-user computing. They commenced their paper by defining end-user computing as the 'adoption and use of information technology by personnel outside the information systems department to develop software applications in support of organisational tasks'. This paper concentrated on the research into the management issues related to end-user computing and used the Rockart and Flannery (1983) classification of users as a basis for the research. Brancheau and Brown (1993, p 477) concluded that 'failure to build on prior EUC research and failure to rely on theoretical knowledge accumulated in key reference disciplines have been major obstacles to furthering our understanding of EUC management'.

At the same time as Brancheau and Brown were espousing their thoughts a broader definition of EUC was introduced. Rainer and Harrison (1993, cited in Downey & Bartczak, 2005, p3) defined EUC 'as the direct, individual use of computers encompassing all the computer-related activities required or necessary to accomplish one's job'.

According to Garavan and McCracken (1993) EUC is defined as the managerial and professional use of computer power as compared with clerical tasks which use the same computer hardware.

A more refined and succinct definition of end-user computing was then proposed by Chan and Storey (1996, p119) where they stated that 'end-user computing was the autonomous use of information technology by knowledge workers outside the IS department' and that EUC is an 'important part of organizational computing today'.

Powell and Moore (2002) picked up where Brancheau and Brown left off using similar research criteria. Since their study followed the same parameters it seems logical that they used the same definition of EUC as Brancheau and Brown however this definition is solely targeted at the "development of applications" and does not look at the use of applications developed for end users. This makes the focus of the research limited to management issues related to end user application development rather than an overall view of the organizational issues being experienced due to the general usage of computers in business.

Martin, Brown, DeHayes, Hoffer and Perkins (2005) define end user computing as an activity which involves implementing all the applications for different levels, such as supportive applications, personal applications and organizational systems. Downey and Bartczak (2005, p4) researched previous definitions and concluded that the most appropriate definition, for their study, was to define EUC as 'the use and/or development of computing technology and software applications by end users to solve organizational problems and assist in decision making'.

From an academic standpoint, the term end-user computing has traditionally been used to refer to the study of the management issues involved with providing services for non-specialist users of information systems. That is essentially anyone who is not an IT specialist who may be involved in developing or supporting systems (Chaffey & Wood 2005, p.558).

As can be seen the definitions of the past have been specifically designed to match the research being undertaken. It is the belief of the author that this is leading to serious confusion not only within the academic community but also with practitioners and managers as to what actually constitutes end user computing and consequently what actually needs to be managed.

DEFINING END USER DEVELOPMENT

Harrison stated that 'EUD is an activity that has been around almost as long as computers' (cited in Pickard 2005, p. 1). Many of the definitions of end user computing within the literature refer to development as part of the definition (Brancheau & Brown, 1993; Downey & Bartczak, 2005; Shah & Lawrence, 1996; Shayo, Guthrie & Igbaria, 1999). However, 'the actual term of end user development would refer however to a non-IT specialist creating their own applications to support their work' (Chaffey & Wood 2005, p.559). McGill (2005) takes the definition a little further by identifying that the development could not only support the end-user developer's work but also the work of other end users in the department or organisation.

From a software engineering perspective, EUD is said to mean, in general, the 'active participation of end users in the software development process' (Costabile et al 2005, p.1). End-user development activities are said to vary from "customization to component configuration" as well as programming, with Office software providing customization facilities and Web scripting said to provide interactivity tools for end-users of Web sites (Fischer et al, 2004)

Jawahar and Elango (cited in McGill 2005, p. 21-22) explicate that EUD of applications form a significant part of organisational systems development 'with the ability to develop small applications forming part of the job requirements for many positions.'

Sutcliffe and Mehandjiev (2004) state that EUD is about taking control, not only of personalizing computer applications (EUC) and writing programs, but of designing new computer-based application without ever seeing the underlying program code.

What can be gleaned from these literature definitions is that end user development is an important part of end user computing and that it can support not only the end user developer in their daily duties but also the duties of other end users in the department.

STUDENT PERCEPTIONS AND DEFINITIONS

Students undertaking a Master of Business (Administrative Management) degree program are required to study a course in Data Management which concentrates on the role of the end user (particularly at an administrative or middle management level) in the data and information management within the organisation. As part of the course the twenty two students were required to research the past definition of end user computing and end user development and then, using the research, propose a new set of definitions which brought the area of research into the 21st century.

To provide a definition of EUC requires an understanding of who the end-users of today are and how they interact with technology. The only difference between the eighties and now is that end user computing is no longer a unique concept confined to the office or a narrow field of study, but has reached the point where practically every task performed in the business environment has a connection to an information system and can therefore be potentially be classified as EUC. As long as technology is used in the workplace and people are expected to use information systems or technology to perform their job, then the final definition in this paper is the most contemporary and applicable. An attempt to narrow the definition denies the fact that technology has become so integrated in both the personal and professional lives of people in developed countries that we are practically all engaged in end user computing on some level. (Student C)

*Table 1. Number of student referrals to particular literature definitions (where total referrals >2) * - references given as part of the course reading materials; ** - course text book*

Reference	End User Computing Definition	End User Development Definition
Amoroso (1988)		3
Bocij et al (2003) *	5	2
Brancheau & Brown (1993)*	7	1
Chaffey & Wood (2005) **	6	5
Costabile et al (2005)		3
Cotterman & Kumar (1989)*	6	
Downey (2004)*	7	
Govindarajulu (2003)*	3	
Jawahar & Elango (2001)		4
McGill (2004)*		7
Powell & Moore (2002)*	4	
Rainer & Harrison (1993)	3	
Rockart & Flannery (1983)	3	
Sutcliffe & Mehandjiev (2004)*		6
Other	47 (from 37 different sources)	14 (from 11 different sources)

Students investigated a plethora of literature to inform their understanding of past definitions of the terms being investigated. Overall fifty eight resources (journal articles, textbooks and internet articles) were used in the development of this understanding. The most common sources are listed in Table 1.

Although the students predominantly cited definitions from literature that had already been sourced for them (either their textbook or required readings), many students were able to locate many other sources of literature which contained definitions of the terms under investigation.

Student B reflected the thoughts of the many of the students by commentingd that 'in the 21st century, EUC should consider as a group or an individual non-technical EU adopting any kind of information technology applications, including information generation and processing, web applications and multimedia approaches under a secure computing environment' While a few of the students were broader in their comments. These comments are best summed up by student C who stated that 'EUC in the twenty first century includes, everyone who uses information systems to deliver a service or develop solutions that provide an information output within an organisation.' Many of the students did not directly develop new definitions but chose to make comment on the definition that they believe best fit the requirements of the assignment. These students chose to reflect on the definitions from Chaffey and Wood (2005), Suttcliffe and Mehandjiev (2004) and Powell and Moore (2002).

Student D made some interesting observations by identifying that 'end user computing and development was now in the hands of the end users themselves, which arose from many reasons including wider use of cheaper and more powerful computers and more user friendly applications for example. Now end users have developed the skills to benefit from information technology much more than they had previously been exposed to during the early years.'

End-user computing and development is a widespread phenomenon; many organisations, despite their size and activity integrate it in their information strategy. The terminology has been subject to fundamental change resulted from technology advancements, change, organisational structures and the way we look at information and knowledge. The technology-based view has replaced by the humanised knowledge management focus. It has moved from being a tactical issue to be a major ingredient in organisation's information strategy. End-users now can respond quicker and more effective to problems due to the given control and responsibility. This can place the organisation on a leading edge, however, lack of training in the strategy and consequently poor development of applications can leave the organisation on a bleeding edge. (Student J)

Student G defined EUC in the 21st century as 'the resultant processing of data obtained and recorded by end users in conjunction with company objectives and overseen with company control.' This definition is quite interesting as it includes the end user as a primary part of the process rather than an outcome as found in the predominate literature of the past. However, in the opinion of the author, the most interesting definition of EUC offered by the students for the 21st century stated that 'end user computing is defined as the management of information technology systems and development, incorporating different levels of personnel to best pursue strategic objectives by facilitating organizational functional requirements' (Student V).

Very few of the students were able to determine a new definition for EUD which reflected the changes in technology and user expertise that have occurred over the past 25 years. Student B determined that '...a modified definition of the term EUD in the 21st century could define as a non-technical EU modified, generated or created customised application using existing IS and advancing technology, providing solutions to personal needs and demands'. On the other hand Student G postulated that 'EUD in the 21st century: the development of complex, server-based processing applications structured in conjunction with company objectives and designed for ease of use for the end users.' This is an interesting definition as it considers end user development as the development of applications for end users, not necessarily by end users. It is this definition that reflects the confusion being purported in previous literature and shows the need for a more definite, clear focus on the definitions of EUC and EUD.

Reflecting on the students' thoughts and attempts at defining the terms the author has developed new definitions for each of the terms. End User Computing (EUC) can now be defined as the use of computing technology and/or software applications, together with the enhancement and/or development of information systems by end users. On the other hand end user development (EUD) is, more specifically, the development, modification and/or enhancement of information systems applications by end users for individual, departmental or organisational use.

FUTURE RESEARCH

The literature of the past 25 years has given us plenty of definitions of end user computing and, to a lesser extent, end user development. The problem with this plethora of definitions is the confusion that can be caused when researching the topic. Researchers need to be aware of the exact context of each of the definitions and then attempt to relate the definition chosen to the context of their new research. Making an incorrect choice of definition could be disastrous as it could completely change the focus of the research being undertaken.

Students trying to understand the concepts of end user computing and end user development are also confused by the mass of slightly different definitions as can be seen in their attempts to redefine the terms given all of the background research.

Thus it is time for a more meaningful and direct definition of each term which will take us through the 21st century and all the possible changes in technology, user ability and technology use. The definitions proposed by the students are a good starting point however the time is now ripe for more in-depth studies of the perceptions and understandings of EUC and EUD in the practical arena with the opportunity to use these studies to finally propose serious 21st century definitions.

This research into the definitions of EUC and EUD forms the starting point for a more in depth look at end user computing and end user development in today's business environment being undertaken by the author. The key foci of this major project are the impacts of EUC and EUD on the business (from many perspectives) and the how management handles the plethora of end user applications being developed. By clearly defining the terms for the 21st century, the author believes that this future research will be easier to describe the terms to the participants which, in turn, will allow the results of the research project to be translatable into today's business environment.

PRACTICAL IMPLICATIONS

For the definitions to be of any practical use they must not only assist the academics in the contextualisation of their research but also allow end users and

managers alike to understand the concepts of EUC and EUD as they apply to their particular context. It will also give management the chance to develop policies and procedures in order to efficiently and effectively manage their personal who undertake end user development within their work environment.

CONCLUSION

This paper has shown that the plethora of definitions of EUC and EUD in the literature of the past has given rise to some serious confusing and misunderstanding by students and academics alike. In an attempt to dispel this confusion, students undertaking a Master of Business degree put forward their ideas and suggestions as to how these definitions could be better explained for the 21st century.

Although no one individual student was able to propose a new, more decisive description of these terms, the author has been able to use a combination of the literature with the student ideas to propose two new definitions which will be used to further the author's research in this field.

Although the author believes that these new definitions will hold in current and future business contexts the thoughts of Student V are pertinent and provide some indication of areas that need consideration when researching this area in the future.

Perhaps it is time to stop looking at the benefits of one group winning over the other and start looking more often at the benefits of both groups working collaboratively. In the end, in a society where development is most often driven by money, history tells us that the most cost effective option will probably endure. To this end the cost versus risk debate will go on until the risks on one end and the costs on the other are minimized. Once this point is reached the definition of end user computing may well look different again. (Student V)

REFERENCES

Alavi, M., & Weiss, I.R. (1985). Managing the Risks Associated with End-User Computing, *Journal of Management Information Systems, 2*(3), 5-20

Amoroso, D.L. (1988). Organizational Issues of End User Computing, *ACM SIGMIS Database, 19*(3-4), 49-58

Bocij, P., Chaffey, D., Greasley, A., & Hickie, S. (2003). *Business Information Systems: Technology, Development and Management for the e-business*, Prentice Hall, Harlow, England.

Brancheau, J.C., & Brown, C.V. (1993). The Management of End User Computing: Status and Directions, *ACM Computing Surveys, 26*(4), 437-482

Chaffey, D., & Wood, S. (2005). *Business Information Management Improving Performance Using Information Systems*, Pearson Education Limited, Essex, England.

Chan, Y.E. & Storey, V.C. (1996). The use of spreadsheets in organizations: Determinants and consequences, *Information & Management, 31*(3), 119-134

Costabile, M.F., Fogli, D., Mussio, P. & Piccinno, A. (2005). A meta-design approach to End-user development, in *Proceedings of the 2005 IEEE Symposium on Visual Languages and Human-Centric Computing*, IEEE Computer Society, 308-310

Cotterman, W.W. & Kumar, K. (1989). User Cube: A Taxonomy of End-users, *Communications of the ACM, 32*(11), 1313-1320

Downey, J.P. (2004). End User Computing Research Issues and Trends (1990-2000), *Journal of Organizational and End User Computing, 16*(4), 1-16

Downey, J.P. & Bartczak, C.A. (2005). End User Computing Research Issues and Trends (1990-2000) in *Advanced Topics in End User Computing, Volume 4,* (pp1-20) ed MA Mahmood, Idea Group Publishing, Hershey, PA, USA,

Fischer, G., Giaccardi, E., Ye, Y., Sutcliffe, A.G., & Mehandjiev, N. (2004). End-user development: meta-design a manifesto for end-user development, *Communications of the ACM*, *47*(9), 33-37

Garavan, T.N. & McCracken, C. (1993). Introducing End-user Computing: The Implications for Training and Development-Part 1, *Industrial & Commercial Training*, *25*(7), 8-14.

Govindarajulu, C. (2003). End Users: Who Are They?, *Communications of the ACM*, *46*(9), 152-159

Jawahar, I.M. & Elango, B. (2001). The effects of attitude, goal setting and self-efficacy on end user performance, *Journal of End User Computing*, *13*(2), 40-45

Leithseier, R.L. & Wetherbe, J.C. (1985). The successful information centre: what does it take? in the *Proceedings of the Twenty-first annual conference on Computer personnel research*, ACM Press, 56-65.

Leithseier, R.L. & Wetherbe, J.C. (1986). Service Support Levels: An Organized Approach to End User Computing, *MIS Quarterly, 10*(4), 337-349

Martin, E., Brown, C., DeHayes, D., Hoffer, J., & Perkins, W. (2005). *Managing Information Technology*, Pearson Education.

McBride, N. & Wood-Harper, A.T. (2002). Towards User-Oriented Control of End-User Computing in Large Organizations, *Journal of End User Computing*, *14*(1), 33-42

McGill, T. (2004). The Effect of End User Development on End User Success, *Journal of Organizational and End User Computing*, *16*(1), 41-58

McGill, T. (2005). The Effect of End User Development on End User Success in *Advanced Topics in End User Computing, Volume 4,* (pp21-41) ed MA Mahmood, Idea Group Publishing, Hershey, PA, USA

Pickard, M.M. (2005). Old issues, new eyes, in *Proceedings of the first workshop on End-user software engineering*, *30*(4), 1-3

Powell, A. & Moore, J.E. (2002). The focus of research in end user computing: where have we come since the 1980s?, *Journal of End User Computing, 14*(1), 5-22

Rainer, R.K. & Harrison, A.W. (1993). Toward development of the end user computing construct in a university setting, *Decision Sciences*, *24*(6), 1187-1202

Rockart, J.F. & Flannery, L.S. (1983). The Management of End User Computing, *Communications of the ACM, 26*(10), 776-784

Shah, H. & Lawrence, D. (1996). A study of end-user computing and the provision of tool support to advance end-user empowerment, *Journal of End User Computing*, *8*(1), 13-21

Shayo, C., Guthrie, R. & Igbaria, M. (1999). Exploring the Measurement of End User Computing Success, *Journal of End User Computing*, *11*(1), 5-14.

Sutcliffe, A. & Mehandjiev, N. (2004). End-user development: introduction, *Communications of the ACM*, *47*(9), 31-32

Torkzadeh, G. & Doll, W.J. (1993). The place and value of documentation in end-user computing, *Information & Management*, *24*(3), 147-158.

Business Process Improvement and Organizational Theory: The Missing Link

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ABSTRACT

The lack of a holistic methodology for Business Process Management has resulted in much confusion for organizations wishing to deploy Business Process Improvement projects. We argue that in order to provide some guidance for process improvement projects in particular, we can turn to existing organizational theories. Accordingly, we propose the use of organizational theories as an aid to identify critical elements in Business Process Improvement (BPI). Agency, resource-based view of the firm theory, and stakeholder theories are used for this purpose. An a-priori model is presented and shows top management involvement, process managers, staff and technical BPI capabilities, and alignment of key stakeholders' requirements as factors affecting achieved levels of BPI.

INTRODUCTION

When organizations embark on Business Process Improvement (BPI) projects, unnecessary non-value adding activities are eliminated, and core activities are improved in order to achieve higher levels of process efficiency and effectiveness. This outcome is achieved by optimizing a number of factors, such as decreasing time and/or cost of processes, increasing quality of processes or improving allocation of resources, while being attentive to the expectations of external stakeholders (Bhatt, 2000; Valiris & Glykas, 2004).

The market forecast for organizations continuing to invest in BPI projects is more bullish than anytime before (Gartner, 2006). Indeed, a recent survey by Wolf and Harmon (2006) found that 58% of the 348 completed surveys were from organizations that spent up to US$500,000 in 2005. Between 25-40% of these projects were focused on process redesign, with 53% of surveyed organizations indicating that their process management efforts, and associated funding, would be stepped up in 2006. However, anecdotal evidence also suggests that organizations are having much difficulty in identifying their processes, let alone being innovative enough to optimize them. Partly to blame for the difficulties faced by organizations is the lack of holistic and versatile methodologies for Business Process Improvement in academic literature as well as the lack of common consensus on what exactly BPM and BPI are and what they involve. In the first steps to developing a theory-backed set of guidelines to enhance the success for Business Process Improvement initiatives, we turn to existing organizational theories in order to investigate whether these can suggest what an organization must consider in order to increase the chances of their BPI initiative being a successful one.

Accordingly, this paper provides an expose of organizational theories that can be applied to the field of BPI in order increase levels of BPI success. We identify three theories in particular, *viz.* Agency Theory, Resource-based View (RBV) of the firm Theory, and Stakeholder Theory, and reason their applicability to this domain. The presented work forms a basis for an *a-priori* model for improving the process of BPI.

The paper is structured as follows. The next section aims to set the context of this work by defining two central terms, *viz.* business process and Business Process Improvement, and providing a brief overview. The following sections introduce and reason the three chosen theories. The paper then introduces a suggested model for improving BPI impacts and concludes with a discussion of limitations and future work.

BACKGROUND

The constantly changing hyper-competitive markets demand higher levels of organizational flexibility and performance (cost, time, and quality). In response to this need, the 1990s witnessed a breakthrough in organizational re-structuring. Organizations were shifted from their traditional function-based operations to new process- and cross-functional based operations (Giaglis, 1999).

Despite the relatively long period of time that BPI has been utilized, the term still has a wide range of definitions and interpretations (Valiris & Glykas, 1999). Larsen *et al.* (1997) and Jones (1994) state that the problem of having a wide range of synonym constructs of BPI also extends to having various definitions of the same construct. Until a common understanding of the terminology is achieved, improvement of processes will be hampered. Therefore, it is important to start by specifying some common definitions in this area.

Business Process

For the purpose of this paper a 'Business Process' is a logical entity made up of a set of ordered activities that may cross functional boundaries such as the procurement process. This logical entity requires input, adds value to this input, and produces an output to achieve a specific goal in the organization (Bal, 1998; Davenport, 1993; Harrington, 1995; Paul, 1987).

Business Process Improvement

In a relatively short period of time, studies have developed numerous explanations and identified steps on how to achieve BPI. The efforts however were not coordinated, and a large range of isolated understandings of BPI now exist. Contributions to the field of BPI, by academics and practitioners alike, can generally be categorized according to two broad dimensions, *viz.*, breadth and depth. The breadth dimension (scope) forms the foci of BPI, such as technical issues, functions, processes, organizational structure, and change management. Whereas the depth dimension focuses on the degree of change expected from BPI, ranging from simple incremental improvements to the more radical re-engineered change. Archer and Bowker (1995) named these variations in terminologies "aliases". Examples of the aliases of Business Process Improvement include "business process innovation" (Davenport, 1993), "core process redesign" (Hagel, 1993; Heygate, 1993), "business restructuring" (Talwar, 1993), "business transformation" (Buckler, 1998), and "process re-engineering" (Hammer & Champy, 1993). These alternative terminologies refer in one way or another to Business Process Improvement.

For the purposes of this paper, 'BPI' represents any of these aliases, and any other variation[1] that refers to the concept of processes and improvement of their performance and design. Furthermore, we accept that the degree of positive change resulting from a BPI initiative refers to any type of process-based improvement whether it is the result of a continuous incremental improvement or a more radical improvement such as business process re-engineering (BPR). Hence, we define BPI as the activity of reducing work processes to their essential elements, by selecting, analyzing, and improving business processes to achieve significant improvements in performance, i.e. cutting costs, increasing revenues, saving time, improving quality, etc.

ORGANISATIONAL THEORIES

The methodology used in this research aims at utilizing the capability of the theories to provide a holistic view of Business Process Improvement requirements. Deriving factors from previously established and proven theories provides a well grounded and comprehensive understanding of the factors and a set of already established measures. These measures in turn can be used to assess the effect of the identified factors that influence BPI levels. Valiris *et al.* (1999, p.73) highlight the effect that organizational theories can have on BPI by stating that "organizational theory methodologies add more elements to [BPI] by addressing the need to focus on… people (agents), their accountabilities, their roles, their interactions, their activities, and their use of available resources". In agreement with Valiris *et al.* (1999), we discuss, in the context of BPI, three organizational theories and how these theories may impact BPI outcomes. Agency theory (AT), resource based-view of the firm theory (RBV), and stakeholder theory (ST) are selected as relevant theories because they offer different organizational focus and understanding. Other theories might also be applicable in this domain, however we argue that the three selected theories have a significant potential impact on the level of achieved BPI outcomes.

Agency Theory

Sometimes called *the principal-agent problem*, agency theory is based on a fundamental premise that owners (principals) establish a relationship with managers (agents) and delegate work to them (Alchian & Demsetz, 1972). Principals and agents have different self-interests (Jensen & Meckling, 1976), which creates an agency problem and requires mechanisms to minimize the problem in each instance.

Eisenhardt (1989) differentiates between two different uses of agency theory – the positivist and the general approach. The positivist approach focuses mainly on the "principal-agent relationship between owners and managers of large, public corporations" (Berle, 1932). The more general approach, followed in this paper, is the 'Principal-Agent' relationship that introduces Agency Theory as the "theory that can be applied to employer-employee, lawyer-client, buyer-supplier, and other agency relationships" (Harris & Raviv, 1979). The general Principal-Agent relationship can be applied to all levels in the organization, thus, providing this study a wider and more relevant coverage

Eisenhardt's (1989) view of agency theory has several implications for BPI. First, agency theory assumes that the basis of the organization is 'efficiency' (Eisenhardt, 1988, 1989), which is one of the fundamental drivers of BPI. It is in the interest of managers to make sure performance within their organization is efficient. Second, cross-departmental changes, such as those resulting from BPI, can have both positive and negative impacts on organizational structures and performances and can be faced with strong opposition. It is therefore suggested that providing strong management involvement for newly introduced changes delivers a sense of obligation and provides incentives for subordinates to accept newly introduced changes. Therefore, we argue that:

H1: *Top management involvement in BPI projects achieves higher levels of BPI.*

Moreover, Yu and Mylopoulos (1994) identify three different types of agency dependency in BPI within the organization, namely: goal, task, and resource. In addition, they provide three different levels of agency relationship: general, committed, and critical, which depend on the degree to which the agent will be affected if the job fails. This general understanding of agency theory is also applicable in process-based organizations and translates into different levels of commitment and into chains of hierarchical responsibilities that establish accountability and control and thus assist in minimizing the agency problems associated with BPI change. Therefore, agency theory, through its understanding of the different interests of staff in the organization, is capable of explaining the rationale in assigning agents (process owners) to different processes as well as explaining the effects of their involvement in BPI projects. It is also argued that business process ownership provides both commitment and a wealth of knowledge to BPI projects.

H2: *A higher level of authority represented in a "process manager" (agent) over the whole process positively influences the level of improvement of the business process.*

Resource-Based View of the Firm Theory

RBV focuses on the internal characteristics and performance of the organization (Porter, 1991). The theory suggests that organizations have different types of resources that fall under two categories: (a) cooperative and strategic, and (b) competitive and financial. The theory is based on the assumption that firms have idiosyncratic, not identical strategic resources. Resources are not perfectly mobile and therefore heterogeneous (Conner, 1991; Wernerfelt, 1984). Thus, organizations are collections of resources, and the scarcer the organizational collection of resources the less the competitive advantage they actually hold.

Moreover, aside from resources, RBV theory also focuses on capabilities. Capabilities are accumulated knowledge in organizations resulting from using its existing resources in an efficient and effective way to achieve its final goals (Idris, Abdullah, Idris, & Hussain, 2003). Capabilities are divided into four main categories: functional differential, positional differential, cultural differential, and regulatory differential (Coyne, 1986). These capabilities develop from existing skills and experience (functional), as preferences of previous actions (positional), as a result of the perceptions of the individual of the organizational stakeholders (cultural), or from organizational policies and regulations (regulatory) (Hall, 1991). Therefore, in the context of BPI, the theory implies that an organization with a culture supportive of BPI, with existing process-based change regulations, and with previous experience in conducting BPI projects, will attain higher levels of BPI capabilities.

BPI shares common standpoints with RBV theory. The commonality is embedded in the belief that resources and capabilities of the organization are limited, thus, surviving organizations tend to use their resources in a cost-effective way. Functioning at optimum levels can lead organizations to create competitive advantage. Sustaining competitive advantage, however, may require continual improvements to differentiate themselves from competitors (Attaran & Attaran, 2004). Sustained competitive advantage is achieved when capabilities are able to produce value, are rare, are imperfectly imitable, and are exploited by the organization (Barney, 1991). Similarly, BPI's fundamental philosophy focuses on improving existing operations within organizations allowing them to use resources more efficiently and effectively (i.e. produce value), and provides tailored solutions to solve specific organizational problems (i.e. unique and imperfectly imitable) (Valiris et al., 2004). Sustaining competitive advantage is specifically related to the human and technical capabilities. Organizational capability in terms of staff with existing BPI-related experience and the ownership and exposure to a variety of technical BPI tools have a major impact on the final results of the BPI project. This accumulated experience has value, is hard to imitate, transfer or substitute and can be exploitable by the organization and thus creates 'sustainable competitive advantage' in accordance with RBV theory. Therefore, RBV theory and its competitive advantage sustainability are tightly related to BPI. Hence:

H3: *A higher level of existing BPI staff capability accumulated through previous experience with BPI has a significant and positive impact on achieving a higher level of BPI; and*

H4: *A higher level of existing BPI related technical capability in an organization has a direct positive impact on achieving a higher level of BPI.*

Stakeholder Theory

A stakeholder in general as defined by Freeman (1984, p.41) is "any group or individual who can affect or is affected by the achievement of the organization's objectives". Freeman (1984) traces the term 'stakeholders' back to the Stanford Research Institute in 1963 defining the term as "those groups without whose support the organization would cease to exist" (Donaldson & Preston, 1995, p.31). Stakeholder theory helps to improve the value of the outcomes of the stakeholder decisions by identifying the interests of various stakeholder groups and prohibiting them from being disadvantaged (Andriof, Waddock, Husted, & Rahman, 2002), ultimately resulting in greater returns to shareholders.

Modern businesses have become more transparent and accountable in order to meet their new, interactive and responsive relationships with stakeholders. Stakeholders should be defined through their legitimate interests in the organization rather than the organization's interest in them (Donaldson *et al*., 1995). Therefore, recognizing obligations to stakeholders helps organizations to become successful (Andriof et al., 2002). This idea is also heavily supported by the agency theory. *Stakeholder focus* is the effort expended by the organization intending to satisfy the majority of the key stakeholders (Idris *et al*., 2003). Key stakeholders in BPI are identified

in terms of the degree of reliance and interaction with the process to be improved. Thus, the larger the process the higher the number of key stakeholders involved. Clarkson (1995) affirms that persistence in dissatisfying principal stakeholders may cause the organization to fail. However, building a trust relationship can significantly lower costs, and therefore impact their performance (Barney & Hansen, 1994; Hill, 1995). The impact of key stakeholders is asserted in a variety of fields such as firms performance (Berman, Wicks, Kotha, & Jones, 1999), decision-making (Wood, 1991), and corporate social performance (Anderson, 1989).

Furthermore, this argument does not deal with the moral foundation of the stakeholder theory and the principle of fairness. The theory does not imply either that all stakeholders should be equally involved in processes (Donaldson *et al.*, 1995). The focus of this research is on the capability of the theory to accomplish multiple purposes although these purposes are not necessarily entirely congruent. Thus, the theory assists in identifying a mechanism to recognize cross points among the different requirements of key stakeholders in a BPI project.

While BPR literature recommends that executives and key staff members to be involved in BPI (Motwani, Kumar, Jiang, & Youssef, 1998), Davenport *et al.* (2004) discovered that less than 30 percent of organizations have achieved even limited information exchange with their suppliers and customers (who are also part of the key stakeholder vision). From the stakeholder theory perspective, BPI personnel should consult with affected key people throughout the different phases of the project (i.e. analysis, design, and implementation) and identify middle ground solutions.

In summary, stakeholder theory, in the context of BPI, suggests that recognizing and aligning key stakeholders' concerns can have a positive impact on the results of the project in particular and the organizational performance in general. This area is largely neglected in the field of BPI. Accordingly, we argue that identifying and aligning with the interests of various key functional based personnel, as well as other external key stakeholder groups, during a business process improvement project has a significant and positive impact on BPI projects' final results.

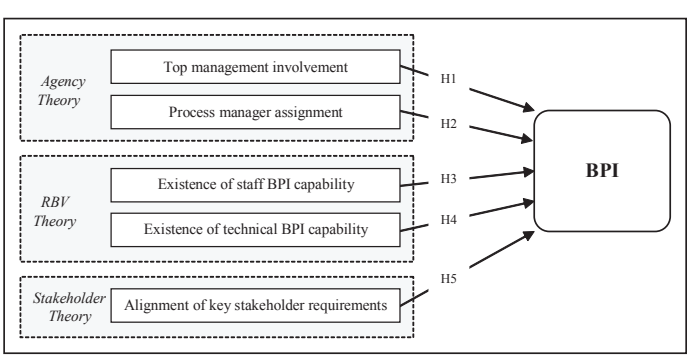
H5: *A higher level of alignment[2] of key stakeholder requirements throughout a BPI project positively enhances the final results of BPI.*

Increasing BPI Success Levels: A Theory-Based Model

Based on the hypotheses derived in the previous section, we derive a model that explains the factors that have a significant impact on the levels of achieved Business Process Improvement in organizations (see Figure 1). The model consists of five independent variables, *viz.* top management involvement, process manager assignment, existence of staff BPI capability, existence of technical BPI capability, and alignment of key stakeholder requirements, contributing to the achievement of higher levels of BPI results.

The empirical results from testing the model using both quantitative and qualitative methodologies will shed more light on a number of vital aspects in this field. First, the results will establish the potential capabilities of organizational theories in analyzing and solving BPI-based problems. Second, the results will show whether the theories are able, as we would expect, to forecast critical elements that can significantly advance the levels of BPI success. Finally, the approach will reemphasize the need maintain a well-built link at all times between theory and practice in any future BPI development.

Figure 1. A-priori research model



CONCLUSION

This paper provided a brief expose of the capability of organizational theories to identify and clearly explain a number of elements that are critical to ensuring better business process improvement. It is expected that deeper analysis of each of the theories will provide comprehensive insights and guidance to BPI. Therefore, we argue that creating a solid theoretical base for BPI will help identify more robust solutions and create strategic guidance to the professional development of Business Process Improvement, ultimately achieving better project outcomes.

The limitations of this work stem from the limited selection of theories chosen at this stage to explain factors that may affect BPI outcomes. Our future work in this area involves (1) identifying other potentially critical factors from the appropriate organizational theories through qualitative research theories such as semi-structured interviews with BPI experts, (2) empirically testing the *a priori* model and identifying any differences through an industry-based survey, and (3) identifying differences in the effect of the factors on various organizational contexts (e.g. industry, sector, size, culture, etc.).

The multi-method study will have an impact on theory and practice. First, it will add to the existing body of knowledge on organizational theory and its links to business process management in general. Second, the validated outcomes of the study are expected to be of significant interest to industry due to the current lack of guidance in Business Process Improvement, and Business Process Management in general (Indulska, Chong, Bandara, Sadiq, & Rosemann, 2006)

REFERENCES

Alchian, A., & Demsetz, H. 1972. Production, information costs, and economic organization. ***American Economic Review***, 62(5): 777-795.

Anderson, J. W. 1989. ***Corporate Social Responsibility***. New York: Quoram Books.

Andriof, J., Waddock, S., Husted, B., & Rahman, S. S. (Eds.). 2002. ***Unfolding Stakeholder Thinking: Theory, Responsibility and Engagement***. Sheffield, UK: Greenleaf.

Archer, R., & Bowker, P. 1995. BPR Consulting: an evaluation of the methods employed. ***Business process Re-Engineering & Management Journal***, 1(2): 28-46.

Attaran, M., & Attaran, S. 2004. The rebirth of re-engineering. X-engineering. ***Business Process Management***, 10(4): 415-429.

Bal, J. 1998. Process analysis tools for process improvement, ***The TQM Magazine***, Vol. 10: 234-354.

Barney, J. 1991. Firm resources and sustained competitive advantage. ***Journal of Management***, 17(1): 99-120.

Barney, J. B., & Hansen, M. H. 1994. Trustworthiness as a source of competitive advantage. ***Strategic Management Journal***, 15: 175-190.

Berle, A. 1932. ***The Modern Corporation and Private Property***. New York: Macmillan.

Berman, S. L., Wicks, A. C., Kotha, S., & Jones, T. M. 1999. Does stakeholder orientation matter? The relationship between stakeholder management models and firm financial performance. ***Academy of Management Journal***, 42(5): 488-506.

Bhatt, G. D. 2000. An empirical examination of the effects of information systems integration on business process improvement. ***International Journal of Operations & Production Management***, 20(11): 1331-1359.

Buckler, B. 1998. Practical steps towards a learning organisation: applying academic knowledge to improvement and innovation in business processes. ***The Learning Organization***, 5(1): 15-23.

Clarkson, M. B. E. 1995. A stakeholder framework for analyzing and evaluating corporate social performance. ***Academy of Management Review***, 20: 92-117.

Conner, K. R. 1991. A historical comparison of resource-based theory and five schools of thought within industrial organization economics: Do we have a new theory of the firm? ***Journal of Management***, 17(1): 121-154.

Coyne, K. P. 1986. Sustainable competitive advantage: what it is and what it isn't. ***Business Horizon***, 29(Jan/Feb): 54-61.

Davenport, T. H. 1993. ***Process innovation: Reengineering Work Through Information Technology.*** Boston, MA: Harvard Business Press.

Davenport, T. H., Harris, J. G., & Cantrell, S. 2004. Enterprise systems and ongoing process change. ***Business Process Management***, 10(1): 16-26.

Donaldson, T., & Preston, L. E. 1995. The stakeholder theory of the corporation: Concepts, evidence, and implications. ***Academy of Management Review***, 20: 65-91.

Eisenhardt, K. M. 1988. Agency- and institutional theory explanations: the case of retail sales compensation. ***Academy of Management Journal***, 31(3): 488-511.

Eisenhardt, K. M. 1989. Agency theory: An assessment and review. ***Academy of Management Review***, 14(1): 57-74.

Freeman, R. E. 1984. ***Strategic Management: A Stakeholder Approach.*** Cambridge, Mass: Ballinger Publishing Co.

Gartner. 2006. Growing IT's Contribution: The 2006 CIO Agenda. Egham, UK: Gartner Inc.

Giaglis, G. 1999. Focus issue on legacy information systems and business process change: On the integrated design and evaluation of business processes and information systems. ***Communications of the Association for Information Systems***, 2(5).

Hagel, J. I. 1993. Keeping CPR on Track, ***The McKinzey Quarterly***: 59-72.

Hall, R. 1991. The contribution of intangible resources to business success. ***Journal of General Management***, 16(4): 41-52.

Hammer, M., & Champy, J. 1993. ***Re-Engineering the Corporation: A Manifesto for Business Revolution.*** London: Nicholas Brealey Publishing.

Harrington, H. J. 1995. Continuos versus breakthrough improvement. Finding the right answer. ***Business process Re-Engineering & Management Journal***, 1(3): 31-49.

Harris, M., & Raviv, A. 1979. Some results on incentive contracts with application to educationand employment, health insurance, and law enforcement. ***American Economic Review***, 68: 20-30.

Heygate, R. 1993. Immoderate redesign, ***The McKinsey Quarterly***: 73-87.

Hill, C. W. L. 1995. National institutional structures, transaction cost economizing and competitive advantage: The case of Japan. ***Organization Science***, 6: 119-131.

Idris, F., Abdullah, M., Idris, M. A., & Hussain, N. 2003. Interacting resource-based view and the stakeholder theory in developing the Malaysian excellence model: a conceptual model. ***Singapore Management Review***, 25(2): 91-109.

Indulska, M., Chong, S., Bandara, W., Sadiq, S., & Rosemann, M. 2006. ***Major Issues in Business Process Management: An Australian Perspective***. Paper presented at the Australian Conference on Information Systems (ACIS 2006), Dec 6-9, Adelaide, Australia.

Jensen, M. C., & Meckling, W. H. 1976. Theory of the firm: managerial behaviour, agency cost, and ownership structure. ***Journal of Financial Economics***, 3: 305-360.

Jones, M. R. 1994. Don't Emancipate, Exaggerate: Rhetoric, Reality and Reengineering. In R. Baskervile, S. Smithson, O. Ngwenyama, & J. I. DeGross (Eds.), ***Transforming Organisations with Information Technology***. North-Holland, Amsterdam.

Larsen, M. A., & Myers, M. D. 1997. ***BPR success or failure? A business process reengineering model in the financial services industry***. Paper presented at the International Conference on Information Systems.

Motwani, J., Kumar, A., Jiang, J., & Youssef, M. 1998. Business process reengineering: a theoretical framework and an integrated model. ***International Journal of Operations & Production Management***, 18(9/10): 964-977.

Paul, G. A. 1987. ***Quality Process Management***. Englewood Cliffs, NJ: Prentice Hall.

Porter, M. E. 1991. Towards a dynamic theory of strategy. ***Strategic Management Journal***, 12(Summer Special Issue): 95-117.

Talwar, R. 1993. Business re-engineering - a strategy-driven approach. ***Long Range Planning***, 26(6): 22-40.

Valiris, G., & Glykas, M. 1999. Critical review of existing BPR methodologies. ***Business Process Management***, 5(1): 65-86.

Valiris, G., & Glykas, M. 2004. Business analysis metrics for business process redesign. ***Business Process Management***, 10(4): 445-480.

Wernerfelt, B. 1984. A Resource-based View of the Firm. ***Strategic Management Journal***, 5(2): 171-180.

Wolf, C., & Harmon, P. 2006. The State of Business Process Management: BPTrends Online.

Wood, D. J. 1991. Corporate social performance. ***Academy of Management Review***, 16(4): 691-718.

Yu, E., & Mylopoulos, J. 1994. ***Using goals, rules, and method to support reasoning in business process reengineering***. Paper presented at the 14th Hawaii International Conference on Systems Science, San Diego, CA.

ENDNOTES

[1] *This assumption aligns with authors such as Kock and McQueen (1995), Archer and Bowker (1995), Weerakkody and Hinton (1999), McAdam (1996), Rohleder and Silver (1997), and Povey (1998), to name a few.*

[2] Alignment: recognition, analysis, and identification of solutions for clashing requirements.

A Purposeful Framework for IS

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ABSTRACT

This paper highlights the need for theories in IS that assign a key role to the influences of human intentionality. Ulrich's (1983) critical systems heuristics and activity theory both satisfy this requirement. A model based on the combination of these two theories is developed and explored in some detail. The background and description of Ulrich's (1983) critical systems heuristics is presented first and then the integration of activity theory with Ulrich's (1983) approach is examined within the context of IS. It is argued here that the combination of these two theories provides a powerful conceptual tool with practical applicability in the range of areas covered by the domain of IS.

1. INTRODUCTION

Gregor (2006) advocates an increased focus on theory development in IS and promotes the idea of integrating different theory types in order to strengthen the theoretical base within the discipline. Ghoshal (2005) contends that the current base of "bad" management theories is having a profound negative influence on management practices and describes how the underlying assumptions of causal determinism and deductive reasoning have permeated theories developed in and applied to the various management related fields. According to Ghoshal (2005), theories based on scientific models that do not include any role for human intentionality lead to a lack of morality and ethics which can, at least partially, explain some of the recent corporate collapses in the United States. Similarly, Gregor (2006) calls for theories that address the omission of causal reasoning commonly found in theories associated with logical positivism. Von Hayek (1989), Ulrich (1983) and Churchman (1979) also point out the potential dangers of using scientific models to analyze social phenomena.

This paper presents a theoretical framework based on the integration of activity theory and Ulrich's (1983) critical systems heuristics. The core strength of the framework arises from the significant role it attributes to human intentionality. Ulrich's (1983) framework would be classified in Gregor's (2006) taxonomy of theory types as a Type V theory which can be used for design and action. Activity theory qualifies as a Type II theory based on its explanatory power. It is argued here that the combination of the two theories results in a powerful conceptual tool for the design and evaluation of information systems in their organizational settings. The critical systems heuristics framework (Ulrich, 1983) encourages system designs that focus on the contribution of the people involved in and affected by the system. Activity theory highlights the role of tools (such as information and technology) and community in the information systems context and provides a more detailed framework for characterizing an organization's activities and the relationship between IS and business activities. In terms of contribution to a general conceptual framework for IS, the model presented here provides practical guidelines for IS research and practice based on theories that give prominence to the key role of human intentionality.

The basic premise of the purposeful systems approach (Ulrich, 1983) is that human activity systems should be seen as social systems, in contrast to theories that take a mechanistic or organic view. Ulrich (1983, p.334) defines a purposeful system as follows:

*"S [is] a purposeful system if S is **self-reflective** with respect to its own normative implications, seen from the point of view not only of the involved, but also of the affected, and if S has at least partial **autonomy** in determining its client, its purposes, etc."*

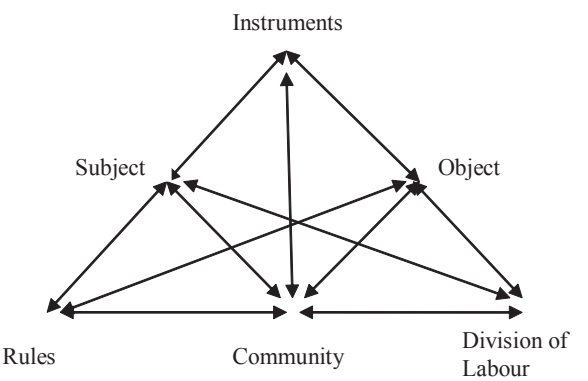
So, if an organization is viewed as a purposeful system, there will be some opportunity for all participants to reflect on the organization's purpose and to choose actions in relation to that purpose. This view of an organization can be contrasted with a mechanistic view where the role of participants is to perform specified duties in support of a well defined purpose. No opportunity is afforded to participants to question or contribute to the definition of goals. Employees mechanically perform specific roles. An organic view of an organization can be distinguished from a mechanistic conception in that employees have some control over how they perform their roles and achieve specified goals. However, no involvement in the definition of goals is supported. Employees decide **how** they will go about their jobs, but have no influence in relation to **what** they are expected to achieve or **why** it is important.

In terms of IS, both organizations and information systems can be seen as purposeful systems and Lewis (2002) highlights some of the potential benefits of applying Ulrich's (1983) framework in this context. Ulrich (1983) argues that the task of the social system designer is to facilitate critical reflection and motivation of those involved in the system, whereas the task of the designer of a mechanistic system is to define, codify and control the optimum configuration of the system. Dietz (2003, p.205) criticizes mechanistic approaches that don't *"do justice to the social character of human beings"*. Ghoshal and Bartlett (1995) point out that the underlying problem with traditional management approaches is in their objective *"to create a management system that minimize(s) the idiosyncrasies of human behavior"*. Ulrich's (1983) purposeful systems approach addresses these criticisms by providing a set of guidelines that encourages the contribution of all stakeholders potentially involved in and/or affected by a system.

Hasan (2002, p.30) proposes that activity theory is a good candidate *to "span and integrate the breadth of the field of IS providing it with unity and identity"*. Consistent with Ulrich's (1983) framework, activity theory also assigns a key role to the influence of human intentionality. As shown in Figure 1, activities are carried out by subjects in order to produce an object and/or outcome using instruments, according to rules and with a division of labor as defined by the associated community. In addition to the key role of human intentionality, activity theory also provides a framework for considering the use of tools and the influence of community which play an important role in any information system. Activity theory suggests that activities can be improved by exploring 'contradictions' within the activity. Incorporating this suggestion with Ulrich's (1983) guidelines for purposeful systems design enables the practical application of the theoretical framework in a range of areas covered by the domain of IS.

The next section will cover the purposeful systems approach in some detail, including its philosophical basis, an outline of how a purposeful system can be seen as a set of problem-solving processes and finally, a set of categories that can

Figure 1. Activity theory framework – adapted from Hasan (2002)



be used to define the various interests of stakeholders either involved in and/or affected by the system. The following section will highlight how activity theory constructs can be used to augment and extend the approach for the IS context. The proposed model uses activity theory to represent the set of problem-solving processes associated with purposeful systems in more detail and to define the link between information systems, their design and their use in a business context. The final section will begin to explore potential areas of application in IS and will also look at possible areas for further research.

2. THE PURPOSEFUL SYSTEMS APPROACH

2.1 Philosophical Basis

Ulrich (1983) developed the purposeful systems approach in order to provide a conceptual framework for critical social inquiry and design. The intent of the approach is to provide a set of guidelines for rational social planning that will help planners to avoid the drawbacks of contemporary, scientific systems approaches. Ulrich (1983) argues that contemporary approaches to planning suffer shortcomings because of their underlying scientific, reductionist assumptions. In the domain of social reality, these assumptions can mask the inherent human interests that are served by the system. In order to overcome these shortcomings, Ulrich (1983) maintains that a rational approach to social planning should expose the underlying assumptions that affect the design and operation of the social system being planned for. The purposeful systems approach addresses this by combining Kantian a priori science with a reinterpretation of the systems approach and applying the combination to the domain of social reality. The critical intent of Kant's philosophy and the practical heuristics provided by systems theory combine to form a powerful tool for assisting with rational social planning.

Social planning, which involves the activities of social inquiry and design, is basically about making choices that improve a particular social system. In the domain of IS, both the organization and the information systems that support the organization's activities can be seen as social systems. Ulrich's (1983) framework is meant to assist with planning activities and to make clear whose interests are being served by the improvements made to the system. Ulrich (1983) endeavors to translate Kant's a priori science from the domain of physical reality to the domain of social reality in order to develop a conceptual tool for thinking about social systems. Combined with this, the systems idea is used to identify components of the system that cannot be completely specified or controlled i.e. to clarify the boundaries of the system. This improves understanding of the whole system leading to opportunities for enhanced designs.

In Kant's development of a priori science, the domain of interest is physical reality. For social planning, the domain of interest is social reality. Within the domain of physical reality, the constructs of space and time are critical for thinking about the domain. For social reality, Ulrich (1983) proposes that the parallel concept for thinking is human intentionality, including self-consciousness, self-reflection and self-determination. Nothing can be understood within the domain of social reality without reference to human intentionality. In Ulrich's (1983) purposeful systems approach the construct of human intentionality is pervasive and is referred to as a "mapping dimension" used to define our conception of the social reality in question.

According to Ulrich (1983), Kant characterizes human thinking as having two fundamental components – reason and understanding. The principle of reason is used to reflect on understanding and can be used to reflect on and expose the underlying assumptions in any social system design. Reason itself has two components – theoretical reason that helps to understand "what is" and practical reason that questions "what ought to be" and incorporates the manifestation of free will. Ghoshal (2005, p.81) also identifies these aspects of thinking as important and points out that if we were to give up our reliance on scientific theories *"Business could not be treated as a science, and we would have to fall back on the wisdom of common sense that combines information on "what is" with the imagination of "what ought to be" to develop both a practical understanding of and some pragmatic prescription for "phenomena of organized complexity"".* Reason can be used to resolve conflicts that might otherwise be decided based on the prevailing distribution of power. Using the principle of reason to reflect on understanding is a difficult task and the guidelines provided by Ulrich (1983) are designed to assist with this task. The guidelines are also meant to ensure that the interests of all relevant parties are represented in the process. Without a set of guidelines to ensure rational planning, there is a risk that the objectives served by the system will not be representative of all those involved in and/or affected by the system.

2.2 Purposeful Systems & Problem-Solving Processes

According to Ulrich's (1983) definition as given in Section 1, the two significant aspects that characterize a purposeful system are the capabilities of self-reflection and partial autonomy. Dewey's (1997, p.6) definition of reflective thought is: *"Active, persistent and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it, and the further conclusions to which it tends."* Therefore, in a purposeful organization employees and broader members of society affected by the operation of the organization will continuously question the organization's vision, the underlying assumptions that support its validity and the implications of pursuing the vision. The mandate for partial autonomy of the system implies that the design of a purposeful organization will support and encourage participants to reflect and pursue actions based on this reflection.

Ulrich (1983) claims that every purposeful system must perform three types of problem-solving processes: inquiry, action and valuation processes. In terms of an organization as a purposeful system, inquiry processes are those that produce knowledge about the purpose (vision/mission) of the organization. Action processes define how the knowledge is put to use and valuation processes are those that facilitate reflection on how the production and use of knowledge affects all those who work and live with the system. These three problem-solving dimensions can be used to assess the purposefulness of an existing system, or to design a purposeful system. A purposeful system implements inquiry, action and valuation processes that encourage reflection and contribution by all those involved in and/or affected by the system.

2.3 System Boundaries

The final aspect of Ulrich's (1983) framework which is of interest here is a set of critically-heuristic categories of pragmatic mapping. These categories help to operationalize the definition of a purposeful system. For example, they help to identify who represents "the involved" vs. "the affected" and they assist in evaluating the capabilities of self-reflection and autonomy inherent in the system. The categories arise out of the systems conception of social reality – specifically by exploring the boundaries of the system in relation to those involved in the system and those affected by it. Ulrich (1983) developed the formulation of categories by asking questions about who might be involved or affected by the system, what their concerns might be and what implications each group and their concerns might have for the planner. The categories provide the planner with a framework for developing criteria to evaluate his/her conception of and design for a social system.

The boundaries of a social system can be explored by investigating four different groups of stakeholders. These include those who provide sources of motivation for the system, those who represent sources of control, those who act as sources of expertise, and those who represent sources of legitimation. An investigation of the roles and concerns of these four groups will help to surface, or make explicit, any underlying assumptions associated with a system's design. The investigation should use reason to reflect on understanding of the system by asking questions about 'what is' and 'what ought to be' in relation to each group.

So, for instance, in relation to the first group – sources of motivation – questions to be asked would include who the client is, what the purpose of the system is and how the success of the system can be measured. For the second group – sources of control – the questions would explore who the decision makers are, what they are able to control and what falls outside their domain of control. The third category – sources of expertise – would involve questions about who the designer is, what type of expertise is required and how the design can be evaluated. The final group to be considered – sources of legitimation - is meant to represent those affected by the system who do not contribute to its design or operation. Since this is such a potentially large and diverse group, a representative category of witness takes on the role of legitimizing the system. This category is concerned with emancipation of the affected. These categories should be kept in mind when 'designing' an organization and planning and developing information systems. The planner's task is to reflect on these categories in order to critically develop a comprehensive system design. Using reason to reflect on these categories of understanding suggests asking questions about "what is" and "what ought to be".

So, for example, questions should be asked about who actually plays the roles in each category as opposed to who should ideally be playing the roles.

It should also be mentioned that Ulrich (1983) envisions a process of discourse that would ensure reason is used to resolve conflicts and that the views of the affected are adequately represented. The philosophical basis for the practical discourse is derived from Kant's a priori science combined with Habermas' communication model. The discursive process would use the four categories above as a guideline for deciding whose views need to be represented in the discourse and would be designed to expose underlying assumptions in a system's design. Underlying assumptions are reflected in implicit boundary definitions which can be made explicit in a discourse following the guidelines outlined above. It is important to note that the goal of the dialogue would be to increase awareness of a design's implications and not to reach a consensual agreement between all of the groups. The discursive process will not be explored further in this paper. For the moment, it will be assumed that the onus is on the planner / system designer to consider the implications of his design for all of those involved and/or affected. The conditions required to ensure that the discourse occurs in an open environment with the appropriate participants would be an interesting avenue for future research.

3. INTEGRATING ACTIVITY THEORY FOR THE IS CONTEXT

The previous section detailed Ulrich's (1983) purposeful systems approach and highlighted how an organization can be viewed as a purposeful system with associated inquiry, action and valuation problem-solving processes. This section will incorporate activity theory constructs into the approach in order to provide a more detailed conception of an organization's processes / activities and to characterize the link between these activities and the information systems that support them. The basic components of activity theory are shown in Figure 1 and have been highlighted in an earlier section.

Each of the problem-solving processes described previously (inquiry, action and valuation) can be viewed as an activity and characterized by the components of activity theory as diagrammed in Figure 1. So, for example, an organization that manufactured shoes would have inquiry processes to determine how to manufacture better shoes, action processes to put this knowledge to use in the manufacturing process and valuation processes to reflect on the implications of the manufacturing process for all those involved in and affected by the process. Using activity theory to model these processes ensures consideration of the instruments used in the process, the community involved in the process and the rules that govern the process.

Information systems can be seen as activities in their own right. The object of an information system is to provide information which can be used to support business activities. Referring to Figure 1, if an information system is modeled using activity theory, the object on the right side in the middle of the triangle would be the information which then flows into the apex of the business activity triangle where it is used as an instrument to support that activity. Using activity theory to model business processes and their supporting information systems provides a method of characterizing the link between the two. When information systems are modeled as a separate activity, recognition is also given to the fact that the rules and community for the information system activity are not the same as the rules and community of the associated business activity. Taking this conceptualization one step further, information system design can be seen as an activity which produces an information system which is then used as an instrument in the ongoing activity of the information system.

In terms of Ulrich's (1983) purposeful systems approach, if an organization is viewed as a purposeful system, then the ongoing activities of an organization are its problem-solving processes which can be classified as inquiry, action and valuation processes. Activity theory can be used to model each of these processes and to define the link between these business processes and their associated information systems. Note that although the supporting information systems would then be viewed as separate triangles for each type of business process, they would not necessarily be distinct information systems in practice. The final step in applying the model within the IS context requires information systems professionals and business professionals to consider the concerns of the various groups of stakeholders when designing, enacting or evaluating information system activities (including information system design) and business activities or processes. This would require the categories described in Section 2.2 with associated interests to be considered in the context of the various business activities and their associated information systems.

4. POTENTIAL APPLICATIONS AND FUTURE RESEARCH

This paper has so far argued that a purposeful systems approach based on the combination of Ulrich's (1983) taxonomy of purposeful systems and activity theory would be a useful contribution towards a general conceptual framework for the IS discipline. The question as to how this approach can be specifically applied to the various areas of IS still remains. The framework would seem to fit naturally with research in the area of knowledge management given the classification of processes into inquiry, action and valuation processes that produce knowledge, use knowledge and reflect on the use of knowledge in support of organisational objectives. Lewis (2002) discusses the application of Ulrich's purposeful systems framework to Alavi's (2000) classification of knowledge management systems and concludes that the guidelines presented in the framework could be used to help with the design and development of knowledge management systems based on Alavi's (2000) network model.

Lewis (2004) also highlights the potential benefits of using the combined model, as presented here, to address issues related to strategic alignment. The ability to explicitly characterise the link between IS and business activities while modelling information systems activities and their environmental influences independently from the associated business activities offers opportunities for improved understanding of strategic alignment. The framework would also seem to have a natural fit with the area of business process management. Characterizing business processes as inquiry, action and valuation processes in support of an organization's purpose provides a conceptual link between **what** a business does (the processes or activities) and **why** (the purpose / vision or mission of the organization).

This paper has presented a theoretical framework with support for the particular orientation of the framework and some indication of its applicability in different areas of IS research and practice. Potential applicability in three areas was highlighted - knowledge management, strategic alignment and business process management. The diversity in these three areas helps to justify the suitability of the framework as a general conceptual tool for the discipline. This paper represents preliminary work which will form the basis for a larger research project in which empirical validation of the appropriateness and usefulness of the approach will be the next step. The main focus here has been to provide a detailed description of the framework and to highlight why it should be considered as a contribution towards a general conceptual framework for IS. The main strengths of the framework arise from its underlying philosophical focus on human intentionality combined with the practical nature of the guidelines it offers for the design and evaluation of human activity systems including organizations and information systems.

REFERENCES

Alavi, Maryam 2000, "Chapter 2 - Systems for Managing Organizational Knowledge" in *Framing the Domains of IT Management: Projecting the Future Through the Past*, R.W. Zmud and M.F. Price (eds.), Pinnaflex Educational Resources Inc., Cincinnati, pp. 15-28.

Churchman, C. West 1979, *The Systems Approach and Its Enemies,* Basic Books, New York.

Dewey, J. 1997, *How we Think*, Dover Publications, New York.

Dietz, Jan L.G. 2003, "Generic Recurrent Patterns in Business" *in Lecture Notes in Computer Science*, vol. 2678, van der Aalst, Wil M.P., ter Hofstede, Arthur H.M., Weske, Mathias (eds.) Springer-Verlag, Berlin Heidelberg New York, pp. 200-215.

Gregor, Shirley 2006, "The Nature of Theory in Information Systems", *MIS Quarterly,* vol. 30, no. 3, pp. 611-642.

Ghoshal, Sumantra 2005, "Bad Management Theories Are Destroying Good Management Practices", *Academy of Management Learning & Education,* vol. 4, no. 1, pp. 75-81.

Ghoshal, Sumantra, Bartlett, Christopher A. 1995, "Changing the Role of Top Management: Beyond Structure to Processes" *Harvard Business Review* Jan/Feb95, vol. 73, issue 1, pp. 86-96.

Hasan, H. 2002, "Information Systems as Dialectic, Tool-Mediated Activity", *Australian Journal of Information Systems,* December, Special Issue, pp.30-39.

Lewis, G. 2004, "Strategic Alignment: A Purposeful Perspective" *proceedings of the 9e Colloque de l'AIM,* INT Evry, France, May 26-28.

Lewis, G. 2002, "Systems Thinking About Purpose", *Australian Journal of Information Systems,* December, Special Issue, pp.50-58.

Ulrich, Werner 1983*, Critical Heuristics of Social Planning,* John Wiley & Sons Ltd., Chichester, England.

Von Hayek, F.A. 1989, "The Pretence of Knowledge" (Nobel Lecture), *American Economic Review,* December: 3-7.

Critical Success Factors for Mobile CRM: A Research Framework

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ABSTRACT

The past few years have seen a rapid development and momentous growth in mobile technologies and their diffusion into societies worldwide. The concept of Mobile Customer Relationship Management (mCRM) has emerged, as a one-to-one marketing strategy focused on services built for individual customers in an increasingly mobile world. However, the experience of many organizations, which deployed a Customer Relationship Management (CRM) strategy in the late 1980s and early 1990s, has left them sceptical. To address this, we propose that a Critical Success Factor (CSF) study of mCRM is both relevant and timely. In this paper, we establish the need for such a study and present a research framework.

INTRODUCTION

Globalisation of markets and the emergence of electronic business channels, enabled by the Internet, have resulted in a marketplace driven by consumers. During the late 1980s and early 1990s, to improve customer lifetime value (Reichheld 1995) and build market share in the consumer driven marketplace, many organizations invested in Customer Relationship Management (CRM) - a business strategy enabled by information technology (Peelan 2005). Following the dot.com bust and economic downturn, however, organizations confronted with the rationalisation of investment in electronic channels began questioning CRM initiatives. In the face of such scepticism and to provide guidelines for future deployment, studies on critical success factors or CSFs for CRM emerged (Williams and Ramaprasad 1996; Gordon 2002; Croteau and Li 2003). These studies proved crucial for organizations, which were confronted with investment optimisation to achieve long-term success.

While organizations are still coming to terms with the investments in CRM, in the past few years the marketplace has been subject to a radical paradigm shift. Consumers are becoming increasingly mobile, and therefore they have come to demand personalised services, anytime, anywhere (Nelson et al. 2003). This shift has been a consequence of the rapid diffusion and acceptance of mobile technologies and services in the world markets. For example, mobile subscriptions rose from 739 million at the end of the year 2000 to 2,168 billion at the end of the year 2005 (World Telecom Indicators 2006). The latest IDC reports reveal that the shipment of mobile devices in the second quarter of 2006 alone touched 20 million units (IDC 2006).

In order to meet the needs of the consumer market, the concept of mobile CRM (mCRM) has emerged as a one-to-one marketing strategy that focuses on services built for individual customers in a mobile world (Nelson et al. 2003). However, other than industry based success stories (Picarille 2004; Compton 2004; PA Consulting Group 2001), which are arguably vendor biased and the optimism of some commentators (Omatseye 2001; Pastore 2001), there are no rigorous critical success factor studies of mCRM to help organizations rationalise what will be yet another investment. In addition, the rapid evolution of mobile technologies and uncertainties regarding 3G-network diffusion, together with recent legal disputes surrounding patents (e.g. BlackBerry), understandably renders some organizations reluctant to deploy mCRM. Nevertheless, a metamorphosis from CRM to mCRM may well already be apparent (Nelson et al. 2003) because mCRM has the potential to become the future of CRM. Encouraged by the efficacy of CSF studies in CRM, we argue that the time is now appropriate for a CSF study of mCRM. This paper presents a research framework for a study of Critical Success Factors (CSFs) for Mobile Customer Relationship Management (mCRM) building on constructs identified in earlier CSF studies of CRM.

LITERATURE REVIEW

A review of related domains and the proposed CSF method is required as a precursor to the design of a research framework appropriate to the proposed study. In this section, we present an evolutionary review of developments from CRM to mCRM, highlighting links and differences. We also present some highlights from the existing CSF studies that have been influential in CRM deployments. Following this, we present a brief review of the method outlined by Rockart (1979) for undertaking critical success factor studies, to illustrate its application in the context of our proposed study.

Customer Relationship Management

Customer relationship management emerged in the late 1980s (Chen and Popovich 2003), as a business strategy, which enables organizations to realise the value of customer retention and to develop in a consumer driven global marketplace. It is a cross-functional, customer driven, technology integrated business process management strategy that maximises relationships, spanning an entire business. Underpinning this strategy is the concept of relationship marketing (Sheth and Pavatiyar 1995) and customer lifetime value, leading to return on investment. For example, studies by Reichheld (1995) demonstrate that even 5 percent increases in retention can deliver impacts as high as 95 percent on the net present value of customers.

CRM systems link front and back office functions via technology applications, with a business customer's touch points including Internet, email, sales, direct mail, telemarketing, call centres, advertising, pagers, stores, kiosks etc (Chen and Popovich 2003). During the second half of the 1990s, the deployment of CRM as part of an integrated eBusiness push was seen as a potential source of operational cost savings. For example, a call centre was able to service clients when there is non-availability of sales staff after hours, at significantly lower costs. Post the dot.com bust, however, businesses began to realise that automating processes, in particular by facilitating business-to-client (B2C) communication, is not sufficient to retain existing or to attract new customers. Some existing CRM implementations were observed to fail to yield expected benefits (Kotorov 2003). The fear of losing long term sustained market share to competition was compounded with a need for economic rationalisation of technology related investments, including CRM.

In the CRM context, critical success factors (CSFs) are those key factors that must be achieved for the success of CRM (Williams and Ramaprasad 1996). CSF studies have been used as a method to help organizations realise the full potential of CRM deployments in the boom period and to rationalise investments in the post dot.com bust period.

Amongst the major CSF studies of CRM reported in the literature are those of Williams and Ramaprasad (1996) conducted prior to the economic downturn and Gordon (2002) and Croteau and Li (2003), post the dot.com bust. These researchers have applied the concept of critical success factors, as described by Rockart (1979), to conceptualise, classify or categorise CSFs for CRM. They have, however, used various methods to elicit the CSFs, including combinations of literature/industry reviews, surveys, statistical analysis and extending technology adoption frameworks. In summary, the CSFs highlighted in the above studies are as presented in Table 1, in descending order of significance.

During the boom period, Williams and Ramaprasad (1996) identified that management commitment is crucial to CRM success, as it reduces resistance to the change that was required when CRM was implemented. Post the dot.com

Table 1. CSFs for CRM

CSF1	Management Support
CSF2	Knowledge Management Capabilities
CSF3	Perceived Operational and Strategic Benefits
CSF4	Actual Return on Investment (ROI)
CSF5	Organisational Readiness
CSF 6	Technical Awareness

downturn, Gordon (2002) elicited four CRM CSFs, based on an examination of best practices in 35 US and Canadian corporations. These four CSFs focussed on technology, people, processes and knowledge/ insights. While Gordon (2002) did not specify any particular order of significance, *management commitment and knowledge/insights* were highlighted as major CSFs.

Croteau and Li (2003) is arguably the recent work in the elicitation of CSFs for CRM. In a comprehensive literature review, and extending the work of Iacovou et al. (1995) on the technology based framework, they categorised five CSFs: CRM impact; perceived operational and strategic benefits; top management support; organisational readiness; and knowledge management capabilities. *CRM impact* refers to the actual ROI from CRM investments, rather than perceived benefits. While *management support* remained a crucial CSF, the *knowledge management capabilities* of the organization emerged as a significant CSF (Croteau and Li 2003:18).

CRM to mCRM

As pointed out in the introduction, we are now at a point in time when customers are demanding personalised services, when and where they need them (Nelson et al. 2003). The diffusion of mobile technologies into everyday life has been the major facilitator of this apparent shift -- which has the potential to change perspectives in relationship marketing (Sheth and Pavatiyar 1995). In the meantime, organizations which are apparently becoming cautious of technology related investments (Bull 2003) are searching for new ways of optimising their resources and have realised that deploying mCRM within their organizations might enable sales and service personnel to become more efficient:

"Mobile CRM has emerged as one of the more critical factors for success in today's competitive environment. In fact, the use of mobility, whether for the enterprise's field force or for servicing customers, will change the traditional approach of engaging customer relationship." (Tong 2004)

Peppers and Rogers (1999) view CRM as a one-to-one marketing process, which emerged from the deployment of sales force automation tools, augmented by advances in enterprise software technologies. Christopher et al. (1991) note that CRM has its roots in relationship marketing, with its emphasis on winning new customers, via the management of cost effective relationships, fostered by field personnel, namely the sales/service force. Conversely, the focus of mCRM is on field force personnel.

PeopleSoft (2002), which presented a comprehensive business case for mobile CRM, highlights the role of the sales force. They are of the opinion that an information gap exists in the traditional CRM life cycle. While sales people manage their notes, information, task lists etc in an organiser, mobile phone or handheld device, field technicians develop their own systems for managing schedules, for taking notes or tracking inventory. The result is that valuable information remains in an ad-hoc form, of which only part gets entered into enterprise-wide CRM systems at the end of the day or week. This information gap then translates into an inability of sales/service staff to address queries quickly. In the event of an employee leaving or being off-shored on a contract, the gap widens. Mobile CRM can address this gap by linking employees instantly into the enterprise-wide framework. Information is instantly transferred from field personnel's devices on to the organization's database.

PA consulting group (2001) has had concurrent deployments of CRM and mCRM and have already achieved success in enabling online access to customer information via the handheld mobile devices of their field personnel. Cingular Wireless in the US improved its interaction with its growing field sales force after successful deployment of mobile CRM in 2004 (Compton, 2004). MCRM helped Smith and Nephew, a provider of medical devices and surgical implants to orthopaedic surgeons at nearly 10,000 US hospitals to give hands-on service (Picarille 2004). Pitney Bowes Inc recently invested USD 20 million in mCRM (Solheim 2005) which has proven to be a cost efficient way of managing 1800 service personnel in real time.

The key to mCRM applications lies in connecting employees and their employers, in particular in developing and enhancing business-to-employee (B2E) sales applications, which was set to grow from USD 70 million in 2000 to USD 1.3 billion in 2005. While both CRM and mCRM are customer relationship focussed strategies, mCRM is apparently more useful in connecting front line personnel to the organization.

The pervasiveness of mobile devices such as phones and PDAs, and the increasing bandwidth available to these devices, via third generation mobile phone networks might also be critical to the success of mCRM. This may, however, be offset by apprehensions regarding 3G network diffusion and the legal patent disputes that the BlackBerry maker faced in 2005, in addition to media speculations and the volatility of the environment, rendering organizations sceptical about mCRM. As Beal (2005) pointed out, for years commentators predicted mCRM was ready to take off, only to be disappointed. To address this scepticism, and encouraged by the usefulness of CSF studies in CRM, we propose a comprehensive and structured study for eliciting CSFs for mCRM.

Toward CSFs for mCRM: A Proposed Study Using Rockart's Approach

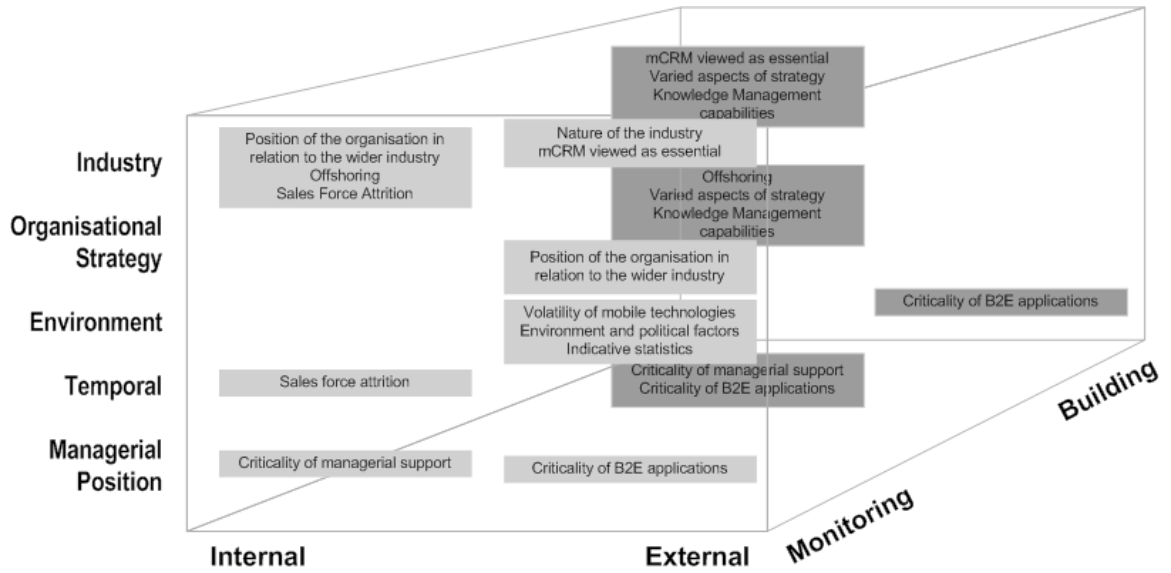
We acknowledge that the CSFs for CRM that were derived from previous studies (see Table 1) may be relevant to mCRM, in particular given their common roots in relationship marketing. However, given its apparent focus on the sales force and its dependence on *technologies* and *the environment*, we anticipated that additional CSFs may emerge for mCRM. Conversely, the CSF studies for CRM seem to have followed varied methods that may not be appropriate to establishing CSFs for mCRM. For example, none of the previous studies of CRM specifically take into account the need to investigate the *environment, political and economic sources* that may well be crucial to understanding the mCRM context. To study mCRM, therefore, we propose to revisit the three-step method, as prescribed by Rockart (1979), which explicitly takes all these influences into consideration.

Rockart (1979) offered a method to provide information to top management, based on Critical Success Factors (CSFs) or the 'few key areas where things must go right'. Specifically, CSFs were the limited number of areas in which satisfactory results will ensure successful competitive performance for the individual, department or organization. The basis of this method was a study conducted for eliciting the information needs of managers in three supermarkets situated in different geographical locations. The study revealed that depending on the manager's situation, organizational or industry context, the CSFs could differ.

The approach is particularly relevant to mCRM, as it provides guidance to managers in understanding where to focus their attention and assists in prioritizing investment decisions. Bullen and Rockart (1981) suggested there are five sources for an organization to consider when identifying CSFs: *the industry, the organization's strategy and industry position, the environment, temporal factors and the managerial position.*

The *industry* related sources are probed to identify a set of CSFs that are determined by the characteristics of the industry itself. For example, Rockart's initial study on the supermarket industry found that managers in each supermarket should be concerned about product mix, inventory, sales promotion and price. Conversely, each *organization* within any industry has its own unique characteristics, determined by its own history and current competitive strategy. *Environmental* factors are those that an organization has limited control over, including national politics, fluctuations in the economy, population trends and regulatory trends, which can contribute to CSFs. *Temporal* factors are those areas of activity within an organization that are critical for a short period of time. A crisis that results from the loss of a large number of executives in an air crash is perhaps a good example.

Figure 1. Potential mCRM CSFs in the Rockart model



Managerial position refers to those generic CSFs associated with the functions of management.

Bullen and Rockart (1981) then presented a useful classification of CSFs according to three dimensions: (a) the above five sources; (b) internal vs external; and (c) monitoring vs building. These are shown in a model adapted to present our conceptual framework (Figure 1). The *internal vs external* dimension refers to the fact that every manager will have internal and external factors that affect their team. Internal factors may relate to matters within managerial control while external factors may pertain to situations such as the availability of raw material that affects production, which falls outside managerial control. The *monitoring* dimension refers to CSFs that involve continued scrutiny of existing situations. Often these relate to actual performance versus budget, personnel turnover rates, or current status of product costs. The *building* dimension refers to those CSFs that involve the role of managers who spend time involved in change management or the implementation of new programs.

Thus, Rockart's model for conceptualising the CSFs takes into account various sources, augmented by multidimensional perspectives for CSF classification. Given the characteristics of mCRM discussed earlier, we argue that Rockart's framework may well prove appropriate to conceptualising and classifying possible CSFs for mCRM.

The three-step method as outlined by Rockart consists of an introductory workshop, interviews within the organization/s and a focus workshop. This paper is restricted to the presentation of the conceptual framework, which will be a preliminary step prior to the implementation of this method.

THE RESEARCH FRAMEWORK

In the proposed investigation of CSFs for mCRM, we revisit Bullen and Rockart's (1981) classification of CSFs according to three dimensions: (a) the five sources (industry, organisational strategy, environment, temporal, and managerial position) (b) internal vs external; and (c) monitoring vs building (see Figure 1). As such there are 20 cells in this classification scheme (5 by 2 by 2).

As a starting point, the six CSFs extracted from the appraisal of the extant literature on CSFs for CRM (see Table 1) were placed into the classification scheme. These were arguably limited to *organisational strategy* and *management support* sources and could be classified as *internal*, embracing both *monitoring and building*. However, we argue that for eliciting CSFs for mCRM, the perspective of the *nature of the industry, its relative position, environment related factors and temporal factors* are necessary. Subsequently, in Figure 1, we provide additional CSFs identified from the discussion of mCRM that can be used to seed a study that extends previous studies of CRM to the world of mCRM.

Specifically, the figure presents the three-dimensional view based on Rockart's classification model. Each of the cells relates to potential CSFs as could be extrapolated from existing CRM related CSFs as well as from the literature. Visibly, there are some overlapping dimensions. For example, mCRM may be viewed as essential to the *organisation* and thus become a CSF. However, the source of this CSF could be *industry* or the *organisation*. Specifically, if the *industry* at large regards mCRM is becoming essential to the organization, it becomes an *externally* motivated CSF, which needs to be *monitored*. Conversely if the organisation also feels that mCRM is essential for the success of the organization, it becomes a CSF that is *internally* motivated and that which an organization will *build* on. Offshoring is a CSF, which seems to have the potential to encompass all the dimensions. Managerial support is of *internal* orientation, but can be of *monitoring /building* dimension.

While Figure 1 is representative of these overlaps as well as 12 of the identified mCRM related CSFs. Table 2 supports the figure, mapping the sources against identified CSFs and their dimensions making it clearer that the sources can be varied for each CSF. At this time, we have only highlighted some of the potential CSFs identified to show the existing gaps that could not be addressed via CRM CSFs. For example, it is clear that all CRM CSFs were internally oriented, while there are a number of potential *external oriented* CSFs for mCRM identified. As the study progresses, more CSFs may emerge and some of the potential ones may merge together to form one CSF. The model as such with its 20 cells may or may not be completely filled with the mCRM CSFs.

Nevertheless, the usefulness of the Rockart model is evident due to its wider coverage of sources and dimensions that could well be relevant to mCRM, given its dependence on the environment, industry and technological factors. Thus, we establish that the model provides a complete structural framework for the proposed study.

CONCLUSIONS AND OUTLOOK

In this paper we have argued that with the development and diffusion of mobile technologies, customers are demanding personalised services when and where they need it. To address this, mCRM has emerged as a one-to-one marketing strategy and is often considered as an extension of CRM. However, organisations are reluctant to deploy a new strategy, given that CRM is yet to realise its complete value.

Table 2. Sources Vs identified CSFs/dimensions

Sources	Identified Potential CSFS and Dimensions
Industry	• Nature of the industry (External/Monitoring) • mCRM viewed as essential to the organization (External/monitoring) • Position of the organization in relation to the wider industry (Internal/Monitoring or External/Monitoring) • Offshoring (External/Monitoring)
Organization Competitive Strategy and Industry Position	• Varied aspects of organisational strategy (Internal/Monitoring and building) • Position of the organization in relation to the wider industry (Internal/Monitoring or External/Monitoring) • mCRM viewed as essential to the organization (Internal/building) • Organisational readiness and awareness of new technologies (Internal/Monitoring or Building) • Knowledge management capabilities (Internal/Monitoring and Building) • Influence of mergers/partnerships (External/Building) • Perceived and actual ROI (Internal/Monitoring and building) • Sales force attrition (Internal/monitoring or building) • Offshoring (Internal or External/Monitoring and building)
Environment	• Volatility of the mobile technologies (External/monitoring) • Changing consumer behaviour (External/monitoring) • Regulatory decisions within the telecom and mobile environments (External/Monitoring) • Economic/Political factors (External/monitoring) • Apprehensions surrounding mobile networks (External/monitoring) • Legal disputes in mobile environment (External/monitoring) • Indicative statistics (External/monitoring)
Temporal	• Sales force attrition (Internal/monitoring) • Offshoring (Internal/External and Monitoring/building)
Managerial Position	• Criticality of managerial support (Internal/Building or Monitoring) • Managerial support directed or participative with sales force (Internal/Building) • Criticality of B2E applications (External monitoring/building or Internal building) • Criticality of change in perspective to promote participation (External monitoring/building or Internal Building)

To address the scepticism of organisations and encouraged by the usefulness of CSF studies for CRM, we proposed a CSF study for eliciting potential mCRM CSFs, using the Rockart (1979) three-step process, adapting his conceptual model for the proposed research framework. We revisited Bullen and Rockart's (1981) classification of CSFs, presented as a model, classified according to three dimensions: (a) the five sources (industry, organisational strategy, environment, temporal, and managerial position) (b) internal vs external; and (c) monitoring vs building, for building a conceptual research framework as a percusor to this study, which is presented in the paper.

As a starting point, the six CSFs extracted from an appraisal of the extant literature on CSFs for CRM, were situated in the classification scheme, to make the gaps apparent. Further the potential CSFs identified from a comprehensive literature review were placed into the framework – emphasising the need to validate mCRM related CSFs. Based on this conceptual framework, we propose to undertake a study for eliciting mCRM CSFs initially in the healthcare sector.

REFERENCES

Beal B, 2005, "Mobile CRM gets a move on", *Mobile Computing News*, 7th December.

Bull C, 2003, "Strategic issues in CRM implementation", *Business Process Management Journal*, 9(5), pp 592-602.

Bullen C, Rockart JF, 1981, A primer on critical success factors, *Sloan School of Management Working Paper Series,* CISR no.69, Sloan WP no 1220-81, pp 1-64.

Chen IJ, Popovich K, 2003, "Understanding customer relationship management (CRM) – People, Process and Technology", *Business Process Management Journal*, 9(5), pp 672-688.

Christopher M, Payne A, Ballantyne D, 1991, *Relationship marketing,* Butterworth-Heinemann, Oxford.

Compton J, 2004, "Mobile CRM seals the deal for Cingular", *Customer Relationship Management,* November, pp 49-50.

Croteau AM, Li P, 2003, "Critical Success Factors of CRM technological initiatives", *Canadian Journal of Administrative Sciences*, 20(1), pp 21-34.

Gordon I, 2002, "Best practices: CRM", *Ivey Business Journal*, November/December, pp 1-5.

Iacovou C, Benbasat, I, Dexter AS, 1995, "Electronic data interchange and small organisations: Adoption and impact of technology", *MIS quarterly*, 19(4), pp 465-485.

IDC, 2006, "Converged Mobile Device Shipments Hit Record High in Second Quarter", September 13th, *Tekrati Research News*, Industry Analyst Report, URL http://ce.tekrati.com/research/News.asp?id=7806, Last accessed 14th October 2006.

Kotorov R, 2003, "Customer relationship management: strategic lessons and future directions", *Business Process Management Journal*, 9(5), pp 566-571

Nelson III HMW, Nelson A, Reaves KN, 2003, "Is MCRM the future of CRM?", URL: http://www.sbaer.uca.edu/research/dsi/2003/procs/392-7310.pdf, Last accessed 14th October 2006.

Omatseye S, 2001, "Mobile CRM growth to soar", *RCR Wireless News*, 20th August, 20(34), p11.

PA Consulting Group, 2001, "Mobile CRM – customer value at your fingertips", *White Paper*, 23rd May.

Pastore M, 2001, "mCRM future lies in B2E", *Wireless*, July 18th, URL: http://gt.clickz.com/stats/sectors/wireless/article.php/803831, Last accessed 14th October 2006.

Peelan E, 2005, *Customer Relationship Management*, Prentice Hall, Pearson Education, UK.

PeopleSoft, 2002, "The business case for mobile CRM: opportunities, pitfalls and solutions", *White Paper Series*, February.

Peppers D, Rogers M, 1999, The one-to-one manager, *Real world lessons in CRM*, Doubleday, NY.

Picarille L, 2004, "Mobile CRM helps Smith and Nephew Reps Give Hands-On Service", *Customer Relationship Management*, February, p 53.

Reichheld FE, 1995, The Loyalty Effect, The Free Press, New York.

Rockart, JF, 1979, "Chief executives define their own data needs," *Harvard Business Review*, 57(2), pp 81-93.

Sheth JN, Pavatiyar A, 1995, "Relationship marketing in consumer markets: antecedents and consequences", *Journal of Academy of Marketing Science*, 23(4), pp 255-271.

Solheim S, 2005, "Pitney Bowes: CRM for Customers and Workers", *eWeek*, February 28th, URL: http://www.eweek.com/article2/0,1895,1770630,00.asp, Last accessed 14th October 2006.

Tong A, 2004, "Winning Factors", *CIO Magazine*, URL: http://www.cio-asia.com/ShowPage.aspx?pagetype=2&articleid=723&pubid=5&issueid=41, Last accessed 14th October 2006.

Williams J, Ramaprasad A, 1996, "A taxonomy of critical success factors", *European Journal of Information Systems*, 5(5), pp 250-260.

World Telecom Indicators, 2006, Statistics, *ITU ICT Eye*, URL: http://www.itu.int/ITU-D/icteye/Reporting/ShowReportFrame.aspx?ReportName=/WTI/CellularSubscribersPublic&RP_intYear=2005&RP_intLanguageID=1, Last accessed 14th October 2006.

Agile Approaches to Software Maintenance: An Exploratory Study of Practitioner Views

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ABSTRACT

Whilst there has been some research into the application of agile approaches to the world of software maintenance, in this paper it is argued that there has not been a coherent investigation that focuses on the collection and analysis of the views and perceptions of agile software maintenance approaches held by experienced software maintenance professionals. In this paper, we report such an exploratory investigation, which has seeded the development of a simple framework for classifying collected views and perceptions. Specifically, a matrix framework has been introduced, to facilitate comparison of the levels of understanding of the issues affecting an agile adoption decision, and the extent to which an agile approach has been implemented. Examples of organizations operating in all four cells of this matrix have been presented.

Keywords: Software Maintenance, Agile Methods, Software Development

INTRODUCTION

Software maintenance has been long-recognized as placing before IT management a critical challenge (Martin & McClure, 1983). Indeed, it can be argued that maintenance decisions can be more critical to system users than decisions taken during software development. Further, with the ever-increasing rate of software development the burden of maintenance increases. Previously developed systems must be maintained to ensure their value and sustainability within an organization. Martin & McClure (1983, p.3) defines software maintenance as "an activity which imposes changes to a software system after its release to the user or customer" and provides varied rationale including: correction of errors, improving the overall design, interfacing a program to other programs and making necessary enhancements.

Many potential solutions or "silver bullets" have been proposed over the years to ease the burden of software maintenance, some boldly proclaiming a dramatic reduction of the burden. While the adoption of some of the "silver bullets" has addressed aspects of maintenance efforts, the burden of maintenance still remains (Bennett, 2000; April et al., 2005). April et al. (2005) even argues that the maintenance burden has been compounded by some of the proposed solutions.

Agile approaches have emerged as a challenge to the status quo as they propose a substantially different, radical philosophy and process for developing software. They are a collection of methodologies, processes and tools for the creative process, that anticipate the need for flexibility and apply a level of pragmatism to the delivery of a finished software product. They seek to deal with the limitations of traditional development approaches, especially the inability to cope with an unstable and rapidly changing requirements environment.

Whilst there has been some research into the application of such agile approaches to software maintenance, we argue that there has not been a coherent investigation that focuses on the collection and analysis of the views/perceptions of agile software maintenance approaches held by experienced software maintenance professionals. In this paper we report such an exploratory investigation, which has seeded the development of a simple framework for classifying aspects of the collected views and perceptions - a framework that may well underpin future studies.

BACKGROUND

In order to situate the present research it is necessary to explore the definitions of both maintenance and agile approaches.

The term "maintenance" has been used since the early 1960s to describe the delivered modification of software on an implemented system. Terms such as "change" or "modification" commonly described activities carried out by personnel participating in the original development, while maintenance usually implies the involvement of personnel who were not party to the original development (Chapin et al., 2001). As maintenance becomes increasingly complex, (including modifications and announcements, adaptive modifications, changes reflecting shifts in processing and environments), a more sophisticated definition of software maintenance is required. Sousa and Moreira (1998, p. 265) in part address this when stating that software maintenance can be viewed as "the modification of the software product after its delivery to the customer, to correct errors, to improve its performance or other attributes, or to adapt the product to a modified environment". For our purposes this is a suitably broad definition.

It is interesting to note that compared to the software development process, research into the maintenance of software is comparatively sparse (April et al., 2005). This may well be a consequence of the so-called software cost "iceberg" (Chapin et al., 2001). Costs and issues associated with software development are explicit and visible. Software maintenance costs surface gradually, later in the system lifecycle, and as such are less visible to management. This has been long argued. Swanson (1976) for example suggests that the metaphorical "iceberg" infers that "much goes on here that does not currently meet the eye, and further that our ignorance in this regard is, in a sense dangerous". Software maintenance is performed in response to software failures, environmental changes and in response to change requests made by users. These activities can be classified as Corrective Maintenance, Adaptive Maintenance and Perfective Maintenance. Yip (1995) suggests that the maintenance component could be as high as 70-75 percent of the overall life cycle cost. In the light of these figures it is perhaps surprising that software maintenance is often overlooked and that it has not been subject to the same intensive research as the software development process.

Of the research reported, a driving focus has been the role of maintenance as a means of resolving software failure (Dekleva, 1992). In addressing this, however, there have been many foci of research interest, including: the quality of the software and its documentation (Lientz & Swanson, 1981; Dekleva, 1992; Yip, 1995; Sousa & Moreira, 1998); coordination and management (Lientz, 1983; Yip, 1995, Sousa & Moreira, 1998); testing of software modifications (Dekleva, 1992; Martin & McClure, 1983); and the domain-specific nature of software (Sousa & Moreira, 1998). To address some of these problems a number of approaches have been proposed, including the adoption of technologies such as relational databases, fourth generation programming languages, object-oriented programming techniques, structured programming techniques, reuse of modules, metrics and computer-aided software engineering environments. All of these technologies, activities and processes have the capacity to reduce, in part at least, the burden of software maintenance.

It is important, however to recognize that the above address only a subset of identified maintenance problems. In order to facilitate a holistic approach to

software maintenance some researchers (e.g. Svenssen & Höst, 2005; Poole & Huisman, 2001; Schuh, 2001) have suggested that agile approaches may have something to offer.

"Agile" or "light weight" software development approaches have emerged over recent years. Proponents suggest that these approaches are revolutionary, and as such have stimulated passionate debate within the industry. The core characteristics and benefits of agile approaches are their emphasis on highly engaged and frequent communication between project participants and clients. This facilitates frequent and intuitive releases of products, which can be evaluated immediately. A further characteristic is the claimed reduction in price to produce quality products in a short period of time, without having to resort to short cuts (Avison & Fitzgerald, 2003). Examples of agile software development approaches include: eXtreme Programming (XP); Scrum; Feature Driven Development (FDD); and Crystal (Beck, 1999; Cockburn, 2002).

As a means of characterizing such approaches, the Agile Alliance (2006) has enunciated the core values underpinning agile approaches, as:

- A means of uncovering better ways of developing software by doing it and assisting others to do it;
- Valuing individuals, interactions, working software, customer collaboration and responding to change as items of most value to practitioners or teams who apply an agile approach; and
- Such considerations are valued over other considerations such as processes, tools, comprehensive documentation, contract negotiation, and the strict adherence to a plan.

Agile approaches have also been characterized in terms of the techniques/methods that typically feature, including: *Incremental Development*; *Time Boxing; MoSCoW Rules; JAD workshops; Prototyping; the roles of Sponsor & Champion; and the adoption of supporting Toolsets* (Avison & Fitzgerald, 2003).

AGILE APPROACHES AND SOFTWARE MAINTENANCE

Lientz (1983) identifies the user-oriented nature of software maintenance as one of the most critical challenges facing IT management. The advocacy of constant and timely communication, coupled with ready feedback and iterative releases, by proponents of agile approaches may, as such, be advantageous to software maintainers. Maintainers can seek to address problems through collaboration and communication with users, thus reducing the potential to introduce further problems (Cockburn, 2002).

Agile approaches as an alternative to the traditional waterfall approach in maintenance have been studied by several researchers. E.g. Poole and Huisman (2001) demonstrate that an agile approach, XP, might be introduced into an organization as a maintenance tool. However they have identified a strong correlation between effectiveness and customer commitment to communicate with the maintenance team. Schuh (2001) suggests, however, that agile approaches might not be a blanket solution to problems faced by the development and maintenance functions. Svenssen and Höst (2005) reinforce this view in their empirical study, suggesting that agile approaches need to be adjusted or adapted to suit an organization's circumstances and situation, and that following each of the processes suggested verbatim can be a recipe for disaster.

Studies conducted thus far have, in a sense, focused upon technical and procedural activities and benefits, as opposed to building a realistic understanding of how the broader philosophy of agile approaches might assist software maintainers and users. We argue that there is a gap in substantial research, capturing the views and perceptions of front line maintenance staff as to the potential capacity of agile approaches to assist them in the performance of their day-to-day software maintenance activities. The present study describes an exploratory study that lays the groundwork for addressing this gap.

RESEARCH APPROACH

To identify practitioners' views and perceptions of the applicability of agile approaches to maintenance, and to understand the factors that influence those views and perceptions, we chose an exploratory, qualitative research approach, administered through face-to-face semi-structured interviews. Eight participants were chosen from a pool of maintenance practitioners, working in some seven different organizations. All practitioners were working as maintenance officers and had at least two years experience – some substantially more. Due care was taken to ensure a range of different systems were represented, thus avoiding domain or software-specific selection. Participants came from organizations of various sizes and types, ranging from small businesses, maintaining web-based applications, to large organizations operating sizable ERP systems and software. Table 1 presents a summary of the participant profiles.

Table 1. Summary of participant profiles

Participant Code	Organization Type	System Maintained
P1	Large banking institution.	Customer information system
P2	Medium-to-large commercial software company.	Large, commercial ERP software system.
P3	Large banking institution.	Distributed Lotus Domino applications.
P4	Small contractor.	Miscellaneous software systems (research to marketing systems).
P5 & P6	Small to Medium Enterprise (SME).	Web-based, Microsoft.NET application.
P7	Small contractor.	Websites and web-based applications
P8	Medium to large international commercial software vendor.	Large, commercial ERP software system.

We acknowledge that the number of participants have limited the validity of findings. However, being a preliminary exploratory study, the scope of this research was set to finding some indicatory insights from practitioners, so as to provide a platform for launching into further research investigations. Therefore, this small sample was rendered sufficient.

INDUSTRY STUDY

To set the scene, the following statement from participant P2 characterizes the view held by all concerning the challenge of software maintenance, as they live it, day to day:

"... We have to deal with history and archaeology. And we recognize it, but time, resources, and money constraints don't allow you to re-architect the entire portfolio in one hit. So you're constantly battling the weight of the old product with all of the measures of some of the newer modules. And that's a tug of war that our sort of business has to wrestle with."

This characterization captures the essence of software maintenance, as a struggle between legacy systems and the unrelenting need and demand for change and progress. Further, an understanding of a system's past is essential, to assist in determining the future viability and applicability of a software system.

In characterizing the views/perceptions of the software maintainers we initially report 4 primary findings. Subsequently (next section), we present a simple framework which has been helpful in practically classifying the situations thus observed in the participant organizations. Theoretically, these classifications may be used for similar studies and could also be modified in accordance with the further situational findings.

Finding 1: Software Modifications and Enhancements vs. Software Corrections and Adaptations

Consistent with the extant literature, the participants confirmed that software enhancements or modifications to an implemented software system are the most significant maintenance activity they face (Lientz, 1983; Yip, 1995). For example, P3 indicated that a high volume of requests is for the provision of upgrades and new functionalities. This was corroborated by P5, P6&P7. It is noteworthy, however, that Sousa and Moreira (1998) identify adaptive maintenance activities as the most costly software maintenance activity, at odds with the present findings.

Finding 2: User/System Knowledge and Knowledge Management are Crucial

Lientz and Swanson (1983) identify knowledge, programmer effectiveness, product quality, time availability, machine requirements and system reliability to be the factors of most pressing concern to maintainers. Consistent with the primacy of knowledge in this list, participants in the present study emphasized the need for user knowledge and system knowledge, and that the lack of documentation and/or the ability to transfer knowledge, were key issues. This problem is further compounded by a user's/customer's lack of understanding of the difficulties and the issues surrounding the performance of software maintenance. P4 provided insight by suggesting that:

"...from a customer viewpoint, they often say there's a problem in the software, it doesn't do what I want it to do… (and) they would probably classify them as software defects, but of course, if the functionality wasn't in the original requirements specification; it's not a defect, it's a modification."

To address this problem, and to introduce some form of knowledge management to maintenance activities, P1, P3, P5&P6 proposed the standardization of practices, and P4 suggested managing customer expectations by involving customers in both the development and maintenance processes.

Finding 3: Prominence of Agile (or at least Flexible) Approaches in Present Software Maintenance

Software maintenance, unlike software development is not requirements driven but is rather event driven, triggered by unscheduled or random external events (Kitchenham et al., 1999). Software organizations do not have defined processes for the conduct of their software maintenance activities, or at best software maintenance is depicted crudely as the final activity in their software development process (April et al., 2005). This view might suggest that software maintenance follows an ad hoc process in many organizations, reflecting at best some coarse steps similar to those depicted within the traditional "waterfall" model of software development. In the present study, this view was supported by P4.

In contrast, many of the participants in the present study indicated that they are using some form of agile or at least flexible process. P1, P5&P6 reported that the use of iterative and incremental development approaches is a means of delivering readily assessable and tangible maintenance benefits to users, coupled with a means of prioritizing requests to deliver the optimum benefits. P1, P3, P5, P6&P8 also emphasized extensive customer participation and frequent feedback in the processes they employed.

It should be noted, however, that the use of such methods, incorporating features commonly associated with agile approaches, was not common to all participants. Indeed P2 and P7 reported adherence to a more traditional "waterfall" based approach of eliciting maintenance requirements from users and executing change requests.

Interestingly, while the approaches above have proven to be relatively successful, the participants did not formally recognize these as involving the use of "agile methodologies". Indeed, as P4 suggested:

"Agile methodologies, in a software maintenance environment, don't translate. Not unless it's a major, like 30 percent of the software is being changed then ok, but if it's a minor software defect change… if it's changes to features… there are stages to be done, waterfall stages. Define, design, code, test, implement."

This view is supported by the studies of Svenssen and Höst (2005) who suggested that a relative degree of adaptation and selection is required in order to successfully apply agile approaches to a software maintenance environment. Cockburn (2002) and Beck (2005) have also suggested that organizations or practitioners, interested in pursuing an agile approach, should select processes or methods which they can successfully apply within their particular domain and undertake a process of assessment and refinement, introducing new methods and refining existing methods in order to elicit the most value and benefit from agile approaches given their implementation context. Based on the responses collected from the participants in this study, the impression is that the participants are either unaware of the principles that drive agile approaches or that they are ignorant to such drivers and principles. With responses such as "a bit more rigor in following the process" (P5&P6) and "jumping into the code and fixing it (without appropriate documentation or knowledge of the software system)" (P3), it is appropriate that there is a degree of skepticism as to the notion of adapting an "agile methodology" as a basis for maintenance. This was expressed most clearly by P4:

"The word agile methodology is thrown around very much in the press. Agile was a buzzword 15 years ago and every time I read a magazine from the IEEE about every 3rd one had agile on the front cover. Each time you look at it, it means something different."

Finding 4: Superficial Understanding of Agile Approaches to Software Maintenance

One of the most interesting findings in the present research, in particular given the above observation of widespread use of methods/techniques that are commonly associated with agile methods, is that most participants, when probed, actually had, at best, superficial formal understanding of agile methodologies. Some participants who claimed an awareness of such approaches, when probed demonstrated substantial misunderstandings of some of the basic tenets of agile development. Boehm (2002) has previously observed this, expressing a view that agile approaches appear less disciplined than they really are, with people almost equating them to undisciplined hacking. Consistent with this, P3 stated:

"… how do we get good design in an agile approach? Because an agile approach, certainly in our case, tends to be jumping in and writing the code."

As an example of such misunderstandings, P5&P6, and to a limited extent P7, stated that they attempt to be flexible in the performance of their maintenance activities but in exercising this flexibility, they employ little adherence to set practices or standards. In summary, they view agile approaches as less disciplined than they really are, equating them, in a sense, to undisciplined hacking.

TAKING THE DECISION TO ADOPT AN AGILE APPROACH TO SOFTWARE MAINTENANCE

Reflecting upon the findings above, it is curious that whilst the maintainers studied saw their focus, somewhat conventionally, to be upon software enhancement and modification of implemented software systems (Finding 1) and argued that such tasks must be supported by substantial extant documentation and associated knowledge transfer mechanisms (Finding 2), they seemed to employ flexible approaches commonly associated with agile approaches which many saw as not supporting system documentation (Finding 3). Further, in many cases they displayed at best limited understanding of some of the basic tenets of agile methodologies (Finding 4).

This raises an interesting issue. To exercise an informed decision to adopt an agile approach in an organisational maintenance situation, it is reasonable to expect that the maintainer should understand agile approaches and the associated issues surrounding the operation of organisational maintenance processes. In the study however, this prerequisite knowledge does not seem to have uniformly been in place.

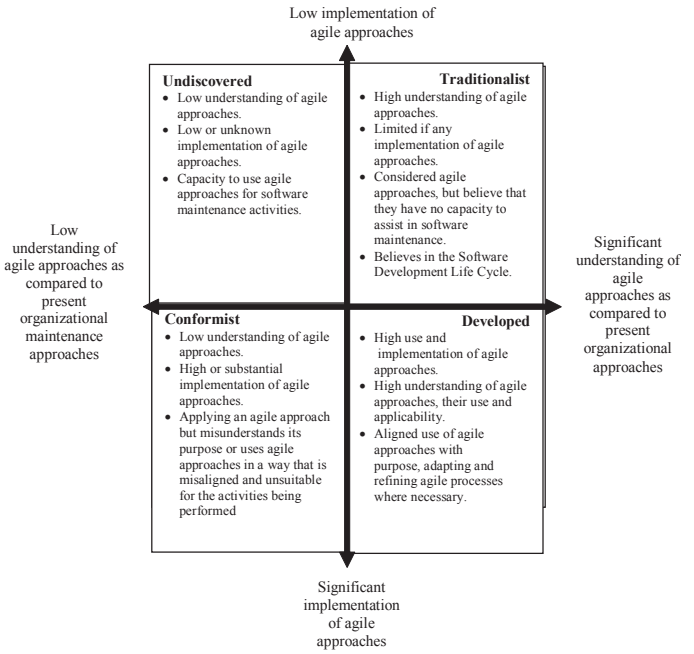
As a means of characterising the situations of the participants in the study, we introduce a matrix framework (Figure 1), to facilitate a comparison of the levels of understanding of the issues affecting an agile adoption decision and the extent to which an agile approach has been implemented.

The matrix involves two axes. The first reflects an organization's knowledge of agile approaches. An organization can possess varying degrees of knowledge of agile approaches, ranging from unaware or having a low understanding of agile approaches, to possessing substantial understanding and knowledge.

This axis also takes into consideration an organization's understanding of its present software maintenance processes, in particular how their present processes compare with agile processes.

The second axis records the level of implementation of an agile approach within the organization's software maintenance context, with organizations applying

Figure 1. The "Agile Understanding Matrix"



agile approaches or methods in varying degrees ranging from no (or low) implementation of agile approaches, to a situation where they apply a substantial implementation of agile approaches in support of performing their software maintenance activities.

As such, organizations can fall within four distinct quadrants characterised by different levels of understanding and different levels of implementation. These quadrants have been termed: undiscovered; traditionalist; conformist; and developed, for the purpose of this study, as shown in Figure 1.

Figure 2 provides a visual representation of the quadrants in which all 8 study participants fit, based on an analysis of the information collected. To illustrate the assessments made, one example for each quadrant is briefly presented.

CONCLUSION AND FUTURE RESEARCH

This research paper reports from an exploratory study that investigated whether agile approaches might have the capacity to assist software maintenance practitioners.

It was observed that the maintainers, somewhat conventionally, felt that their focus should be on software enhancement and modification of implemented software systems, which involves tasks supported by substantial extant documentation. Conversely, they seem to employ flexible agile approaches, which have been characterised as not supportive of such system documentation, with limited understanding of the basic tenets of agile methodologies.

We argue that to exercise an informed decision to adopt an agile approach in an organisational maintenance situation, the maintainer should understand the basic tenets and associated operational issues. Based on the participant situations in the study reported in the paper, a matrix framework has been introduced, to facilitate a comparison of the levels of understanding of the issues affecting an agile adoption decision and the extent to which an agile approach has been implemented.

The characterisation of organisations taking decisions concerning the adoption (or non-adoption) of agile software maintenance approaches, as developed in this paper, may well provide a framework for on-going study of software maintenance practitioner views. Further, based on the indicatory results of this study, which is limited by the number of participants, structured empirical studies could be initiated calling for participation from specific industry sectors and organisations classified by size. As we have pointed out earlier, there is a gap in substantial research, capturing the views and perceptions of front line maintenance staff as to the potential capacity of agile approaches to assist them in the performance of their day-to-day software maintenance activities. The results of empirical studies seeded from this preliminary study could be of valuable contribution to the body of knowledge in this area, benefiting both academia and practice.

REFERENCES

Agile Alliance, 2006, "What is Agile Software Development?", Online Resource Site, Last Accessed: 26 September 2006, URL: <http://www.agilealliance.org/intro>.

April, A., Huffman Hayes, J., Abran, A., & Dumke, R., 2005, "Software Maintenance Maturity Model (SMmm): The Software Maintenance Process Model", Journal of Software Maintenance and Evolution: Research and Practice, Vol. 17, No. 3, pp. 197-223.

Avison, D., & Fitzgerald, G., 2003, Information Systems Development: Methodologies, Techniques and Tools, 3rd eds, McGraw-Hill, Berkshite, UK.

Boehm, B., 2002, "Get Ready for Agile Methods, With Care", Computer, Vol. 35, No. 1, pp. 64-69.

Chapin, N., Hale, J.E., Khan, K.Md, Ramil, J.F., & Tan, W., 2001, "Types of Software Evolution and Software Maintenance", Journal of Software Maintenance and Evolution: Research and Practice, Vol. 13, No. 1, pp. 3-30.

Cockburn, A., 2002, Agile Software Development, Addison-Wesley, Boston, USA.

Dekleva, S., 1992, "Delphi Study of Software Maintenance Problems", Proceedings. International Conference on Software Maintenance, Orlando, FL, USA.

Kitchenham, B.A, Travassos, G.H., Mayrhauser, A.v., Niessink, F., Schneidewind, N.F., Singer, J., Takada, S., Vehvilainen, R., & Yang, H., 1999, "Towards an Ontology of Software Maintenance", Journal of Software Maintenance: Research and Practice, Vol. 11, No. 6, pp.365-389.

Lientz, B.P., 1983, "Issues in Software Maintenance", ACM Computer Surveys (CSUR), Vol. 15, No. 3, pp. 271-278.

Martin, J., & McClure, C., 1983, Software Maintenance: The Problem and its Solution, Prentice-Hall, New Jersey, USA.

Poole, C.J., & Huisman, J.W., 2001, "Using Extreme Programming in a Maintenance Environment", IEEE Software, Vol. 18, No. 6, pp. 42-50.

Schuh, P., 2001, "Recovery, Redemption, and Extreme Programming", IEEE Software, Vol. 18, No. 6, pp. 34-41.

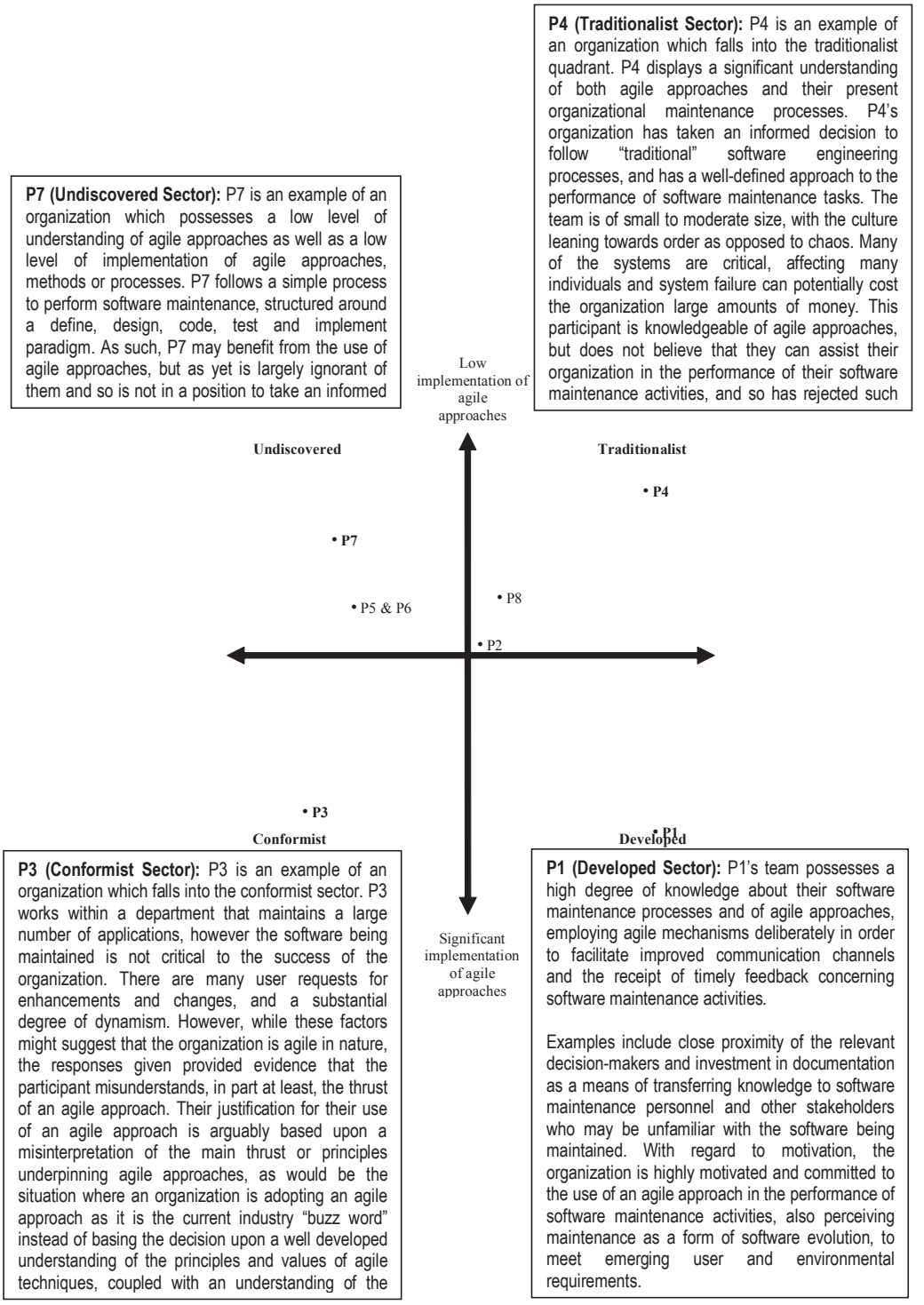
Sousa, M.J.C., & Moreira, H.M., 1998, "A Survey of the Software Maintenance Process", Proceedings. International Conference on Software Maintenance.

Svenssen, H., & Höst, M., 2005, "Introducing an Agile Process in a Software Maintenance and Evolution Organisation", Proceedings. Ninth European Conference on Software Maintenance & Reengineering, Manchester, UK.

Swanson, E.B., 1976, "The Dimensions of Maintenance", Proceedings. 2nd International Conference on Software Engineering, Long Beach, CA, USA.

Yip, S.W.L., 1995, "Software Maintenance in Hong Kong", Proceedings. International Conference on Software Maintenance, Opio, France.

Figure 2. Placement of participants within the "Agile Understanding Matrix"



An Exploratory Investigation of Instructors Acceptance of E-Learning

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ABSTRACT

The use of e-learning and information technologies in teaching have changed the instruction approaches. There are several factors that need to be considered while developing or implementing E-learning environment. This paper is intended to identify and measure e-learning critical factors as perceived by instructors. In line with the literature, five factors were identified and measured, namely instructor self efficacy, student perceived benefits, instructor attitude towards information technologies used in e-e-learning, instructor attitude towards the technical support of e-learning tools, and e-learning acceptance and usage by instructors. A sample of 606 instructors was used to validate the proposed e-learning factors. The results revealed that 40% of the instructors perceived technical support as the most critical factor in e-learning success. The instructor self efficacy was viewed as the most critical factor by 30% of the participants, while 31% viewed it as the third most critical factor. The items used in measuring each factor were validated and showed acceptable reliability and discriminant measures.

Keywords: Improving classroom teaching; e-learning; Evaluating CAL systems; Teaching/learning strategies.

INTRODUCTION

The use of E-learning and information technologies as teaching tools have expanded and changed the instruction approaches (Alavi, 1994; Selim, 2003, 2004, 2006). E-learning concept has been around for decades and is one of the most significant developments in the information systems industry (Wang, 2003). E-learning is the delivery of course content via electronic media, such as Internet, Intranets, Extranets, satellite broadcast, audio/video tape, interactive TV, and CD-ROM (Urdan & Weggen, 2000). Fostering e-learning acceptance among individual instructors remains a critical challenge for universities and e-learning service providers. E-learning acceptance by instructors is needed to develop an environment with minimum resistance.

Instructor attitudes towards e-learning are vital factors of developing efficient and effective e-learning environments for teaching. There are very few articles in the literature that address the acceptance of e-learning from the instructor's perception (Hu, Clark, & Ma, 2003; Kollias, Mamalougos, Vamvakoussi, Lakkala, & Vosniadou, 2005; Liaw, Huang, & Chen, 2006). This paper reports on an exploratory study aims to identify and measure the critical factors affecting e-learning acceptance by instructors. The exploratory study will lead to the development of an instructor e-learning acceptance model.

METHOD

Participants

An online survey was available on the World Wide Web and advertised to universities in the United Arab Emirates (Dubai, Abu Dhabi, and Sharja). Respondents for this study consisted of 606 instructors. Table 1 summarizes the demographic profile and descriptive statistics of the respondents. Instructor ages ranged from 22 to 61 years, with a mean age of 42.3 years (S.D. =8.3). Male respondents represented 81%. Instructors came from 31 different countries (see Table 2). Participants represented 11 colleges namely, business, engineering, medicine, law, science, humanities & social, education, food & agriculture, libraries, information technology, and general requirements. The majority of the participating instructors had 5 years or more experience with personal computers (89.1%).

Table 1. Demographic profile and descriptive statistics of surveyed instructors

Item		Frequency	Percentage
Gender	Male	490	80.9
	Female	116	19.1
Age	22-29	38	6.3
	30-37	126	20.8
	38-41	252	41.6
	46-49	100	16.5
	50-57	72	11.9
	58-61	18	2.9
Years at current university	0-4	392	64.7
	5-9	154	25.4
	10-14	44	7.3
	15-19	12	2.0
	> 22	2	0.3
Title	Professor	68	11.2
	Associate Prof.	104	17.2
	Assistant Prof.	214	35.3
	Instructor	182	30.0
	Other	38	6.3
Years of PC use	1-2 years	28	4.6
	3-4 years	38	6.3
	> 4 years	540	89.1
College	General Requirements	122	20.1
	Business	120	19.8
	Humanities & Social Science	96	15.8
	Science	80	13.2
	Engineering	66	10.9
	Medicine	32	5.3
	Food & Agriculture	28	4.6
	Education	26	4.3
	Information Technology	22	3.6
	Law	10	1.7
	Libraries	4	0.7

Table 2. Participants' countries

Country	Frequency	Percentage	Country	Frequency	Percentage
Egypt	110	18.2	Ghana	6	1.0
UAE	80	13.2	New Zealand	4	6.6
USA	76	12.5	Greece	4	6.6
UK	56	9.2	Pakistan	4	6.6
Canada	56	9.2	Lebanon	4	6.6
Jordan	50	8.3	Austria	4	6.6
Algeria	32	5.3	South Africa	4	6.6
Afghanistan	28	4.6	Libya	2	3.3
Sudan	18	3.0	Panama	2	3.3
Palestine	12	2.0	Belgium	2	3.3
Iraq	10	1.7	Morocco	2	3.3
India	8	1.3	Turkey	2	3.3
Australia	6	1.0	Bangladesh	2	3.3
Syria	6	1.0	Singapore	2	3.3
Ireland	6	1.0	France	2	3.3
Ireland	6	1.0			

Instrument

This study proposed four factors that could lead to the acceptance of teaching using e-learning tools by instructors. The four factors are: (1) instructor self efficacy - ISE, (2) student benefits as perceived by instructors - SPB, (3) instructor attitude towards Information technology as an enabler of e-learning - IAIT, and (4) instructor attitude towards technical support provided by e-learning providers - IATS. A fifth factor was used to represent the e-learning usage - ELU. Each factor was represented by a latent construct that was observed via a number of indicators. Several survey instruments have been developed to measure e-learning satisfaction and acceptance (Angeli, 2005; Hu et al., 2003; Lee, Cheung, & Chen, 2005; Liaw et al., 2006; Selim, 2003, 2004, 2005, 2006; Shih et al., 2003). Therefore, various potential indicators exist to measure each factor. A survey instrument was developed that consisted of 6 sections, one for each one of the five factors in addition to a demographic characteristics section.

The instructor self efficacy (ISE) construct section included 6 items (ISE1-ISE6). The ISE factor was operationalized and validated by previous research (see Appendix for the item details). items ISE1 to ISE6 were adopted from (Compeau & Higgins, 1995; Hu et al., 2003) to capture instructor's self efficacy. The items were reworded to fit the e-learning context.

Six items were used in assessing the perceived students' benefits construct (PSB1-PSB6). The 6 items measured how the instructor perceives students' benefits of attending e-learning enabled classes. The items are listed in the appendix. Seven items were developed to measure the instructor's attitude towards information technology (IAIT) tools such as Internet, personal computers, course management systems, and student information system. The instructor's attitude towards technical support section consisted of 5 items (IATS1-IATS5) and all of them were developed to capture the effectiveness and efficiency of the provider's technical support. The last section was dedicated to capturing the perceived acceptance and usage of e-learning by instructors via 6 items (ELU1-ELU6), see the appendix.

The items were randomly arranged and some of them were negatively worded. All items used a five-point Likert-type scale of potential responses: strongly agree, agree, neutral, disagree, and strongly disagree. The instrument was pre-tested by a random sample of 100 instructors. Minor changes to the order and wording of the items resulted from the pre-testers opinions. A website was developed to publish the instrument. Emails were sent to instructors and faculty members of 4 major universities in the United Arab Emirates (Dubai, Abu Dhabi, and Sharja). The participants were informed that all data were anonymous and were to be used in assessing the acceptance and usage of e-learning technology. Table 3 shows the mean and variance of each item in the e-learning assessment instrument.

Instructors were asked to rank the four factors (ISE, PSB, IAIT, and IATS) based on their level of importance and criticality to the success of e-learning.

Table 3. Descriptive statistics of e-learning assessment indicators

Item	*Mean*	*S.D.*
ISE1	3.98	0.958
ISE2	3.81	0.986
ISE3	3.58	1.039
ISE4	3.44	1.075
ISE5	4.20	0.937
ISE6	3.34	0.989
PSB 1	3.53	0.972
PSB 2	3.46	0.940
PSB 3	3.96	0.910
PSB 4	3.50	0.946
PSB 5	4.03	0.905
PSB 6	3.50	0.907
IAIT 1	3.88	1.093
IAIT 2	3.55	1.043
IAIT 3	3.54	1.001
IAIT 4	3.37	0.963
IAIT 5	3.68	1.013
IAIT 6	3.52	0.926
IAIT 7	3.70	0.944

Item	*Mean*	*S.D.*
IATS1	3.38	1.050
IATS2	3.10	0.929
IATS3	3.32	0.910
IATS4	3.26	0.942
IATS5	3.07	1.026
ELU1	4.07	0.879
ELU2	4.09	0.804
ELU3	4.06	0.929
ELU4	4.23	0.865
ELU5	3.95	0.938
ELU6	4.03	0.890

The rating for each factor was placed between 1 and 4. Table 4 shows the rank of the four e-learning factors as perceived by instructors. The instructor attitude towards the technical support factor was given the most critical rank by 40% of the surveyed instructors. Perceived student benefits (PSB) and Instructor attitude towards information technology were perceived to be the least critical to the success of e-learning in teaching as perceived by 34% and 35% of the surveyed instructors, respectively. Instructor self efficacy was viewed as the most critical and important factor by 30% of the participants while 31% viewed it as the third important factor.

Table 4. E-leaning critical factors ranking

	1	2	3	4	Average
ISE	30% (184)	23% (140)	31% (186)	16% (96)	2.33
PSB	18% (108)	28% (168)	20% (124)	34% (206)	2.70
IAIT	20% (122)	23% (142)	21% (130)	35% (212)	2.69
IATS	40% (244)	29% (176)	22% (132)	9% (54)	2.00

Exploratory Factor Analysis

Exploratory factor analysis was conducted to identify the underlying critical items in each of the e-learning critical factors (ISE, PSB, IAIT, IATS, and ELU). The same factor analysis was used to validate the e-learning critical factors. LISREL version 8.54 was used to develop the polychoric correlation and asymptotic covariance matrices used in generating the factor loadings because all the items were represented by ordinal variables. Table 5 shows the output results for the Promax-rotated factor loadings. Items intended to measure the same e-learning factor must demonstrate a factor loading of >0.50.

The 6 items (ISE1-ISE6) proposed to measure the instructor self efficacy factor as a critical factor of e-learning success were highly correlated with it, as indicated by the factor loading values of >0.65 in Table 5. This testifies to the validity of the indicators used to capture the instructor self efficacy. The items comprised in this factor were related to the instructor's capabilities of implementing and using e-learning methods such as Internet, PCs, and LCD projectors. This factor was ranked as the most critical factor by 30% of the participants and third most critical factor by 31% of the participants (see Table 4).

The exploratory factor analysis applied to the 6 indicators used in measuring the perceived student benefits by using e-learning yielded good results. All items correlation values (loadings) with the identified factor (PSB) were >0.60. This factor captured instructor's perception about the effect of e-learning on student interactivity, quality of coursework activities, usefulness, and readiness.

The instructor's attitude towards the information technologies (IAIT) used in e-learning was measured by 7 indicators, all of them loaded with correlations of values >0.50. The indicators used in this factor were related to the ease of Internet access and navigation, web-based course management system, computer networks, student information system, and the information technology infrastructure reliability and effectiveness. Most of the instructor responses to the 7 items were positive. The instructors were mostly satisfied with the on-campus Internet access, and course websites available via the course management system used.

The instructor attitude towards the technical support (IATS) was measured using 5 indicators; all of them had factor loadings of > 0.60. All the items were related to the helpdesk and e-learning training. The last factor was related to the instructor perceived usage of e-learning in teaching as an indicator of their acceptance of this technology. The e-learning usage (ELU) factor was measured by 6 indicators; all of them had high factor loading values of > 0.65. The ELU factor included the intention of teaching e-learning based courses in the future, how e-learning fits into the instructor's teaching style, and the instructors' perception about e-learning in general. Instructors indicated positively that they will teach e-learning based courses in the future which indicated a positive attitude toward accepting the e-learning technology. Finally, it can be concluded that the indicators used in e-learning critical factors assessment instrument truly represented the concepts of interest.

E-learning assessment instrument's reliability was measured using Cronbach alpha. Table 6 shows Cronbach alpha values for the 5 e-learning assessment factors emerged from the factor analysis given in Table 5. The suggested accepted value of Cronbach alpha is ≥ 0.70 (Hair, Anderson, Tatham, & Black, 1998). All factors exhibited a high degree of internal consistency as the alpha values were ≥ 0.847. It was concluded that the indicators could be used to measure the factors with acceptable reliability. The average variance extracted, which reflects the overall amount of variance in the items accounted for by the factor. The average variance extracted is more conservative than Cronbach alpha as a composite reliability measure and its accepted value is 0.5 or above (Fornell & Larcker, 1981). As shown in Table 6, all the average extracted variance values are ≥ 0.69. Average extracted variance can be used to evaluate the discriminant validity. The square root of the average extracted variance for each factor should be greater than the correlations between that factor and all the other factors (Fornell & Larcker, 1981). Table 7 shows the correlation matrix of the e-learning assessment factors and the square root of the average extracted variance. The discriminant validity does not reveal any problems.

Table 5. Factor loadings

	ISE	PSB	IAIT	IATS	ELU
ISE1	***0.729***	-0.015	-0.052	0.039	0.016
ISE2	***0.825***	0.020	-0.040	-0.019	-0.025
ISE3	***0.758***	-0.053	0.139	0.000	0.127
ISE4	***0.705***	0.065	-0.054	0.012	0.087
ISE5	***0.901***	-0.015	0.007	-0.046	-0.018
ISE6	***0.685***	0.043	0.094	0.012	-0.030
PSB1	0.088	***0.601***	0.086	0.001	0.196
PSB2	0.093	***0.679***	0.184	-0.067	0.063
PSB3	-0.124	***0.700***	-0.006	-0.011	0.357
PSB4	-0.049	***0.726***	0.017	0.082	0.168
PSB5	0.047	***0.745***	-0.022	0.014	0.071
PSB6	0.065	***0.688***	-0.076	0.096	0.015
IAIT1	0.071	0.084	***0.808***	-0.074	-0.098
IAIT2	0.042	0.142	***0.824***	-0.125	-0.123
IAIT3	-0.148	0.095	***0.784***	0.077	0.122
IAIT4	-0.079	-0.170	***0.644***	0.103	0.074
IAIT5	0.051	-0.194	***0.809***	-0.099	0.187
IAIT6	-0.032	-0.026	***0.662***	0.314	0.067
IAIT7	0.221	-0.051	***0.564***	0.179	-0.049
IATS1	0.036	0.081	0.094	***0.635***	0.003
IATS2	-0.057	0.011	-0.079	***0.932***	-0.040
IATS3	-0.025	0.018	-0.025	***0.785***	0.011
IATS4	-0.002	-0.134	-0.028	***0.814***	-0.009
IATS5	-0.028	0.080	0.077	***0.783***	-0.015
ELU1	0.192	0.005	0.006	-0.051	***0.695***
ELU2	-0.045	0.067	0.001	-0.078	***0.926***
ELU3	0.262	0.025	-0.015	-0.012	***0.680***
ELU4	-0.069	0.084	-0.033	0.009	***0.861***
ELU5	0.121	0.010	0.031	0.082	***0.718***
ELU6	0.101	0.050	-0.071	0.117	***0.750***

CONCLUSIONS AND FUTURE WORK

Information technology and intense competition are reshaping higher education institutions worldwide. E-learning has been integrated in several higher education institutions. Consequently, several adoption-related factors must be carefully

Table 6. E-learning survey instrument reliability

Factor	Cronbach Alpha	Variance Extracted
ISE	0.893	0.771
PSB	0.901	0.691
IAIT	0.888	0.730
IATS	0.847	0.795
ELU	0.909	0.777

Table 7. Correlation matrix of e-learning CSFs

Factor	ISE	PSB	IAIT	IATS	ELU
ISE	***0.878****				
PSB	0.493	***0.831****			
IAIT	0.390	0.248	***0.857****		
IATS	0.360	0.308	0.511	***0.892****	
ELU	0.509	0.581	0.185	0.278	***0.881****

** Square root of the average extracted variance*

evaluated before any adoption attempt is made by universities and instructors. The adoption of e-learning technology is a complex process of establishing and developing an integrated information technology system. This study, in line with the literature, identified and measured four critical factors that assist universities and instructors to adopt e-learning technologies. Critical factors which were identified and measured from instructor perceptions, included: instructor self efficacy, student perceived benefits, instructor attitude towards information technology, and instructor attitude towards technical support. The four factors impact the decision to adopt e-learning technology in higher education institutions.

A sample of 606 instructors was used to identify and measure the proposed e-learning factors. The instructors perceived the four factors as critical success factors in e-learning. The surveyed instructors indicated that technical support to e-learning tools and technologies is the most critical factor. Surprisingly 35% and 34% of the participants viewed instructor attitude towards information technology and perceived student benefits as the least important factors of successful e-learning. The instructors indicated that when a higher education institution attempts to adopt e-learning based courses the following factors should be critically considered:

- Instructors should have sufficient computing skills and enthusiasm.
- Construction of an effective information technology infrastructure in order to facilitate fast Web access, email, course management system, and other e-learning services.
- Establishment of reliable and responsive e-learning support services.
- Development of orientation programs to both students and instructors.
- Easy and fast Internet access

All indicators of the instructor self efficacy factor were important and significant measures. Generally, instructors felt comfortable using e-learning in teaching if they get sufficient training. Some instructors found it easy to get e-learning tools do what they wanted to do. Instructors perceived valuable student benefits such as better quality of coursework activities and better in-class interactivity.

The instructor attitude towards the information technologies used in e-learning was an important factor of e-learning success. Important items used in measuring this factor included reliability of the information technology infrastructure, Internet access and speed, course management system, and student information system. The instructor attitude towards the technical support of e-learning tool was viewed as critical success factor. Technical support factor was measured by how the helpdesk is responsive and effective. Instructors indicated that they would teach e-learning based courses in future assuring their positive attitude and support to e-learning technology and tools.

This study explored the instructors' perceptions in identifying and measuring e-learning critical factors within higher education schools. Further study can expand on this research to develop a causal research model that includes all the 5 constructs (ISE, PSB, IAIT, IATS, and ELU). The objective of the causal research model would be to study the effects of the first 4 factors on e-learning acceptance as indicated by ELU. The proposed research model can generate causal relationships among the 5 factors.

REFERENCES

Alavi, M. (1994). Computer-Mediated Collaborative Learning: An Empirical Evaluation. *MIS Quarterly, 18*(2), 159-175.

Angeli, C. (2005). Transforming a teacher education method course through technology: effects on preservice teachers' technology competency. *Computers & Education, 45*(4), 383-398.

Beyth-Marom, R., Chajut, E., Roccas, S., & Sagiv, L. (2003). Internet-assisted versus traditional distance learning environments: factors affecting students' preferences. *Computers & Education, 41*(1), 65-76.

Compeau, D. R., & Higgins, C. A. (1995). Computer self-efficacy: Dveleopment of a measure and initial test. *MIS Quarterly, 19*, 189-211.

Fornell, C., & Larcker, D. (1981). Evaluating structural equation models with unobservable variable and measureent error. *Journal of Marketing Research, 18*, 39-50.

Hair, J., Anderson, R., Tatham, R., & Black, W. (1998). Multivariate data analysis. In (5 ed.): Prentice Hall.

Hu, P. J., Clark, T., & Ma, W. (2003). Examining technology acceptance by school teachers: a longitudinal study. *Information & Management, 41*, 227-241.

Kollias, V., Mamalougos, N., Vamvakoussi, X., Lakkala, M., & Vosniadou, S. (2005). Teachers' attitudes to and beliefs about web-based Collaborative Learning Environments in the context of an international implementation. *Computers & Education, 45*(3), 295-315.

Lee, M. K. O., Cheung, C. M. K., & Chen, Z. (2005). Acceptance of Internet-based learning medium: the role of extrinsic and intrinsic motivation. *Information & Management, 42*(8), 1095-1104.

Liaw, S.-S., Huang, H.-M., & Chen, G.-D. (2006). Surveying instructor and learner attitudes towards e-learning. *Computers & Education, Inpress*.

Selim, H. M. (2003). An empirical investigation of student acceptance of course websites. *Computers & Education, 40*(4), 343-360.

Selim, H. M. (2004). *E-learning critical success factors: An exploratory investigation of student perceptions.* Paper presented at the 2005 IRMA International Conference, New Orleans, Louisiana, USA.

Selim, H. M. (2005). Videoconferencing-Mediated Instruction: Success Model. *Journal of Distance Education Technologies, 3*(1), 62-80.

Selim, H. M. (2006). Critical success factors for e-learning acceptance: confirmatory factor models. *Computers & Education, Forthcoming*.

Shih, T., Antoni, G., Arndt, T., Asirvatham, A., Chang, C., Chee, Y., et al. (2003). A survey of distance education challenges and technologies. *International Journal of Distance Education Technologies, 1*(1), 1-21.

Urdan, T. A., & Weggen, C. C. (2000). *Corporate e-learning: Exploring a new frontier*: WRHAMBRECHT+CO.

Wang, Y. (2003). Assessment of learner satisfaction with asynchtonous electronic learning systems. *Information & Management, In Press, uncorrected proof*.

APPENDIX

E-learning Acceptance Instrument

Instructor Self Efficacy (ISE)

ISE1	I would feel comfortable using e-learning in teaching if I get training support from the university.
ISE2	I can learn how to implement e-learning in my teaching by myself.
ISE3	I find it easy to get e-learning methods to do what I want to do.
ISE4	I have become dependent on e-learning methods in both teaching and learning.
ISE5	I can handle technologies such as, course websites, PCs, and computer projectors effectively.
ISE6	I am getting the training I need to be able to use e-learning in my teaching from the university.

Perceived Student Benefits (PSB)

PSB 1	Utilization of e-learning has enabled students to submit better quality coursework activities
PSB 2	Students have come to rely on e-learning in performing their coursework
PSB 3	All in all I think that e-learning is extremely useful to the students
PSB 4	E-learning has improved student interactivity in class
PSB 5	Students need more orientation in order to utilize e-learning affectively.
PSB 6	Students are prepared to handle e-learning activities in the class

Instructor Attitude towards IT (IAIT)

IAIT 1	Easy on-campus Internet access
IAIT 2	Internet browsing speed is satisfactory
IAIT 3	I can count on the computer network to be “up” and running
IAIT 4	I can get student information from the student information system easily
IAIT 5	I can use any on campus PC using the same authentication
IAIT 6	Overall, the university information technology infrastructure is efficient
IAIT 7	It is easy to learn how to use the computer systems I need

Instructor Attitude towards Technical Support (IATS)

IATS1	I can get technical support from technicians easily
IATS2	The information technology people I deal with understand the day-to-day objectives of my teaching and learning needs
IATS3	The IT support teams takes real interest in helping me solve my teaching and learning problems
IATS4	When I make a request for service or assistance, support team normally responds to my request in timely manner
IATS5	I am satisfied with the level of e-learning technical support planning at my university

E-learning Usage/Acceptance (ELU)

ELU1	I intend to teach courses that use e-learning methods.
ELU2	E-learning is an effective method of teaching and learning.
ELU3	Using e-learning methods fir well into the way I teach.
ELU4	All in all I think that e-learning is an important tool for my university.
ELU5	I personally benefited from the existence of e-learning activities and tools in my university.
ELU6	Using e-learning methods would make my teaching more efficient and effective.

Exploring Change and Knowledge Management in Developing Countries: The Case of Iranian SMEs

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ABSTRACT

The main target of this research is to discuss two important strategic management disciplines in some Iranian SMEs. Change management and knowledge management will be discussed simultaneously for taking insight into the topic. Based on review of recent literature, this paper has identified major factors of both knowledge and change management disciplines in the field. For the research methodology, a structured survey has been implemented by the authors. The outcome of the research can be implemented as a guideline for change management during KM programs. This study provides an integrated perspective of critical issues for both knowledge and change disciplines in the organizations especially in SMEs of developing countries. It gives invaluable information and guidelines which hopefully will help the leaders to mange essential changes for accomplishing knowledge management through their organizations.

Keywords: Knowledge management, Change management, SME, Iran.

INTRODUCTION

If there is an even more ubiquitous topic writing about change, whether it is books, practitioner or academic journals, the topic of change is sure to be one of the most researched and well-published subjects (Washington and Hacker, 2005).

Attempts to impose order on what Weick and Quinn (1999) call "the sheer sprawl of the change management literature" have led to attempts at classification of change as either "discontinuous and episodic" or "continuous and emergent" (Treleaven and Sykes, 2005).

If there is one constant in the real business world, it is surely the change. Some researchers such as Attaran (2000) have declared that nearly 75 percent of all American corporations have gone through some type of systemic change program.

The concept of societal transformation today has also come to be associated primarily with the changes underway in former socialist countries. The process has been described in many different ways, such as "deep metamorphosis", "paradigm crisis," "crisis of working society," and "crisis of organized modernity" (Thurow, 1999).

In such a landscape, it is not surprising that knowledge and information management has emerged as one of the most popular strategic change management approaches in the dawn of the 21st century (Davenport and Prusak, 1998). Its supporters argue that organizations may achieve significant competitive advantages by analyzing the data and information that often remain unexploited in organizational systems and by transforming them into useful and actionable knowledge (Giaglis, 2002).

Adoption of knowledge management system in the organization may face with some challenges which is usually understood. This subject requires a specific change management program to lead knowledge management efforts in the organization.

It is necessary to say that we are now changing gradually from an information age to a knowledge age, where knowledge has been recognized as the most important aspect in human life. Individuals and organizations are starting to understand and appreciate knowledge as the most valuable asset in the emerging competitive environment. Knowledge is a powerful tool that can make changes to the world. It is now considered as the main intangible ingredient in the melting pot that makes innovation possible (Syed-Ikhsan and Rowland, 2004).

Bergeron (2003) defines knowledge management in this way:" Knowledge management is a deliberate, systematic business optimization strategy that selects, distills stores, organizes, packages, and communicates information essentials to the business of a company in a manner that improves employee's performance and corporate competitiveness".

Knowledge management is the process of managing knowledge and expertise in the organization in a way that facilitates identification, capture, codification, storage and sharing the knowledge which accelerates knowledge creation towards the strategies of the organization.

Change and knowledge retention affect a firm's knowledge production. Tradeoffs in the amount of resources dedicate to these activities influences the development and distribution of knowledge within firms across time (March, 1991). For instance, a firm that preserves the past via retention may dedicate fewer resources to creating knowledge through variation activity and to acquiring tacit knowledge and skills, or human capital. On the other hand, a firm may import more knowledge via inflows of human capital when it trades off exploiting the past for increasing knowledge creation or variation (change) activity. As a consequence, a general concern of studies examining learning and adaptation is the balance between a firm's variation and retention activities (Madsen and McKelvey, 1996).

Knowledge-based approach is a useful framework which is needed to give the depth to the study of discursive change processes. This framework focuses on both the emergent nature of change itself and on the reforms and recreations of knowledge produced in terms of organizational knowledge. It also offers an understanding towards change processes and covers the tensions generated during the process. Such re-conceptualizing of organizational change to address multi-vocality opens up new ways of researching which shows how organizing and re-organizing processes in organizations produce intended and unintended effects.

In this paper, we are supposed to discuss change management during knowledge management establishing program in some Iranian small and medium size enterprises (SME). This study will explore change efforts and KM programs simultaneously. It is important to say that knowledge management adoption in an organization requires some changes. The succession of KM program is dependent on the way changes are managed. If the changes are not implemented in a suitable way, the knowledge management program will face the failure. In this way, knowledge management programs have a close relationship with the related changes. That's why the authors are to discuss knowledge management and change management simultaneously in this research.

WHAT ARE SMES IN THE REAL WORLD?

The result of the knowledge revolution is represented by the new economy or the knowledge-based economy, which is radically different from the previous economy types known by mankind. Essentially, the knowledge-based economy is characterized by the conversion of knowledge into essential raw material, capital, products, production factors of the economy and through economic processes within which such activities as generating, selling, buying, learning, storing, developing, sharing and protecting the knowledge become a predominant and decisive condition

for profit generation and the long-term durability for the organizations including SMEs at micro level and economy at the macro level.

Until the middle seventies, SMEs had a minor role in the debate about economic development due to the dominance of the mass production paradigm in industry. After this period, this paradigm was increasingly challenged, leading to large firms' fragmentation, unemployment growth and creation of new SMEs (ACS, 1992).

There are a number of definitions of what constitutes a small to medium enterprise (SME). Some of these definitions are based on quantitative measures such as staffing levels, turnover or assets, while others employ a qualitative approach (MacGregor and Vrazalic, 2004). Meredith (1994) suggests that any description or definition must include a quantitative component that takes into account staff levels, turnover, assets together with financial and non-financial measurements, but the description must also include a qualitative component that reflects how the business is organized and how it operates (MacGregor and Vrazalic, 2004).

There are two main findings in the literature that have implications for economic policy concerning SMEs. The first is that the nature of innovation adoption differs according to the size of the firm. The second is that clusters of small firms or industrial districts can be important for regional development (Lebre, 1998).

As Rothwell and Dodgson (1993) warn, both SMEs and large firms have advantages in innovation adoption, but these advantages differ. While large firms have material advantages, due to their greater capability to support R&D, SMEs have behavioral advantages that stem from their greater flexibility and ability to adapt to changes in the market.

A combined study of Danish, Irish and Greek SMEs carried out in the early 1990's by Neergaard (1992) concluded that there were four main reasons for the acquisition of IT by SMEs. These were increased productivity, streamlining work procedures, better client service and better record keeping (Neergaard, 1992). Fink and Tjarka (1994) described their three reasons for IT acquisition as 'doing the right thing', 'doing things right' and 'improving the bottom line' in a study of Australian executives.

The differences between SMEs and their larger counterparts are highlighted even more when their approaches to IT are considered. Khan and Khan (1992) suggest that most SMEs avoid sophisticated software and applications. This view is supported by studies carried out by Chen (1993), Cragg and King (1993), Holzinger and Hotch (1993) and DelVecchio (1994). In addition, the locations of the SMEs are also important. Gillespie et al. (1995) note that the use of IT applications can vary in different regions of a country.

Considering the rapid changes in the competitive era, the SMEs should adapt themselves with the harmony of change, and while the knowledge is assumed as the main resource of organizations especially for innovations, knowledge management is so important for SMEs to lead their efforts towards competitiveness and innovation.

SMES IN IRAN

As above discussed, until the middle seventies, SMEs had a minor role in the debate about economic development due to the dominance of the mass production paradigm in industry. After this period, this paradigm was increasingly challenged, leading to large firms' fragmentation, unemployment growth and creation of new SMEs (ACS, 1992).

Nevertheless, the most SMEs in Iran are still traditional and their school of thought is belonged to last few decades. The today's dance of changes is dictating a new model thinking as a basic requirement. The SMEs in Iran have to restructure their way of thinking which has a deeply roots in their culture. The difference between culture in east and west is under the influence of school of thought they have been growing up under. In this way, to bring a change in SMEs, firstly should be started by changing the culture and beliefs towards the changes whether is possible or not. Then, the reengineering of the processes, approaches, techniques, methodologies, etc. should be started on the base of change management program. The way the SMEs in west are behaving in the case of change, is under the influence of the techniques and thoughts commonly used in that environment. The preliminary instruments used in daily activities in SMEs in west, is a big project in the SMEs in east. For example, the topic of knowledge management commonly used in SMEs in the west as a daily routine process, if is traced in eastern SMEs, no trace or little trace can be monitored. In Iran, hardly you may find the small scale industries with the knowledge management systems. The value of any organization in today's market is based on the brain ware and intellectual capital. So, the main and important factor in bringing changes in an organization is the ability and the power of knowledge. In this way, the relationship between change paradigm and knowledge management in Iranian SMEs can be clearly discussed. That is the main concept which has been recently understood by some technologic and knowledge based SME leaders in Iran little by little. The Iranian SMEs are almost weak in knowledge management, and it necessary to be discussed in micro and macro levels to bring and ease of related change in Iranian SMEs.

KNOWLEDGE MANAGEMENT IN SMES

According to the knowledge-based view of the firm (Grant, 1996; Spender, 1996), knowledge is regarded as the most important source of competitive advantage. We are living in a knowledge society that yields high returns on knowledge resources (Drucker, 1999). In the last 10 years the number of articles on knowledge management and intellectual capital has been increasing at an average annual rate of 50 percent (Renzl et. al, 2006).

Furthermore, the importance of knowledge management is clear to many organizations and the leaders search for the main reasons and factors for being successful in knowledge management system design and implementation through their organizations (Akhavan et al, 2006).

Nowadays mature governments have also understood the importance of knowledge and management of it, so the related activities are led by top levels and ranks in those countries especially in advanced and developed countries (Akhavan and Jafari, 2006).

Furthermore, it is important to say that the main component of the knowledge-based economy is the knowledge-based organization, which presents some characteristics which clearly differentiate it from the traditional industrial company, currently prevailing at international level. The knowledge based economy becomes the crucial component (engine) of the national and international economy. The transition to the knowledge-based economy is an inevitable, extremely complex and difficult process, which generates many opportunities and threats for SMEs. These opportunities are based on some factors such as the creation and commercialization of the new products, services and technologies; the amplification and diversification of demands on local, regional, national and international markets; the externalization of an important part of the activities for the big companies, state and public institutions; the extension of home work and tele-work for the companies; the development of the organizational and technical networking structured on branches and/or territorially and so on.

Niosi and Rivard (1990) reported that 'SMEs, as niche producers with a smaller range of technologies to offer, may provide easier learning opportunities to industrial firms in developing countries'. In addition, Gomes-Casseres and Kohn (1997) concluded that the competitive advantages of smaller US firms, which derived mostly from their technological leadership, allowed them to adapt and evolve with changes in the international economy, particularly in the industrializing parts of the world.

A SME offers two advantages in initiating research on knowledge management. As Davidson and Griffin (2003) comment, small businesses have contributed many innovative ideas and technological breakthroughs to our society. Further, decisions in a SME are often enacted within a shorter time frame than in larger organizations.

As Delahaye (2005) points out, it was once held that the two most basic resources available to an organisation were money and time and that one could be exchanged for the other. Unfortunately, though, there is no simple exchange equation between money and time, on the one hand, and knowledge on the other, as knowledge has to be created, learned and maintained not simply purchased and maintained (Delahaye, 2005). Further, knowledge is the primary resource for individuals, organisations and the economy (Drucker, 1995).

RESEARCH METHODOLOGY AND DATA COLLECTION

For the research methodology, the authors implemented a structured survey. At first, the main areas of the research domain were questioned from some experts that had sophistications in SME topic and also had some academic research in related domains. After that, a questionnaire was designed based on the feedbacks taken from the experts. The content of the questions has been summarized for better readability

Table 1. The 20 questions on KM and CM

No.	Criteria
Q1	Knowledge management is positively related with organizational size
Q2	Knowledge management is positively related with organizational mission
Q3	Knowledge is tacit rather than explicit in SMEs
Q4	Knowledge sharing is done face to face rather than IT deployment in SMEs
Q5	Learning is done experimental rather than applying the documents
Q6	CEO support and commitment is positively related with KM adoption in SMEs
Q7	Learning is positively related with training in SMEs
Q8	Learning is positively related with interactive participation of employees in SMEs
Q9	Learning is positively related with CEO support and commitment in SMEs
Q10	Learning is positively related with flat structures in SMEs
Q11	The changes are necessary for KM adoption in the organization
Q12	The process are appropriate for knowledge management
Q13	There is a translucent atmosphere in the organization
Q14	Confidence about job security
Q15	Confidence about salaries and rewards
Q16	Confidence about organizational job position
Q17	The hold sessions were effective for change programs
Q18	Motivation systems are very important for change and KM adoption
Q19	The employees accompany with changes
Q20	Reach to knowledge objectives in KM area after the changes

as listed in table 1. The selected response can be strongly disagree, disagree, no opinion, agree, or strongly agree that is evaluated by a Likert Scale.

The main sampling targets were senior managers and department managers who were involved in change and knowledge efforts in the organization.

The research targets were members of 31 SMEs in Iran, specializing and working in IT, communication and electronic domain including hardware and software, electronic and communication circuit design and implementation, ICT consulting and ICT services.

The questionnaire consists of two main parts; the first part was the questions related to knowledge management analysis in organization, and the other part was due to the change factors. The questions were asked in a unit questionnaire. The KM part had asked about knowledge, learning, and their relations with some important organizational features such as organizational size, organizational mission, organizational structures, CEO support and commitment. It also asked about some crucial factors for KM adoption such as training and IT deployment in the organization.

The "change" part of questionnaire asked about change factors from different perspectives. Some questions analyzed the "resistance against the change" factor with some questions about job security, salaries and rewards, and organizational position. If the agree rate of answers in these questions are high, it shows that the change program has not been successful and in this way, we should expect vulnerability in our KM programs. The other section of questionnaire change part analyses the necessity about the changes for KM adoption in the organization. The respondents are questioned about the fitness of available processes, structures, and totally, the current situation of the organization and the necessity of the changes.

Finally, the degree of reaching to knowledge objectives has been asked from the employees in order to understand the rate of success in our programs. Table 1 summarizes the content of the 20 questions.

DISCUSSION

After the reliability test, the questionnaires were analyzed by some statistical methods as follows. With reliability analysis, you can get an overall index of the repeatability or internal consistency of the measurement scale as a whole, and you can identify problem items that should be excluded from the scale. The Cronbach's alpha is a model of internal consistency, based on the average inter-item correlation. The Cronbach's alpha (Likert & Rensis, 1974) calculated from the variables of this research was 0.928, which showed high reliability for designed measurement scale. The selected response can be strongly disagree, disagree, no opinion, agree, or strongly agree that is evaluated by a Likert Scale as discussed.

CEO support and commitment is the important and common factor of every system that should be implemented or established in the organization (Akhavan et al, 2006). The analysis also showed that this factor is so important in the selected SMEs for KM adoption. This factor is also positively related with learning in the organization, which has been confirmed by questionnaire analysis through selected SMEs. It is because we can trace a consensus as much as 89 percent on the positive rate of respondents to the related question (number 9) showing the positive relation between CEO support and learning.

It is important to say that learning itself is the main element of a learning organization, and for moving towards learning organization, the requirements should be considered. CEO support can act as an enabler for the necessities of the learning process for moving towards learning organization.

On the other hand, the analysis showed that knowledge management is positively related to organizational mission. It means that the organizations with knowledge based missions need knowledge management more. As a matter of fact, we have a lot of SMEs in Iran which are playing important roles in Iranian industries and Iranian economics as a sensitive node in Iranian industrial network. Therefore, their missions are more important and sensitive because of the role they are playing in succeeding the Iranian industrial and economical missions. For example, those who are working in information technology, ICT, electronic, computer (hardware and software), and etc. are playing more important role in development and knwledge era. Therefore, we can say that they are the SMEs with the main frame of knowledge and modern technology.

The technologic/ high-tech organizations are highly dependent to their intellectual capital rather than physical assets. As most of the SMEs in this research have been selected from technologic ones including IT firms, and communication and electronic industries, they highly agree that the more advanced and strategic mission for the organization require strong necessity for knowledge management adoption in the organization.

The statistical analysis results showed that there is no relationship between knowledge management and the size of the organization. This may be resulted because of the nature of knowledge and the necessity of its management, free from the usual organizational features. Knowledge management can be established and implemented in every part of the organization including all departments and sub departments; and even it can be considered and generalized from micro level in the organization to a macro level in a country, that can facilitates knowledge based development (Akhavan et al., 2006).

It is important to say that the nature of SMEs supports tacit knowledge rather than explicit knowledge. The analysis also showed that the selected Iranian SMEs matter to tacit knowledge rather than explicit and believe that knowledge is tacit rather than explicit in the SMEs.

Meanwhile, the selected SMEs were limited from the geographical point of view, and because of their size, the skills and experiences of employees play an important role in the organizations. Also, as the work places are near to each other, the employees prefer to share their knowledge face to face rather than applying information technology. The analysis also confirms this opinion and the respondents in the selected SMEs prefer not to use IT for knowledge sharing. The respondents also believe that learning is also done through experience sharing between the employees and not through the documents. This may be because of the lack of an integrated documentation system or because of the previous explanations about fact to face knowledge sharing.

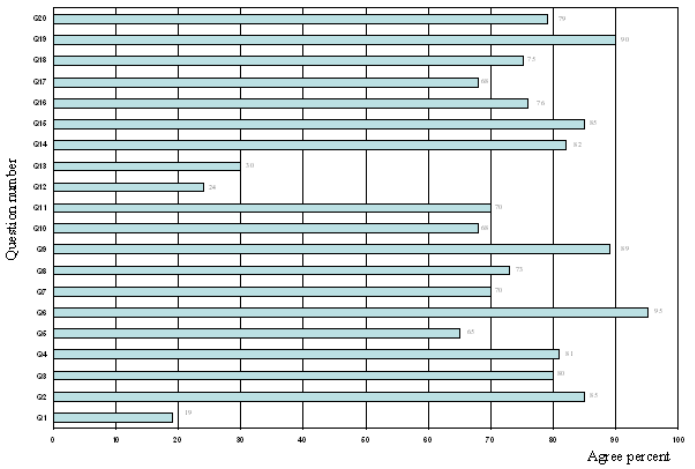
The questionnaire analysis also showed that learning is positively related with interactive participation of employees and flat structures in the SMEs. It is important to say that participation of employees in decision making process is dependent to flatness of the organization. Flat structures encourage employees to take part in decision making and management process by removing middle management layers.

The results also showed that learning is positively related with training. Training process can facilitate knowledge efforts and learning, because there are some skills that may be transferred by educations and training.

On the other hand, the results showed that the employees believe the nature of change and agree and accompany with it. It is also clear from the answers that the respondents believe that the current processes and structures of the organization are inappropriate and should be changed.

The analysis showed that motivation systems play an important role in change programs for KM adoption. The answers also showed that the change program has been successful in conquering against the important factor of "resistance against the change" because the employees were confident about relevant factors such as their job security, their salaries and rewards, and their organizational job

Figure 1. Agree percent of the questions



position. It may be because of the sessions and trainings hold for employees to get familiar with KM foundations and its benefits which helped the acceptance of change programs so much and it is also clear from the answers.

Finally the analysis showed that we have reached many of our knowledge objectives through the change program while most of the respondents were agree with it. Figure 1 shows the agree percent of answers for each question.

CONCLUSION

Nowadays, knowledge is known as a vital and the most important property of the organizations and knowledge management is playing undeniable role in existence of an organization. It gives the ability and power of competitiveness to the organizations. The most valuable thing in today's market is also knowledge and the most valuable organizations are those who can manage their valuable asset called knowledge. Having a successful knowledge management in an organization, is the result of different changes in the firm which should be managed completely.

This article enlightened the relationships between the changes which are necessary for KM adoption in the organizations and knowledge management itself in order to have a successful knowledge management in some Iranian SMEs. Furthermore, this research was designed in order to analyze change management during knowledge management adoption in those Iranian SMEs as the SMEs play an important role in the economies. We are experiencing a new kind of economy in the recent era that is known as knowledge economy which considers the knowledge as the main resource of the organization for innovation and competitiveness. Considering the SMEs as the micro element of the society and a part of macro economy, knowledge management is crucial for driving them towards sustainable competitiveness.

In this paper we explored knowledge management in some Iranian SMEs through a change program. A structured survey was designed and implemented. The findings showed that although the research was implemented in some SMEs, but the results showed that there is no relationship between organizational size and the need for knowledge management. Knowledge management can be considered as the need and requirement of an organization at any size. The results also showed that CEO support and commitment plays a vital role in knowledge management adoption and learning process. Learning itself was confirmed to be positively associated with some factors such as training, employee's participation, and flat structures.

Findings also showed that IT doesn't have an important role in knowledge management in selected Iranian SMEs. It may be resulted because of the level of IT deployment in Iran as a developing country. Although IT is being expanded widely in Iran, but it seems that the Iranian SMEs look at it as a tool for facilitating some of their works and processes and not as a strong tool and important enabler for knowledge management.

The analysis also showed that the change program has conquered against the "resistance against the change" factor and it has been successful in reaching the knowledge objectives as the respondents reached to consensus to the related questions. The answers showed that some related factors such as confidence about job security, confidence about salaries and rewards, and confidence about organizational job position reached consensus. These factors are directly showing the resistance against the change and the analysis showed that the employees are confident about them (job security, salaries and rewards, job position) which may be the result of different sessions and trainings and the motivation systems in the organization.

REFERENCES

ACS, Z.J. (1992), Small business economics: a global perspective, Challenge, November-December.

Akhavan, Peyman, Jafari, Mostafa, and Mohammad Fathian (2006), Critical Success Factors of Knowledge Management Systems: a Multi-Case Analysis, European Business Review Journal, Vol. 18, No. 2, pp. 97-113.

Akhavan, Peyman and Mostafa Jafari (2006), Critical Issues for Knowledge Management Implementation at a National Level, Vine: The journal of information and knowledge management systems, Vol. 36, No.1, pp. 52-66.

Bergeron, Bryan (2003), Essentials of knowledge management, John Wiley & Sons.

Chen, J.C. (1993), The impact of microcomputers on small businesses: England 10 years later, Journal of Small Business Management, Vol. 31, No. 3, pp 96 – 102.

Cragg, P.B., King, M. 1993, Small firm computing: motivators and inhibitors, MIS Quarterly, Vol. 17, No. 1, pp 47 – 60.

Davidson, P & Griffin, R. (2003), Management: An Australasian Perspective (2nd edn.), John Wiley & Sons, Brisbane, Australia.

Delahaye, B. (2005), Human Resource Development: Adult Learning and Knowledge Management (2nd edn.), John Wiley & Sons, Brisbane, Australia.

Drucker, P. F. (1999) 'Knowledge–Worker Productivity—The Biggest Challenge', California Management Review, Vol. 41, No.2, pp. 79–94.

Drucker, P (1995), Managing in a Time of Great Change, Truman Talley Books/ Dutton, New York.

DelVecchio, M. (1994), Retooling the staff along with the system, Bests Review, Vol. 94, No. 11, pp 82 -83.

Davenport, Thomas H. and Prusak (1998), Working Knowledge – How Organizations Manage What They Know, Harvard Business School Press, Boston, Massachusetts.

Fink, D., Tjarka, F. 1994, Information systems contribution to business performance: a study of information systems executives' attitudes, Australian Journal of Information Systems, Vol. 2, No. 1, pp 29 – 38.

Giaglis, George (2001), European Research on Knowledge and Information Management: Current Status and Future Prospects, Available: http://www.eltrun.gr/papers/ICSTM_Giaglis_KIM.pdf

Gomes-Casseres, B. and Kohn, T. (1997) 'The Case of the United States', in P. Buckley, J. Campos, H. Mirza, and E. White (eds) International Technology Transfer by Small and Medium-Sized Enterprises, pp. 280–98. New York: St Martin's Press.

Grant, R. M. (1996) 'Toward a Knowledge-Based Theory of the Firm', Strategic Management Journal 17(Winter Special Issue), pp. 109–22.

Giaglis, George (2002), European Research on Knowledge and Information Management: Current Status and Future Prospects, Available: http://www.eltrun.gr/papers/ICSTM_Giaglis_KIM.pdf

Holzinger, A.G., Hotch, R. (1993), Small firms usage patterns, Nations Business, Vol. 81, No. 8, pp 39 -42.

Khan, E.H., Khan, G.M. (1992), Microcomputers and small businesses in ,Bahrain industrial management and data systems, Vol. 92, No. 6, pp 24 – 28.

Lebre, R. (1998), Small and medium-sized enterprises and IT diffusion policies in Europe, Small Business Economics, Vol.11, No.1, pp.1–9.

Likert and Rensis (1974), "The method of constructing an attitude scale in Gray M. Marshall", Chicago aldine publishing company, pp. 21-43.

Madsen, T.L., McKelvey, B. (1996), "Darwinian dynamic capability: performance effects of balanced intrafirm selection processes", Best papers proceeding, Business policy & strategy division, Academy of management, pp. 26-30.

March, J.G. (1991), Exploration and exploitation in organizational learning, Organization science, Vol. 2, pp. 71-78.

MacGregor, R. and L. Vrazalic (2004), Electronic commerce adoption in Small to Medium Enterprises (SMEs), A Comparative study of SMEs in Wollongong (Australia) and Karlstad (Sweden), University of Wollongong, May 2004.

Neergaard, P. (1992), Microcomputers in small and medium-size companies: benefits achieved and problems encountered, Proceedings of the Third Australian Conference on Information Systems, Wollongong, pp 579 – 604.

Niosi, J. and Rivard, J. (1990), 'Canadian Technology Transfer to Developing Countries through Small and Medium Sized Enterprises', World Development, Vol. 18, No. 10, pp. 1529–42.

Renzl, Birgit, Matzler, Kurt, and Hans Hinterhuber (2006), Organizational Knowledge, Learning and Capabilities, Management Learning Sage Publications, London, Thousand Oaks, CA and New Delhi. Vol. 37, No. 2, pp. 139–141.

Rothwell, R., Dodgson, M. (1993), Technology-based SMEs: their role in industrial and economic change, Inderscience Enterprises.

Spender, J.-C. (1996) 'Making Knowledge the Basis of a Dynamic Theory of the Firm', Strategic Management Journal 17(Winter Special Issue), pp.45–62.

Syed-Ikhsan, Syed Omar Sharifuddin and Fytton Rowland (2004), Benchmarking knowledge management in a public organization in Malaysia, Benchmarking: An International Journal, Vol. 11, No. 3, pp. 238-266.

Weick, C.E. and Quinn, R.E. (1999), "Organizational change and development", Annual Review of Psychology, Vol. 50, pp. 361-86.

Healthcare Information Assurance: Identification Issues

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ABSTRACT

The paper summarizes identification issues pertaining to healthcare information assurance, including National Provider Identifier, identification in HIPAA, Electronic Medical Records, Electronic Data Interchange, and Disease Management. In conclusion, it discusses the need for further research of interlinks and dependencies among various identifiers of healthcare information to support confidentiality, integrity, and availability of a trustworthy national healthcare information system.

1. INTRODUCTION

Healthcare is a trillion-dollar industry in the United States, accounting for 14 percent of the nation's gross domestic product, with about 10 million employees sharing approximately 400 job titles. While the industry grows, it is also undergoing rapid transformation in the area of Web-based activities and increased security needs.

Healthcare providers and insurance companies amplified their Internet presence with Web-based applications such as online doctor-patient interactions, appointment scheduling, patient records administration, electronic claims, and online referral to specialists, computerized physician order-entry, dissemination of healthcare information over wireless networks to laptop computers and other devices, and many other forms of information delivery.

This paper reviews some issues of identification, de-identification, authentication, privacy and security for Healthcare Information Assurance and their application to a trustworthy national healthcare information system.

2. HIPAA

The Health Insurance Portability and Accountability Act (HIPAA), passed by Congress in 1996, recognizing the need for privacy and security protection of healthcare information, set national standards for identifiable Protected Health Information (**PHI).** It requires all health plans, healthcare clearinghouses, and healthcare providers that operate with PHI to comply with HIPAA's Privacy Rule and Security Rule.

2.1 HIPAA Components and Regulations

PHI is characterized as the following:

- It describes past, present, or future physical or mental health, or condition of an individual; or
- It describes a provision of health care to an individual; or
- It describes a payment for the provision of health care to an individual; or
- It identifies or provides a reasonable basis to believe it can be used to identify an individual.

Three main components of HIPAA are:

- Privacy of patients' PHI with national standards (The Privacy Rule),
- Security of electronic transactions with patients' PHI (The Security Rule), and
- Transactions and code set standards (for claims, enrollment, eligibility, payment, coordination of benefits, etc)

The Privacy Rule implemented on April 14, 2003 has privacy provisions applicable "to health information created or maintained by health care providers who engage in certain electronic transactions, health plans, and health care clearinghouses." [HSS 2006] It protects confidentiality of the individual's PHI when this PHI is used or disclosed in any form—paper, oral, electronic. HIPAA privacy and security regulations enforce accountability and apply to healthcare providers and to anyone who provides financial, legal, business, or administrative support to health care providers or health plans.

HIPAA privacy and security regulations enforce accountability and apply to healthcare providers and to anyone who provides financial, legal, business, or administrative support to health care providers or health plans.

HIPAA Transaction and Codes Sets regulations require that transmission of all healthcare data electronically be based on standard transactions, code sets, and identifiers. Thus, for Electronic Data Interchange (EDI), HIPAA has identified ten standard transactions (e.g., claims and encounter information, payment and remittance advice, and claims status and inquiry) and the code sets to be used in those transactions.

The four categories of code sets for claims are: pharmacy code set (from National Council for Prescription Drug Programs) and dental, professional, and healthcare institutional code sets (all three from Washington Publishing Company)

HIPAA regulations are based on the following Key Concepts:

- *Principle-based*. Complying with a series of security best practices and principles.
- *Reasonableness*. Mitigating all reasonably-anticipated risks by balancing resources and business requirements against the risks.
- *Full compliance.* Having workforce members of the covered entity in compliance with the regulations.
- *Documentation*. Having security processes, policies, and procedures approved and documented.
- *Ongoing compliance.* Revising security policies and procedures as needed, providing regular security training, and building awareness of the workforce.

2.2 HIPAA Security Rule

The HIPAA Security Rule established "national standards for the security of electronic health care information… This final rule specifies a series of administrative, technical, and physical security procedures for covered entities to use to assure the confidentiality of electronic protected health information." [Security 2003]

It specifies administrative, technical, and physical security procedures for covered entities to assure the confidentiality of "all electronic protected health information the covered entity creates, receives, maintains, or transmits." [Security 2003] It requires that each covered entity engaged in the electronic maintenance or transmission of identifiable health information pertaining to individuals assesses potential risks and vulnerabilities to electronically maintained or transmitted healthcare information and develop, implement, and maintain appropriate security measures to protect that information. [HSS 2006]

While HIPAA Privacy Rule applies to all PHI, the HIPAA Security Rule applies only to the **electronically maintained** or **transmitted** subset of PHI (ePHI).

Three basic categories of security mechanisms are: administrative procedures, physical safeguards, and technical security mechanisms. In addition, the security solutions must provide protection against the following:

- any reasonably anticipated threats or hazards to the security or integrity of such information;
- any reasonably anticipated uses or disclosures of such information that are not permitted or required by the Privacy Rule

Other important components of Healthcare information Systems that need protection are Electronic Medical Records EMR (also called electronic Health Records) and National Provider Identifiers (NPI).

Identification, de-identification, and authentication are common security concerns for various healthcare applications. They are addressed within the scope of the HIPAA Security Rule.

2.3 Implementation of HIPAA Privacy and Security Rules

A Privacy and Security Office in charge of consistent HIPAA compliance is responsible for Risk Analysis and Evaluation, as well as reporting of suspected security incidents and incident handling, including documentation, determination of notification requirements, remediation, and reporting to management. Overall, the HIPAA security standard requires comprehensiveness in terms of all aspects of security; scalability; and technological neutrality. Therefore, HIPAA Security Rule implementation must follow the guiding principles listed below:

- *Scalability.* All sizes of covered entities must comply with the rule, from the one-person doctor office to the insurance company with thousands of employees.
- *Comprehensiveness.* Principle of "defense in depth" as a unified security approach
- *Technology neutral.* No requirement for specific security technology (firewall or IDS) making selection a provider's choice.
- *Internal and external security threats* protection. Must protect ePHI against both internal and external threats.
- *Risk analysis*. Must regularly conduct thorough and accurate risk analysis.

Security Rule protecting identifiable PHI makes distinction between ''required'' and ''addressable'' specifications. Required implementation specifications are mandatory and must be met. Addressable specifications, depending on the specifics of the covered entity environment (size, capability, risk), are implemented as follows: if the covered entity determines that a given addressable specification is a reasonable and appropriate safeguard in its environment, it must implement the specification; otherwise, the covered entity may implement another equivalent measure or choose to not implement or substitute it at all if the standard can be met in some other way but to the same end result. [Security 2003]

Required implementation specifications are listed in Table 1.

Examples of addressable implementation specifications include Workforce Security with Clearance Procedure; Facility Access Control with Access Control and Validation Procedures; Access Control with Encryption and Decryption.

Table 1. HIPAA security rule "required" specifications

Standards	***Implementation of Required Specifications***
Administrative Safeguards	
Security Management Process	Risk Analysis
	Risk Management
	Sanction Policy
	Information System Activity Review
Information Access Management	Isolating Health Care Clearinghouse Functions
Security Incident Procedures	Response and Reporting
Contingency Plan	Data Backup Plan
	Disaster Recovery Plan
	Emergency Mode Operation Plan
Business Associate Contracts and Other Arrangements	Written Contract or Other Arrangement
Physical Safeguards	
Device and Media Controls	Disposal
	Media Re-use
Technical Safeguards	
Access Control	Unique User Identification
	Emergency Access Procedure

3. ELECTRONIC MEDICAL RECORDS (EMR)

"The EMR is the core component around which the totality of clinical care IT progress will necessarily revolve." [Hagland 2006]

Identification and authentication of Medical Records Information, i.e., assuring a reliable match of EMRs with patients, involves complex technical and social issues for potentially over 300 million EMRs accessible through a national health information network. It should be based on a technology-assisted authentication of the patient and an EMR compiled from multiple sources (and locations). However, such technological solution is likely to lead to a number of false-positive record authentications for a particular patient and, consequently, may result in significant health harm. Another problematic situation is authentication under accident or severe disability constraints: the patient may be unconscious or unable to communicate. Whatever the solution is it must strengthen portable EMRs and measures of their safety.

3.1 Identification of EMR

EMR Identity Management with the network-wide patient identifier helps to alleviate these problems and to integrate and exchange the patient's clinical and administrative information dynamically within a Healthcare Information Network (HIN), which may include hospitals, primary care physician, specialists, ambulatory care centers, etc.

The scope of the EMR is characterized by vastly different dimensions, such as the following:

- Continuum of care such as preventive, acute, post-acute, sub-acute chronic, long-term care, community and home care.
- Local needs and practice patterns that vary significantly in the information and functionality across the entire country.
- Clinical specialties such as emergency care, laboratory, radiology, pharmacy, intensive care, medical and surgical services, etc.
- Industry sectors such as hospitals, physicians and other clinicians, payers, community and social service organizations, government/public health, and even life science companies.

This inconsistency in data categories is further complicated by a patient's history, which may span many **legacy identifiers**. Thus, information can be sourced from multiple databases that were established over a long period of time. It may also include SSN, driver's license, individual hospital account and medical record numbers, lab system identifiers, pharmacy system identifiers, that had been changed or not valid any longer.

The solution to such disparity of identifying data is a cross-reference repository of identifiers across all systems, such as EMPI - Enterprise Master Person Index, which evolved from the previous hospital master patient index.

An Enterprise Master Patient Index (EMPI) can be described as a database that contains a unique identifier for every patient in the enterprise (including medical centers, clinics, practice offices, etc.) and provides a cross-reference for all systems, data records and applications throughout the healthcare information network. All registration systems would look to the EMPI to obtain patient information based upon several defined identifiers.

An EMPI will have either the deterministic indexing where one can search based on an exact match of the identifying aggregate data (e.g., combination of name, SSN, date of birth, sex) or the probabilistic searching mechanism based on truncated search data (e.g., truncated last name). A widely known example of it is a search using Soundex formula, which indexes names by their sound when pronounced in English so that matching can occur despite minor differences in spelling. Algorithm for Soundex formula are implemented in various computer languages, including Visual Basic. [Gillham 2001]

Implementation of an EMPI depends on the system architecture and may require conversion of the IT systems or a merge of the medical records. There are two types of patient/record identification: passive identification based on the existing patient's ID document (one factor identification and authentication) and active identification using the EMPI data and algorithms.

Development of EMR is progressing in the USA and in other countries. In the USA, there are plans to develop portable EMRs for every individual. However, a maze of EMR ownership and frequent incompatibility of technical, procedural and clinical requirements are hindering integration of EMRs. Thus, EMR systems are often lacking interoperability, offered on a variety of hardware and software platforms. Their approach and design are not consistent and they have no uniformity in interfaces, vocabularies, coding systems.

The key integration issues of EMRs lay in three areas: identification, authentication, and access control within the entire healthcare delivery chain; network security; and stakeholder commitment.

3.2 De-identification of EMR

One important approach for sharing patient publicly while protecting its privacy is de-identifying healthcare records. De-identified healthcare information (e.g., aggregate statistical data or data stripped of individual identifiers) requires no individual privacy protections and is not covered by the Privacy Rule.

New approaches for data de-identification have emerged to improve quality of research while protecting privacy. Among them, the following two methods of de-identification of PHI are most common:

- Statistical de-identification is performed by a qualified statistician who using accepted analytic techniques concludes that the risk of identification is substantially limited, i.e. that the information used alone or in combination with other reasonably available information is unlikely to identify the subject of the information.
- "Safe-harbor" de-identification method allows a covered entity or its business associate to de-identify information by removing specific PHI identifiers.

Researchers indicate that only 30-60% of all personally-identifying information can be found using the straightforward approach of global searching by the patient's name and replacing all occurrences with a pseudo name. Identifying information is often hidden in other correlated data and in the written free-form notes and letters exchanged among doctors. Other techniques yield to much better results to minimize risk to patient confidentiality. [Sweeney 1996]

For example, Scrub system uses multiple detection algorithms executed in parallel to label contiguous characters of text. Each detection algorithm is designed to recognize only one specific entity (e.g., name or address or date, etc.)

These detection algorithms are employed in a way similar to speech recognition: they use local knowledge sources (e.g., area codes, first names, medical terms) to determine whether searched words "sound" like identifiers (e.g.., medical terms, names). Then, the algorithm with the highest precedence and the greatest certainty above a minimal threshold prevails and its results may be made available for future use. [Sweeney 1996]

The accuracy of this technique is relatively high:

- 100% for well-defined references in the upper-lower case counterparts or numerical codes (such as names, addresses, organizations, cities, states, zip codes and phone numbers); however, this accuracy drops down to 94% when such reference is presented in all upper case letter configuration.
- 99% for more obscure references (such as nick names, abbreviations, ID numbers)
- 95% for references not distinguished by upper-lower case (95%)

HIPAA "Safe Harbor" de-identification of EMR requires that each of the 18 identifiers of the individual or relatives, employers, or household members of the individual must be removed from medical record information in order for the records to be considered de-identified. Examples of such identifiers include names, address, all elements of dates (except year), phone, email, Account numbers, biometric identifiers, and others.

"Safe harbor" de-identification may include the assignment of re-identification codes to the de-identified healthcare record information. These re-identification codes must be securely managed to prevent unauthorized access to information linking these codes with corresponding PHI.

4. NATIONAL PROVIDER IDENTIFIER (NPI)

In addition to the EMR identification, HIPAA requires standard unique identifiers for health care providers, as well as for health plans. National Provider Identifier (NPI), due for compliance by May 23, 2007 for large health plans and a year later for small plans, is the standard unique health identifier assigned to health care providers and an important component of Healthcare Information Assurance. NPI's 10-position number has a 9-position unique identifier plus one position for the check-digit data validation. It is intelligence-free, i.e., does not itself convey information about the provider, and it is compatible with health insurance card issuer standard.

All health care providers are eligible to receive an NPI, but only entities covered by HIPAA are required to use the NPI when submitting and processing electronic transactions. (For example, x-ray technicians and dental hygienists may apply for an NPI but are not required to have an NPI.)

Provider types affected by NPI requirements are legal entities characterized as entity type 1 or entity type 2:

- entity type 1 - individuals (e.g., physicians, dentists, nurses, pharmacists, and physical therapists),
- entity type 2 - organization health care providers and suppliers (e.g., hospitals, ambulatory care facilities, laboratories, HMOs, group practices, suppliers of durable medical equipment, pharmacies, etc.

Additionally, an organization may designate subparts of a covered organization healthcare (like departments, divisions), which are not legal entities themselves but need to be uniquely identified in standard transactions with their own NPIs (that does not apply to individuals). [NPI 2006]

The NPI is to replace all "legacy" identifiers that are currently used, such as Provider Identification Numbers (PINs), National Supplier Clearinghouse (NSC) numbers, Unique Physician Identification Numbers (UPINs), etc. It is also permitted to be used for other lawful non-HIPAA transactions and identification.

The Centers for Medicare & Medicaid Services (CMS) developed the National Plan and Provider Enumeration System (NPPES) to assign NPIs. The NPPES is designed to accept health care provider data (including those who do not participate in Medicare) for unique identification and assigning an NPI. The NPPES performs three required functions: (a) assign a single, unique NPI to health care provider; (b) collect/maintain information about health care providers; and (c) reactivate or deactivate NPIs. It also disseminates NPPES information. [NPPES 2006]

5. ELECTRONIC DATA INTERCHANGE (EDI) AND X12 STANDARD

Electronic Data Interchange (EDI), a fundamental component of the healthcare information network, is the computer-to-computer exchange of business data in standard formats (for example, Purchase Orders, Invoices, Shipment Notices, Health Care Claims). The data is structured by patient's identifier, transaction type, and code sets.

The X12 standard commonly used in healthcare networks defines data structure for electronically exchanged documents using 315 or more EDI transaction sets. The documents are organized as data separated by "delimiter" characters (not as fixed length fields) and include: Transaction Sets consisting of delimited data; Functional Groups consisting of related Transaction Sets; and Interchange wrapping Functional Groups. X12 standard does not define a transmission type.

A new Context Inspired Component Architecture (CICA) standard - the XML equivalent of the current X12 standard - enables XML-built business documents in a cross industry setting. The large-scale structure of this architecture has seven discrete levels of granularity - each level builds on the levels below it: from DOCUMENT level to PRIMITIVE level. CICA helps to facilitate a common reusable vocabulary across multiple industries and creates an environment for convergence with other standards of organizations, industry associations or data content committees. [CICA 2002]

6. IDENTIFICATION IN DISEASE MANAGEMENT (DM)

Disease Management (DM) is another area of healthcare information where patient identification is required.

DM has its own specificity in implementation of three tenets of information security: confidentiality, integrity, and availability. The major application processes of DM systems that require security protection are analytic systems, predictive modeling, stratification algorithms. They are at the core of DM and require full confidentiality, integrity, and availability protection. *Analytic systems* integrate data from several sources and provide early identification of members needing services. *Predictive modeling* of medical and pharmacy data (with automated health risk assessment tools and electronic clinical laboratory results) helps to identify high risk members. *Stratification algorithms* are designed to provide informational guidance to a nurse about health status and an acuity level of a patient. [Johnson 2004]

Three components of technological platform for healthcare systems deserve special attention: Web-based applications and data banks, email, and online biometric devices. Web-based healthcare information systems with online data banks for diagnostics, care progress tracking tools, and health care alerts delivered to a portable device are utilized by clinical practitioners more than ever. This information is often integrated into email or other communication systems that need to be protected. It should be noted that biometric devices coupled with communication mechanisms, which provide consistent collection of clinical information, automated transmission of results, and tracking of findings, have inherent information security vulnerabilities. [Johnson 2004]

7. TRUSTWORTHY HEALTHCARE INFORMATION SYSTEM (THIN)

The ultimate goal of IT development at healthcare organizations is building a trustworthy nationwide healthcare information system. The identifiers used for identification, de-identification, and authentication need to be interlinked to support Access Control with confidentiality, integrity, and availability of healthcare information.

The ultimate goal of IT development at healthcare organizations is building trustworthy healthcare information systems to meet the requirements of confidentiality, integrity, and availability specific to healthcare industry.

The information and processes to be protected are diverse in context, workforce preparedness, applications, geography, and technological platforms. Identification, de-identification, and authentication of protected patient information (PHI), medical records (EMR), and providers (NPI) in all kinds of healthcare systems are important for assuring *confidentiality* of information and are addressed in HIPAA's Privacy and Security Rules.

Integrity, i.e. protection from intentional or accidental unauthorized changes, and *availability* are obviously vital requirements for healthcare information and processes. Among two threats to availability of the healthcare information and processes – (a) human actions or natural disasters and (b) network intrusions like denial-of-service – the first threat is more likely to occur than the second one. All three types of control mechanisms – administrative (e.g., access control policies, operating procedures, contingency planning), physical (e.g., off-site backup storage), and technical (e.g., fault-tolerance mechanisms) – play important roles in assuring availability.

The priorities for implementation of confidentiality, integrity and availability (and, consequently, the use of identifiers) may differ from one application to another. For example, in EMR systems confidentiality is clearly a priority, while in DM systems integrity and availability could be of the same or higher concern as confidentiality.

Identification plays a particularly important role in DM applications where risks are characterized by higher single loss expectancy and interlinks to affected members of population are vital (particularly where mass health disaster may occur).

Database vulnerabilities and threats can sufficiently be enforced with common DBMS controls. Although discretionary access controls are prevalent in current healthcare systems, for large systems the preference should be given to the mandatory (policy based) or role-based access controls (with established sensitivity of data and appropriate protection mechanisms).

Use of portable devices, removable media, and email is a common practice in healthcare networks and as such may also have many vulnerabilities. Identification of these devices may also be required to support a high level confidentiality.

EDI exchanging information among various entities is a centerpiece of many healthcare systems. The standard transactions for healthcare systems include identifiers and are covered by HIPAA Transaction and Codes Sets regulations.

8. FUTURE WORK

Integration of various healthcare systems will further complicate issues of identification, de-identification and authentication. Future research will address interlinks and dependencies among various identifiers of healthcare information for modeling a trustworthy nationwide healthcare information system.

9. CONCLUSION

Identification and de-identification play an important role in authentication and security of healthcare information. Recently enacted regulations, while satisfying the needs of relevant systems, do not go far enough in viewing and defining various types of healthcare identifiers in an integrated manner. Model for trustworthy nationwide integrated healthcare systems will have to incorporate critical identifiers and the relationships among them to satisfy requirements of integrated healthcare information assurance.

REFERENCES

HSS (2006). *Medical Privacy - National Standards to Protect the Privacy of Personal Health Information*. Office for Civil Rights – HIPAA. US Department of HSS. http://www.hhs.gov/ocr/hipaa/

Security (2003). *45 CFR Parts 160, 162, and 164. Health Insurance Reform: Security Standards; Final Rule*. Part II. Department of Health and Human Services. Office of the Secretary. Federal Register. Thursday, February 20, 2003

Sweeney, L. (1996). *Replacing Personally-Identifying Information in Medical Records, the Scrub System*. In: Cimino, JJ, ed. Proceedings, Journal of the American Medical Informatics Assoc. Washington, DC: Hanley & Belfus 1996:333-337.

NPI (2006). NPI – Medicare Policy on Subpart Designation. Medical Learning Network. CMS. http://www.cms.hhs.gov/MLNMattersArticles/downloads/SE0608.pdf

NPPES (2006). National Plan and Provider Enumeration System (NPPES). https://nppes.cms.hhs.gov/NPPES/Welcome.do

CICA (2002). ASC X12 Reference Model: Context Inspired Component Architecture (CICA). ASC X12C Communications and Controls Subcommittee. Technical Report Type II. October 2002.

Gillham, Brian (2001). Function for the Soundex Formula. VBCity.com. VB5, VB6. 4/18/2001 http://www.vbcity.com/pubs/article.asp?alias=soundex

Johnson, Alison et al (2004). Disease Management: Changes and Challenges. HCT Project Volume 2. July 2004. http://www.hctproject.com/documents.asp?d_id=2768

Hagland, Mark (2006). Nine Tech trends: Electronic Medical Records. Healthcare Informatics Online. February 2006. http://healthcare-informatics.com/issues

Is Optional Web-Based Seminar an Effective Way of Learning as a Part of Information Management and Information Systems Development Course?

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ABSTRACT

This paper describes the use of the web as a complementary addition to conventional lectures in the learning of the basic concepts of information management and information systems development. We utilize conventional lecture material, search engines on the web, and the Optima learning environment. The solution enables a web-based seminar supporting learning in various ways. First, in our approach the students compose a coursework report focusing on the main concepts of the subject area. This occurs by using lecture handouts and search engines on the web. Second, in the web-based seminar students can familiarize themselves with the coursework reports of other students. We claim that in this way learning can be promoted in the spirit of both cognitive and social constructivism. During the coursework and while in the seminar the students worked in small groups of two to four students or they completed the coursework as an individual task. In the web-based seminar the students had a workspace in the Optima environment for publishing their coursework presentations. At the final phase of the course the students were expected to familiarize themselves with the presentations of other groups. In this paper we analyze the benefit of our WWW-based seminar based on the goals of the course. At the beginning and end of the course the students were expected to analyze their own knowledge of the themes of our course. These themes were: (1) administrative view to information resources management, (2) technological view to information resources management, (3) building information systems, and (4) organizational applications. In addition, the students were expected to analyze how they experienced the coursework. The study found out that the WWW-supported coursework and seminar have a neutral effect on learning different themes of the course in most cases. However, the students of IT faculty benefited more from the web-based coursework in the learning of topics 1 and 3. We also found that the Optima-based coursework suits a little bit better for younger students, males and the students of information technology and it may be more effective as an individual task.

Keywords: Learning of information systems, web-based learning environment, constructivist learning.

INTRODUCTION

In a traditional classroom, learning occurs in the behaviorist manner (behaviorism). The traditional classroom puts a learner in the position of an object of assessment: an instructor initiates, a learner responds, and the instructor then closes the sequence by either accepting or rejecting the learners' turn (Sinclair & Coulthard, 1975). The constructivist learning approach (constructivism) contrasts to the behaviorist approach. From the perspective of these learning approaches, the last decade has been the time of constructivism even at the university level.

Traditional lecture-based teaching is problematic in many ways (Isaacs, 1994 & Rosenthal, 1995). Problems associated with this type of teaching include ineffectiveness, passiveness, and alienation of students. In the context of technology and related sciences, some revisions have been suggested to improve lecturing as a teaching method by activating students using, for example, co-operative learning in small groups and essay-writing assignments about technical topics (Isaacs, 1994). From this perspective lecturing is not without potential if the previously mentioned problems can be corrected, but other learning methods must also be considered.

In the constructivist approach learning is comprehended as the development of mental models. Brandt (1997) emphasizes that constructivism is an essential basis when applying the WWW for teaching and learning. It provides the teacher with a structure for teaching. By focusing on concepts and connecting them to mental models, teachers can gain both confidence and control over the amount of material they cover in the small blocks of time usually allotted to teaching and training. Integrated with experiences that learners use to alter and strengthen mental models, the constructivist approach to teaching information retrieval also gives users the structure needed to get the most out of the Internet.

Based on the aforementioned we suggest a coursework focusing on the main concepts of the learning area. First in this coursework, students need to report what they learned from a lecture handout and give some examples of learning. Second, the students need to search area-related information on the web and give some examples of learning. In this way the students can focus on the main concepts and enrich their learning in a constructivist way.

In the spirit of the social constructivist learning theory for improving the benefits of our web-supported coursework we suggest the use of a virtual learning environment (Optima) and its shared workspace feature. This occurs by publishing and presenting seminar work; by commenting on seminar works created by other students (or groups) and by reading comments expressed by other students.

This paper introduces our approach to carry out a web-supported coursework and seminar. Additionally, it provides the analysis of it focusing on the success of our coursework and seminar from the perspective of the goals of the course. This occurs by comparing the ratings of the students who completed the web-supported coursework to the ratings of the students who did not participate in this coursework.

Our analysis has many goals. We want to know

- how the students' knowledge of different themes was improved,
- how the students experienced the coursework methods, and
- whether age, group size, a gender and a faculty affected the effectiveness of the learning of different themes.

Before discussing the study itself, we first provide an overview of constructivism and the WWW in learning from the perspective of our study.

CONSTRUCTIVISM

Widely known and discussed views associated with (computer-supported) learning include behaviorism and its opposite, constructivism. Behaviorism is interested in a student's behavior (reactions) in relation to teaching (stimulus) while constructivism is interested in the mental processes which affect the behavior of a student (Risku, 1996). A traditional lecture is mainly based on the behaviorist approach while coursework and projects are typical constructivist learning. Most web-based instruction today is based on behaviorism (Morphew, 2002).

Jonassen (1994) summarizes what he refers to as "the implications of constructivism for instructional design". The following principles illustrate how knowledge construction can be facilitated by:

- providing multiple representations of reality,
- representing the natural complexity of the real world,
- focusing on knowledge construction, not reproduction,
- presenting authentic tasks (contextualizing rather than abstracting instruction),
- providing real-world, case-based learning environments, rather than predetermined instructional sequences,
- fostering reflective practice,
- enabling context-and content dependent knowledge construction, and
- supporting collaborative construction of knowledge through social negotiation.

According to Brandt (1997), constructivism asserts that learners construct knowledge by making sense of experiences in terms of what is already known. In constructivist learning the concept of a mental model is essential. Learning is comprehended as the development of a learner's mental models (or a student's knowledge structures). Brandt (1997) emphasizes that constructivism is an essential basis when applying the WWW for teaching and learning. While the goal of constructivism is to recognize and help to facilitate a learner's ability to construct knowledge when applied to teaching information retrieval on the Internet, it also provides the teacher with a structure for teaching. By focusing on concepts and connecting them to mental models, instructors and teachers can gain both confidence and control over the amount of material they cover in the small blocks of time usually allotted to teaching and training. Integrated with experiences that learners use to alter and strengthen mental models, the constructivist approach to teaching information retrieval also gives users the structure needed to get the most out of the Internet.

Despite the promise of constructivism several researchers emphasize the importance of guidance. For example, Silverman (1995) points out that by providing the right amount of traditional instruction, students seem to favor constructivist environments. Additionally, he suggests different tools (e.g. a multimedia authoring environment, better communication media, and easily integrated microworld simulators) to support lessons based on the constructivist approach.

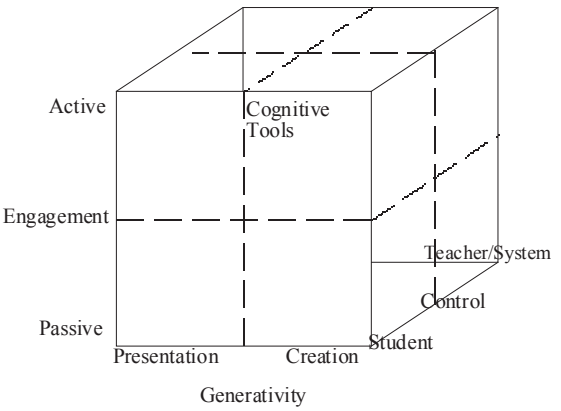
THE WWW IN LEARNING IN OUR CONTEXT

Vast information resources are available to teachers and students via the WWW. However, the problems inherent in any information system such as disorientation, navigation inefficiency and cognitive overload are multiplied on the Internet (Brandt, 1997). On the other hand, these problems can be overcome using a suitable pedagogical approach and/or appropriate tools.

In the case of coursework one approach may be by seeing Internet tools as cognitive tools, in other words, tools for knowledge construction. A cognitive tool is a term introduced by Jonassen in his discussion of hypermedia tools (Jonassen, 1992). He claims that cognitive tools actively engage learners in the creation of knowledge that reflects their comprehension and conception of the information rather than focusing on the presentation of objective knowledge. These tools are learner controlled, not teacher or technology driven. The use of a cognitive tool changes the role of the student into that of an active learner. Figure 1 shows cognitive tools in the general three-dimensional framework for computer-based learning. (Jonassen, 1992). These dimensions are generativity, control, and engagement.

In the same way, web-based tools, like Optima, can be seen in an active context. The students can use Optima and its presentation feature for introducing their ideas, receiving feedback, and managing coursework. This leads to learning by constructing knowledge based on both a student's own ideas and other students' ideas.

Figure 1. Cognitive tools in the general framework of computer-based learning



In the case of a web-based seminar it is useful to discuss the use of the WWW from the perspective of media research. Haythornthwaite (2001) stresses the interpersonal ties that affect the character of web-based communication. According to her, strong ties between students improve web-based communication: based on this we claim that traditional teaching and learning are needed as a part of a course. The traditional parts of a course develop these ties in the way that is not possible in a totally virtual training setting. In this way we can create contexts in which effective WWW-based learning is possible.

Based on the above, it is important to appreciate these views of learning while outlining courses and to understand the use of the WWW in learning. We stress the following three issues. First, we must discuss what the right amount of traditional (behaviorist) teaching should be. Second, we must analyze what is the right way to use the WWW. Active learning must be promoted and situations conducive for successful web-based learning must be created. Third, scaffolding support is needed to support constructivist learning based on the WWW. We claim that after the introductory course level many courses of information systems science can be built on the constructivist approach of learning. This occurs based on coursework that works as the core of the course.

METHODS

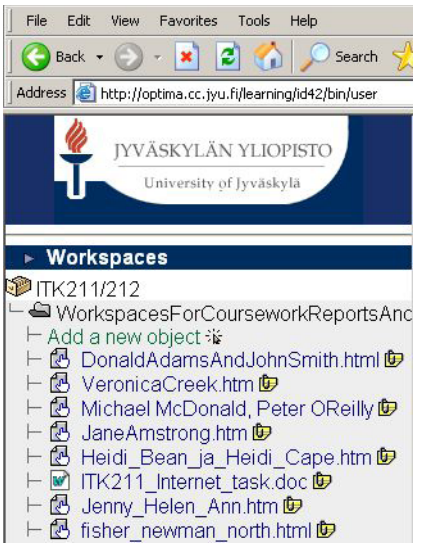
We pursued the study, including a WWW-supported coursework, using the Optima environment. In this section we describe our experiment, sample, and results.

Experiment

At the University of Jyväskylä, the themes of the course Information management and information systems development are (1) administrative view to information resources management, (2) technological view to information resources management, (3) building information systems, and (4) organizational applications. The course was inspired by a textbook, Information Technology for Management: Transforming Business in the Digital Economy (Turban et al., 2002). The course usually lasts for seven weeks including lectures (36 hours), coursework (feasibility study) as well as the final exam. The course given in fall 2004 also lasted for this length of time and included the above-mentioned activities and in addition material and activities on the WWW to support the lectures in the constructivist fashion.

To realize the benefit of the lecture notes we organized a coursework in which students were expected to enter their findings in their diaries. Before this the students were expected to familiarize themselves with the lecture handout of the course (128 pages) and try to find more information from the web to understand the possible difficult matters in our material. The students needed to report what (a) they learned based on the lecture handout, and (b) what useful links they found by using search engines and directories. Additionally, the students were expected to give various examples (for example www links) of what they had learned during the coursework. To promote the students' participation in the optional coursework, the students got credits by completing the coursework for the final examination. Although the coursework is a constructivist part of the course, the

Figure 2. Screenshot from students' workspace of web-supported coursework



teacher's office hours were available as an additional resource to promote their work. The students had six and a half weeks for the coursework before the final examination. The work was expected to be conducted as an individual task or in groups of two or three students.

The groups placed the presentations in the web-based workspace on the Optima web-based learning environment. Other groups were expected to familiarize themselves with these presentations. All the groups had permission to upload files to this workspace. Additionally, it was possible to attach comments regarding any work of other groups on this workspace. For authoring the coursework, the groups had six weeks. After these six weeks the groups were expected to comment on at three other coursework presentations. These comments were placed in the Optima workspace. The students had one week for this. In the comments the students were expected to clarify what they learned by reading a coursework report given by others.

Figure 2 shows the first view of students' workspace on Optima. With the help of this outlook the students had a possibility to upload and see files, and comment on the presentations created by other groups. By clicking a yellow button after the filename of a presentation the students were able to comment on the reports by other groups.

Sample

Forty-five students, 14 females and 31 males, whose mean age was 24 years (range 18-39 years), participated in the experimental group including the web-based seminar. 6 students studied informatics as a minor and 39 students as a major. 40% of them completed the coursework individually, 11.1% in groups of two students, 40% in groups of three students, and 8.9% in groups of four students. We call this group the WWW group in this paper.

Forty-six additional students, 10 females and 36 males, whose mean age was 23 years (range 17-46 years), were involved in the control group. 13 students studied informatics as a minor and 33 students as a major. We call this group the non-WWW group in this paper.

All the students had been initiated into the use of a PC and a WWW browser, and all of them were familiar with university lecturing. The pre-questionnaire conducted at the beginning of the course showed that the students both in the experimental group and the control group were at the same level concerning the main topics of the course: (1) administrative view to information resources management, (2) technological view to information resources management, (3) building information systems, and (4) organizational applications.

Collecting Data

The data for this study was collected by administering a questionnaire both at the beginning and the end of the course. The respondents rated the personal competence level of four main topics with regard to how excellent they considered the knowledge of each topic (where 1=very poor and 5=very good). Additionally, the respondents rated how beneficial they considered the coursework of the course (where 1=very useless and 5=very useful).

Results

How students' knowledge was improved

Since the data based on the responses of the students concerning the goals of the course agreed with the normal distribution, the one-way ANOVA test was appropriate for the analysis of the data. Concerning knowledge to learn different themes, and according to the one-way ANOVA test, the study found that the WWW-based coursework was equally useful in the learning in most cases. The statistical analysis did not show any difference between the groups except for the learning of building information systems. The details of the analysis concerning skills are shown in table 1. For this analysis the students were expected to analyze their skills based on a 5-point Likert scale in the questionnaires.

How students experienced coursework in general

Table 2 shows the students of the WWW-group ratings on the coursework and seminar in general. The students were expected to rate how they experienced the coursework generally. The result shows that their attitude is mainly positive in both groups concerning the coursework generally.

Evaluating the effect of age, group size, gender and faculty

In order to clarify whether age affects the learning of different themes, the Pearson correlation coefficients were calculated. Based on the correlations younger students appear to benefit from the web-supported coursework and the use of the Optima tool. Table 3 shows the details of our analysis in the non-WWW group and table 4 (see next page) in the WWW group.

Table 1. Analyzing the students' knowledge of different themes

	Mean at the beginning of the course			Mean at the end of the course		
	Non-WWW group	WWW group	P	Non-WWW group	WWW group	p
Administrative view to information resources management	2.46	2.53	.141	3.23	3.48	.070
Technological view to information resources management	2.39	2.47	.117	3.26	3.40	.435
Building information systems	2.44	2.33	.294	3.30	3.73	.004
Organizational applications	2.31	2.23	.156	2.83	3.00	.309

Table 2. Students' attitude concerning coursework generally

n	44
Mean	4.02
Very insignificant	0
Insignificant	2
Moderately significant	2
Significant	33
Very significant	7

Table 3. Analyzing ratings based on age in non-WWW group

At the beginning of the course	Administrative view to information resources management	Technological view to information resources management	Building information systems	Organizational applications
Correlation Coefficient	.188	.355	.379	.191
p	.210	.016	.010	.210
At the end of the course				
Correlation Coefficient	.280	.097	.224	.112
p	.059	.521	.134	.457

Table 4. Analyzing ratings based on age in WWW group

At the beginning of the course	Administrative view to information resources management	Technological view to information resources management	Building information systems	Organizational applications
Correlation Coefficient	.396	.412	.297	.438
p	.007	.005	.048	.003
At the end of the course				
Correlation Coefficient	.382	.285	.011	.315
p	.010	.058	.944	.035

By analyzing ratings based on group size we found that group size does not affect the learning of most themes. The one-way ANOVA test did not show significant differences in the ratings between the students who completed the individual course work (n=18) and the students who did the coursework in the groups (n= 24) at beginning of the course (p varying from .121 to .147). On the other hand, at the end of course we found the significant difference (p=.045) between the WWW-group and the non-WWW group concerning the learning of the building information systems theme. The learning of this theme worked better as an individual task.

The analysis of ratings based on gender shows that the gender affects the perceived benefit of any topic to learn ((1) administrative view to information resources management, (2) technological view to information resources management, (3) building information systems, and (4) organizational applications). By analyzing the ratings of females we found that the web-supported coursework does not affect the learning of most themes. The one-way ANOVA test did not show significant differences in the ratings between the female students both at the beginning and end of the course (p varying from .165 to .695). On the other hand, we found by comparing the ratings of males that web-supported coursework is beneficial for them. The one-way ANOVA showed no significant difference concerning ratings between the male students of the WWW-group and the male students of the Non-WWW-group (p varying from .145 to .907) at the beginning of the course. At the end of the course there was a significant difference between the groups concerning topic 1 (p=.022) and topic 3 (p=.009). These themes were better learned in the WWW-group.

Finally, we compared the ratings of the students of the faculty of information technology to the ratings of the students of other faculties (including open university, economics, humanities, and natural sciences). The analysis of ratings by using the one-way ANOVA test shows that the faculty usually affects equally the perceived benefit of the studied features ((1) administrative view to information resources management, (2) technological view to information resources management, (3) building information systems, and (4) organizational applications) in the coursework. At the beginning of the course the statistical analysis did not show the difference between the groups in any faculty. However, the analysis shows that the students of IT benefit more from the web-based arrangements in the learning of administrative view to information resources management (mean of the WWW group of IT faculty students is 3.40 and p=.029, mean of the non-IT faculty students is 3.21 and p=.255) and building information systems (mean of the WWW group of IT faculty students is 3.61 and p=.003, mean of the non-IT faculty students is 3.15 and p=.976).

DISCUSSION

In this paper we analyzed a web-supported coursework focusing on the effect on the topics to learn. The results show that a web-based coursework including a seminar is a potential way to organize a coursework if we have a crowded course. The results are promising because most teachers appreciate the cost-effectiveness of web-based education (Morphew, 2002). Our comparison shows that the Optima-based coursework suits a little bit better for younger students, males and the students of information technology, and it may be more effective as an individual task. The Optima-based coursework suits better for the students of the IT faculty in the learning of administrative view to information resources management and building information systems.

Our results show that the students´ attitude concerning web-supported coursework was positive. This could be the basis for the next step of our research. As mentioned the constructivist approach of learning is divided into two schools. In our approach the first phase, creating a coursework report, represents the cognitive constructivist approach of learning. In this phase the main focus of learning is concepts. In contrast to this, the second phase, participating in a web-based seminar, represents the social constructivist approach of learning. The key point here is interaction and brainstorming through the web in this phase. Based on this it is fruitful to compare the attitudes of the students concerning the first and second phase of the web-supported coursework. The phases present different sides of constructivism.

Nevertheless, this paper demonstrates that a successful seminar for a crowded course is possible using the Optima environment. Without the Optima or other related tools it may not be always possible. In this way the WWW brings new possibilities for education.

REFERENCES

Brandt, D. A. (1997) Constructivism: Teaching for Understanding of the Internet, *Communications of ACM*, 40, 10, 112-117.

Haythornthwaite, C. (2001) Tie Strength and the Impact of New Media, *Proceedings of the 34th HICSS, Hawaii International Conference of Systems Science*, IEEE Computer Society Press. CD-ROM

Isaacs, G. (1994) Lecturing Practices and Note-Taking Purposes. *Studies in Higher Education*, 19, 2, 203-216.

Jonassen, D. H. (1992) "What are Cognitive Tools?" in P. A. M. Kommers, D. H. Jonassen., J. T. Mayes (eds.). *Cognitive Tools for Learning*, Springer-Verlag (NATO ASI Series), Berlin.

Jonassen, D. H. (1994) Thinking technology, *Educational Technology*, 34, 4, 34-37.

Morphew, V. N. (2002) "Web-Based Learning and Instruction: A Constructivist Approach" in M. Khosrow-Pour (ed.) *Web-Based Instructional Learning*, IRM Press.

Risku , P. (1996) *A Computer-Based Mathematics Learning Environment in Engineering Education*, Report 71, University of Jyväskylä, Department of Mathematics, Jyväskylä.

Rosenthal J. (1995) Active Learning Strategies in Advanced Mathematics Classes, *Studies in Higher Education*, 19, 2, 223-228.

Silverman, B. G. (1995) Computer Supported Collaborative Learning (CSCL), *Computers in Education*, 25, 3, 81-91.

Sinclair, J. & Coulthard, R. M. (1975) *Towards an Analysis of Discourse: the English Used by Teachers and Pupils*, Oxford University Press, London.

Turban, E., McLean, E. Wetherbe J. (2002) *Information technology for management: transforming business in the digital economy*, John Wiley & sons, New York.

Mining Multiple Markets' Exchange Rate: An Artificial Intelligence Tools Survey

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ABSTRACT

Foreign exchange rate prediction is an expanding industry with various commercial services throughout the world, employed various techniques providing foreign exchange rate predictions. This paper examined the daily exchange rate data from six different countries and used that data to discover the correlation relationship among them. In this study, we used five of the exchange markets' daily data to predict the sixth market's exchange rate of the next day. We used four different artificial intelligence algorithms as our tools and our experiments yield quite interesting results.

Keywords: Exchange rate, Prediction, Artificial Intelligence.

1. INTRODUCTION

It is often argued that it is futile to attempt to predict foreign exchange rates because the foreign exchange market is an efficient market. The market is efficient in that the major participants are believed to have access to all the current information that may impact on price or at the assumption that the historic exchange rate information contains no useful information that can be used to predict the future exchange rates.

Many empirical studies of the exchange rate market have used statistical analysis or more sophistic models such as artificial intelligence algorithms in an effort to uncover significant pattern in the historical exchange rate data. These studies have found that the exchange rate data appear to have no significant pattern.

A couple of studies have found evidence through their research marginally profitable in the foreign exchange market. Our study, in using five foreign exchange rate markets and predicting the future exchange rate of sixth market produced quite accurate results. We compared the performance of four different artificial intelligence algorithms through our data set and found that all have very high predictive accuracy.

2. RELATED WORKS

Based on the concept of speculative runs Alexander [6] shown that a currency that has risen significantly is likely to continue its upward trend and a currency that has fallen significantly will continue to follow its downward trend. Bleaney [5] examined the claim that error-correction models of exchange rates can perform well in out-of-sample forecasting tests at long horizons. Rose and Selody [1] performed a test on daily data on five mature exchange rate markets shown that the data reject the joint hypothesis of exchange rate market informational efficiency and no risk premium. Logue and Sweeney [3] in their study of the Franc/Dollar spot rate found that while the data seemed to be white noise using spectoral analysis, there were a number of simple trading rules which yielded at least marginal profits. The k percent rules are used which buy a currency after it has risen k percent from its previous low and see it after it has fallen k percent from previous high. Logue, Sweeney and Willet [4] later came to a different conclusion that the foreign exchange markets are at least weakly efficient. From their results shown that k percent rules yielding substantial profits as compared with a buy and hold strategy. In a recent study by Chen, Kuo and Hoi [7] found contradicting evidence that the hypothesis that GP can generate profitable trading strategies in the foreign exchange markets does not win strong support.

In this paper we evaluated the predictive accuracy of foreign exchange rate markets using a variety of artificial intelligence algorithms providing a good test of market efficiency and correlativity in the foreign exchange markets.

3. EXCHANGE MARKETS

The foreign exchange market exists whenever one currency is trade for another. Capital wise it is by far the largest trading market in the world. The parties involve are banks, corporations, governments, traders, etc. The foreign exchange market is unique because of its several characteristics:

- Large trading volume
- Liquidity of the market
- Large participants in the market
- Geographical diverse
- Long trading hours due to the different time zone
- Variety factors that affect exchange rates

There is no single unified foreign exchange market due to its over the counter nature of the currency trading, different currency instruments are traded on a number of interconnected markets. The main trading centers are in London, New York and Tokyo, but banks throughout the world participate. As the Asian trading hours end, the European hours begin, then the US and back to Asia. It is a non stop trading throughout the world. Traders can react to the news as it become available, rather than wait and response during the market hours.

There is little or no inside information in the foreign exchange markets as the rates are fluctuate due to various factors such as GDP growth, inflation, interest rates, deficits or surplus and other macroeconomic conditions.

Controversy about currency speculators and their effect on currency devaluations and national economics recurs regularly. Many economists argue that speculators perform the important function of providing a market for hedgers and transferring risk from the one to another. Others consider this argument to be based more on politics and free market philosophy than on economics. Currency speculation is considered a highly suspect activity in many countries. While investing in traditional financial instruments like bonds or stocks often is considered to contribute positively to economic growth by providing capital, currency speculation does not.

4. ARTIFICIAL INTELLIGENCE ALGORITHMS

Artificial intelligence algorithms have been widely utilized for computational intelligence in the field of finance and economic. In this study, we applied four different artificial intelligence algorithms: multi-layer perceptron, radial basis functions, support vector regression model and regression by discretization model. Here is a brief description of each:

Multi-layer perceptron - This neural network uses backpropagation to train. A neural network is a powerful data modeling tool that is able to capture and represent complex input/output relationships. The motivation for the development of neural network technology stemmed from the desire to develop an artificial system that could perform "intelligent" tasks similar to those performed by the human brain. Neural networks resemble the human brain in the following two ways:

1. A neural network acquires knowledge through learning.
2. A neural network's knowledge is stored within inter-neuron connection strengths known as synaptic weights.

The true power and advantage of neural networks lies in their ability to represent both linear and non-linear relationships and in their ability to learn these relationships directly from the data being modeled.

The most common neural network model is the multilayer perceptron (MLP). This type of neural network is known as a supervised network because it requires

a desired output in order to learn. The goal of this type of network is to create a model that correctly maps the input to the output using historical data so that the model can then be used to produce the output when the desired output is unknown. A graphical representation of an MLP is shown below in Figure 1.

In neural networks, an activation function is the function that describes the output behaviour of a neuron. The most common activation functions are sigmoid and Gaussian functions.

- Sigmoid function $f(\mu_i) = \frac{1}{1+e^{-\mu_i/\sigma}}$
- Gaussian function $f(\mu_i) = e^{-\mu_i^2/\sigma^2}$

Radial basis functions - a normalized Gaussian radial basis functions network. It uses the k-means clustering algorithm to provide the basis functions and learns either a logistic regression (discrete class problems) or linear regression (numeric class problems) on top of that. Symmetric multivariate Gaussians are fit to the data from each cluster. If the class is nominal it uses the given number of clusters per class. It standardizes all numeric attributes to zero mean and unit variance. Radial basis functions (RBFs) are the natural generalization of coarse coding to continuous-valued features. Rather than each feature being either 0 or 1, it can be anything in the interval , reflecting various degrees to which the feature is present. A typical RBF feature, i, has a gaussian (bell-shaped)response, $\phi_s(i)$,dependent only on the distance between the state, s, and the feature's prototypical or center state, ci , and relative to the feature's width, $\phi_s(i)$:

$$\phi_s(i) = \exp\left(-\frac{||s-c_i||^2}{2\sigma_i^2}\right).$$

The norm or distance metric of course can be chosen in whatever way seems most appropriate to the states and task at hand. Figure 2 shows a 1-dimensional example with a euclidean distance metric.

An RBF network is simply a linear function approximator using RBFs for its features. The primary advantage of RBFs over binary features is that they produce approximate functions that vary smoothly and are differentiable. In addition, some learning methods for RBF networks change the centers and widths of the features as well. Such nonlinear methods may be able to fit the target function much more precisely. The downside to RBF networks, and to nonlinear RBF networks especially, is greater computational complexity and, often, more manual tuning before learning is robust and efficient.

Figure 1. A MLP neural network model

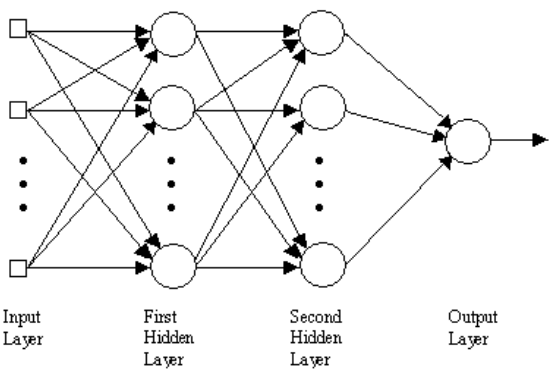
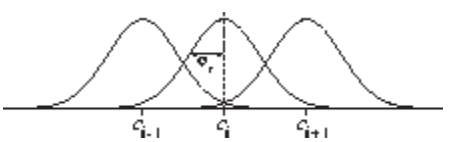


Figure 2. One-dimensional radial basis functions



Support vector regression model - Implements Alex Smola and Bernhard Scholkopf's [2] sequential minimal optimization algorithm for training a support vector regression model. This implementation globally replaces all missing values and transforms nominal attributes into binary ones. It also normalizes all attributes by default. (Note that the coefficients in the output are based on the normalized/standardized data, not the original data.)

SMO was proposed [9] that puts chunking to the extreme by iteratively selecting subsets only of size and optimizing the target function with respect to them. It has been reported to have good convergence properties and it is easily implemented. The key point is that for a working set of 2 the optimization subproblem can be solved analytically without explicitly invoking a quadratic optimizer. While readily derived for pattern recognition by Platt

[1999], one simply has to mimic the original reasoning to obtain an extension to Regression Estimation. The modifications consist of a pattern dependent regularization, convergence control via the number of significant figures, and a modified system of equations to solve the optimization problem in two variables for regression analytically.

Note that the reasoning only applies to SV regression with the insensitive loss function - for most other convex cost functions an explicit solution of the restricted quadratic programming problem is impossible. Yet, one could derive an analogous non-quadratic convex optimization problem for general cost functions but at the expense of having to solve it numerically. The exposition proceeds as follows: first one has to derive the (modified) boundary conditions for the constrained 2 indices (i, j) subproblem in regression, next one can proceed to solve the optimization problem analytically, and finally one has to check, which part of the selection rules have to be modified to make the approach work for regression.

Regression by discretization- A regression scheme that employs any classifier on a copy of the data that has the class attribute (equal-width) discretized. The predicted value is the expected value of the mean class value for each discretized interval (based on the predicted probabilities for each interval).

5. EXPERIMENTS AND RESULTS

We used the exchange rate date of US/UK, US/Italy, US/Canada, Us/Japan, US/Singapore and US/Taiwan markets from 1990 to 2004. We selected the date from 1990 to 2003 as our training/validating data and 2004 as our testing data. We selected the daily data of US/UK, US/Italy, US/Canada, Us/Japan, US/Singapore as our input and the next day's US/Taiwan data as our predicted target.

We used an artificial intelligence software package called WEKA from University of Waikato. It is a data mining environment that provides various artificial intelligence and statistical algorithms and a unify format for input and output data.

We used ten folds cross validation on our training data and here are the training results.

In our training data, we can see that the regression by discretization (decision tree) algorithm is the most accurate.

We then applied the 2004 test data to the trained models. Here are the results.

Table 1. Training result from 10-fold cross validation

Algorithms	Correlation coefficient	Mean absolute error	Root mean square error
Multilayer perceptron	0.9803	0.0006	0.0008
Radial Basis Networks	0.993	0.0003	0.0005
Support Vector by Regression	0.9405	0.001	0.0013
Regression by discretization (decision tree)	0.9944	0.0003	0.0004

Table 2. Testing results (next day's predictive accuracy) from the 2004 data.

Algorithms	Mean absolute error	Root mean square error
Multilayer perceptron	0.0007	0.001
Radial Basis Networks	0.0044	0.0058
Support Vector by Regression	0.0029	0.0031
Regression by discretization (decision tree)	0.0053	0.0065

Figure 3. Multi-layer perceptron

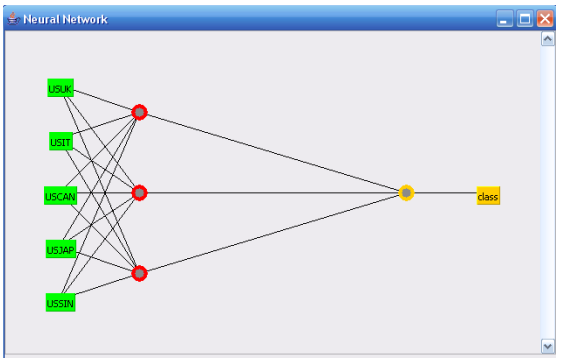
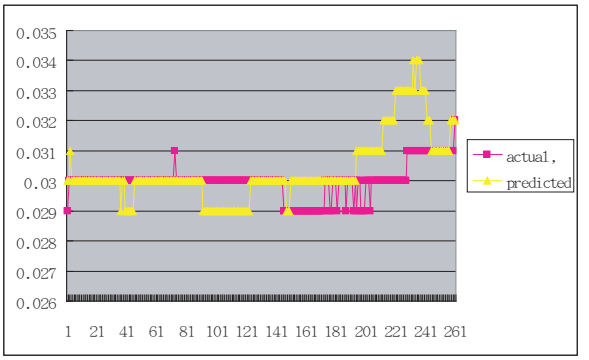


Figure 4. Actual and predicted output from 2004 testing data



From the above experiments we conducted, we found that for out of sample testing (year 2004) the multi-layer perceptron (neural network) (see Fig. 3) had the lowest mean square error and root mean square error. Here are the actual and predicted output data from multi-layer perceptron using the 2004 testing data. (Fig. 4)

6. CONCLUSIONS AND FUTURE WORKS

Our finding in this study is quite interesting that it contradict the hypothesis that the foreign exchange rate market is efficient. In this study, we can get very accurate prediction using the data from other related markets. For the future work, we would like to expand the system to provide investor an exchange rate trading strategy based on the predicted output. And we would like to also expand the algorithms used in the study to include other major artificial intelligence algorithms used by other researcher in this area.

7. REFERENCES

[1] A. Rose and J. Selody, "Exchange Market Efficiency: A Semi-Strong Test Using Multiple Markets and Daily Data", *The Review of Economics and Statistics*, Vol. 66, No. 4. pp 669-672, 1984.

[2] A. Smola, B. Scholkopf, "*A Tutorial on Support Vector Regression*". NeuroCOLT2 Technical Report Series - NC2-TR-1998-030, 1998.

[3] D. Logue and R. Sweeney, "White Noise in Imperfect Markets: The Case of the Franc/Dollar Exchange Rate", *Journal of Finance,* pp. 159-174, 1978.

[4] D. Logue, R. Sweeney and T. Willett, "Speculative Behavior of Foreign Exchange Rates During the Current Float", *Journal of Business Research*, pp. 761-768, 1978.

[5] M. Bleaney, "Exchange Rate Forecasts at Long Horizons: Are Error-Correction Models Superior", *The Canadian Journal of Economics*, Vol. 31, No. 4. pp 852-864, 1998.

[6] S. Alexander, "Price Movement in Speculative Markets: Trends or Random Walks", *Industrial Management Review*, pp. 24-26, 1974.

[7] S. Chen, T.Kuo and K. Hoi, "Genetic Programming and Financial Trading: How Much about "What we Know"? *Handbook of Financial Engineering.*

[8] S. Goodman, "Foreign Exchange Rate Forecasting Techniques: Implications for Business and Policy", *The journal of Finance,* Vol. 34, No. 2, pp.415-427, 1978.

[9] J. Patt, "Fast training of support vector machines using sequential minimal optimization. In B. Scholkopf, C.J. C. Burges and A. J. Smola, editors, Advances in Kernel Methods-Support Vector Learning, MIT Press, pp. 185-208.

APPENDIX A.

The following graphs illustrated the daily data from six exchange markets from 1986 to 2004.

Figure 5. USA vs. Japan exchange rate

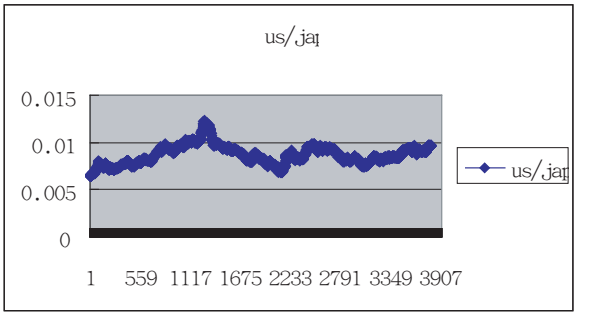


Figure 6. USA vs. UK exchange rate

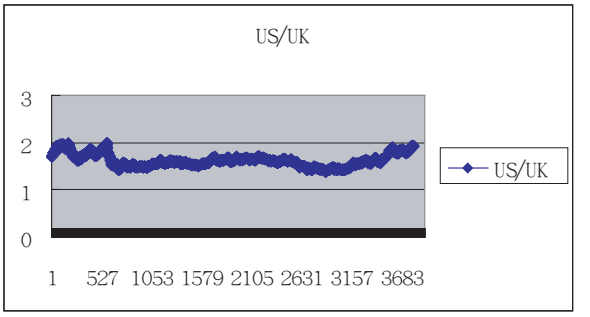


Figure 7. USA vs. Italy exchange rate

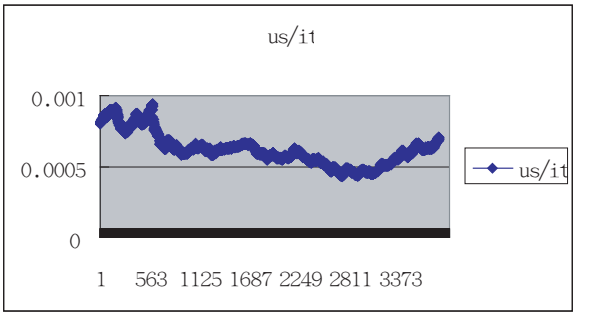


Figure 8. USA vs. Canada exchange rate

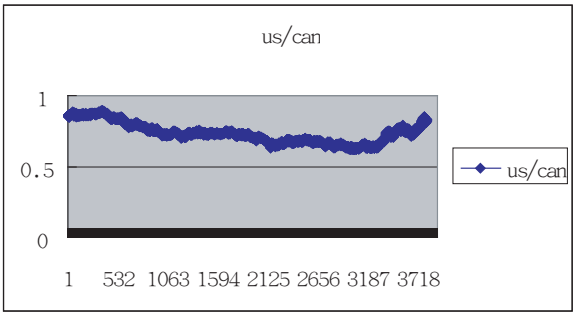


Figure 9. USA vs. Taiwan exchange rate

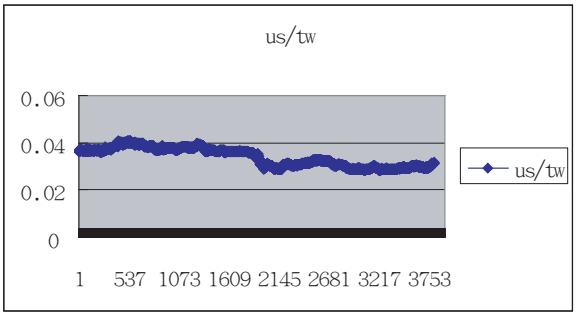
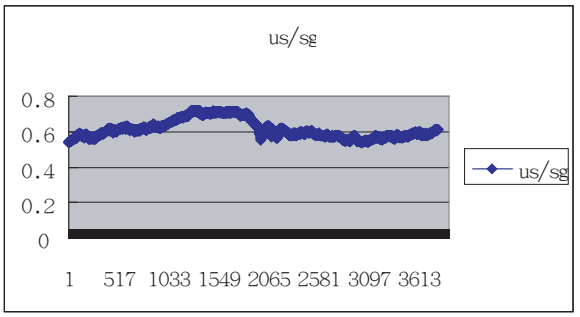


Figure 10. USA vs. Singapore exchange rate



Study of the Extended Technology Acceptance Model in the U.S. Navy: Case of Combat Information System

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ABSTRACT

The U.S. Navy continues to be a major developer and procurer of information systems (IS), yet very limited research has been done to determine the factors that influence technology acceptance by naval personnel. Literature suggests that efforts to embrace information technology in improving decision-making and reducing workload heavily depend on the use of such systems. Moreover, previous research has shown the validity of the technology acceptance model (TAM) and computer self-efficacy (CSE) to model technology acceptance in numerous environments. However, very little research was done specifically addressing such technology acceptance with military combat IS. Thus, this study examines the applicability of the extended TAM with a CSE construct model to the U.S. Navy's combat IS. A survey sample of 237 sailors from five (5) different U.S. Navy aircraft carriers was used to assess such extended model on a U.S. Navy's combat IS. Results indicate that perceived ease-of-use, perceived usefulness, and CSE were valid antecedents of technology acceptance (as indicated by intention to use). Moreover, high Cronbach's Alpha was observed on all measures indicating additional reliability of the measures also in the context of military organizations.

Keywords: Technology acceptance model, computer self efficacy, IS in military/U.S. Navy, combat information systems, perceived usefulness of military IS, perceived ease of use of military IS, attitude toward military IS, intention to use IS in military.

INTRODUCTION

There is a large body of research regarding technology acceptance of information systems (Davis, 1989; Chau, 1996; Chau & Hu, 2001; Hu, Chau, Sheng, & Tam, 1999; Legris, Ingham, & Collerette, 2003; Venkatesh, Morris, Davis, & Davis, 2003; Ma & Liu, 2004), but a scarce number of studies regarding technology acceptance by members of the U.S. Navy. A common misconception of the military is that it is wholly structured. In reality, aboard a naval ship there are sometimes overlapping applications that a sailor can choose to use or ignore. Especially of interest is the usage or lack thereof of Decision Support Systems – that by their nature are designed to improve the quality of choices made by fleet personnel. There is anecdotal evidence that systems that provide situation awareness and decision support are not fully utilized by the intended audience.

Between 2001 and 2005, the U.S. Navy had an annual budget of about $120B (Globalsecurity.org, 2005). The exact amount that the Navy spends on information technology is hard to quantify, but a line item review of the budget indicates that the amount spent on information technology is measured in the billions of dollars (Globalsecurity.org, 2005). A focus of information technology development is to reduce shipboard manning. Achievement of this goal will require the development and integration of improved information systems (Bisantz, Rothe, Brickman, et al., 2003). It can be asserted that considering the funds being applied to information technology, a model for technology acceptance and the factors that influence information system usage should be determined (Davis, 1989; Chau, 2001).

Researchers have recommended replication of instruments and revalidation of models for unique environments (Amoako-Gyampah & Salam, 2004). Many technology acceptance studies have taken place in academic settings (Davis, 1989; Taylor & Todd, 1995; McFarland & Hamilton, 2006), but the military environment is different. Technology acceptance studies have been successfully replicated in many environments, but with varying factor loading between constructs (Legris, et. al., 2003). Examples of different environments where technology acceptance has been studied include a public hospital system (Chau & Hu, 2001), a construction-engineering environment (Lowry, 2002), Decision Support Systems in use in Egypt (Elbeltagi, McBride, & Hardaker, 2005) and a large corporation undergoing ERP implementation (Amoako-Gyampah & Salam, 2004).

Development of a technology acceptance model for the U.S. Navy will result in a validated instrument for assessing the acceptance and expected usage of an information system. A validated model also can be used as a tool to identify weaknesses in a technology implementation and adjust the approach. This information is valuable to a Program Manager who must make decisions on how to invest in system improvements.

THEORETICAL BACKGROUND

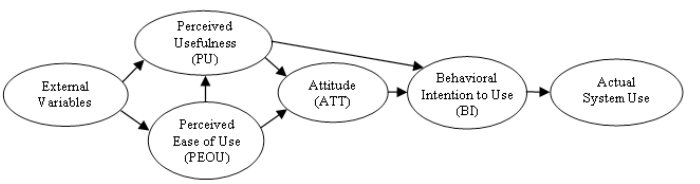
Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) has been studied extensively with many of variations and in many different environments (Chau, 1996; Hu et al., 1999; Legris et al., 2003; Venkatesh et al., 2003). The TAM model is grounded in Theory of Reasoned Action (TRA) proposed and validated by Ajzen and Fishbein (1975). The essence of the model is in using users' perceptions about usefulness, ease of use, and attitude toward technology in order to predict users' intention to use as well as actual usage of a technology. The overall approach of TAM is predictive in nature, attempting to uncover the constructs that impacts users' intensions to use technology. Figure 1 provides an overview of the conceptual map proposed by Davis, Bagozzi, and Warshaw (1989).

Numerously various studies have validated the TAM model in different contexts (Venkatesh et al., 2003). However, no prior work was done on validating the TAM model in military context, in particular not on combat information systems. As such, this study is unique in its attempt to validate an extended TAM model in the context of antecedent construct that impact soldiers' intension to use combat information systems.

The factors in TAM that predict usage are perceived usefulness, perceived ease of use, and attitude. Perceived Usefulness is defined as "the degree to which a person

Figure 1. Davis, Bagozzi, and Warshaw (1989)'s conceptual map of the TAM model



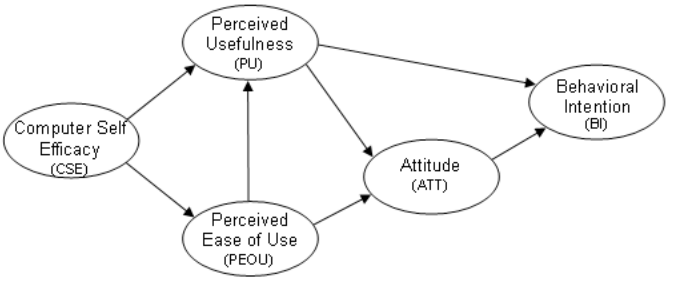
believes that using a particular system would enhance his or her job performance" (Davis, 1989, p. 320). Perceived Ease-of-use is defined as "the degree to which a person believes that using a particular system would be free of effort" (Davis, 1989, p. 320). Attitude has been defined by Yang and Yoo (2004) as a combination of "how much the person likes the object of thought" and "specific beliefs related to the object" (p. 20).

Hu et al. (1999) studied how well the TAM modeled physician's intention to use telemedicine. The study, with 408 participants, examined perceived usefulness, perceived ease-of-use, attitude, and intention to use. Hu et al. (1999) found that TAM was applicable to the professional environment of a hospital. The attitude construct was found to significantly influence intention to use. In contrast, perceived ease of use did not have a significant effect on perceived usefulness and attitude. Hu et al. (1999) concluded "the explanatory power of TAM, particularly the perceived ease of use factor, may weaken as the competency of the users increases" (p. 106). This finding suggests that "competency" is an external variable to the TAM. Thus, this study adds a measure of perceived computer competency, computer self-efficacy, as an external variable to the TAM.

Computer Self-Efficacy

Computer Self-Efficacy (CSE) construct immerged from the general concept of self efficacy by Compeau and Higgins' (1995) and is founded on the social cognitive theory (Bandura, 1977; 1982; 1984). CSE is defined as "an individual's perception of his or her ability to use a computer in the accomplishment of a job task" (Compeau & Higgins, 1995, p. 193). Numerous studies in literature suggest that CSE has a very high reliability and strong validity across different contexts (Agarwal, Sambamurthy, & Stair, 2000; Chung, Schwager; & Turner, 2002; Durndell & Haag, 2002; Hasan, 2006; Potosky, 2002; Sheng, Pearson, & Crosby, 2003; Stone, Arunachalam, & Chandler, 1996; Stone & Henry, 2003; Thatcher & Perrewe, 2002; Torkzadeh, Chang, & Demirhan, 2006; Yi & Im, 2004). Moreover, CSE has been validated in numerous studies with its relationship as an extension of the TAM model (McFarland & Hamilton, 2006; Venkatesh & Davis, 1996).

Figure 2. Conceptual map of the research model



Chau (2001) conducted a study of extending the TAM model with CSE on 360 business students. Although providing validation for the TAM model, his study suggests that CSE as well as computer attitude should impact perceived ease of use and perceived usefulness. There is evidence from literature to support the belief that CSE may serve as a predictor of PEOU and PU, there is little support in literature for using attitude as a predictor of the two constructs, indicating somewhat a deviation from the original TAM model. Thus, this proposed study attempted to validate the use of CSE as an external variable that impacts the key TAM constructs following the traditional TAM where attitude is between PEOU, PU and BI. Figure 2 provides a conceptual map of the proposed research model. The proposed modified model is based on the relationships proposed in the extension of the TAM model noted by scholars (McFarland & Hamilton, 2006; Venkatesh & Davis, 1996).

METHODOLOGY

A survey instrument was adapted from Chau and Hu (2001) which provides validated measures for the constructs relevant to perceived usefulness, perceived

Table 1. Descriptive statistics and Cronbach's Alpha

Summary of Measurement Scales: (n=206)				
Construct	**Measure**	**Mean**	**SD**	**Cronbach Alpha**
Computer Self Efficacy (CSE)				
CSE1	I am comfortable working with computers	1.85	1.28	
CSE2	If I am given some training, I can learn to use most computer programs	1.77	1.10	*0.77*
CSE3	I can learn to use most computer programs just by reading the manuals and help	2.86	1.67	
Perceived Usefulness (PU)				
PU1	Using [*] will improve my support of casualty control, situational awareness and logistical references	2.54	1.53	
PU2	Using [*] will enhance my effectiveness in supporting combat operations	2.27	1.27	*0.83*
PU3	I find [*] useful for my work on the ship	2.54	1.29	
Perceived Ease of Use (PEOU)				
PEOU1	It was easy for me to learn to use [*]	2.59	1.29	
PEOU2	It is easy for me to become skillful in [*]	2.67	1.27	*0.91*
PEOU3	I find [*] easy to use	2.72	1.36	
Attitude (ATT)				
ATT1	Using [*] is a good idea	2.25	1.28	
ATT2	Using [*] is pleasant	2.81	1.39	*0.65*
ATT3	Using [*] is beneficial to my ship	2.20	1.27	
Behavioral Intention (BI)				
BI1	I intend to use [*] for casualty control, situational awareness and logistical references as often as needed	2.54	1.36	*0.89*
BI2	To the extent possible, I will use [*] in my work	2.53	1.26	

* - *The name of the system was concealed for obvious reasons.*

ease-of-use, attitude, and behavioral intention to IS use. The measures used by Chau and Hu were adapted from measures validated by Taylor and Todd (1995) as well as Davis (1989). Computer self efficacy measures were adapted from Compeau and Higgins (1995). All measures for constructs (i.e. CSE, PU, PEOU, BI, and ATT) were adapted from their original sources noted above and slightly modified to fit within the survey format and better relate to the environment under study (i.e. a U.S. Navy's combat IS). This adaptation was accomplished by reviewing the survey instrument with subject matter experts experienced with the U.S. Navy's combat IS implementations on five U.S. Navy ships. The results of the subject matter expert reviews were minor wording changes to clarify the intent of the questions for the U.S. Navy sailors. The minor modifications included the notation to the system's name instead of generic notation of IS, particularly in the measures of the original TAM construct (i.e. PU, PEOU, ATT, and BI). The subject matter experts indicated that including the system's name may help reduce threats to internal validity (see questions text in Table 1).

An information system used by the combat systems department onboard U.S. Navy aircraft carriers was chosen as the target system for model testing. This IS is used by combat systems watch officers for situational awareness, casualty control, and maintenance management (Green, 2003). The system was selected for this study because its use is not mandatory, rather it is available to use at the discretion of the combat systems watch officer. The survey instrument was distributed onboard the five separate ships over a six-month period. The survey instrument was distributed on paper and was anonymously completed. Responses were collated and entered into two separate spreadsheets by two separate people. The separate spreadsheets were then compared to assure that no data entry errors were made. Any difference in data was traced back to the original survey questionnaire and the correct score was entered.

A total of five U.S. Navy aircraft carriers were represented in the sample. A total of 326 surveys were issued and 237 completed surveys were returned, for a response rate of 73%. The survey response rate was high because the sample population was a captive audience. Each of the 237 returned surveys were checked for completeness and analyzed to determine if the participant marked the same score for all items suggesting a response set. Kerlinger and Kee (2000) noted that "response-set can be considered a mild threat to validity measures" (p. 713). They noted that scanning the data for response-set and removing those from final analysis help with the overall validity of the results. Thus, the data were observed for response-sets indicating 31 cases of sailors who just marked the whole survey on the same score. Such response-sets were eliminated providing a total of 206 usable records for further analyses.

DATA ANALYSIS AND RESULTS

Analysis of Measurement Validity

Table 1 provides the results of the analysis of measurement validity. Results indicating that most measures produce a very high reliability of 0.91, 0.89, 0.83, 0.77, and 0.65 Cronbach's Alpha for PEOU, BI, PU, CSE, and ATT respectfully. These results provide an indication that the survey instrument is reliable in its measurements and consistent with results found in prior literature.

Model Testing Results

AMOS 6.0 was used to perform the path analysis model fit. Literature suggest seven common measures of model-fit analysis including chi-square/degrees-of-freedom (Chi-square/df), goodness-of-fit index (GFI), adjusted goodness-of-fit index (AGFI), normed fit index (NFI), non-normed fit index (NNFI), comparative fit index (CFI), and standardized root mean square residual (SRMSR) (Chau & Hu, 2001; Chau, 2001; Somers, Nelson, & Karimi, 2003). Within these seven model-fit measures, literature provides specific guidelines to the recommended values in order to indicate the performance of the model. Carmines and McIver (1981) recommended that a value of Chi-square/df less than three indicates good fit. Additionally, Somers et al. (2003) noted that Chi-square/df less than two indicates even "more restrictive [fit]" (p. 610) or a higher quality of model fit. Table 2 provides both the recommended values and the results of this study. Chi-square/df was found to be 1.6, which much lower than both the regular recommended value (<3.00) and the restrictive fit (<2.00) indicating a good support for the model-data fit. Two other common measures of model-fit analysis are GFI and AGFI. GFI measure is based on the amount of variance and covariance difference, while AGFI is similar to GFI but adjusted to the degrees of freedom relative to the number of variables in the model (Shumacker & Lomax, 2004). On both GFI and AGFI zero (0) indicates no fit and one (1) indicate perfect fit. Researchers suggested that values for GFI and AGFI above .80 and .90, respectively, indicate a good fit (Chau, 2001; Chau & Hu, 2001; Somers et al., 2003). Results of this study's model indicate support for the model fit with GFI of .93 and AGFI of .895. Additionally, three more common measures of model-fit analysis are NFI, NNFI, and CFI. For these three measures researchers suggested that values for grater than .90 indicates support for the model fit (Chau, 2001; Chau & Hu, 2001; Somers et al., 2003). Based on these model fit measures, results of this study's model indicate a near perfect model fit with NFI of .940, NNFI of .969, and CFI of .976 providing additional support for a good model-date fit. Mayers, Gamst, and Guarino (2006) suggested that SRMSR below .08 indicates good fit, between .08 and .10 indicates moderate fit and above .10 indicates poor fit. Shumacker and Lomax (2004) also concurs such model fit values. Results of this study's model indicate SRMSR of .054, which additionally supports the fitness of the model.

Table 2. Goodness-of-fit measures of the research model

Goodness-of-fit Measure (n=206)	Recommended Value*	Research Model	Chau (2001)
Chi-square (χ^2)		112.2	NR
Degrees of freedom (df)		70	NR
Chi-square/df	<3.00	1.602	2.09
Goodness-of-Fit Index (GFI)	>0.90	0.930	0.90
Adjusted Goodness-of-Fit Index (AGFI)	>0.80	0.895	0.88
Normed Fit Index (NFI)	>0.90	0.940	0.94
Non-Normed Fit Index (NNFI)	>0.90	0.969	0.91
Comparative Fit Index (CFI)	>0.90	0.976	0.94
Standardized Root Mean Square Residual (SRMSR)	<0.10	0.054	0.05

* - Per Chau (2001)
NR – Not Reported

Figure 3. Extended TAM and CSE model testing results

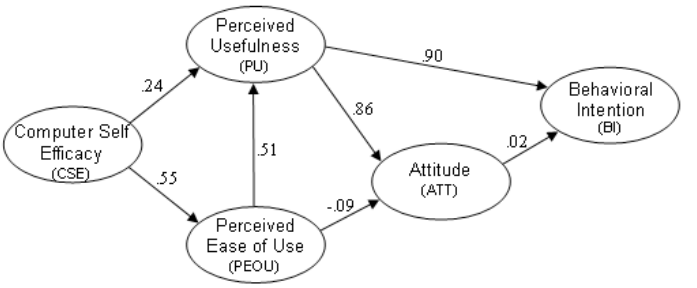


Figure 3 indicates the results of the model path. As noted the direct effect between CSE and PEOU appears to be stronger (.55) than the direct effect between CSE and PU (.24). The effect of PEOU on attitude and the effect of attitude on BI appear to be narrow. Additionally, a strong effect was found between PU and attitude (.86), while the strongest effect found was between PU and BI (.90). This finding suggests that one unit increase in sailor's perceived usefulness results in a .86 unit increase in their attitude towards the system and a .90 unit increase in their intention to use it. These results are consistent with the Hu et al. (1999) study.

DISCUSSION

The TAM model has long been a central model in IS research with numerous studies validating it in various contexts. However, very little work was done in the context of military information systems, in particular assessing IS that provide combat support. This study is very unique as it provides additional empirical evidence by validating the extended TAM model in the context of a U.S. Navy combat IS.

Results of the model show very strong validation with high degree of model fit and with better results of what published previously in non-military context. Moreover, analysis of measures validity indicates high Cronbach's Alpha for four of the instrument constructs calculated at over 0.75, while the remaining construct (attitude) provided an acceptable reliability measure of 0.65. These reliability results further validate the survey instrument proposed in literature.

Several limitations and opportunities for future research can be observed for this study. First, examination of any military information systems is an unexplored phenomenon. Although results of this study are valid as indicated by the analyses, additional measures should be explored in the context of military information systems. An observed limitation of this study deals with the high amount of response-set. Although this study was able to collect relatively high response rate (~73%) from the U.S. Navy sailors, there was a large amount (~10%) of respondents who simply marked the survey the same score on all measures in order to obey the request of their military superiors to participate in the study. Thus by providing response-set, these sailors prevented assessment of their true perceptions and feelings about this U.S. Navy combat IS. This resulted in the need to eliminate these response sets from the data prior to any analysis and a final response rate of 63%.

ACKNOWLEDGMENTS

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REFERENCES

Ajzen, I., & Fishbein, M. (1975). *Belief, attitude, intension, and behavior: An introduction to theory and research*. Reading, MA: Addison-Wesley Publishing Company.

Agarwal, R., Sambamurthy, V., & Stair, R. M. (2000). Research report: The evolving relationship between general and specific computer self-efficacy - An empirical assessment. *Information Systems Research, 11*(4), 418-430.

Amoako-Gyampah, K., & Salam, A. F. (2004). An extension of the technology acceptance model in an ERP implementation environment. *Information & Management, 41*, 731-745.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191-215.

Bandura, A. (1982). Self-efficacy: mechanism human agency. *American Psychologist, 37*(2), 122-147.

Bandura, A. (1984). Recycling Misconceptions of perceived self-efficacy. *Cognitive Therapy and Research, 8*(3), 231-255.

Bisantz, A., Rothe, E., Brickman, B., Gosbee, L., Hettinger, L., & McKinney, J. (2003). Integrating cognitive analyses in a large-scale system design process. *International Journal of Human-Computer Studies, 58*, 177-206.

Chau, P. Y. (1996). An empirical assessment of a modified technology acceptance model. *Journal of Management Information Systems, 13*(2), 185-205.

Chau, P. Y. (2001). Influence of computer attitude and self-efficacy on IT usage behavior. *Journal of End User Computing, 13*(1), 26-33.

Chau, P. Y., & Hu, P. J. (2001). Information technology acceptance by individual professionals: A model comparison approach. *Decision Sciences, 32*(4), 699-718.

Chung, S. H., Schwager, P. H., & Turner, D. E. (2002). An empirical of students' computer self-efficacy: Differences among four academic disciplines at a large university. *The Journal of Computer Information Systems, 42*(4), 1-6.

Compeau, D. R., & Higgins, C. A. (1995). Computer self-efficacy: Development of a measure and initial test. *MIS Quarterly, 19*(2), 189-211.

Carmines, E. G., & McIver, S. P. (1981). *Analyzing models with unobserved variables: Analysis of covariance structures*. In G. W. Bohrnstedt & E. F. Borgatta (Eds.), Social measurement: Current issues. Beverly Hills, CA: Sage, p. 23.

Davis, F. D. (1989). Perceived usefulness, perceived ease-of-use, and user acceptance of information technology. *MIS Quarterly, 13*(3), 319-340.

Davis, F. D., Bagozzi, R. P., Warshaw, P. R. (1989). User acceptance of computer technology: A comparison of two theoretical models. *Management Science, 35*(8), 982-1003.

Durndell, A., & Haag, Z. (2002). Computer self efficacy, computer anxiety, attitudes towards the Internet and reported experience with the Internet, by gender, in an East European sample. *Computers in Human Behavior, 18*, 521–535.

Elbeltagi, I., McBride, N., & Hardaker, G. (2005). Evaluating the factors affecting DSS usage by senior managers in local authorities in Egypt. *Journal of Global Information Management, 13*(2), 42-65.

Globalsecurity.org (2005) *FY 2005 Navy Budget Materials.* Downloaded May 19, 2005 from http://www.globalsecurity.org/military/library/budget/fy2005/navy/

Green, B. D. (2003). Integration of TSIMS and ICAS for condition based maintenance. *ASNE Proceedings of Intelligent Ship Symposium*, Philadelphia.

Hasan, B. (2006). Effectiveness of computer training: The role of multilevel computer self-efficacy. *Journal of Organizational and End User Computing, 18*(1), 50-68.

Hu, P. J., Chau, P. Y. K., Sheng, O. R. L., & Tam, K. Y. (1999). Examining the technology acceptance model using physician acceptance of telemedicine technology. *Journal of Management Information Systems, 16*(2), 91-113.

Kerlinger, F. N., & Lee, H. B. (2000). *Foundations of behavioral research (4 ed)*. Toronto, CA: Wadsworth Tomson Learning.

Legris, P., Ingham, J., & Collerette, P. (2003). Why do people use information technology? A critical review of the technology acceptance model. *Information & Management, 40*, 191-204.

Lowry, G. (2002). Modeling using acceptance of building management systems. *Automation in Construction, 11*, 695-705.

Ma, Q., & Liu, L. (2004). The technology acceptance model: A meta-analysis of empirical findings. *Journal of Organizational and End User Computing 16*(1), 59-72.

Mayers, L. S., Gamst, G., & Guarino, A. J. (2006). Applied multivariate research. Design and interpretations. Thousands Oaks, CA: Sage.

McFarland, D. J., & Hamilton, D. (2006). Adding contextual specificity to the technology acceptance model. *Computers in Human Behavior, 22*, 427-447.

Potosky, D., (2002). A field study of computer efficacy beliefs as an outcome of training: the role of computer playfulness, computer knowledge, and performance during training. *Computers in Human Behavior, 18*, 241–255.

Somers, T. M., Nelson, K., & Karimi, J. (2003). Confirmatory factor analysis of the end-user computing satisfaction instrument: Replications within an ERP domain. *Decision Sciences, 34*(3), 595-621.

Sheng, Y. P., Pearson, J. M., & Crosby, L. (2003). Organizational culture and employees' computer self-efficacy: An empirical study. *Information Resources Management Journal, 16*(3), 42-58.

Shumacker, R. E., & Lomax, R. G. (2004). *A beginner's guide to structural equation modeling (2 ed.)*. Mahwah, NJ: Lawrence Erlbaum Associates.

Stone, D., Arunachalam, N., & Chandler, V. (1996). Cross-cultural comparisons: An empirical investigation of knowledge, skill, self-efficacy and computer anxiety in accounting education. *Issues in Accounting Education, 11*(2), 345-367.

Stone, R. W., & Henry, J. W. (2003). The roles of computer self-efficacy and outcome expectancy in influencing the computer end-user's organizational commitment. *Journal of End User Computing, 15*(1), 38-53.

Taylor, S., & Todd, P. (1995). Understanding information technology usage: A test of competing models. *Information Systems Research, 6*(2), 144-176.

Thatcher, J. B., & Perrewe, P. L. (2002). An empirical examination of individual traits as antecedents to computer anxiety and computer self-efficacy. MIS Quarterly, 26(4), 381-396.

Torkzadeh, G., Chang, J. C.-J., & Demirhan, D. (2006). A contingency model of computer and Internet self-efficacy. *Information & Management*.

Venkatesh, V., & Davis, F. D. (1996). A model of the antecedents of perceived ease of use: Development and test. *Decision Sciences, 27*(3), 451-481.

Venkatesh, V., Morris, M.G., Davis, G.B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly 27*(3), 425-478.

Yang, H., & Yoo, Y. (2004). It's all about attitude: revisiting the technology acceptance model. *Decision Support Systems* 38, 19-31.

Yi, M. Y., & Im, K. S. (2004). Predicting computer task performance: Personal goal and self-efficacy. *Journal of Organizational and End User Computing, 16*(2), 20-37.

Performance Analysis of 3-Stage Cell Search Process in WCDMA System

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ABSTRACT

In this paper, we study the performance benefits of cell search algorithm. The purpose of the cell search algorithm in UMTS is to estimate the spreading code of the serving base-station and its corresponding timing offset. The search procedure consists of 3 sequential and distinct stages: (1) slot-boundary synchronization, (2) frame-boundary synchronization with code-group identification, and (3) scrambling code identification. Also, we study the performance benefits of estimating multiple "code-time" hypotheses in each stage of the cell-search process. In addition, we also study the effect of oversampling and non-ideal sampling. Our results indicate that, in the presence of non-ideal sampling, performance improves significantly if the received signal is oversampled by a factor of 4 or more. We also show that an estimating 4 "codetime" hypothesis instead of 1 in the cell-search stages reduces the search-time (i.e. the code-acquisition time) considerably, in particular at low SNR.

Keywords: WCDMA, UMT, SSC, PSC, FHT, CSD,P_{FA}, V_{TH}

1. INTRODUCTION

WCDMA is a wideband Direct Sequence Code Division Multiple Access (DS-CDMA) system, which means that the user information bits (symbols) are spread over a wide frequency bandwidth by multiplying the user data bits with a spreading code sequence of "chips" [1], [2]. In the asynchronous W-CDMA system each base station is identified by a unique scrambling code. The mobile station has to synchronize to the scrambling code of the serving base station in order to descramble the downlink traffic channels [3],[4]. The synchronization process is commonly referred to as the cell search procedure, i.e. cell search is the process of synchronization between the mobile and the base station. The purpose of the cell search algorithm in UMTS is to estimate the spreading code of the serving base-station and its corresponding timing offset. A three-step hierarchical cell search process has been introduced in the UMTS standard that is supported by several auxiliary synchronization channels [5]. These include the Primary Synchronization Channel (P-SCH), the Secondary Synchronization Channel (S-SCH), and the Common Pilot Channel (CPICH) [9].The cell search procedure is split into three stages, stage 1 performs slot synchronization, stage 2 performs frame synchronization and scrambling code group identification, and stage 3 acquires the cell-specific scrambling code.

2. CELL SEARCH ALGORITHM

We use the algorithms for code acquisition presented in [4],[5],[6] as baseline for benchmarking our enhanced algorithms. Since the frequency acquisition stage presented in [6] can be used without modification after stage 3, in our study, we assume an oversampled received signal at the mobile. However, as was mentioned above, after slot synchronization in stage 1, the signal is down-sampled to chip-rate for further processing.

The cell search algorithm is divided into the following stages:

(1) Slot boundary synchronization,
(2) Frame synchronization and code group identification,
(3) Scrambling code identification,
(4) Frequency acquisition, and,
(5) Cell identification.

The last two stages need to be performed only during initial cell search [10].

Stage 1: Slot Boundary Synchronization

During stage 1 of the cell search algorithm the mobile station uses the Primary Synchronization Code (PSC) to acquire slot synchronization to a cell. This is typically done with a single matched filter matched to the PSC which is common to all cells. The slot timing of the cell can be obtained by detecting peak values in the matched filter output. However, decisions based on observations over a single slot may be unreliable, when the signal-to-noise ratio (SNR) is low or if fading is severe. Reliable slot synchronization is required to minimize cell search time. In order to increase reliability, observations are made over multiple slots and the results are then combined. This ensures that the correct slot boundary is identified.

Stage 2: Frame Synchronization and Code Group Identification

During stage 2 of the cell search algorithm, the mobile station uses the Secondary Synchronization Code (SSC) to achieve frame synchronization and identify the code group of the cell found in stage 1. This is done by correlating the received signal with all possible SSC sequences and identifying the maximum correlation value. Since the cyclic shifts of the sequences are unique, the code group as well as the frame synchronization is determined in this stage.

Stage 3: Scrambling Code Identification

During stage 3 of the cell search algorithm, the mobile station determines the exact primary scrambling code used by the cell. The primary scrambling code is typically identified through symbol-by-symbol correlation over the CPICH with all codes within the code group identified in stage 2. In this stage, a threshold value is used to decide whether the code has been identified. The threshold value can be predetermined using a parameter called probability of false alarm rate.

2.1 Slot Synchronization

Conventional detection of the slot boundary entails:

(a) correlating the received data over 256 chips with the PSC,
(b) then performing this correlation over Nt slots, which is set to 15 slots (= 1 frame) in all our simulations ,
(c) then accumulating all the Nt correlation values, and
(d) finally selecting the hypothesis that corresponds to the maximum correlation value.

Matching Filter

A basic problem that often arises in study of communication systems is that of detecting a pulse transmitted over a channel that is corrupted by additive noise at the front of the receiver. The filter input X(t) consists of a pulse signal g(t) corrupted by additive noise w(t), as shown

$$X(t) = g(t) + w(t) \qquad 0 \le t \boxtimes T$$

Where T is an arbitrary observation interval. The pulse signal g(t) may represent a binary symbol 1 or 0 in a digital communication system . With the received signal X(t) used as filter input , the resulting filter output , y(t) is defined by the convolution integral :

$$(t) = \int_{-\infty}^{\infty} x(\tau)\, h_j(t-\tau)\, d\tau$$

Slot Matching Filter
The MS first needs to acquire the PSC which is common to all the BSs. These codes are of length 256 chips. The matched filter output is given by,

$$Y = \sum_{J=0}^{255} R_j \cdot C_{pj}$$

Where *Rj* is the jth sample of the received complex signal, and *Cpj* is the jth bit of the PSC.

PSC Sequence
The hierarchical sequences used for generating the PSC are constructed from two constituent sequences X1 and X2 of length n1 and n2, respectively, using the following equation [12]:

Cp (n) =X1(n mod n2) +X2(n div n1) modulo 2, n=0, 1,.., (n1*n2)-1

Where n1=n2=16. The constituent sequences X1 and X2 are both defined as:

X1=X2= (1, 1,-1,-1,-1,-1, 1,-1, 1, 1,-1, 1, 1, 1,-1, 1).

Slot Boundary Detection
A traditional matched filter implementation would require 256 taps and a large adder circuit. This would increase the delay as well as power consumption at the receiver which is not desirable. Thus, a hierarchical structure is used for performing the matched filter operations which will need lesser number of taps, reduced circuitry and lower power consumption. The hierarchical matched filter consists of two concatenated matched filter blocks. The first matched filter receives the input signals serially from the base station. After 16 clock cycles when the shift register 1 is filled, the data stored in the shift register 1 is matched in parallel with the code applied to the taps of the matched filter (tap coefficients). The tap coefficients are the PSC sequences which are the same for all the base stations [11],[12].Hence, the same matched filter structure can be used for all the base stations.

2.2 Frame Synchronization and Code Group Identification
During stage 2 of the cell search procedure, the MS uses the SCHs Secondary Synchronization Code (SSC) to achieve frame synchronization and identify the code group of the cell found in stage 1. This is done by correlating the received signal with all possible SSC sequences and identifying the maximum correlation value. Since the cyclic shifts of the sequences are unique, the code group as well as the frame synchronization is determined. The Secondary SCH consists of 15 sequences belonging to a family of cyclic codes (SSCs), each of length 256 chips. These SSCs are transmitted repeatedly in parallel with the Primary SCH. The procedure for constructing the cyclic codes is similar to that of the hierarchical sequence for the Primary SCH except that it uses specific sequences of length 16 from Table1 for each code group. The procedure for constructing the cyclic hierarchical sequence Csi,1 for slot 1 is exactly the same as constructing the hierarchical sequence Cp for the Primary SCH. The sequence Csi,1 for slot 1 will be referred to as the zero cyclic shift sequence as no shift is applied to the constituent sequence X1i. For slots 2 to 15, the cyclic codes are constructed from the two constituent sequences X1i,k-1 and X2i,k-1 of length n1 and n2 respectively using the following formula[12]

Csi,k(n)=X2i,k-1 (n mod n2)+X1i,k-1 (n div n1) modulo 2, n=0,1,..,(n1*n2)-1

Table 1. Sequences X1i and X2i for Code Groups 1 to 32

Code Group		Code Group	
1	1 1 1-1-1-1 1-1-1 1 1-1 1-1 1 1	17	1-1 1 1-1 1-1 1 1 1-1 1 1 1-1 1
2	1-1 1 1-1 1 1 1-1-1 1 1 1 1 1-1	18	1 1 1-1-1-1-1-1-1 1-1-1-1 1-1-1-1
3	1 1-1 1-1-1-1 1-1 1-1 1 1-1-1-1	19	1-1-1-1 1-1-1 1 1 1 1-1-1-1-1 1
4	1-1-1-1-1 1-1-1-1-1-1-1 1 1-1 1	20	1 1-1 1 1 1-1-1 1-1 1 1-1 1-1-1
5	1 1 1-1 1 1-1 1-1 1 1-1-1 1-1-1	21	-1-1-1 1 1-1-1 1 1-1 1-1 1 1-1-1
6	1-1 1 1 1-1-1-1-1-1 1 1-1-1-1 1	22	-1 1-1-1 1 1-1-1 1 1 1 1 1-1-1 1
7	1 1-1 1 1 1 1-1-1 1-1 1-1 1 1 1	23	-1-1 1-1 1-1 1-1-1 1 1-1-1-1-1-1
8	1-1-1-1 1-1 1 1-1-1-1-1-1-1 1-1	24	-1 1 1 1 1 1 1 1-1-1 1 1-1 1-1 1
9	1 1-1 1-1-1-1 1 1-1 1-1-1 1 1 1	25	-1 1 1 1-1-1 1 1 1-1-1-1-1-1-1 1
10	1-1-1-1-1 1-1-1 1 1 1 1-1-1 1-1	26	-1-1 1-1-1 1 1-1 1 1-1 1-1 1-1-1
11	-1 1-1-1-1-1-1 1 1 1 1-1 1-1 1-1	27	-1 1 1 1 1 1-1-1 1-1-1-1 1 1 1-1
12	-1-1-1 1-1 1-1-1 1-1 1 1 1 1 1 1	28	-1-1 1-1 1-1-1 1 1 1-1 1 1-1 1 1
13	1-1-1-1 1-1-1 1-1-1-1 1 1 1 1-1	29	-1 1-1-1 1 1 1 1 1-1 1 1 1 1-1 1
14	1 1-1 1 1 1-1-1-1 1-1-1 1-1 1 1	30	-1-1-1 1 1-1 1-1 1 1 1-1 1-1-1-1
15	1-1-1-1-1 1 1-1 1 1 1-1 1 1 1-1	31	-1 1 1 1-1-1 1 1-1 1 1 1 1 1 1-1
16	1 1-1 1-1-1 1 1 1-1 1 1 1-1 1 1	32	-1-1 1-1-1 1 1-1-1-1 1-1 1-1 1 1

where i is code group number, k=2,3,..,15 is slot number, n is chip number in slot, n1=n2=16, and the constituent sequences X1i,k-1 and X2i,k-1 in each code group i are chosen to be the following sequences from Table 1.The constituent sequence X2i,k-1 (inner sequence) is exactly equal to the base sequence X2i in every slot, i.e. X2i,k-1=X2i at all k.

The constituent sequence X1i,k-1 (outer sequence) are formed from the base sequence X1i by cyclic right shifts of X1i on k-1 positions (from 0 to 15) clockwise for each slot number k, from 1 to 15 . The generation of the cyclic codes can be understood clearly by considering the following example.

For the first code group the sequence is given by

X11,0=(1,1,1,-1,-1,-1,1,-1,-1,1,1,-1,1,-1,1,1), k=1 for slot 1, No cyclic shift

X11,1=(1,1,1,1,-1,-1,-1,1,-1,-1,1,1,-1,1,-1,-1), k=2 for slot 2, cyclic right shift by 1 position

X11,14=(1,-1,-1,-1,1,-1,-1,1,1,-1,1,-1,1,1,1,1), k=15 for slot 15, cyclic right shift by 14 positions.

The same procedure for forming the cyclic codes will be used for other code groups. Thus, for the 32 codes groups and 15 slots (in one frame), 512 different cyclic codes with a length of 256 chips each are constructed. These 512 cyclic codes are unique for each code group/slot locations pair. Thus, it is possible to

uniquely determine both the scrambling code group and the frame timing in the second stage of the initial cell search.

2.3 Scrambling Code Identification

After achieving code group and frame synchronization, the scrambling code is identified by correlating the symbols in the CPICH with all possible scrambling codes in the code group. The codes are generated using a scrambling code generator and the descrambling operation is carried out using a descrambler.

Scrambling Code Generator

Each cell is allocated one and only one primary scrambling code. The scrambling code sequences are constructed by combining two real sequences into a complex sequence. Each of the two real sequences are constructed as the position wise modulo 2 sum of38,400 chip segments of two binary sequences generated by means of two generator polynomials of degree 18 [14]. Let x and y be the two sequences respectively. The resulting sequences constitute segments of a set of Gold sequences. The x sequence is constructed using the primitive polynomial $1+X^7+X^{18}$. The y sequence is constructed using the polynomial $1+X^5+X^7+X^{10}+X^{18}$. The sequence depending on the chosen scrambling code number n is denoted as zn. Furthermore, let x(i), y(i) and zn(i) denote the ith symbol of the sequence x, y, and zn, respectively.

The sequences x and y are constructed as:

x(i+18)=x(i+7)+x(i) modulo 2, for i=0,1,..,218 - 20

y(i+18)=y(i+10)+y(i+7)+y(i+5)+y(i) modulo 2, for i=0,1,..,218 - 20

The nth Gold code sequence zn, n=0,1,..,218 - 2, is then defined as [11],[12]:

zn(i)=x((i+n) modulo (218 -1))+y(i) modulo 2, i=0,1,..,218- 2

Finally, the nth complex scrambling code sequence sn is defined as:

sn(i)=zn(i)+jzn((i+131,072) modulo (218-1)), i=0,1,..,38,399

Table 2. Masking functions used in Stage 3: Scrambling code generator

	Masking Function For I Channel Code In LFSR 1	Masking Function For Q Channel Code In LFSR 1
Code1	000000000000000001	001000000001010000
Code2	000000000000000010	010000000010100000
Code3	000000000000000100	100000000101000000
Code4	000000000000001000	000000001000000001
Code5	000000000000010000	000000010000000010
Code6	000000000000100000	000000100000000100
Code7	000000000001000000	000001000000001000
Code8	000000000010000000	000010000000010000
Code9	000000000100000000	000100000000100000
Code10	000000001000000000	001000000001000000
Code11	000000010000000000	010000000010000000
Code12	000000100000000000	100000000100000000
Code13	000001000000000000	000000001010000001
Code14	000010000000000000	000000010100000010
Code15	000100000000000000	000000101000000100
Code16	001000000000000000	000001010000001000

The pattern from phase 0 up to the phase of 38,399 is repeated for every radio frame.

The scrambling codes are divided into 512 sets each of a primary scrambling code and 15 secondary scrambling codes. The primary scrambling codes consist of scrambling codes n=16*i where i=0,1,..,511. The ith set of secondary scrambling codes consists of scrambling codes 16*i+k, where k=1,2,..,15. There is a one-to-one mapping between each primary scrambling code and 15 secondary scrambling codes in a set such that ith primary scrambling code corresponds to ith set of secondary scrambling codes [17]. The set of primary scrambling codes is further divided into 32 scrambling code groups, each consisting of 16 primary scrambling codes. The jth scrambling code group consists of primary scrambling codes 16*16*j+16*k, where j=0,1,..,31 and k=0,1,..,14. In this stage, 16 scrambling codes need to be generated in parallel.

In order to reduce the hardware utilization, in stage 3 of both the designs only one scrambling code generator is used to generate 16 codes in parallel when 32 code groups are used as shown in above figure. Sixteen masking functions are used to generate the codes in parallel. Masking functions can generate codes which have minimum overlap and reduce the hardware circuitry to a single scrambling code generator at the expense of a few logic gates.

Masking function for I and Q Channel Code in linear feedback shift register (LFSR) 2 were kept fixed as 000000000000000001 and 001111111101100000. Besides reducing the hardware from 16 code generators to one code generator, the design also reduces the ROM size to 32X18 from the size 512X18 if 16 code generators were used.

3. SIMULATION AND MODELING

3.1 Slot Synchronization

Figure 1, shows sample transmitter model, fig. 2, shows slot detector model

Figure 1. Transmitter model

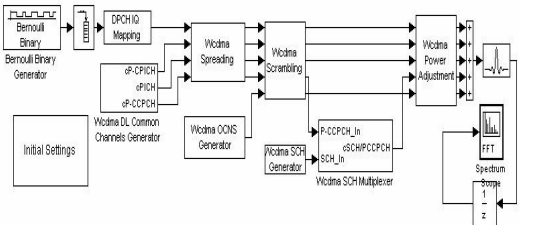


Figure 2. Slot detector model

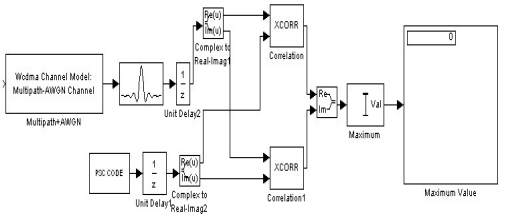
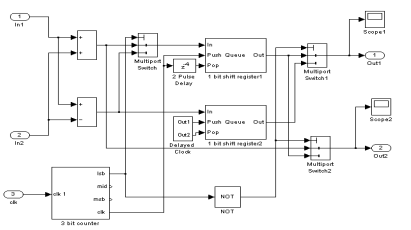


Figure 3. Individual stage of FHT



3.2 Frame Synchronization

Figure 3, shows an individual stage of the FHT. Each stage has an upper and a lower input terminal. The upper input terminal is configured to receive multiple input signals which are either Walsh chips (if the stage is the first stage of the FHT) or intermediate correlation coefficients (if the stage is not the first stage of the FHT)[15]. If an input of N-Walsh chips is to be processed then the upper input terminal receives N/2 input signal bits and the lower input terminal receives the other N/2 input bits.

Figure 4, shows the design for a FHT structure which is used for decoding a 16 chip sequence. The design proposed is a very compact and efficient implementation is used for decoding a 16 chip sequence. The design proposed is a very compact and efficient implementation as compared to previous designs

4. SIMULATION RESULTS

In the simulation results, when the received signal was correlated with the PSC sequences generated at the MS, some peak values were obtained and the maximum of those peak values was displayed as the slot value for that particular frame. In frame synchronization process, a FHT was used to match arbitrary SSC sequence with the frames and 16 values were obtained. In code synchronization process, the 16 values obtained are match with the values generated at the MS and the max of those values will be taken. The results satisfy most of the requirements of the parameters mentioned in the 3GPP specifications.

Figure 4. Design for a 16 chip FHT

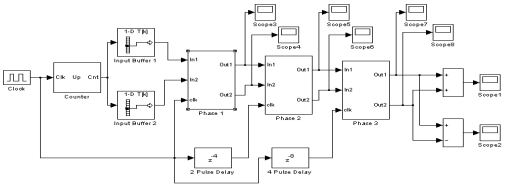


Figure 5. Code group detector model

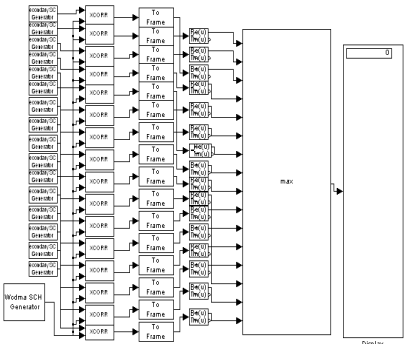


Figure 6. Scrambling code identifier model

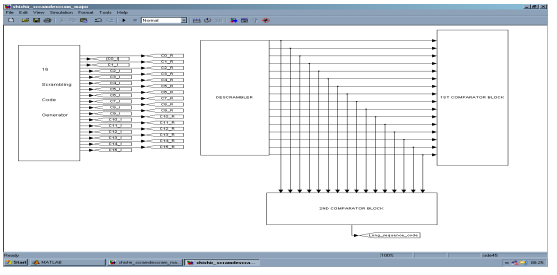


Figure 7. Spectrum for transmitted signal

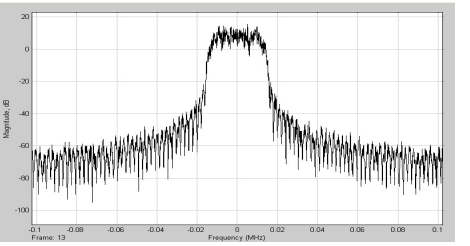


Figure 8. Maximum value in a frame

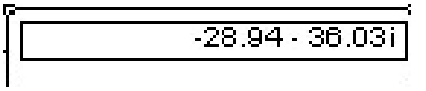


Figure 7, shows the spectrum for transmitted signal. The incoming signal is passed through a real-imaginary block to break signal into real and imaginary components. Similarly, PSC code signal is also broken into real and imaginary components. Those real parts are correlated together and the imaginary parts are correlated together. The final outcome of both the correlations is combined to form a complex value. Figure 8, shows the peak value obtained after correlating input signal with the codes generated by the PSC code generator is -28.94-36.03i. Figure 9,10,11,12 shows the first, second, third and final FHT scope. Figure 13, shows the Code Group values for real part of signal.

Frame Synchronization

In frame synchronization process, a FHT was used to match arbitrary SSC sequence with the frames and 16 values were obtained. Figure 5&6 shows stages

Figure 9. First FHT scope

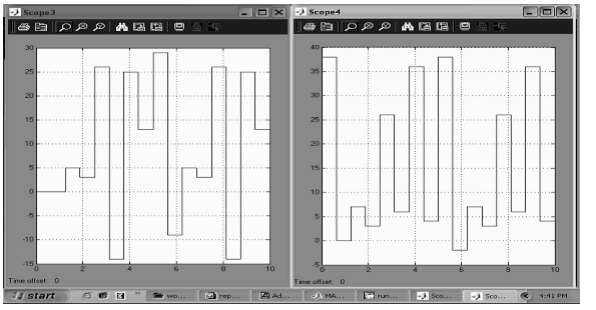


Figure 10. Second FHT scope

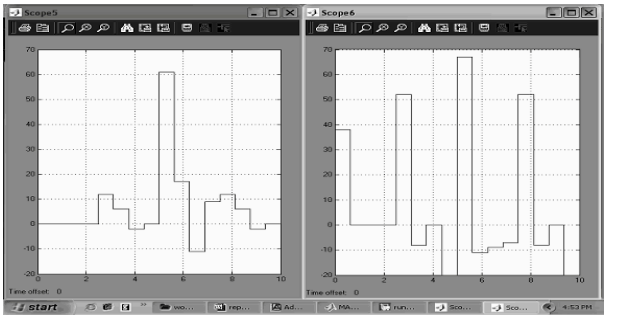


Figure 11. Third FHT scope

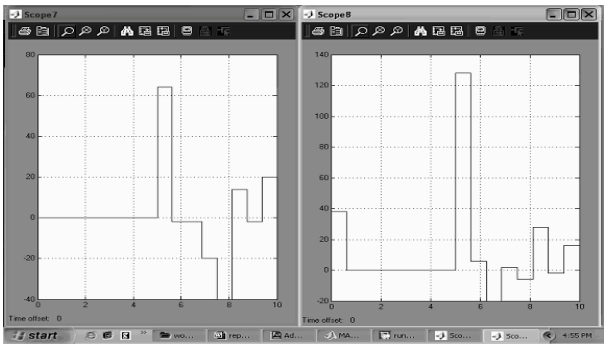


Figure 12. Final FHT scope

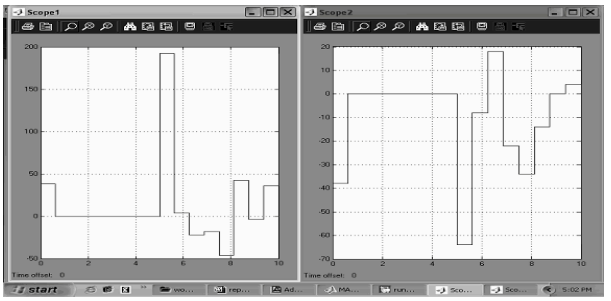
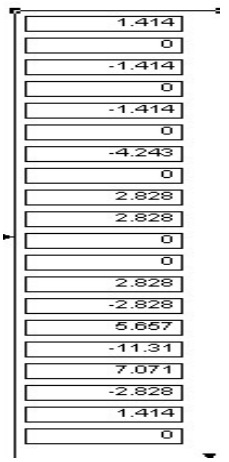


Figure 13. Code group values for real part of signal



of the FHT. Each stage has an upper and a lower input terminal. The upper input terminal is configured to receive multiple input signals which are either Walsh chips (if the stage is the first stage of the FHT) or intermediate correlation coefficients (if the stage is not the first stage of the FHT). If an input of N-Walsh chips is to be processed then the upper input terminal receives N/2 input signal bits and the lower input terminal receives the other N/2 input bits. Figure 4 shows the design for a FHT structure which is used for decoding a 16 chip sequence.

Also, we study the system performance in terms of overall acquisition time Ta. The stage duration is held constant at N_I=15 (= 1 frame). The target false alarm probability is chosen to be $P_{FA}=10^{-4}$ for all simulations. We assume a frequency

Figure 14. Effect of oversampling (Nt=15, case I, non-ideal sampling, $P_{FA}=10^{-4}$)

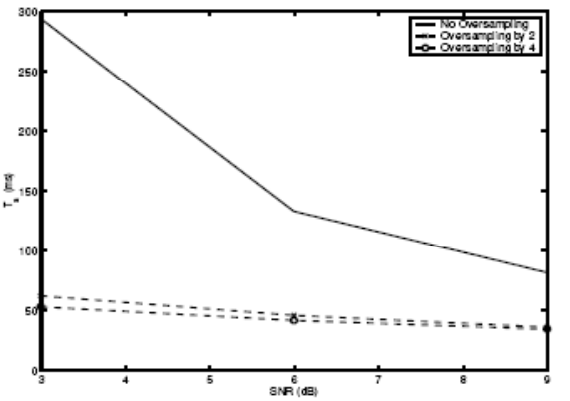
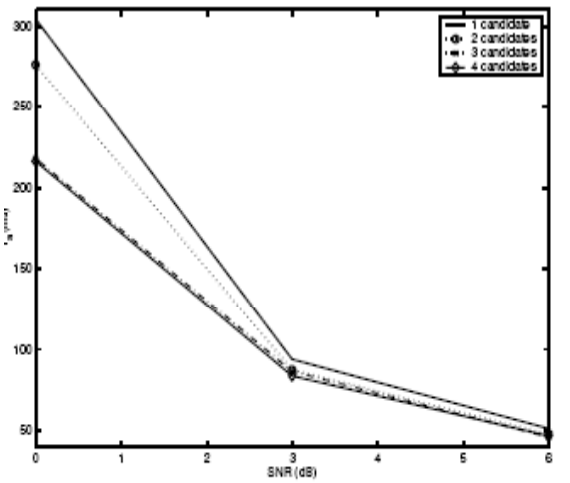


Figure 15. Influence of the number of candidates (Os=4, Nt=15, case II, ideal sampling, $P_{FA}=10^{-4}$)



offset due to receiver oscillator inaccuracies of 20 kHz. Non-ideal sampling is introduced by means of a fractional delay filter that introduces a delay of half a sampling period (worst case). The advantage of oversampling becomes evident in Fig. 14. Chip rate sampling leads to unacceptable performance at lower SNR. Clearly, oversampling in the presence of non-ideal sampling reduces Ta dramatically. Furthermore, simulation results show a saturation of performance with increasing oversampling factors. Therefore, we assume an oversampling factor of Os=4 .

The dependence of the acquisition time Ta on the number of slot boundary candidates passed between stage 1 and stage 2 is illustrated in Fig. 15.

Clearly, the performance gain obtained by passing several candidates between stages increases at lower SNR, and it reaches 30% at 0dB compared to the case with a single time-code candidate. Furthermore, no noticeable performance improvements are observed beyond 3 time-code candidates.

CONCLUSIONS AND FUTURE WORK

This paper was able to study the various steps involved in the Cell Search process and an attempt was made to simulate them. Also we investigate the code and time synchronization of the cell search algorithm. In addition to code and time

synchronization, frequency synchronization between the MS and the BS needs to be achieved. When the received signal was correlated with the PSC sequences generated at the MS, some peak values were obtained and the maximum of those peak values was displayed as the slot value for that particular frame. In frame synchronization process, a FHT was used to match arbitrary SSC sequence with the frames and 16 values were obtained.In code synchronization process, the 16 values obtained are match with the values generated at the MS and the max of those values will be taken. Our study has shown that oversampling of the received signal can have a significant impact on the cell search performance in the presence of non-ideal sampling. We found that an oversampling factor of 4 was sufficient to mitigate the detrimental effects of non-ideal sampling, whereas chip-rate sampling leads to unacceptable performance. Furthermore, it was shown that the performance of the cell search algorithm in 3GPP UMTS can be improved significantly by passing several "code-time" candidates between the three stages of the hierarchical procedure. Our results show that with 4 candidates, saturation-performance is achieved for the propagation scenarios defined by the standard. Depending on the scenario, acquisition time can be reduced by up to 50% at low SNR values compared to the single candidate case. There is another cell search called target cell search, which needs to be performed during a call, and when a MS is in motion and moves from one cell to another. VLSI implementations to perform target cell search efficiently need to be investigated.

REFERENCES

[1] T . Ojanpera and R.Prasad, " An overview of air interface multiple access for IMT- 2000/UMTS", IEEE Commun. Mag.,vol. 36, pp. 82-95, Sept. 1998.

[2] E. Dahlman, P.Berning, J.Knutsson, F.Ovesjo, M.Persson, and C.Roobol, "WCDMA the Radio Interface for Future Mobile Multimedia communications", IEEE Trans. Veh. Tech.., vol. 47,pp. 1105-1118, Nov. 1998.

[3] Harri Holma, Antti Toskala, "WCDMA for UMTS: Radio Access for Third Generation Mobile Communications", John Wiley, 2000

[4] Y.-P. E. Wang, T. Ottoson, "Cell search algorithms and optimization in W-CDMA", IEEE VTC, pp. 81-86, 2000

[5] Y.-P. E. Wang, T. Ottoson, "Cell search in W-CDMA", IEEE JSAC, vol. 18, no. 8, pp. 1470-1482, August 2000

[6] Y.-P. E. Wang, T. Ottoson, "Initial frequency acquisition in WCDMA", Proc. IEEE VTC, Amsterdam, pp. 1013-1017, Sep. 1999

[7] Chi-Fang Li ,Wern- Ho Sheen, Ho,J.J.-S.,Yuan-Sun Chu, "ASIC Design for Cell Search in 3GPP W-CDMA",Fall. IEEE VTC 2001, vol.3,pp. 1383-1387.

[8] "3G TS 25.214 – Technical specification group radio access networks: physical layer procedures (FDD)", www.3GPP.org, Release 1999.

[9] S. Sriram, S. Hosur, "An analysis of the 3-stage search process in WCDMA", Proc. IEEE VTC 2000, Boston.

[10] A. O. Nielsen, S. Korpela, "WCDMA initial cell search", Proc. IEEE VTC 2000, Boston.

[11] K.Higuchi, M.Sawahashi and F.Adachi, " Fast cell search algorithm in DS-CDMA mobile using long spreading codes", in Proc. IEEE 1997 Veh. Technol.Conf.,Phoenix, May 1997, pp. 1430-1434

[12] Kamal Bahl S. "Designing Hardware Efficient Acquisition Units for Initial Cell Search in WCDMA", in Proceedings 3GWireless 2003, San Francisco, CA, May 2003

[13] Nystorn,K.Jamal, Y.-P.E. Wang, and R.Esmailzadeh, " Comparison of cell search methods for asynchronous wideband CDMA cellular system", in Proc. IEEE, Int. Conf.Universal Personal Communication., Florence, Italy, Oct 1998.

[14] Ericsson, "New downlink scrambling code grouping scheme for UTRA/FDD", TSG-RAN Working Group 1 Meeting 6, TSGR1#6(99)884.

[15] A.Amira, A.Bouridane, P.Milligan and M.Roula, "Novel FPGA Implementations of Walsh-Hadamard transforms for signal processing", in Proc. IEE Vision, Image and Signal Processing, Dec 2001, vol. 148,no.6, pp. 377-383.

[16] M. Kiessling and S.A. Mujtaba, "Performance Enhancements to the UMTS (W- CDMA) Initial Cell Search Algorithm", IEEE International Conference on Communications, vol. 1, May 2002, pp. 590-594.

[17] Shailendra Mishra,Nipur "Code & Time synchronization of the Cell Search Design" in HB of Research in Mobile business: Technical, Methodological & Social perspectives , IDEA Group Publishing (IGP) Hershley PA USA pp 173-183,April 2006

Business-to-Business Transaction Diffusion: X12 Standards

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ABSTRACT

Accredited Standards Committee (ASC) and Data Interchange Standards Association (DISA) as the administrative arm is the United States business to business (B2B) transaction standard developing organization (SDO). This paper focuses on ASC's challenges in the standardization diffusion process of the X12 standard. Specific questions include what industry of X12 membership is most actively involved and what is the most active role played by the different organizations involved in the X12 B2B exchange? The progression of X12 membership is examined over the years, and strategies to improve this. The findings reveal that the most active sector is the computer and consulting industry followed closely by the healthcare which is driven by the Health Insurance Portability and Accountability (HIPPA) legislation. The Finance, and Insurance, show reluctance in joining the wagon probably because they formed there own alliances within the industry. Furthermore, the early adopters, the automotive sector, no longer participate in the X12 standard, because they have established their own B2B data platforms that support their business requirements.

Keywords: X12 standards, diffusion, and business to business e-commerce

1. INTRODUCTION

Business to business (B2B) e-commerce is a successful technological innovation involving sending and receiving information using computer technology which has been used for decades. The first electronic data exchange formats came with industrial suppliers to the United States (U.S.) government in the 1950s. As more players from different industries got involved, over the years the U.S. realized a need to develop common Electronic Data Interchange (EDI) formats and build cross industry standards to increase efficiency. In 1979 American National Standards Institute (ANSI) as the U.S. standardization member body of International Organization for Standardization (ISO) chartered Accredited Standards Committee (ASC) X12 to develop and maintain the cross-industry B2B U.S. standard. Today X12 is being modified to support EXtensible Markup Language (XML) as the newer syntax rising out of needs for organizations to reinvent their business processes and information technological infrastructures. The U.S. is still the region in the world responsible for the highest volumes of B2B revenues. United States based B2B e-commerce transactions continue to drive the global adoption rate (McGann, et al 2005).

The objectives of this paper are (1) to review the status of B2B e-commerce diffusion by X12 standards in the U.S. Specifically we assess X12 diffusion by industry sectors, (2) to identify the characteristics of main adopters in terms of roles played in the B2B supply chain, (3) to capture the strategies of increasing diffusion of X12 standards. These would be beneficial to other industrialized nations that are aiming to replicate the adoption pattern of the U.S.

The paper is organized as follows. Chapter 2 gives a brief background about B2B standards focusing on the X12 standard, followed by the methodology used in addressing the goals. Chapter 3 presents the research approach used for this study. Chapter 4 presents our empirical findings gathered at DISA and analysis of the findings. Chapter 5 presents our concluding remarks and issues for future work.

2. B2B STANDARDS

A standard as a key strategic element for successful e-commerce transactions among different trading partners is paramount (Reimers, 2001). Standards contribute to improving business processes, reducing purchase and inventory costs, increasing productivity and market efficiency, and taking advantage of new business opportunities with market intelligence techniques (Choudhury, 1997, Nelson and Shaw 2005, Medjahed et al, 2004).

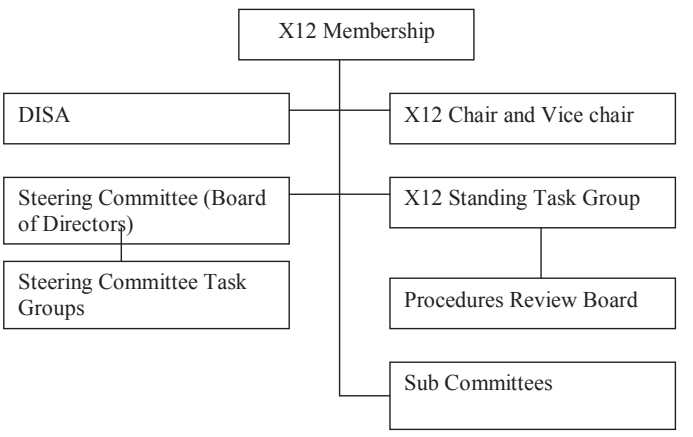
2.1 X12 Standards

Among many other standards, X12 was the first and still is the predominant cross-industry B2B electronic transactions standard in the U. S. (Cline, and Piazza, 1992). Since 1979, X12 has the mandate of developing the B2B transaction standards. In 1987, X12 created Data Interchange Standards Association (DISA) as a non profit to serve as its secretariat. Representatives from the various industries as employees of member companies, meet face to face three times a year, and vote on agreed upon standards that are published by ANSI ASC. Development of the standard is done in between the meetings as an ongoing process. The member company representatives continue to discuss through e-mail, or teleconference until a standard is approved for publication. Membership is open to all interested organizations. The ASC X12 standards and transaction sets are available at a fee from DISA. The general membership is responsible for electing a chair and vice chair every two years that makes up the management committee supported by a steering committee that includes the immediate past chair, vice-chair and elected members of the various subcommittees.

The technical and business processes knowledge is acquired from the members as they know best what kind of standards they need. There are Industry sub-committees, namely government, finance, transportation, and healthcare to address the specific needs of the industry. Figure 1 below shows the organizational structure of X12.

The (ASC) X12 published its first version in 1983, since then it publishes versions annually and releases transaction sets after the trimester meeting. The latest version is 5, release 3 (5030). The transaction sets which are an equivalent of smart documents in EDI, enable data to be exchanged between agreed upon business partners in various industries. ASC X12 facilitates electronic commerce with more than 315 transaction sets across government, education, finance, supply-chain, legal, transportation, healthcare and insurance industries. Since 1997 X12 has

Figure 1. X12 organizational structure



been cooperating closely with the United Nations, Electronic Data Interchange For Administration Commerce and Transport (UN/EDIFACT), the global standard in EDI transactions.

Adoption of X12 is predominant in the very large companies. Smaller and medium-sized companies (SMEs) do not have the infrastructure to tag documents using X12 and hence they do not want to spend the money on it because it is too expensive, difficult, and complex (Subramaniam, and Shaw 2002). Small companies want other ways to work around the costly issues but still get the benefits of doing B2B e-commerce (Amoroso, and Sutton, 2002). However it is still believed that the general adoption of B2B is heavily influenced by SMEs. The efficiencies and benefits are still in involving the SMEs because everybody gains that way (Wagner, 2003).

3. METHODOLOGY

In the first phase of data collection to gain an understanding of B2B e-commerce adoption across industry sectors, documentation sources of DISA were reviewed. In tables 1 and 2 we present relevant inferences showing the membership as a representation by sector, and role area. The sample size was 250 who comprise X12 membership at the time of data collection. The President of DISA, Mr Jerry Connors and current (ASC) X12 Chair, Dan Kazzaz were also interviewed. Before visiting the interviewees they were contacted, with a brief introduction to the purpose of the study. Each interview was approximately forty five minutes. First they were asked about scope and e-commerce applications that they have implemented in their respective roles and future plans. Secondly we asked them to recall general problems that they encountered from the diffusion process, and then we specifically discussed the strategic issues. The interviews were organised in a pattern as to look out for similar categories for the analysis stage.

Table 1. List of companies by industry (N=250)

Sector	100%
Financial and Insurance	15
Computer and Consulting	34
Health	32
Transportation	07
Other (Manufacturing, Apparel, Chemical, e.t.c	12

Table 2. Companies by roles

Role Area	100%
General Interest	25
User	25
User-Provider	10
Vendor- Provider	12
Not Identified,	27

4. ANALYSIS

The Analysis chapter presents the findings and interpretation of the results. The highest representative sector percentage is the computer and consulting industries at 34 percent. The computer and software industry have been at the lead of using advanced EDI to streamline processes. Combining XML techniques with the company's system configuration into a supply chain management is on the top of the agenda of most of the industry. The X12 efficiencies have attracted both the big and small businesses, software developers like Ahmer Taylor, I.M. to computer consultants like EDI Source Inc and IBM Corporation. Companies are actively involved in open channels in different forms of applications with their business customers. The other representative analogy of companies and firms under this sector representing the biggest percentage is the vastness of the industry, from general computer companies, consulting, and software companies to standards developers.

The Health sector follows at 32 percent using X12 adoption under the Health Insurance Portability and Accountability (HIPPA) act. This is probably one of the few sectors that have attracted government participation more than any other. This could be based on the reasoning that the other sectors are more driven by the private rather than the public systems.

The financial, and insurance is at 15 percent. This can be explained by the ease of developing XML standards with groups such as Interactive Financial Exchange (IFX) an open standard financial data protocol. Other competitors include Open Financial Exchange (OFX), dealing with small transactions and Automated Teller Machines (ATM) standards. In the industry there is no unified standard, but efforts are underway to have all these standards working compatibly. Interactive Financial Exchange has been struggling financially to keep going so they have not been able to get as many members to come to the table and work with them and pay dues to the organization. Problems come from most companies wanting to use the standards but not ready to be involved in the startup operations of setting up the framework. In the age of internationalization of products and services through the Internet, coupled with stiff competition, banks, insurance companies and other financial institutions need to strategically rethink the fundamental ways they provide financial services. A revolution is going on and for the financial institutions not using the right strategies. The member organisations in this category are banks, banking financial and banking government.

Transportation sector is at 7 percent. The high need of connecting business partners and their goods and services, internationally is hopefully going to bring more participation from the transportation sector. This is all geared at making trade in the industry faster and cost effective. The companies include general transportation, transportation-motor, transportation-rail, and transportation-ocean.

The combined sector at 12 percent includes all the other sectors that are not generally classified above; examples include manufacturing, apparel, and chemical for example DuPont Company. The industries like automotive that were expected to continue being major players are not well represented and Jerry Connors, DISA President has an explanation for that. "These were among the founding member companies in the 70s but as they implemented they found no need to develop new transactions and, hence they pulled out". Dan Kazzaz, the ASC X12, current chair concurs with this notion "it is hard to get big companies to continue working after they completed developing their core message."

As shown in table 2, generally as far role playing (in the B2B transaction) is concerned the majority are the users at 25 percent; we have some few user-providers at 10 percent and vendor-providers at 12 percent. The User refers to the companies and organisations in the supply chain that generally receive, standardized documents using B2B e-commerce. The General Interest Companies are the firms that have shown some level of adoption. These are actors with a two way relationship, in form of Users. In addition they send all their transactions over the EDI platform. They have possibility scenarios of many to one. Vendor-Provider these are more than users themselves in sending and receiving but they also provide the technical platform for the supply chain management, in the transaction process. Through secure and authenticated connections the vendor-providers authorize their respective end users for the B2B connections.

4.1 X12 Performances

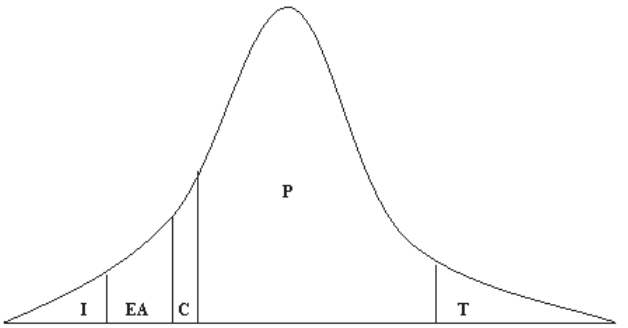
The use of X12 has been steadily growing from the mid 80's (see table 3) when the concept became popular for cutting costs and reducing processing time. However the late 90's and early 2000, plagued by the dotcom era problems, experienced a slight decline. This however is picking up as new models reveal how B2B e-commerce can reduce transaction costs such as time and effort in finding products, services solutions, potential buyers and suppliers. The highest percentage is from 2003 to 2006, (33 percent) which could be explained by regained confidence after the dotcom era. This also confirms (Bonaccorsi, and Rossi, 2002) reference made to the higher the number of adopters the higher the probability for others with the intent to adopt to join the band wagon effect.

Other issues include the telecommunication infrastructure, the greater numbers in the firms using the technology the greater the investment in the infrastructure which in turn brings in more adopters. In deciding to adopt there was reference of how many other adopters are in the sector and how many other intend to adopt. Other firms wait for early adopters to see their performance and decide whether

Table 3. Progression of EDI X12 membership in the last 2 decades

Period	%
1985-90	17
1991-96	27
1997-02	21
2003-06	33

Figure 2. From Moore (1991) showing adoption process



they will join or not. Critical mass of early adopters brings forth the industry pressure needed to bring in the majority and late adopters. Then the decrease as most firms adopt. These patterns with the sigmoid path as seen in figure 2 below. Starting with a few companies adopting the e-commerce technology and adoption increasing as other firms learned about the new technology. Other inferences include variables such as the size of the organization; value of the technology has little to do with the technology adoption. Technology adoption process has variances between the technology expectations and the technology value. This conforms to Moore's technology adoption life cycle (Moore, 1991) with the main categories of adopters as innovators (I), early adopters (EA), pragmatists (P), and the traditionalists (T). Chasm (C) is the time lag between the early adopters (EA), pragmatists (P).

4.2 Performance by Industry Sector

The healthcare industry in spite of being a late starter shows tremendous growth (as shown in table 1). Jerry Connors says "healthcare industry is the most active industry today." He adds that this is partly because the federal government of the U.S. mandated that all medical practices use the HIPPA law. And HIPPA requires requires that all medical practices and all healthcare insurance companies use X12 for claims and other administrative transactions. So, it is a constantly emerging situation that will be going on for a long time. Currently in the healthcare sector, there are many other different standards; X12 mostly works with administration and billing not clinical. There is a need to harmonize these standards so that they can be more interoperable.

In the 80s subsequent to the recession in the 70s, the automotive industry needed to change how it did business. In order to have just-in-time inventory you have to have messages from the manufacturer all the way through the supply chain coming in very quickily. The automotive sector had not been doing Just in Time (JIT) inventory replinshement, so they were either buying too much that created storage problems or too little and hence runing out of stock while they made their cars. As a result they knew that they needed to switch to JIT. This drove X12 adoption and they basically pumped the resources into X12 to make it happen for all their suppliers. For its sucess, software vendors, and standard organisations were needed for the suppliers to communicate. So, the automotive industry made it happen in their value chain. Similarly, the apparel industry pushed on the retail industry to try and save themselves and the apparel industry did not succed so well in saving themselves because they ended up sending all their manufacturing overseas. But they basically were trying to do JIT inventory for themselves. They picked up the same idea as they moved it to retail. The whole supply chain activities that happen inside the retail environment happen using the X12 standards.

Through the progression of years the big companies like General Motors concluded that they have got what they needed, so membership dropped to about half. Jerry Connors says "for a long time in the late 80s and 90s we had huge participation with a membership of up to 700 to 800 from all industries across the country, and thousands at the meetings." Mr. Connors adds that in the last few years some of the big companies have got what they needed; "they have B2B data platforms that meet their needs, so, they don't feel the need to participate as actively as they did before." With big companies it is very hard to get them to agree, some especially in the automotive industry felt the need to go international, which also affected X12 membership (see table 3). Today the automotive industry does not participate in X12 and has minimal representation with United Nations Centre for Trade facilitation and Electronic Business, (UN/CEFACT). As stated above they are not building new messages. Their participation is missed and there are efforts to bring the two organizations together to see this reversed. They have a wealth of experience and financial clout, which would greatly enhance the ASC X 12 performances. This would help X12 in general build better standards.

ASC X12, strategies of increasing diffusion of X12 include using the emerging language XML, with the highly acclaimed syntax neutral architecture called Context Inspired Component Architecture (CICA), which is more flexible and human readable than EDI. Jerry Connors, says" what we are tying to do with this architecture is to set ourselves for the long term future so that whatever comes along in XML we will be ready for it." With this approach ASC X12 with its experience and technical expertise, as the U.S. B2B primary standards body is leading the way to convergence of EDI and XML Standards to handle the business processes within an Internet based e-commerce environment. Challenges with the CICA architecture are that it is complicated. It is hard to get a wide group of people to understand that they can model their business and build messages simultaneously. Dan Kazzaz says, "What we are trying to do is to encourage the software community to develop tools, so that the data involved in a particular business message can be entered into the tool and the tool will help them model their message, the model can then automatically populate the X12 CICA." "This is a very high priority for us right now. The people at the end in the sub-committees vary in technical expertise; we want to create a platform that will allow as many as possible to build CICA complaint messages without having to understand all the new nuances of the architecture. If they enter the data it will come out the back end the way they want it and have strong, reusable component."

5. CONCLUDING REMARKS

All indicators show a continued interest in B2B e-commerce in the U.S. The obvious advantages that B2B e-commerce brings with it such as efficiency makes B2B e-commerce a perquisite across all industries in the transportation, government, real estate, healthcare, education, retail, grocery, warehousing, and financial services. However, there are considerable gaps and mysteries in the different sectors to the new adoption insights. The business relationships between many companies have been unique to their business processes, hence their concerns over the new ideologies that the ASC X12-XML would address all the bottlenecks in electronic business. In addition concerns with data security and the reliability of the standard still arise.

Our findings show that much of the healthcare sector has woken up to the potential of B2B e-commerce, as confirmed in the interview with the X12 Chair. From the interviews, among the challenges to adoption significant issues identified include; barriers to prioritization by top management, implementation obstacles such as integration with internal application systems and existing business methods, and, for banks, consideration of B2B e-commerce technologies as a close relation to corporate banking.

EDI platforms built by the Fortune 500 companies to exchange electronic messages were very expensive; hence they are not keen on the change because of the high investments in terms of time, money and human resources made earlier on. Besides, many of them believe they are doing fine with their EDI platforms and are not interested in investing more money in making vast changes, though some are willing to make small incremental changes as they watch closely the return of investment. Main questions still remain what is the move to XML going to get me? Hence the challenge for X12 remains to determine and teach its member-

ship and potential members the value proposition of using syntax neutral model (CICA) to create new messages. They intend to address this through a strategy of proposing new bodies of work and working to ensure that application software vendors support these new messages. Moving from EDI to XML by small increment changes, with compatible content, rather than big moves as the value of moving over is appreciated. E-commerce activity is geared towards empowering SMEs to participate. This is expected to bring back the software vendors to build relationships, hence increasing the diffusion rate. However, before all this happens, harmonization is needed for the different standards within X12 and the newer XML to be more interoperable. Efforts to address this are there but still in their early stages. Mr. Kazzaz, adds, "my vision includes seeing the American standard being synonymous with the international standards. Harmonizing the standards will create more efficiency." With this said challenges remain for ASC X12 like to get the competing standards groups to stop and evaluate the benefit that would come from harmonization.

6. FUTURE WORK

To further the research of B2B e-commerce adoption beyond the U.S., we propose to look at a comparative study of government case studies of U.S., versus European Union and its member states. Eliminating paper based business transactions with its expenses has been the main motivation behind business to business (B2B) adoption. As we have seen the more able larger organizations have seen tremendous growth in doing their business-to-business electronic transactions over the widely accepted standards of the US (ANSI X12) for the U.S. organizations. For European Union, a case study of Sweden and, UN EDIFACT, could be examined to compare the different firms, and present a synopsis of the adoption for the two predominant standards.

REFERENCES

Amoroso, D. and Sutton, H. (2002) Identifying e-Business Readiness Factors Contributing to IT Distribution Channel Reseller Success: A Case Study Analysis of Two Organizations, 35th Hawaii International Conference on System Sciences, IEEE Computer Society

Bonaccorsi, A. and Rossi, C. (2002), The Adoption of Business to Business E-Commerce: Heterogeneity and Network Externality Effects. Available online at http://www.

Choudhury, V. (1997), Strategic Choices in the Development of Interorganizational Information Systems, Information Systems Research (8:1), pp. 1-24.

Cline, M. and Piazza, C. (1992), EDI and X12: What, Why and Who? Serials Review. 18(4):7-10.

Graham I, Spinardi G, Williams R and Webster J. (1995) "The Dynamics of EDI Standards Development" Technology Analysis and Strategic Management, Vol. 7, pp. 3-20.

McGann, S., King, J. and Lyytinen, K. (2005), "Globalization of E-Commerce: Growth and Impacts in the United States of America," Sprouts: Working Papers on Information Environments, Systems and Organizations, Volume2, Issue 2 (Spring), pp 59-86. http://sprouts.case.edu/2002/020205.pdf

Medjahed B., et al (2004). Business-to-business interactions: issues and enabling technologies. The International Journal on Very Large Data Bases, 12(1), pp. 59-85.

Moore, G. A. (1991) Crossing the Chasm, HarperBusiness, New York.

Nelson, M., and Shaw, M. (2005) "Interorganizational system standards diffusion: The role of industry-based standards development organizations," http://www.business.uiuc.edu/Working_Papers/papers/05-0126.pdf

Reimers, K. (2001). Standardizing the new e-business platform: Learning from the EDI experience. Routledge, 11(4), pp. 231-237.

Subramaniam, C. and M. J. Shaw, (2002) "A Study of the Value and Impact of B2B e-Commerce: The Case of Web-Based Procurement," *International Journal of Electronic Commerce*, 6, 4,.

UN / CEFACT: United Nations centre for trade facilitation and electronic business. Available online at http://www.unece.org/cefact/

Wagner, B. A., Fillis, I. and Johansson, U. (2003) "E-Business and E-Supply Strategy in Small and Medium Sized Businesses (SMEs)," Supply Chain Management: *An International Journal*, Vol. 8, No. 4: 343-354,.

Peak Oil to Peak People: Education – A Resource in the Knowledge Society

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INTRODUCTION

This paper suggests that as oil supplies run out and prices rise in the knowledge economy, an education system is needed that is based on information technology rather than on transport and building technologies to provide an alternate resource for sustained economic growth. The world is at a tipping point where it is running out of oil, but not people. It is argued that the knowledge society will be based on the infinite resources of the world-its people. We need to tap and develop this resource through education and training and so move from peak oil to the production of peak people. The key driver of change is going to be innovative rethinking on how people are educated for an unpredictable, information technology-based future. The current debate under the rubric of globalisation is on peak oil, and a clear contradiction between peak oil theory, the continual increase in oil reserves and production, and the rising cost. Peter Huber and Mark Mills (2005) argue that the price of oil remains high because the cost of oil remains so low. We are not dependent on the Middle East for oil because the world's supplies are diminishing, but because it is more profitable to tap Middle East supplies. New sources are not being explored and new refineries not being built (Huber and Mills, 2005). Since the industrial revolution, world economies have run on oil. Societies have been through 'peaks' in critical resources throughout history, only to be saved by some human ingenuity and discovery of a new and 'inexhaustible' resource. It was oil that 'rescued' civilisation to deal with sustainable economic growth. Can highly educated peak people do the same? As the price of oil worldwide continues to soar, societies globally struggle to find alternative fuels that range from coal, solar, wind farms and nuclear energy to drive their economies. But these are still expensive, and the means to exploit alternative energy using technology remain oil fed. That oil will run out is certain; only the timing is not. However, when oil does run out or becomes unaffordable particularly for the developing nations and their growing populations, its decline will change the world in radical and unpredictable ways. Perhaps even more concerning is that because oil is a strategic resource, as supplies become scarce, societies are witnessing increasing geopolitical and global conflicts, environmental deterioration, pandemics and ideological and cultural clashes. Oil created the industrial society as we know it, but at the dawn of the knowledge society, it is a finite resource. Around the world, societies now believe that their future advancement can no longer only depend on their land, climate and extractive fuels, but rather upon the peak capability of their people. Therefore, with knowledge as competitive advantage, education for human resources development will be the engine that drives the global economy.

DUAL CRISES AND THE NEED FOR A NEW PARADIGM

Philip Coombs's 1968 classic *The World Crisis in Education* reflected a universal concern that educational systems were becoming dinosaurs out of synch with societies' needs. He revisited the issue in 1985 and found that in fact the crisis had deepened (Coombs, 1985).

Today we face two crises, peak oil and the crisis in education where current education systems seem unable to provide the dimensions and skills needed for problem solving in an unpredictable and fast-moving future.

The modern university as we know it is designed to operate according to the prevailing paradigm and infrastructures in the society in which it is located. It is based on building and transport technologies that bring together teachers, learners, knowledge and problems by providing communication networks to effect education. However, building and transport technologies based on depleting oil supplies are becoming more costly. At the same time, rapid advances in communication and information technologies especially the internet offer alternative and complementary learning spaces to respond to the increasing demand for tertiary education worldwide to up skill employees for the emerging, competitive, global knowledge economy.

FROM PLACE-BASED TO SPACE-BASED LEARNING

In his speech on July 26 2006 to the OAS, Nicholas Negroponte suggested that no matter which global problem we address, the solution always includes education. He argues that it is through using IT both as a tool of learning and as a window on the world that people will learn most.

Some of the main challenges facing universities today include the need to break away from the limitations of time and space the conventional classroom imposes; and to consider the impact of the internet as education becomes global competitive and commercial.

THE UNIVERSALS OF UNIVERSITIES: TEACHING/LEARNING/KNOWLEDGE

Some critical factors that constitute higher education, the universals of a university-the creation processing and application of knowledge to real-life problems in culturally appropriate ways-will not change whatever the episteme, the place, the language, the culture or the medium used. The main difference that distinguishes e-learning from on-campus learning is that instead of bringing students and teachers together physically by means of local transport systems and buildings for face-to-face interaction, e-learning uses computers and telecommunications to bring them together as telepresences on the global internet (Tiffin and Rajasingham, 2003).

The internet is still evolving and will continue to do so as computers become more powerful and wearable, and bandwidth increases. Today computers are an essential tool for communication as interactive multimedia on the internet allows the global networking of human intelligence in unprecedented and revolutionary ways.

Curricula designed for use in a particular institution within a particular nation and context and posted on the Internet are now open to scrutiny from a global perspective as the professional application of knowledge increasingly takes place in a global as well as in local contexts. The conventional university system is designed and localised for the nation in which it operates according to the rules, regulations, taxation, laws and language of that country.

Universities are associated with knowledge, which by singularly adding value is the engine that drives economic growth. But knowledge is an elusive and abstract concept that defies definition. Knowledge exists in explicit as well as implicit modalities. Not only is knowledge being deconstructed into a multiplicity of subjects, but is seen differently from university to university, country to country and language to language. The growing fragmentation of knowledge and lack of consensus as to what constitutes knowledge creates a context for discordant value and quality judgement. From a postmodern perspective, we see multiple 'knowledges' on the same theme (Lyotard, 1984) and all seek legitimisation for problem solving in their own cultural settings. As the university changes with a new episteme, so too must the knowledge it teaches and researches.

Today, professionals need to know about international practice as it operates in the global economy. Pandemics such as AIDS, SARS and Avian Flu, terrorism and

environmental issues know no frontiers, and people everywhere need to be able to collaborate internationally to deal with these global issues. The trickle down of knowledge over time is suddenly bypassed and so is the intermediary position of the teacher as education becomes learner-centred, non-linear, and self-directed, thus shifting paradigms.

Furthermore, universities face competition and commercialisation as students as fee-paying customers now compare and evaluate what is taught in other countries by using the World Wide Web and linking in chat rooms with students from around the world. Universities need to attract students, remove the regulatory and administrative barriers to developing innovative research and quality curricula. Let the customer decide what they want, and provide it. Good teachers and good researchers should be well remunerated and supported. The ineffective ones should go.

As education becomes big business, universities are challenged to resolve the dichotomy between business ideals and pedagogical imperatives that embody the universals of a university, and help improve the quality of **what** and **how** we teach with integrity and maintain their *raison d'etre*- the creation, processing, dissemination and application of knowledge. As universities face increasing fiscal constraints resulting from reduced government subsidies, they seek to become businesses for profit. With reduced staffing, increasing on-seat student numbers and cutting staff and student support systems, staff/student ratios rise. Inevitably, standards fall (Rajasingham, 2006).

THE NEED

What is needed is effective, cost-efficient, culturally appropriate instruction that can match the needs for global skills related to rapid technological change, delivered interactively at the convenience of the learner. The learner, no matter where their physical location will be able to interact with the teacher, content and one another in synchronous and/or asynchronous mode using text, words and still and moving images, and in future smell, taste and touch. A global virtual university on the internet could meet this need. It will be global, competitive, commercial, and will be on broadband using virtual reality (VR) HyperReality (HR) and artificial intelligence (AI) providing learning through our five senses.

Curricula design for the global market is needed to allow societies to act global, and then localise in consonance with local thinking and upgrade the relevance of what is taught. With instructional design principles for internet based learning, basic courses that are the currency of higher education whatever the country can be re-addressed from the multiple perspectives of different countries, cultures and languages to develop new curricula to match global concerns (Tiffin and Rajasingham, 2003).

FORWARD MARCH

Education is communications. Both are information intensive, technology-based and culturally contextualised activities. The 1900s saw the use of correspondence based on postal services and radio in education. The 1960s, saw educational television and the 1980s, the advent of the personal computer in education. The 1990s saw the use of narrowband internet and virtual reality in education. In this decade of the new millennium we see the rapid advances in computer power that bring new sophisticated clusters of technology such as nanotechnology, AI and HyperReality on broadband internet changing the way we bank, shop, play and learn.

Virtual universities today proliferate on the internet with variable success and shelf-lives. Globalisation and the rapid advances in the internet will introduce new ways of learning and teaching and challenge the traditional classroom, not replace it but to provide alternative and complementary communications environments that will extend educational opportunities for more people than is possible with conventional classrooms. This is the virtual class based on distributed virtual realities on the internet where teachers and learners and curricula interact in telepresence and make globalisation of education a reality for anyone, anywhere.

THE FUTURE UNIVERSITY: GLOBAL, MULTICULTURAL, MULTILINGUAL AND BIG BUSINESS

In his foreword to the text *The Virtual Class: Education in an Information Society* (1995) Reidar Roll, the Secretary General of the International Council for Distance Education made an important distinction between quality in what we now call e-learning, and quality in conventional education and argued that we are not only talking about better educated citizens but differently educated citizens. He called for a balance between the need for global skills and knowledge and the need to respect and preserve cultural identity. This is a yin and yang relationship between global and national education.

In ensuring quality education and the universals in curricula, it is argued that if knowledge varies according to a country or a culture, then global issues can only be addressed from the perspective of that country and culture. As universities offer their courses online and become competitive, the question as to who determines quality which is a complex and nebulous subjective concept becomes an issue that education must urgently address. When the quality of education is only measured and promoted by national standards we have a recipe for the kind of clash in cultures that we have today where one nation's freedom fighter is another nation's terrorist. No country is an island unto itself as all societies are inextricably interconnected through the internet. So what kind of university will be needed in the knowledge society?

Lev Vygotsky (1978) suggested that education at its simplest is the coming together for interaction between teacher, learner and problem. As there is a close relationship between universities, knowledge and civilisation, it is argued that teachers help learners to apply knowledge to problems. Vygotsky, however did not envisage that the teacher need not be human.

To respond to multiperspectives in a globalised world, the virtual university on the internet will need to be global, commercial, multilingual and multicultural, where students are equipped with global skills to solve global problems, and at the same time act local in consonance with their own cultures and social networks. The HyperClass is a step towards this.

THE HYPERCLASS IN THE VIRTUAL UNIVERSITY

The HyperClass is based on HyperReality, a technological platform conceptualised by Nobiyoshi Terashima. It allows the intermeshing of virtual reality (VR) physical reality (PR) and artificial intelligence (AI) in a way that is seamless and allows interaction in fully immersive environments. A HyperClass is the interactive conjunction of a real class made of atoms with a virtual class made of bits of information. It makes possible a future where the people and the objects around you may be real or may be virtual and may have human intelligence or artificial intelligence, providing multimediated, immersive simulated learning environments. Because HyperClasses in universities can exist in real and virtual dimensions at the same time, they will provide an intersection between the local and global dimensions in education.

A student could go to a conventional class in a conventional university or stay at home and use a PC and the internet to link to a virtual class in a virtual university. A HyperClass allows a student to do both. A HyperClass exists where the virtual and real dimensions intersect. This is a coaction field where students and teachers in a conventional classroom can synchronously interact with students and teachers in other universities that may be in other countries.

A coaction field conceptualised by Terashima (2001:9-12) is where students and teachers in a conventional classroom can synchronously interact for the purpose of learning with students and teachers in other universities, possibly in other countries. The HyperClass is where real and virtual dimensions of students and teachers intersect providing a common field to reconcile the learning that is local with learning that is global in order to understand the subject from multiple perspectives of other cultures than one's own (Tiffin and Rajasingham, 2001; 2003).

Participants in a HyperClass come together because of their interests in a specific subject on a shared domain of knowledge. In the HyperClass, the relationship between knowledge and problem domains suggests another important contrast to conventional classroom processes. In a conventional classroom the application of knowledge to problems is expressed symbolically, through alphanumeric notation and two-dimensional still pictures displayed on a display unit such as a whiteboard.

However, it is suggested that when problems have a real life referent in the participants' social reality, then classrooms with whiteboards may not be the best place for learning and proves the inadequacy of alphanumeric and diagrammatic instruction alone. The challenge is to transfer learning from the classrooms to real life situations and testing the application of knowledge to real life situations in whatever form they take in multimediated simulated environments. The

HyperClass introduces a new dimension in education with the juxtaposition of knowledge with problems that have a referent in physical reality (Tiffin and Rajasingham, 2001).

With HyperReality technology, objects are created in 3-D using an array of videocameras, creating a database/library of problem case studies that could include dangerous conditions. Learners could for example, be faced with a vast array of different situations and could seek solutions to their problems with the help of their teachers and peers from diverse cultural perspectives where each participant or group can manipulate the 3-D modelled learning objects (Terashima, 2001). A significant strength of HyperReality as contrasted with virtual reality today is that while the communication process in a virtual class is prescribed using the shapes and designs that have already been created as computer generated virtual reality by computer graphic designers, HyperReality on the other hand allows a syncretion of cultures, where the quality of the content being studied can be designed, altered, and objects modelled by the participants themselves to catalyse collaborative learning from multicultural perspectives, and this capability that is contextualised is critical for improving the quality of the knowledge content being studied. Problems can be real. But knowledge is always abstract (Rajasingham 2006).

LEARNING, TEACHING AND JITAITS

Perhaps the most profound aspect of the teacher/learner axis in a HyperClass is that the avatars of teachers and students may not necessarily represent human intelligence. Today we are familiar with the little cartoon character, a wizard looking like a paper clip that keeps popping up on the computer screen offering to help where someone has tried to programme a just-in-time (JITAIT) artificially intelligent teacher. In a HyperClass a teacher and a learner can be virtual or real. A virtual teacher can have human intelligence (HI) or artificial intelligence (AI). Teachers and learners can communicate synchronously, using speaking avatars, or asynchronously, using written words or visuals. Knowledge and problems can be embodied in the teacher and the learner or they can be represented alphanumerically, or in simulacra.

Today human teachers can only respond immediately to a learner in working hours and if there is only one student seeking help. In large classes student questions have to wait until a teacher is available. In higher education much learning is done asynchronously and students get feedback on an assignment a week or more after doing it and most students have forgotten the things they found difficult. It is time for the just in time artificially intelligent teacher (JITAIT). As the name implies, this is an AI teacher that can be available whenever and wherever a student needs help (Tiffin and Rajasingham, 2003).

JITAITs are expert systems, effective where the domain of knowledge they address is restricted, paradigmatic and orientated toward problem solving. A JITAIT can therefore be an expert teacher on a subject that formed the domain knowledge of a coaction field in HyperReality. JITAITs would always be ready to help any learner in the coaction field and would improve from each encounter with a learner provided it received feedback from a human teacher, and could act as personal teachers to individual students. JITAITs could have avatar form and a personality and act as a guide and mentor in the manner of the servant-tutor pedagogues of ancient Greece. As each intake of students asks the same questions and has the same problems, JITAITs can be used and at this level could be shared between human and AI tutors. As time went by and JITAITs handled more and more FAQ's, their role would increase and the student teacher ratio could be progressively increased without lowering quality.

The upper level is that of the subject specialist, the professors and professionals who have achieved academic stature through research, publications and experience and can arbitrate on content. Their primary purpose is to communicate a synthesis of the subject matter in a way that brings it up to date, places it in context and encourages students to question. They do this by lecturing, and are supported by a team of teaching assistants who do the tutoring at the local level, leaving the professor to lecture to very large classes. With e-learning they could stream their lectures to the whole world, and there need be no limits to the numbers who could attend. Instead of being salaried employees, professors who could attract such numbers would be valuable property and they could relate to their universities in the way authors relate to their publishers (Kats, 1999: 48) receiving royalties for each student taking their programme.

THE GLOBAL VIRTUAL UNIVERSITY

The infrastructure of the virtual university which is on the internet is the technology that makes possible telelearning, telebanking, teleworking, teleshoping and telemedicine without leaving one's home. Distance from any place need no longer be a limiting factor. It does not matter where the university is physically located and learners in any country can as easily access courses from the global virtual university as they can from their neighbourhood university. In fact as internet access increases for people who are housebound, in hospitals, at work or travelling, or for convenience, it offers an invaluable alternative access to educational opportunities.

In the case of modern universities, accreditation of a degree programme, who can teach and how is legally defined by the government that supports the university through taxation. Curricula were set in concrete and it took years to bring in changes. Inevitably, national universities as virtual universities promulgate the national culture. This was acceptable and successful in the industrial age. But in the knowledge society, it creates problems for global education that not only caters for the English speaking world, but also for multilingual and multicultural environments.

The internet is a strangely dynamic environment that changes the nature of access to knowledge and hence the very nature of higher education. Knowledge is no longer based on the scientific paradigm, fixed and an end in itself. Virtual universities on the Internet opens up choice in content as well as learning styles, and provided there is access to the internet, equity of opportunity becomes an achievable ideal.

However, it must be noted that the issue of accreditation of a global virtual university is critical. If learners can choose from a smorgasbord of subjects offered by different universities in the education marketspace for credit towards their degree, who will validate the degree and give appropriate credit value?

Perhaps there could be a board of eminent international scholars and professors in the manner of a top journal's editorial board to scrutinise quality and provide the accreditation. Further discussion on this important topic is beyond the scope of this paper.

IN CONCLUDING…

Seymour Papert said: "Errors benefit us because they lead us to study what happened, to understand what went wrong, and through understanding, to fix it" (Brand, 1988: 127).

Whereas conventional universities are geared to the study of what is known and what is knowable, virtual universities address the unknowable in order to prepare people who can shape the future.

A global virtual university will by definition be open to competition and commercialism. What happens to education as a public good when it is open to market forces? However, we have to find a balance between the old and the new; and between the virtual and the real. It is therefore critical to research on how the world's untapped resource, its people can be educated for an unpredictable, rapidly changing future.

This paper suggests that if globalisation is to mean anything other than continued exploitation and increasing differentials of wealth and poverty then the development of global virtual universities will be one way to meet the social and economic needs of the world in the 21st century.

REFERENCES

Coombs, P.W. (1985). *The World Crisis in Education: The View from the Eighties,* New York: Oxford University press

John Tiffin & Lalita Rajasingham. (1995). *In Search of the Virtual Class: Education in an Information Society,* London, and New York: Routledge

…' The HyperClass', (2001). J. Tiffin and N.Terashima (eds.) *HyperReality; Paradigm for the Third Millennium,* London: Routledge

… (2003). *The Global Virtual University*, London, and New York: Routledge

Lyotard, J. (1984) *The Postmodern Condition: A report on knowledge,* Minneapolis: University of Minnesota Press

Negroponte, N. Lecture Series of the Americas, Organization of American States, 26 July 2006, online: www.oas.org (retrieved: 8 December 2006)

Peter Huber & Huber and Mark Mills (2005). 'Oil, Oil, Everywhere' *The Wall Street Journal,* January 27, 2005

Rajasingham, L. (2006) Re-focusing Universities and Improving the Quality of Higher Education for the Knowledge Society. 22nd World Conference, International Council for Open and Distance Education, 3-6 September 2006, Rio de Janeiro, Brazil. Proceedings on CD-ROM

Seymour Papert. (1980). Brand, S. (1988). *The Media Lab: Inventing the Future at MIT,* New York: Penguin Books

Terashima, N.(2001) 'Definition of HyperReality' J. Tiffin and N.Terashima (eds.) *HyperReality; Paradigm for the Third Millennium,* London: Routledge

Vygostky, L. S. (1978) *Mind in Society: The Development of the Higher Psychological Processes,* Cambridge MA: Harvard University Press

From Specification to Implementation: A Method for Designing Multi-Agent Systems in a Transformational Style

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ABSTRACT

The suitability of using the Chemical Reaction Metaphor (CRM) to model multi-agent systems (MASs) is justified by CRM's capacity in specifying dynamic features of multi-agent systems. This paper presents a module language that facilitates a transformational method for implementing the specified multi-agent systems. A computation model with a tree-structured architecture is proposed to support the module language. The computational model is a straightforward abstraction of networked computing sources with minimum assumptions. In this model, the multicast network functionality pragmatizes the implementation of communications and synchronization among distributed agents. The transformational method is a rewriting process that translates the CRM specification into a program in the module language.

Keywords: Multi-agent systems, the chemical reaction models, program specification, very high-level languages, distributed systems, software architecture

INTRODUCTION

Agent-oriented design has become one of the most active areas in the field of software engineering. The agent concept provides a focal point for accountability and responsibility for coping with the complexity of software systems both during design and execution (Yu, 2001). In this approach, a distributed system can be modeled as a set of autonomous, cooperating agents that communicate intelligently with one another, automate or semi-automate functional operations, and interact with human users at the right time with the right information. Such a model should be general enough to address common architectural issues and not be specific to design issues of a particular system.

The modeling issue in the abstract computing machine level has been studied in (Banâtre, Fradet, & Radenac, 2004), where the chemical reaction model (Banatre & Le Metayer, 1990 & 1993, Banatre, Fradet, & Radenac 2005a, Le Metayer, 1994) is used to model an autonomic system. Given the dynamic and concurrent nature of multi-agent systems, we find that the chemical reaction metaphor provides a mechanism for describing the overall architecture of the distributed multi-agent systems precisely and concisely, while giving the design of the real system a solid starting point and allowing step-by-step refinement of the system using transformational methods (Lin, 2004; Lin & Yang, 2006).

As pointed out in (Banâtre, Fradet, & Radenac, 2005b), however, a direct implementation of a CRM specification is unlikely to be efficient and the authors also pointed out that this is another exciting research direction. The difficulty in reaching an efficient implementation of CRM specifications is caused by the use of multisets as the basic data structures and that a direct implementation of the selection operations in the reaction rules requires a brute force testing of the data. We observe that implementation of CRM specifications in the system architecture level, e.g., the architectural specification of an MAS, and that in the programming level can be handled in different ways. By using network communication functions to facilitate reaction testing, we can implement the specifications without brute force testing. This implementation allows further refinement of node-specific programs using proprietary techniques.

The presentation of our method will be in the following organization: In the second Section, we present a brief description of the Chemical Reaction Metaphor; In the third Section, we describe the proposed method for implementing CRM specifications of MASs. Discussions and Conclusions are drawn in the last section.

THE CHEMICAL REACTION MODEL

Based on the computation model of CRM, The Gamma language (Banatre & Le Metayer, 1990 & 1993) was introduced to program the computation. In the Gamma language, parallelism is left implicit and therefore a Gamma program is a true natural parallel program. The Gamma language was found suitable for describing a distributed and/or evolving system consisting distributed entities that execute and interact with one another asynchronously and that are added into the system or deleted from the system dynamically. Follow-up researches revealed that the Gamma language can successfully address the architectural design issues since its computation model captures the dynamic characteristics of a distributed system (Inverardi & Wolf, 1995; Banatre & Le Metayer, 1996; Le Metayer, 1998). For instance, it is a distinguished language for the architectural design in coordination programming (Holzbacher, 1996), configuration programming (Kramer, 1990), and software architecture (Allen & Garlan, 1994; Garlan & Perry, 1995).

The basic term of a Gamma program is molecules (or γ-expressions), which can be simple data or programs (γ-abstractions). The execution of the Gamma program can be seen as the evolution of a solution of molecules, which react until the solution becomes inert. Molecules are recursively defined as constants, γ-abstractions, multisets or solution of molecules. The following is their syntax:

$M ::=$	$0 \mid 1 \mid \ldots \mid$ 'a' $\mid$ 'b' $\mid \ldots$	; *constants*
$\mid$	$\gamma P[C].M$	; *γ-abstraction*
$\mid$	M_1, M_2	; *multiset*
$\mid$	$\langle M \rangle$	; *solution*

The multiset constructor "," is associative and commutative (AC rule). Solutions encapsulate molecules. Molecules can move within solutions but not across solutions. γ-abstractions are elements of multisets, just like other elements. They can be applied to other elements of the same solution if a match to pattern P is found and condition C evaluates to true and therefore facilitate the chemical reaction. The pattern has the following syntax:

$$P ::= x \mid P, P \mid \langle P \rangle$$

where x is a variable. In addition, we allow for the use of tuples (written $x_1 : \ldots : x_n$) and names of types. For example, γ-abstraction

$$\gamma(x: \textbf{Int}, y: \textbf{Int})[x \geq y].x$$

can be interpreted as: replace x, y by x if $x \geq y$, which is equivalent to finding the maximum of two integers.

The semantics of γ-Calculus is defined as the following:

$(\gamma p[c].m_1), m_2$;*γ-conversion*	$= \phi m_1$	if match$(p / m_2) = \phi$ **and** ϕc
m_1, m_2 ;*commutativity*	$= m_2, m_1$	

$m_1, (m_2, m_3) = (m_1, m_2), m_3$
; *associativity*
$E_1 = E_2 \Rightarrow E[E_1] = E[E_2]$
; *chemical law*

The γ-conversion describes the reaction mechanism. When the pattern p matches m_2, a substitution ϕ is yielded. If the condition ϕc holds, the reactive molecules $\gamma p[c].m_1$ and m_2 are consumed and a new molecule ϕm_1 is produced. $match(p/m)$ returns the substitution corresponding to the unification of variables if the matching succeeds, otherwise it returns **fail**.

Chemical law formalizes the locality of reactions. $E[E_1]$ denotes the molecule obtained by replacing holes in the context $E[\ ]$ (denoted by $[\ ]$) by the molecule E_1. A molecule is said to be *inert* if no reaction can be made within:

$$Inert(m) \Leftrightarrow (m \equiv m'[(\gamma p[c].m_1), m_2] \Rightarrow match(p/m_2) = \textbf{fail})$$

A solution is inert if all molecules within are inert and *normal forms* of chemical reactions are inert γ-expression. Elements inside a solution can be matched only if the solution is inert. Therefore, a pattern cannot match an active solution. This ensures that solutions cannot be decomposed before they reach their normal form and therefore permits the sequentialization of reactions. The following inference rule governs the evolution of γ-expressions:

$$\frac{E_1 \rightarrow E_2 \quad E \equiv C[E_1] \quad E' \equiv C[E_2]}{E \rightarrow E'}$$

For example, assume M, N, and R are names of three types, and f and g are two molecules that transform an element of M into an element of N, and from N into R, respectively, a producer can be defined as the following γ-abstraction:

$$prod = \gamma(x: M)[\textbf{true}].\ \langle f, x\rangle: N, prod$$

and a consumer can be defined as:

$$cons = \gamma(x: N)[\textbf{true}].\ \langle g, x\rangle: R, cons$$

A producer-consumer program that allows stream processing in which the producer and the consumer work concurrently can be written:

$$PC\ M_0 = \langle M_0, prod, cons\rangle$$

where M_0 is the initial set of values of M type.

IMPLEMENTING ARCHITECTURE SPECIFICATIONS

Although there were discussions about implementing the Gamma language on parallel computers (Creveuil, 1991; Gladitz & Kuchen, 1996; Lin, Chen, & Wang, 1997), it is commonly accepted that there is no straight implementation of the Gamma language that is efficient. After all, the Gamma language was designed as a very high level language for program specifications and is, therefore, used to specify the architectures of the coordinating systems. In a sequel, node-specific software design in a distributed system still relies on conventional software engineering methods. In a distributed multi-agent system, the separation of architectural design and the design on proprietary platforms is deemed even more necessary for dealing with the complexity of the system (Lin, Lin, & Holt, 2003). Therefore, we will restrict the following discussion to implementing the Gamma specification of the multi-agent systems in the architectural level with a minimum assumption about the computation model supported by the underlying system.

Computation Model

The computation model on which we discuss the implementation of a Gamma specification is a multi-process system, with processes dynamically created and deleted and interacting with one another. No assumption is made about the allocation of the processes on distributed nodes of the underlying computing network. That is to say that multiple processes can run on a single node or on distributed nodes. The hierarchy of the multi-processes is a tree structure, in which processes have full control over the creation/deletion of their descendent processes in the lower level, but not vice versa. A process can "lock/unlock" its activities. Locking means the freeze of all local computations and unlocking is the reverse operation. However, locking/unlocking does not apply to communications between the manipulated processes and other nodes. Communications among nodes are performed through communication channels which support unicast and multicast communications. However, these communication functions are process based instead of IP address based. That is to say, for example, multicast involves a set of processes instead of a set of nodes with distinct IP addresses.

Module Specification

We propose a language for specifying processes that run on an execution environment that supports the above computation model. Processes are specified by *modules* in the module language. A module is composed of a name, a parameter list used to take initial data when the process starts running, and a body block consisting of sequentially executed statements.

```
module name(parameter-list)
begin
        statement-sequence
end
```

First-class values are stored in a data pool named pool(*mid*), where mid is the name of the module. We leave the data structures of the data pool unspecified to maintain high-level abstraction. Their implementation is left to the stage of coding in a concrete programming language, which is subject to proprietary platform technologies. We do assume, however, that data items are addressed in the data pool so that we can locate particular data items and delete them.

Each module is associated with two multicast groups: sync(*mid*) and dist(*mid*). sync(*mid*) is the multicast group used to implement atomic captures of molecules. It involves synchronization using *syn* and *ack* messages, as described above. dist(*mid*) is the multicast group for distributing produced molecules. We use *mid* as an argument to identify the multicast group to which *mid* belongs, such as sync(*mid*) and dist(*mid*). We may use sync or dist along if there is no ambiguity. Note that both sync and dist can be either syntactically (statically) or semantically (dynamically) checked. The syntactic check is used in this paper. We will show how to do the syntactic check in Section 3.4.

Operations performed by a process include local operations, communications, and process control operations. There are four local operations that can be performed by a process:

- Add(data): add data into the pool
- Delete(data): delete data from pool
- Select(): select a set of element in pool that may match the pattern. The set of selected elements is returned by the function if the selection is successful, or **fail** otherwise.
- Release(): release the selected elements and return them to pool.

two communication operations:

- Send(type, sid, data): send a message. type can be syn, desyn, ack, or dis. Semantics of Send operation differs with different types. A syn/desyn message is sent to all processes in multicast group sync, while an ack message is unicast to the sender of the syn message identified by sid. In addition, data field of the ack message is empty. A dis message is sent to all processes in multicast group dist and sid is insignificant.
- Recv(type, sids, data): Probe the message queue, return the first message (through parameters type, sids, and data), or **fail** (through function return

value) otherwise. Recv() function can return data sent by multiple senders identified by ids, e.g., Recv(ack, sync,) checks whether the syn message has been acknowledged by all processes in sync.

and five process control operations:

- Create(id, arg1, arg2, …, argn): create a module with the given name and argument list. The argument list is used to pass initial data set to the created module.
- Delete(id): delete the module whose id is specified in the parameter and collect the resulting multiset in pool of module id and join it with the local pool. Also, add id into the local pool. If module id is not inert, Delete(id) does not have effect and return immediately.
- Inert(): This is an overloaded operation. The default version (no argument) freezes local activities in the local module if no more actions can occur, and return **true**, or **false** otherwise; while the version with a module id (Inert(id)) tests whether module id is inert. Inert() function does not affect communications between the module and other modules. In addition, once a module is inert, a message is sent automatically to the solution module in the immediate upper level. If Inert() is called by a solution module, it automatically checks whether there are still active modules in the lower level by checking the received messages. A solution module will not become inert until all lower level modules are inert.
- React(): resume local activities in the local module. Also, once a module is re-activated, a message is sent automatically to the solution module in the immediate upper level.
- Thread(abs, arg1, arg2, …, argn) : create a thread, which runs the program represented by the abs parameter. This feature is used to support mobile agents, codes sent by other modules and run on the environment of the module that receives it. The mobile agent is run as a thread so that it shares the data in the execution environment of the receiving module. The result of the thread, if any, can be retrieved by <abs>.

The body block of a module consists of a sequence of statements separated by ";". A statement is either a call to the one of above operations, a conditional statement, or a looping statement. The following is the BNF definition:

block ::= begin *statement-sequence* end

statement-sequence ::= *statement* ; *statement-sequence* | empty

statement ::= *operations* | *conditional* | *looping*

conditional ::= if *reactions* fi

reactions ::= *reaction* ; *reactions* | empty

reaction ::= *cond* -> *actions*

cond ::= *actions*, *bool-expression*

actions ::= *action* , *actions* | empty

action ::= *statement*

looping ::= do *reactions* od

bool-expression ::= … ; an expression returning either **true** or **false**

operations ::= … ; the operations described above

The conditional statement has the following semantics: conditions are tested and one of the statements whose corresponding conditions test to **true** is executed. If none of the conditions tests to **true**, the control falls through the if statement and continues to execute the statement that follows it. Its semantics of the looping statement is: in each iteration, conditions are tested and one of the statements whose corresponding conditions test to **true** is executed. This process is repeated until none of the conditions evaluates to **true**. This semantics of the conditional and looping statements is non-deterministic since no rule is set to govern how to select the statement to execute when multiple conditions are evaluated to **true**.

Note that even the module language is still a high level specification language, e.g., it leaves data structures and underlying communication mechanisms unspecified and has nondeterministic control structures, it is a language based on the realistic computation model. No higher-order operations exist in a program in the module language.

For example, the three modules designed for the producer-consumer problem are in the following. PC is the solution module, which creates the producer module (prod) and consumer module (cons). In this particular program, sync is empty because the patterns of prod and cons do not intersect. Dist(prod) = {cons} and Dist(cons) = Φ, which means that the produced molecules are sent from prod to cons but not vice versa.

```
module PC(M0)
begin
   Create(prod, M0); Create(cons);
   do
      !Inert() ->                    ; polling the status of both prod and cons
   od
   Delete(prod); Delete(cons)
end

module prod(N)
begin
   do
      x: M = Select() -> Thread(f, x), Delete(x), Send(dist, cons, <f>);
   od
end

module cons()
begin
   do
      x: N = Select() -> Thread(g, x), Delete(x);
   od
end
```

The modules designed for the nth element program follow.

```
module nth(M0 n)
begin
    Create(sigma, M0);
    do
       Inert(sigma) -> Delete(sigma), Create(extr, pool, n);
    od
    Delete(extr);
end

module sigma(M)
begin
    do
       {(a, i): M, (b, j): M} = Select() and i < j and a > b
-> Delete((a, i): M, (b, j): M)), Add((b, i): M, (a, j): M);
    od
end

module extr(M, n)
begin
    do
       {(a, i): M, n: Int} = Select() and i = n -> Delete((a, i): M, n: Int),
    Add(a);
    od
end
```

The above module specifications have artificial simplifications that make them different from the module specifications obtained in an automatic transformation (depicted in Section 3.4). For example, in a reaction, there should be a test whether the sync group is empty before replacing elements. If the sync group is not empty, a syn message must be sent and acknowledged before performing the replacement. Similarly, after the reaction, there should be a test to the dist group.

By removing higher-order operations in the module level, we make the specification of the system closer to actual program. Implementation of the program in the module language can be carried out fairly directly on a system that supports the computation model of the module language. Note that the implementation of

local computations is out of the scope of this paper. It is left to the phase when the use of concrete language and platform are determined. We will rely on software engineering technologies for finding an efficient implementation of local computations. For example, further refinement of the specification should include the use of data structures to organize the data sets and implement the Select operation by an algorithm designed in accordance with the data structure.

We refer the readers to (Lin, 2006) for case studies of the proposed method. (Lin, 2006) uses a higher-order Gamma formalism proposed by Le Metayer (1994). More current studies including case studies and applications in Gamma Calculus is being prepared for publication in the near future.

DISCUSSIONS AND CONCLUDING REMARKS

The chemical reaction models were proposed years ago to address high-level design issues of large distributed systems. Our work shows that it can be used to design multi-agent systems in a top-down fashion and benefits the design methodology with the reasoning capability of a formal system. While have shown that implementing such a system is feasible on a network computing environment, we would like to point out that our method can only be exerted to the module level, i.e., we can only derive the system to the specifications of module interfaces and operations. The implementation of individual modules will rely on conventional software engineering technologies. Further studies are needed to address the issues concerning module implementation and, perhaps, module abstraction, if we are to follow a "bottom-up" approach to design the multi-agent system, i.e., build the system on top of a set of existing functional units that coordinate over networks.

We present a method for implementing multi-agent system specifications in Gamma Calculus using a transformational style. Our existing work has demonstrated that Gamma Calculus, the newest formalism of the chemical reaction models, is suitable to describe high-level architectural properties of multi-agent systems and allows for systematic derivation and implementation of the systems. In this paper, we present a set of rules that can be used to derive the specified system into a module language, which is an intermediate language that do not include any higher-order operations as those in Gamma Calculus and is supported by most common networking execution environment. This study paves the way for implementing the specified system by using a sequence of program transformation and offers a new method for multi-agent system design.

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REFERENCES

Allen R., & Garlan, D. (1994). "Formalising architectural connection," Proc. of the IEEE 16th International Conference on Software Engineering, 71-80.

Banatre, J.-P., & Le Metayer, D. (1990). "The Gamma model and its discipline of programming," Science of Computer Programming, (15), 55-77.

Banatre J.-P., & Le Metayer, D. (1993). "Programming by multiset transformation," CACM, (36:1), 98-111.

Banatre, J.-P., & Le Metayer, D. (1996). "GAMMA and the chemical reaction model: Ten years after," In J-M. Andreoli, C. Hankin, and D. Le Metayer, editors, Coordination Programming: Mechanisms, Models and Semantics. Imperial College Press.

Banâtre, J.-P., Fradet, P., & Radenac, Y. (2004). "Chemical specification of autonomic systems," In Proc. of the 13th International Conference on Intelligent and Adaptive Systems and Software Engineering (IASSE'04).

Banâtre, J.-P., Fradet, P., & Radenac, Y. (2005a). "Principles of chemical programming," In S. Abdennadher and C. Ringeissen (eds.): Proc. of the 5th International Workshop on Rule-Based Programming (RULE'04), Vol. 124, ENTCS, 133-147.

Banâtre, J.-P., Fradet, P., & Radenac, Y. (2005b). "Higher-order Chemical Programming Style," In *Proceedings of Unconventional Programming Paradigms*, Springer-Verlag, LNCS, (3566), 84-98.

Creveuil, C. (1991). "Implementation of Gamma on the Connection Machine," Proc. Workshop on Research Directions in High-Level Parallel Programming Languages, Mont-Saint Michel, 1991, Springer-Verlag, LNCS 574, 219-230.

Garlan D., & Perry, D. (1995). Editor's Introduction, IEEE Trans. on Software Engineering, Special Issue on Software Architectures.

Gladitz, K., & Kuchen, H. (1996). "Shared memory implementation of the Gamma-operation," Journal of Symbolic Computation 21, 577-591.

Holzbacher, A.A. (1996). "A software environment for concurrent coordinated programming," Proc. of the 1st Int. Conf. on Coordination Models, Languages and Applications, Springer-Verlag, LNCS 1061, 249-266.

Inverardi, P., & Wolf, A. (1995). "Formal specification and analysis of software architectures using the chemical abstract machine model," IEEE Trans. on Software Engineering, (21:4), 373-386.

Kramer, J. (1990). "Configuration programming, A framework for the development of distributable systems," Proc. COMPEURO'90, IEEE, 374-384.

Le Metayer, D. (1994). "Higher-order multiset processing," DIMACS Series in Discrete Mathematics and Theoretical Computer Science, (18), 179-200.

Le Metayer, D. (1998). "**Describing software architecture styles using graph grammars**," IEEE Transactions on Software Engineering, (24:7), **521-533**.

Lin, H., Chen, G., & Wang, M. (1997). "Program transformation between Unity and Gamma," Neural, Parallel & Scientific Computations, (5:4), Dynamic Publishers, Atlanta, 511-534.

Lin, F.O., Lin, H., & Holt, P. (2003). "A method for implementing distributed learning environments," Proc. 2003 Information Resources Management Association International Conference, Philadelphia, Pennsylvania, USA, 484-487.

Lin, H. (2004). "A language for specifying agent systems in E-Learning environments," in: F.O. Lin (ed.), Designing Distributed Learning Environments with Intelligent Software Agents, 242-272.

Lin, H., & Yang, C. (2006). "Specifying Distributed Multi-Agent Systems in Chemical Reaction Metaphor," The International Journal of Artificial Intelligence, Neural Networks, and Complex Problem-Solving Technologies, Springer-Verlag, Vol. 24, No. 2, pp.155-168.

Yu, E. (2001). "Agent-oriented modelling: software versus the world," Agent-Oriented Software Engineering AOSE-2001 Workshop Proceedings, LNCS 2222, Springer Verlag, 206-225.

Implementing Process Improvement in Nine Software Organizations: A Case Study

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ABSTRACT

This paper describes the experience of implementing a CMMI-based software process improvement (SPI) project in a group of nine software organizations. We explain the approach we followed to design and implement the project, enumerate the main problems we encountered during its implementation, and mention the principal lessons learned and the critical success factors we think should be considered for this type of projects. Finally, the project's results are summarized and future work is outlined. The issues discussed in this paper may interest software organizations, company consortiums, governments, and international financial institutions interested in conducting SPI projects involving software organizations.

Keywords: software process improvement, process maturity assessment, CMMI.

1. INTRODUCCTION

Quality is one of the most important competitive factors of a global industry such as software development. To demonstrate quality software organizations must assess their processes using international standards or models, such as the Software Engineering Institute's Capability Maturity Model Integration (CMMI) (Chrissis M.B. et al., 2004).

In July 2005, we initiated a software process improvement (SPI) project in 9 small and medium size software companies with the objective of improving their competitiveness. We used the CMMI as our quality model and initially focused on the 7 process areas at maturity level 2 in the first 9-month phase of the project.

In general small software organizations the necessary knowledge, expertise, and resources required to implement software quality programs by themselves. Their cash flow and available human resources do not allow them to make the necessary investments in training, consulting services, and human resources needed to implement a long-term software quality improvement program good enough to achieve CMMI maturity level 3 or above (Paulk M., 1999, Jenkins M., 2004a, Jenkins M., 2004b). In our case, a collaborative project with shared costs among the 9 participating companies was the only viable mechanism to implement the project.

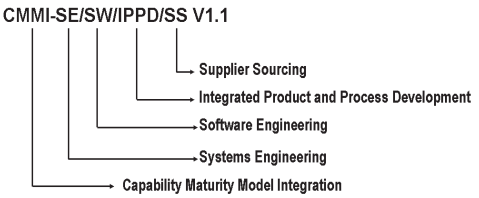
Eight of the nine participating companies in our project are small (less than 60 employees), with an average size of 40 employees. The ninth company is a medium size organization of 220 employees. All of them develop management information systems (mainly ERP´s) of different kind, costume-made web systems, and banking systems. Three of the nine organizations had an ISO 9000:2000 quality certification before starting this project (ISO, 2000), which gave them a leg up, and only three them currently export software to other countries.

2. BACKGROUND

2.1 The CMMI

The Capability Maturity Model Integration (CMMI) (Chrissis M.B. et al., 2004) is a software quality management model proposed by the Software Engineering Institute (SEI) as a guideline for software process improvement and capability determination. The CMMI is the result of merging 3 previous models: the software CMM, the System Engineering Capability Model (SECM), and the Integrated Product Development Capability Maturity Model (IPD-CMM).

The CMMI version 1.1 was published in 2003 and incorporates the following 4 disciplines altogether. Systems engineering and software engineering are the two core disciplines. Integrated product and process development and supplier sourcing are two additional sets of practices that can be incorporated by organizations that whish or must implement them.



Process areas (PA's) are the major building blocks in establishing the process capability of an organization. Each PA defines a set of specific goals that can be achieved by performing a collection of related practices. There are 25 process areas (PA's) in the CMMI-SE/SW/IPPD/SS that encompass more than 500 practices altogether.

The CMMI has two representations:

- The staged representation groups the PA's in 5 maturity levels. Each process area has been defined to reside at one the 5 maturity levels in the staged representation. To reach a given maturity level, the organization has to satisfy the goals associated with all the PA's at that level and below.
- In the continuous representation, the PA's are organized in 4 categories: project management, process management, engineering, and support. In a formal SCAMPI [6] appraisal, a capability level from 0 to 5 is assigned to each PA, thus defining the capability profile of the organization.

Figure 1 shows the CMMI staged and continuous representations. They both have the same 25 process areas, but organized differently. In our project we used the staged representation.

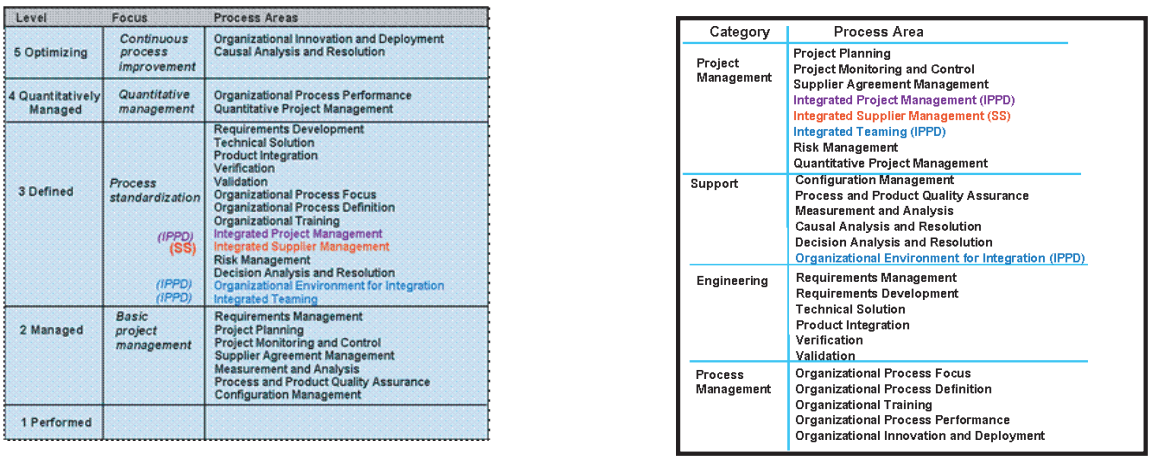
3. IMPLEMENTATION OF OUR PROJECT

3.1 The Project Tasks

The first phase of our improvement project was focused on the 7 process areas at CMMI level 2. During the 9-month period between July 2005 and April 2006 we performed the following tasks:

1. Basic CMMI training (3 days) for key personnel in the 9 companies.
2. CMMI level 2 implementation training (3 days) for key personnel in the 9 companies.
3. Conduct an initial assessment in each one of the 9 organizations
   - Perform the first SCAMPI type C assessment (SEI, 2001) of CMMI level 2 in each organization (1 day per company).

Figure 1. The CMMI staged representation (left) and continuous representation (right).



Level	Focus	Process Areas
5 Optimizing	*Continuous process improvement*	Organizational Innovation and Deployment Causal Analysis and Resolution
4 Quantitatively Managed	*Quantitative management*	Organizational Process Performance Quantitative Project Management
3 Defined	*Process standardization*	Requirements Development Technical Solution Product Integration Verification Validation Organizational Process Focus Organizational Process Definition Organizational Training (IPPD) Integrated Project Management (SS) Integrated Supplier Management Risk Management Decision Analysis and Resolution (IPPD) Organizational Environment for Integration (IPPD) Integrated Teaming
2 Managed	*Basic project management*	Requirements Management Project Planning Project Monitoring and Control Supplier Agreement Management Measurement and Analysis Process and Product Quality Assurance Configuration Management
1 Performed		

Category	Process Area
Project Management	Project Planning Project Monitoring and Control Supplier Agreement Management Integrated Project Management (IPPD) Integrated Supplier Management (SS) Integrated Teaming (IPPD) Risk Management Quantitative Project Management
Support	Configuration Management Process and Product Quality Assurance Measurement and Analysis Causal Analysis and Resolution Decision Analysis and Resolution Organizational Environment for Integration (IPPD)
Engineering	Requirements Management Requirements Development Technical Solution Product Integration Verification Validation
Process Management	Organizational Process Focus Organizational Process Definition Organizational Training Organizational Process Performance Organizational Innovation and Deployment

- Define a process improvement plan for each organization based on the assessment's results.

4. Each organization implemented its improvement plan for the next 5 months performing the following tasks:
   - Define the process architecture.
   - Document the organizational policies.
   - Define the software product templates for the main software work products.
   - Plan the definition and implementation of the organization's procedures.
   - Define the software metrics to be used in the software process.
   - Define the organizational procedures.
   - Implement the procedures and software metrics program.
5. Perform the second SCAMPI type C assessment of CMMI level 2 in each organization (1 day per company).
6. Close the gaps found in the second assessment (3 months).
7. Perform the third SCAMPI type C assessment of CMMI level 2 in each organization (1 day per company).
8. Report final results to Management in each organization.
9. Close this phase of the improvement project.

3.2 The Assessments

As part of our project we performed a total of 3 SCAMPI type C assessments in each one of the 9 organizations. They were aimed at verifying "coverage" of the organization's defined process with the goals and practices contained in the 7 process areas at CMMI level 2. The objective is to determine the existing gaps between the current process and the CMMI model just for internal process improvement. This assessment is a quick look at the state of the organization's process and does not verify implementation of that process in specific projects, a task that would require a SCAMPI type A or B assessment (SEI, 2001).

For documenting the assessments results, we defined a simple 3-level ranking system to determine the level of coverage of the organization's process for each one of the 7 process areas at CMMI level2. Each CMMI specific practice is compared against the practices in the organization's process and assigned a ranking value as follows:

1. Red: the practice is not covered at all. This has a value of 0.
2. Yellow: the practice is partially covered. This has value of 1.
3. Green: the practice is fully covered in the process definition. This has a value of 2.

This simple evaluation system allows us to quantify the level of coverage of a given process with respect to the CMMI level 2.

The percentage of coverage for each PA is calculated as a weighted average as follows:

$$\%\ \text{coverage PA} = \frac{(\#\text{red} * 0) + (\#\text{yellow} * 1) + (\#\text{green} * 2)}{\text{Total Number of PA practices} * 2} \times 100\%$$

The same formula is used to compute the coverage of the entire CMMI level 2, as follows:

$$\%\ \text{coverage PA} = \frac{(\#\text{red} * 0) + (\#\text{yellow} * 1) + (\#\text{green} * 2)}{\text{Total Number of CMMI level 2 practices} * 2} \times 100\%$$

Table 1 below shows a portion of the findings of an assessment at one of the organizations.

The first column specifies the CMMI-expected practices and sub-practices; the second column is to checkmark once the practice is verified. The third column lists all the documentation reviewed for the analysis, and the last column contains a justification of the evaluation and any additional observations, including opportunities for improvement. In this example, there are a total of 7 practices with 2 in red (0 points each), 1 in yellow (1 point each), and 4 in green (2 points each). Therefore, the coverage of this portion of PP is calculated as follows.

$$\%\ \text{coverage PP} = \frac{(2 * 0) + (1 * 1) + (4 * 2)}{7 * 2} \times 100\% = 64\%$$

4. THE PROJECT´S RESULTS

The improvement achieved by some of the organizations in documenting and implementing their processes was remarkable. Figure 2 shows the progress obtained by company X in each one of the 7 PA´s of the CMMI level 2 through out the 3 assessments.

Figure 3 shows the CMMI level 2 overall coverage of company X, one of the organizations that achieved the most progress. They started this project with a coverage of 17%, increased to 59% in the second assessment, and finished with 82% of CMMI level 2 covered.

Figure 4 shows the coverage of CMMI level 2 obtained by each organization at the end of this project. The straight line shows de average coverage for the 9 organizations at 67%. Five organizations were above average, one was at 54%, and the remaining three were lagging behind in the 30´s. The relatively slow progress achieved by these 3 organizations is due mainly to the lack of commitment from the organizations Management, lack of available resources to invest in the improvement project, and their inexperience in defining and implementing quality management systems.

Table 1. An example of the assessment of a group of project planning practices

Goals and Practices	Verifications		Notes
SG2 - A project plan is established and maintained as the basis for managing the project.	**Verified Yes No**	**Document Reference**	
SP2.1-1 Establish and maintain the project's budget and schedule.	X ☐	KJ:24 Task schedule KJ:25 Control Plan KJ:21 Software Development Plan Sales Management Procedure	The Schedule is created in Project 2003 based on a RUP template. The project's budget is manager using a standard Excel spreadsheet apart from the main plan. There is no documented procedure to create the project's budget.
1 Identify major milestones.	☐ ☐		
2 Identify schedule assumptions.	☐ ☐		
3 Identify constraints.	☐ ☐		
4 Identify task dependencies.	☐ ☐		
5 Define the budget and schedule.	☐ ☐		
6 Establish corrective action criteria.	☐ ☐		
SP2.2-1 Identify and analyze project risks.	X ☐	KJ-20 Risk list	There are three RUP templates to specify the project's risks.
1 Identify risks.	☐ ☐		
2 Document the risks.	☐ ☐		
3 Review and obtain agreement with relevant stakeholders on the completeness and correctness of the documented risks.	☐ ☐		
4 Revise the risks as appropriate.	☐ ☐		
SP2.3-1 Plan for the management of project data.	X ☐	None	The information of the projects is stored in carpets on the server. There are confidentiality letters signed with customers. The development plan defines the list of deliverables. There are no documented policies or procedures to manage the project´s information.
1 Establish requirements and procedures to ensure privacy and security of the data.	☐ ☐		
2 Establish a mechanism to archive data and to access archived data.	☐ ☐		
3 Determine the project data to be identified, collected, and distributed.	☐ ☐		
SP2.4-1 Plan for necessary resources to perform the project.	X ☐	KJ:24 Task schedule KJ:25 Control Plan KJ:21 Software Development Plan Outsourcing of technical resources Sales Management Procedure	The project's plan and Schedule include the required human resources. The other resources are specified in the bid to the customer.
1 Determine process requirements.	☐ ☐		
2 Determine staffing requirements.	☐ ☐		
3 Determine facilities, equipment, and component requirements.	☐ ☐		
SP2.5-1 Plan for knowledge and skills needed to perform the project.	X ☐	KJ:24 Task schedule KJ:25 Control Plan KJ:21 Software Development Plan LD-03 Description of roles and positions	The project's schedule includes all training activities. The project's plan defines the roles and responsibilities of the development team. Although there is an organizational training plan, the template for the project's development plan does not contain a section to plan the development of the skills needed to perform the project. The H.R. Department manages a skill matrix for all the team members. There is a documented description of the roles and positions in the organization.
1 Identify the knowledge and skills needed to perform the project.	☐ ☐		
2 Assess the knowledge and skills available.	☐ ☐		
3 Select mechanisms for providing needed knowledge and skills.	☐ ☐		
4 Incorporate selected mechanisms in the project plan.	☐ ☐		
SP2.6-1 Plan the involvement with identified stakeholders.	X ☐	KJ:24 Task schedule KJ:25 Control Plan KJ:21 Software Development Plan	The development plan includes the identification of all project stakeholders
SP2.7-1 Establish and maintain the overall project plan content.	X ☐	KJ:24 Task schedule KJ:25 Control Plan KJ:21 Software Development Plan LR-07 Repository location definition	A plan, schedule and proposal are documented. Each document is signed and approved. LR-07 Repository location definition defines the structure and location of the project's repository.

Figure 5 shows the average percentage of coverage of the 9 companies for each PA at CMMI level 2. Clearly the most difficult PA's to cover and the ones with the least progress are Measurement and Analysis (MA) and Process and Product Quality Assurance (PPQA), whose final average coverage was 51% y 47% respectively. Supplier Management agreement (SAM) was only evaluated in the third assessment for only 3 of the 9 organizations because the other 6 companies do not sub-contract projects.

5. CONCLUSIONS

The different organizations initiated this project at different levels of process maturity, commitment to the project, and process improvement experience. For example, three of them already had an ISO 9000:2000 certification when the project started, thus they already had experience documenting and deploying processes, so they were able to hit the road running. On the other hand, other companies had virtually no experience in process management, so for them it was extremely difficult to roll out the project.

The following are the main problems we faced during this project:

1. Lack of commitment from upper management.
2. Absence of a project manager and appropriate human resources for the SPI project.
3. Inexperience in designing and implementing software processes.
4. Some organizations went through a restructuring process that hampered the SPI project.

Figure 2. Progress made by company X in each of PA´s through out the project

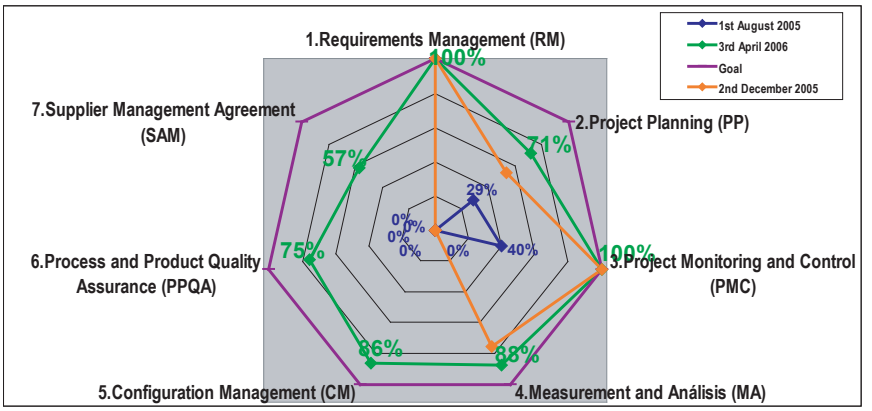
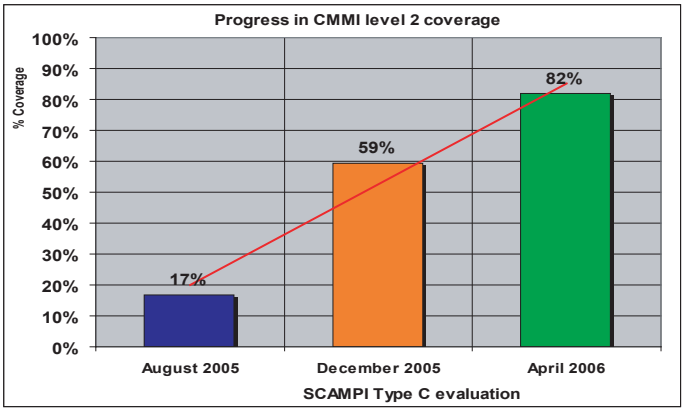


Figure 3. Overall progress made by company X through out the project



5. Change of organizational priorities due to market fluctuations or change of company's business model.

The organizations that achieved the greatest progress were those in which management was fully committed to the project, they designated a person directly responsible for it, and had previous experience with process management. Our experience shows that these are three of the most important success factors in SPI projects.

The three organizations with ISO 9000:2000 certifications had initial CMMI level 2 coverages of 23%, 66%, and 52% respectively. This demonstrates that in software organizations ISO 9000 quality systems generally do not cover most of CMMI level two's practices. On the other hand, organizations using commercial available processes such as Rational Unified Process (RUP) (Kroll P., Kruchten P., 2003) or Microsoft Solutions Framework (MSF), find it much easier and quicker to develop their CMMI-compliant processes. This is because RUP and MSF were specifically designed to cover CMMI levels 2 and 3.

This group of software organizations is now working in a second phase of this improvement project which will focus con CMMI level 3, but this time we are going to select only those that are really committed with the project and work with only 4 or 5 of them to assure a more uniform progress.

REFERENCES

Chrissis M.B. et al. (2004) *CMMI guidelines for process integration and product improvement*. Addison-Wesley.

ISO (2000). *International Standard ISO 9001*. ISO 2000.

Jenkins M. (2004a) Mejorando los Procesos de la Industria de Software en Costa Rica, *3ª Conferencia Iberoamericana en Sistemas, Cibernética e Informática (CISCI 2004),* Orlando, USA, pags. 141-145.

Jenkins M. (2004b) PRO-SOFTWARE: A Government-Industry-Academia Partnership that Worked, *17th IEEE Conference on Software Engineering Education & Training, 2004,* Norfolk, Virginia, USA, pags. 92-97.

Figure 4. Coverage of CMMI level 2 obtained for each organization at the last assessment

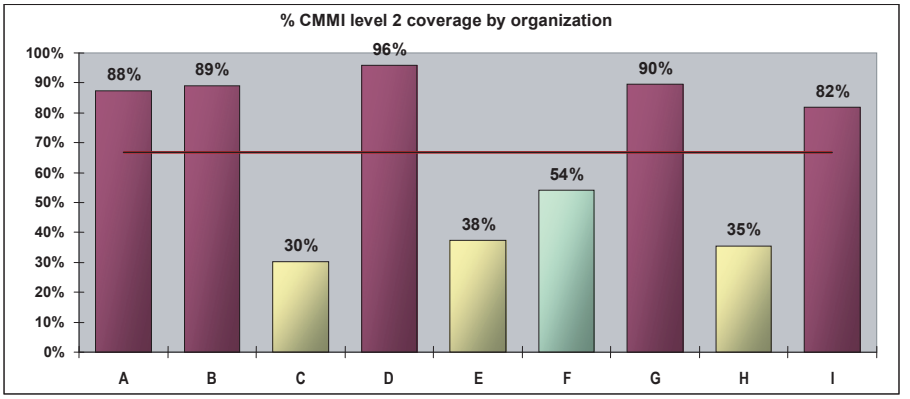
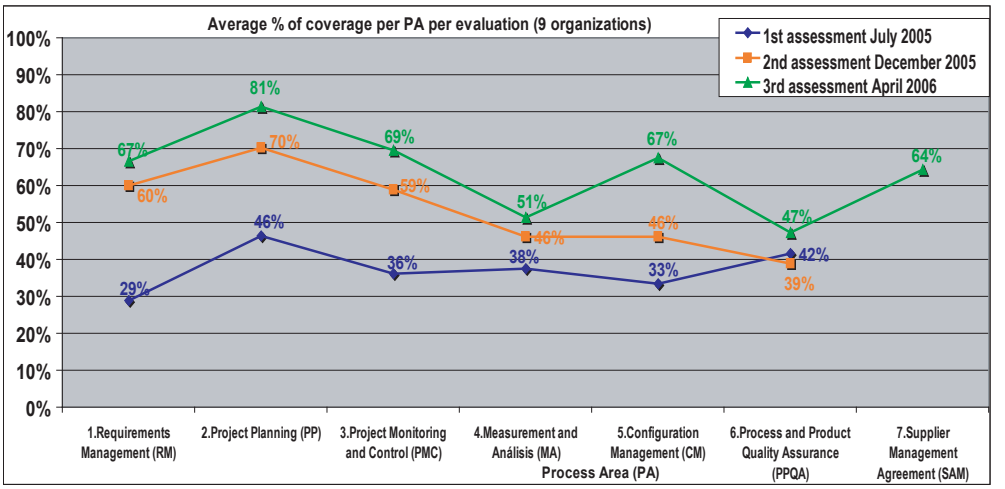


Figure 5. Average coverage of the 9 organizations for each PA at CMMI level 2



Kroll P., Kruchten P. (2003) *The Rational Unified Process Made Easy,* Addison Wesley.

Paulk M (1999). Using the Software CMM with Small projects and Small Organizations, in *Software Process Improvement: Concepts and Practices*. Eugene McGuire ed., Idea Group Publishing, pags. 76-92.

SEI (2001). *Standard CMMI method for process improvement (SCAMPI) version 1.1. CMU/SEI-2001-HB-001, Software Engineering Institute,* www.sei.cmu.edu.

Why Do Software Applications Fail and What Can Software Engineers Do About It? A Case Study

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ABSTRACT

In many of today's companies application software has become a vital resource to successfully run the business. Since outages of application software may lead to operational and financial difficulties, companies have a vested interest to ensure high availability of their application software. In this paper, data from Credit Suisse, a large commercial bank operating internationally is examined. As a first step, the main causes that led to outages are analyzed. The analysis shows that administration-related tasks are the largest cause for application software outages. On the other hand, the analysis reveals that outages due to hardware failure plays an almost negligible role. In a second step, selected approaches on how availability of applications can be improved are presented. One of the most important means to reduce outages in our case is to address availability not only with system and platform engineers, but with software engineers in particular, since their awareness concerning availability has proven to be limited. Based on that, a set of recommended practices to be addressed by software engineers has been developed; a subset of them are presented here.

1. INTRODUCTION

More and more companies, in particular in the service industry, rely substantially on application software. The product creation, sales and after-sales processes depend heavily on up-to-date application software. Not only do company employees depend on enterprise-owned application software intensively, but external stakeholders such as private and corporate clients, providers, vendors and contractors also depend on such applications. This also implies that in most companies the number of software applications has increased over the years. In addition to that we have to consider that companies today operate in different times zones as their partner and branches are geographically dispersed. This in turn means that time periods for maintenance work have become smaller over time. Furthermore, in the era of the Internet, expectations in terms of availability, timeliness and response time have increased. All of these aspects lead to higher, more ambitious requirements in terms of availability. In short, many of today's applications have to run in a 7 day by 24h mode, the number of outages must be minimal to non-existent, and the time period to repair failures must be shortened.

The rest of the paper is structured as follows: Section 2 shortly describes the company this paper is based on. Section 3 analyses the outages that occurred within the last reporting period and shows the main causes. Section 4 presents some possible approaches on how availability can be improved. Section 5 presents selected software engineering-related approaches the company has chosen to improve availability of its custom-built software. Finally, section 6 summarizes the main points and states the main conclusions.

2. COMPANY PROFILE AND IT INFRASTRUCTURE

The empirical data presented in this case study stem from Credit Suisse, a global bank, operating in over 50 countries and headquartered in Zurich. The two main lines of business are private/retail and investment banking. The company employs over 40,000 people worldwide. The main geographic areas of employment are Asia, USA, and Europe.

To support the many employees, clients, third parties and the underlying business processes, hundreds of applications are in place and running today. Most of the banking-related applications are built and supported by the company's own IT department. The internal IT department not only provides application development and maintenance, but also systems engineering activities such as configuration of servers, middleware, components and networks. All application software runs in the internal data centre.

The number of applications we are concerned about in this study numbers approximately 300. The size of the application software is quite remarkable as it sums up to more than 30 million lines of code. The programming languages used are mainly PL/1 and Java. Some of the COTS applications are based on C and other languages. The runtime platforms are Sun (Solaris) and IBM (z/OS).

3. OUTAGES OF APPLICATION SOFTWARE

In order to improve availability of application software it is essential to know current statistics. For example: how many outages occurred over a certain period of time? What were the causes?

To properly understand the numbers given in Table 1, the measurement approach applied at Credit Suisse is described below:

- Data sources used: To gather the outages during the last reporting period, three different data sources were used: (a) outages reported by users; (b) outages reported via robots (artificial users); (c) outages reported via systems management software (in our case, Tivoli Enterprise Console is used)
- In scope: main banking applications (approximately 300)
- Out of scope: (a) industry-neutral support applications such as Microsoft Outlook; (b) applications used by small number of people (<50).

How is an outage defined? In this paper, the terms *outage* and *unavailability* are used interchangeably. Application unavailability or application outage means – in accordance to IEEE (2002) – that an application is not accessible when it is required for use.[1] 'When required for use' implies two things, for each application it must be known (specified) when the application is required for use and, second, an outage of an application is handled as an outage only if the outage falls into the period of time the application should be available. To practice the first aspect, the SLA[2] levels are used. At Credit Suisse every application must belong to one of three SLA levels. The most demanding SLA level is called 7x24. It means that the application should be available at all times.[3] The second-highest SLA level requires that applications are available from 6am to 11 pm; the third (lowest) SLA level requires that applications are available from 6am to 7 pm. Outages of applications that do not fall into these required up-times are not considered here.

Table 1 shows that a total of 222 outages have been registered during the last reporting period. To identify the hot spots, these 222 outages have been grouped into five categories: administration, software, hardware, environment, and unknown causes. These categories have been used by Gray (1985), who published the well-known causes of failures of Tandem systems. The use of the same categories makes it possible to compare the results.

- **Administration**: 36 percent of outages were caused by administration-related activities. Within this category the main cause for outages lies in operations

Table 1: Reported outages at Credit Suisse and Tandem systems

	Case Study		Results from Gray (1985)
Cause	Number of outages	Percent of outages	Percent of outages
Administration	80	36%	42%
Software	72	32%	25%
Hardware	4	2%	18%
Environment	18	8%	14%
Unknown cause	48	22%	3%
Total	222	100%	103% [1]

and configuration activities. To give a better idea of what is meant by operations and configuration-related causes, some examples of causes – taken from the outage reports – are listed: (a) "Database administration runs a job which exclusively reserved a pointer checker"; (b) "Database xyz was not available because of database reorganization"; (c) "Database reload locked some DB2 tables"; (d) "Change of certificate was not accomplished properly"; (e) "Volume copy action blocks transactions"; (f) "Web server was suspended"; (g) "Role for database access was removed"; (h) "Database files were overwritten due to incorrect software distribution"; (i) "The power for the technology centre wrongly switched off by construction worker!". Another subcategory of administration was labeled "unsatisfactory monitoring". Through a more intensive, and real-time monitoring, some outages of application could have been prevented. "Low on disk space", "too high CPU load", "queues were full" are typical examples that led to outages of applications.

- **Software**: According to our outage reports, errors in software represent the second largest cause that led to unavailable applications. Out of the 72 software-related outages, 37 were caused by erroneous application software whereas most of this software was custom-built. 35 outages were caused by incorrect system software. The rather high 'contribution' of system software is surprising as this category of software runs in hundreds or thousands of companies. What are examples of application software-related causes leading to outages? A few examples are listed here: (a) "Data sharing caused deadlocks"; (b) "An order without an amount was processed. This caused the crash of the program"; (c) "Duplication of a row caused a SQL-811 error"; (d) "Transaction xyz fails due to deadlocks"; (e) "Functional error in application". As mentioned earlier, not only flaws in application software cause outages but also erroneous system software. To illustrate this point again, a few examples are given: (a) "Error in load balancer"; (b) "Deadlocks in DB2"; (c) "Bug in operating system"; (d) "Database block is not working"; (e) "Malfunction of router".
- **Hardware**: Hardware-related outages were very rare. On the one hand, hardware over the years has become more and more reliable. On the other hand, monitoring of hardware components has become more common. In the case of Credit Suisse, only four outages (2 percent) were caused by hardware. In one instance, a broken fan led to an outage of the server, in another case the memory of a server was defective, and in a third case the power supply accumulator was damaged.
- **Environment**: The term 'environment' is vague. It has however been used to make the results comparable to the ones published by Gray (1985). In the case of Credit Suisse outages in the category 'environment' are mostly related to communication problems with company-external systems. A few examples which illustrate this are: (a) "No connection between Reuters and Credit Suisse"; (b) "Wide area network broken"; (c) "Network switch lost connection"; (d) "Fibre channel has been damaged".
- **Unknown**: According to Table 1, some 48 cases (22 percent of all outages) were not able to have been categorized properly. In a considerable number of these cases, it was not possible to identify the root cause of the outage. Many of the so-called unknown causes are transient and could not be traced. Examples are: (a) Server was down; (b) Memory leak; (c) "Hanging process"; (d) "Application not responding".

When comparing the data gathered from Credit Suisse with those published by Gray (1985), some interesting parallels arise. Firstly, both studies identify administration-related work as the primary cause for outages (36 percent vs. 42 percent).[4] The second most important 'contributor' to outages is the category of the software. While 32 percent of the outages are caused by software, this category accounts for 25 percent in the study of Gray (1985). However, Gray does mention in his paper, that this category is probably under-reported.

According to Gray, hardware represents the third category of causes as they caused 18 percent of outages at Tandem systems. In the case of Credit Suisse, the numbers are quite different as hardware-related problems caused only 2 percent of the outages. More than twenty years ago Gray wrote: "In the future, hardware will be even more reliable due to better design, …" (1985, p. 12). Based on our empirical data he was absolutely right.

4. HOW TO IMPROVE AVAILABILITY?

Over the years a large number of approaches, methods, and techniques have been suggested to improve availability and reliability[5] of systems and software. It is *not* the aim of this paper to present the sheer endless pallet of instruments suggested by scholars and practitioners,[6] instead, the aim is to illustrate the *range* of possible approaches, with some (rather accidental) approaches being mentioned in this section.

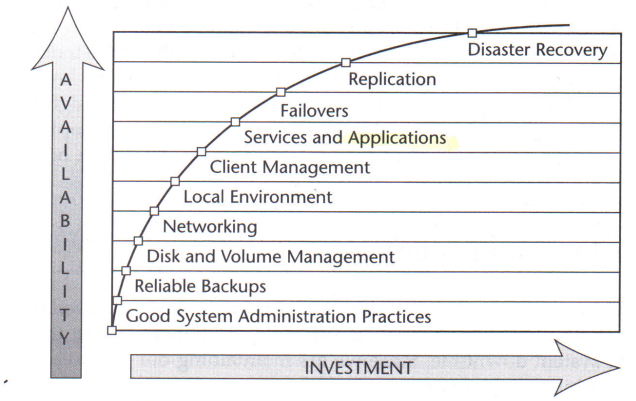
Probably the most commonly recommended approach is the use of *N-Version Programming (NVP)* described by Avižienis/Chen (1977). This approach implies that N-independent programs are executed in parallel on identical input, and the results are obtained by voting upon the outputs from individual programs. In order to ensure the development of independent program versions, different algorithms, programming languages, environments and tools must be used. Theoretical as well as empirical investigations indicate a positive effect of N-version programming (see Cai/Lyu/Vouk (2005)).

According to Viega/Voas (2000), aspect-oriented programming helps to improve availability and reliability as it offers powerful mechanisms for exception handling. Widmaier et al. (2000) propose the use of formal specifications. Green (1997) recommends to improve availability through the use of commercial off-the-shelf components. Candea/Fox (2001) emphasize the importance of recursively restartable systems as they make it possible to restart collections of components/subsystems with little or no advance warning.

By reading the various views that address availability and reliability engineering, one gets the impression that "you just have to do *this*" and everything will work properly. According to Meyer (1999) each community defines "this" differently. Meyer writes:

- *the management school*, which holds that all that really matters is better approaches in management;
- *the formal specification school*, which suggests we won't achieve anything unless we specify everything mathematically—and then we won't need testing at all;
- *the testing school*, which views formal specifications as an academic pastime and believes that the only meaningful solution is to devise systematic testing strategies;

Figure 1. Ten availability technologies (taken from Marcus/Stern, 2003, p.51)



- *the metrics school*, which focuses on assessing everything quantitatively;
- *the open source community*, which believe that only by extensive public scrutiny can we successfully develop reliable software".

The message put forward by Meyer is clear: Although the different communities claim to know what to do in order to improve availability there is no one best approach. Instead, problem and domain-specific approaches are more appropriate.

The richness of possible mechanisms to increase availability is well illustrated in the book by Marcus/Stern (2003); see Fig. 1. This model is conceptual in nature and does not attempt to graph particular levels of availability against specific amounts of investments. However, Marcus and Stern recommend to start with 'technologies' (to use their term) situated at the bottom and to gradually increase.

5. WHAT CAN SOFTWARE ENGINEERS DO TO IMPROVE AVAILABILITY?

As the previous section shows, there is no shortage of potential mechanisms and approaches to improve availability of application software. However, the mechanisms and techniques to be applied depend on various factors; e.g. on the causes that led to outages in the past, on the service or availability levels to be achieved, on the infrastructure in place, on the current software development processes, on awareness of software developers, etc.. Generally speaking, availability can be influenced by two groups of stakeholders, the *systems engineers* who provide the application platform the application runs on, and the *software engineers* who develop the application software; see Fig. 2. In this paper we discuss approaches to be applied be the software engineers.

To improve availability by means of software engineering we formulated twelve so-called 'recommended practices'. To give an idea how the issue is addressed at Credit Suisse some examples of recommended practices are presented here.

Two aspects have to be noted: (a) The recommended practices have not been deduced formally. They are based on both a gap analysis and best practices applied in selected areas. (b) The recommended practices are not universally valid. They fit to our environment.

A. Anticipate Outages of Subsystems and Components

Rationale: Applications are composed of subsystems and components. An outage of such a part should not lead to a full outage of the application. The impact to the user should be minimal.

Tasks for the Software Engineers:

- Ensure that an outage of a subsystem or a component (which are part of the application being built) has no or minimal impact on the use of the application.

Example: In an online-banking application for instance, an outage of the payments module should not impact the functions provided for brokerage.

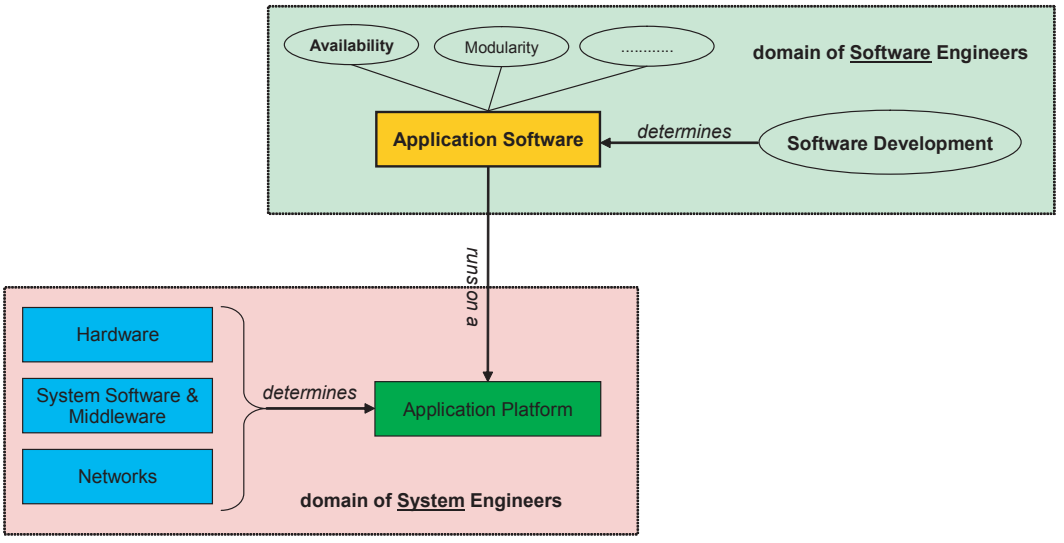
B. Minimize Exclusive Use of Shared Data in Terms of Scope and Time

Rationale: If large portions of a database are exclusively used by a single application, or if small portions of a database are locked for long periods of time, other applications are negatively impacted in terms of availability. Therefore the portion of data exclusively used by one application at a certain moment in time should be as small as possible.

Tasks for the Software Engineers:

- Minimize exclusive use of shared data in terms of scope and time.
- Keep the Logical Unit of Work[7] short.

Figure 2. Leveraging availability by system and software engineers



Example: An end of day batch job must not exclusively reserve tables of an online application.

C. Select Appropriate Processing Mode

Rationale: In terms of processing modes, there are two extremes: *real-time processing* (e.g. on-line transaction processing) and *batch processing* (e.g. end of day processing). In between there are two other options: *asynchronous processing* and *asynchronous processing plus latency*.

Synchronous processing (real-time processing) requires that all components involved are able to execute the requests immediately (i.e. in the same logical unit of work). This may in turn negatively impact availability and robustness of the applications being built. From an availability point of view, the synchronous processing mode should be implemented only when absolutely necessary; i.e. when immediate response and timeliness of data are critical.

Tasks for the Software Engineers:

- Use asynchronous processing as much as possible.

Example: To create a statistical report, synchronous processing is not required. From an availability point of view, asynchronous processing plus latency is more appropriate.

D. Test Behavior of Application when Selected Components and Interfaces are 'Switched Off'

Rationale: It must be guaranteed that mechanisms which have been implemented to treat unavailable or malfunctioning components/interfaces function as planned. Failures of one or several parts of a system must be observed. The planned utilization of imperfect parts (components, interfaces, etc.) is sometimes called "fault injection testing".

Tasks for the Software Engineers:

- Identify the application-*internal* and application-*external* availability-critical components and interfaces that may fail. Test the behavior (robustness) of the application by 'switching-off" (or not providing) selected components and interfaces.
- Specify the required test environment and test cases.

Example: When an online-banking application is to be tested, the interface providing the current exchange rates should be switched off in order to check whether the application's behavior is compliant to the design.

E. Build Applications that Require No Manual Administration

Rationale: Since human error is a leading cause of downtime, one important way to improve availability is to reduce the number of mistakes that humans (administrators) can make on critical systems. By making systems simpler you do just that. Simpler systems require less administrative attention, so there is less chance for human error which can lead to an outage of the application, see Marcus/Stern (2003), p. 103.

Tasks for the Software Engineers:

- Build applications that require no manual administration or intervention.
- If manual administration cannot be made obsolete, incorporate a mechanism that checks the outcome of tasks performed immediately. It must not be the case that an incorrect execution is detected with delay.
- Design all applications in such a way that they can be run in a 7x24h mode.

Example: If an application has been designed in such a way that a periodical reorganization of the database has to be initiated manually, then the principle mentioned above is not met.

6. CONCLUSIONS

The analysis of 222 outages of application software shows that (a) administration-related task are the largest cause of application software unavailability, (b) imperfect software (custom-built application software and system software) represents the second largest contributors, (c) environment-related causes 'occupy' the third place, and (d) outages of applications caused by defective hardware is very rare in the company considered.

As there is no best approach to improve availability, the various options have to be considered. They include *systems management-related approaches* such as disk and volume management and the use of redundant hardware as well as more *application software-related approaches*. In our case the focus has been put on the second category, since the potential to improve availability has been considered as being most effective in this area.

Where do we stand today at Credit Suisse? Twelve so-called recommended practices have been defined and communicated to software engineers. None of these recommended practices require additional infrastructure in order to be implemented. The enforcement of these practices takes place on the one hand via company-internal education. On the other hand, software engineers have to demonstrate just how the recommended practices have been applied in their software development projects. The initial feedback from software engineers has been quite positive. They now see the software development discipline broader than before (as many of them have not spent a lot of attention to availability issues in the past) and, not of lesser importance, the teamwork between system engineers and software engineers has become closer.

The primary conclusion is as follows: Every company who builds and uses application software to a larger extent should analyze the causes of outages carefully. Based on both the cause analysis and the mechanisms already in place, company-specific measures can be taken. If these two steps are omitted, inadequate or even useless actions might be implemented, which in turn, lead to unnecessary costs. Our impression is that the power of *system and hardware-related mechanisms* to improve availability is overestimated, while *software engineering-based approaches* are not adequately rated. One reason behind that behavior might be that some mechanisms addressing the first category can be bought, while the second category has to be addressed mainly via awareness, motivation, education, inspiration, and knowledge.

Finally, our literature research has revealed that the issue of availability of application software has not been intensively addressed up to now. In particular, software-engineering related approaches, to ensure high availability of large sets of applications, have been treated only fragmentarily. From our perspective, this in turn means that it would be fruitful for the software engineering community to further consider this topic in future research and teaching activities.

7. REFERENCES

Avižienis/Chen (1977). Avižienis, Algirdas; Chen, L.: On the Implementation of N-Version Programming for Software Fault Tolerance During Execution. *Proceedings of the Computer Software and Applications Conference, Annual International (COMPSAC'97)*, IEEE, pp. 149-155.

Candea/Fox (2001). Candea, George; Fox, Armando: Designing for High Availability and Measurability. *Proceedings of the 1st Workshop on Evaluating and Architecting System Dependability (EASY'01), IEEE.*

Cai/Lyu/Vouk (2005). Cai, Xia Cai; Lyu, Michael R. Lyu; Vouk, Mladen: An Experimental Evaluation on Reliability Features of N-Version Programming. *Proceedings of the 16th IEEE International Symposium on Software Reliability Engineering (ISRE'05),* pp. 161-170.

Gray (1985). Gray, Jim: *Why Do Computers Stop and What Can Be Done About It?* Tandem Computers, Technical Report 85.7, June 1985.

Green (1997). Green, Paul. The Art of Creating Reliable Software-based Systems using Off-the Shelf Software Components. *Proceedings of the 16th Symposium on Reliable Distributed Systems (SRDS'97),* IEEE, pp.118-120.

IEEE (2002). *IEEE Standard Glossary of Software Engineering Terminology*. Std 610.12-1990(R2002).

Lyu (1996). Lyu, Michael: *Handbook of Software Reliability Engineering*. IEEE Computer Society Press and McGraw-Hill, 1996.

Marcus/Stern (2003). Marcus, Van; Stern, Hal: *Blueprints for High Availability*. Wiley Publishing, Indianapolis, 2003.

Meyer (1999). Meyer, Bertrand: Every Little Bit Counts – Toward More Reliable Software. *IEEE Computer*, Vol. 32, Issue 11, Nov 1999, p. 131-135.

Oppenheimer et al. (2003). Oppenheimer, David; Ganapathi, Archana; Patterson, David: Why Do Internet Services Fail, and What Can Be Done About It? *Proceedings of the Usenix Symposium on Internet Technologies and Systems (USITS'03)*, pp. 1-16.

Viega/Voas (2000). Viega, John; Voas, Jeffrey: Can Aspect-Oriented Programming Lead to More Reliable Software? *IEEE Software*, Vol. 17, Issue 6, Nov/Dec 2000, pp. 19-21.

Widmaier/Smidts/Huang (2000). Widmaier, James; Smidts, Carol; Huang, Xin. Producing More Reliable Software – Mature Software Engineering Process vs. State-of-the-Art Technology? *Proceedings of the 22nd International Conference on Software Engineering (ICSE),* ACM Press, 2000, pp. 88-93.

ENDNOTE

[1] Availability is defined as follows: "The degree to which a system or component is operational and accessible when required for use." IEEE (2002).

[2] SLA stands for *S*ervice *L*evel *A*greement

[3] To be precise, even in a 7 by 24h operation mode short periods of time for maintenance work (e.g. deployment of new versions) are inevitable. These periods of unavailability depend on the type of software. E.g. for the software that controls the cash machines the interruptions should be below one minute.

[4] The relevance of administrator-related failures is further supported by the empirical study of Oppenheimer et al., (2003).

[5] "Reliability. The ability of a system or component to perform its required functions under stated conditions for a specified period of time." (IEEE, 2000).

[6] A good overview can be found in Lyu (1996)

[7] A logical unit of work is a set of transactions where either all are successfully applied against the database, or none have any impact on the database.

[8] This number (103%) has been taken from Gray (1985).

Reviewing 802.11 Wireless LANs Security: A Case Study Approach

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ABSTRACT
This paper proposes a set of technical and managerial solutions which can be adopted by organizations to protect their 802.11 wireless LANs. A case study methodology was carried out by selecting five individual cases, including two wireless vendor cases and three organizational user cases. The primary source of data was face-to-face interviews. Another portion of the data came from extensive secondary materials. Findings from the case study were integrated with the ones from the existing literature to shape the final conclusions and recommendations of this research.

Keywords: 802.11 Wireless LANs; security; guidelines; case study

1. INTRODUCTION
Compared with wired networks, wireless networks may be more vulnerable and easy to attack. In a wired network, an attacker must penetrate some physical security perimeter to gain network access. In a wireless environment, attackers can easily gain access to the wireless network without getting into the building. The broadcast nature of wireless networks also makes traditional link-layer attacks readily available to anyone (Arbaugh 2003). According to a survey conducted by Computer Weekly's InfoSecurity User Group (CWIUG), more than four companies in five are worried about the security of wireless mobile products and services (O'Halloran 2004).

This research aims to present a set of security solutions, from both the technical and managerial perspectives, which can be adopted by organizations to protect their 802.11 wireless LANs. The paper is organized as follows: the next section discusses the literature review. After that, the research method employed in this work is described. Thirdly, a case study analysis is carried out to further improve the research findings. Lastly, based on the findings from the literature review and the case studies, a set of operational guidelines is proposed.

2. LITERATURE REVIEW
The solutions to address different aspects of 802.11 wireless LANs security fall into two main categories: technical solutions and managerial solutions, which mainly concentrate on the theory and practice of sound security management processes.

2.1 Technical Solutions
2.1.1 Authentication and Encryption
Mishra & Arbaugh (2002) argued that, due to the broadcast nature of wireless LANs, strong access control must be a feature of the security solutions used to protect wireless LANs from various attacks. Mutual authentication should also be implemented because access points are untrusted. Moreover, they emphasized that strong confidentiality should be addressed and dynamic rekeying is needed as an inherent part of the design. Williams (2004) also stated that authentication and encryption are the basic requirements of wireless LANs security.

2.1.2 Detection
Several authors (Karygiannis and Owens 2003; Rittinghouse and Ransome 2004) believe that if organizations require high levels of security, they should implement an Intrusion Detection System (IDS) because it provides an added layer of wireless LANs security. Rittinghouse & Ransome (2004) also pointed out that, network design, projected transactional load, the depth of security policy desired, the real and future costs, implementation, and management overhead are critical factors that should be considered when organizations configure a wireless IDS security product. Other authors (Gast 2004; Solms and Marais 2004; Williams 2004) highlight that organizations need to have a solution in place to combat rogue access points, which is a serious problem with 802.11 wireless LANs.

2.1.3 Additional technical enhancements
Researchers (Wong 2003; Mateti 2004; Rittinghouse and Ransome 2004) have argued that wireless LANs security can be enhanced by using firewalls, antivirus software and application layer security technologies such as Secure Shell (SSH) and Kerberos. They also suggest installing personal firewall and antivirus software on each client.

2.1.4 Segmentation between the Wireless LAN and the Wired LAN
Rittinghouse (2004) pointed out that, in order to reduce the chances of the wired network being attacked via a wireless LAN, organizations need to separate wireless LANs from the wired network using segmentation devices, such as routers, layer 3 switches, VPN concentrators, firewalls, enterprise encryption gateways and enterprise wireless gateways.

2.2 Managerial Solutions
Current research suggests that wireless security is not solely a technical issue. "There is also a human element that must be addressed by appropriate employee awareness of the issues, user education, and a clear statement of acceptable organization policies, procedures, and practices by management" (Pike 2002, p.2). As pointed out by Potter (2004), relying on technology itself can't solve the problems created by wireless security. "Without users, a secure wireless network is simply an expensive atmospheric heater" (Potter 2004, p.5). Therefore, Karygiannis & Owens (2003, p.ES-3) commented, "security management practices and controls are especially critical to maintaining and operating a secure wireless network".

In summary, current research suggested seven categories of management practices for deploying and maintaining a secure wireless LAN. These practices include:

- Control wireless LANs coverage area and reduce RF leaking
- Management of access points, including proper configuration of access points, controlling reset functions, access points inventory and proper placement of access points.
- Establish security policies
- Regularly check patches and upgrades
- Regularly conduct security audits
- Provide user education
- Control physical security regarding wireless network facilities

2.2.1 Control Wireless LANs Coverage Area and Reduce RF Leaking
A number of researchers (Hassick 2002; Maxim and Pollino 2002) argued that, the chances of attacks resulting from the broadcasting nature of the wireless networks can be reduced by controlling the coverage area and reducing RF leakings. These measures can be accomplished by using site surveys, appropriate access point placement and RF containment.

Generally, a site survey involves evaluating the building, including surrounding areas and the obstacles that need to be overcome. Outer and inner wall construction, window treatments and window glass material must all be identified and considered. Access points and roaming wireless clients should also be used to decide the network coverage with optimal performance and security. (Maxim and Pollino 2002). The objective of RF containment is to limit the scope of the wireless networks within the known boundaries. Although coverage control provides certain level of security, it is not an absolute solution. Karygiannis & Owens (2003) argued that attackers still can use high-gain antennas to eavesdrop on the wireless network traffic.

2.2.2 Management of Access Points

Proper Configuration of Access Points

Many authors (Karygiannis and Owens 2003; Wong 2003; Mateti 2004; Rittinghouse and Ransome 2004) suggested that the default settings of an access point should be changed before its deployment. They also described some guidelines on access point configuration:

- Update the default administrator password
- Use the MAC access control list function
- Change the default SSID
- Change the default shared keys
- Establish proper encryption settings
- Change SNMP parameters
- Change default Channels
- Disable DHCP and use static IPs if feasible. If using a static IP is not feasible and offers little value, two solutions can be adopted by organizations. One solution is to implement a DHCP server behind the wired network's firewall, which grants access to a wireless network located outside of the wired network's firewall. Another solution is to use access points with an integrated firewall, moving authentication and access control to the link layer

Rittinghouse & Ransome (2004) suggested using a local serial port interface to configure the access points in order to minimize the exposure of sensitive management. They also suggested enabling a user authentication mechanism for the management interfaces of the access points.

Control the Reset Functions

A reset function may return the access point to its default settings. If an access point is placed in an insecure place and the attacker has gained physical access to the access point, he/she may reset the access point and cancel all the security settings. Therefore several researchers (Karygiannis and Owens 2003; Rittinghouse and Ransome 2004) suggested that the reset functions should be used only when needed and should be only invoked by an authorized group of people.

Access Point Inventory

Williams (2002) suggests that organizations keep the access point infrastructure current by tracking the locations of all access points and recording the configuration of all access points to ensure each access point follows corporate standards and uses the latest software patches and firmware upgrades.

2.2.3 Establish Security Policies

Several authors (Maxim and Pollino 2002; Karygiannis and Owens 2003; Potter 2003; Regan 2003; Rittinghouse and Ransome 2004) made the point that security policies are a critical and essential part of wireless security and they should cover the following areas:

- Issues of wireless devices
- Wireless users configuration and activity
- Link level security
- Network and application level security
- Level of security protection
- Patches upgrade
- Offsite use of wireless devices
- Security audit

2.2.4 Regularly Check Patches and Upgrades

A number of researchers (Karygiannis and Owens 2003; Wong 2003) suggested that network administrators need to check with the vendor the availability of security patches and upgrades regularly, and apply them as needed.

2.2.5 Regularly Conduct Security Audits

Karygiannis & Owens (2003) argued that security audits are essential tools for organizations to check the security of a wireless network and determine corrective action to make sure it remains secure. They argued that the security assessment approach should be holistic and two methods can be adopted by organizations to perform security audits:

- Use wireless network analyzers and other tools, such as ***Netstumbler***, to check whether access points transmit data correctly and operate on the correct channels.
- Conduct third party audits. Organizations providing audit services are usually more up-to-date on security vulnerabilities, better trained on security solutions, and well equipped to assess the security of a wireless LAN.

2.2.6 Provide User Education

Keenan (2004) argued that every organization deploying a wireless LAN needs to develop a serious user training program to assure that users understand they each have a personal responsibility to keep their wireless network safe from intrusion. In addition, the user training should not only let users know about security protocols and how to follow them, but also let them know why these protocols exist. He also stated that, although wireless security protocols are set by the IT department, education and enforcement are best implemented by the Human Resources department. Karygiannis & Owens (2003) held a similar opinion on the importance of training users and making them aware of wireless risks. Moreover, they pointed out that network administrators also need to be fully aware of the security risks associated with wireless LANs. The administrators must work to ensure security policy compliance and to know what steps they need to take if an attack occurs.

2.2.7 Control Physical Security

Karygiannis & Owens (2003) argued that physical security is the most fundamental step to ensure that only authorized users have access to wireless network facilities. Two measures can be adopted by organizations to ensure physical security of the wireless network facilities:

- Conduct physical access control, such as photo identification, card badge readers or biometric devices, to minimize the risk of improper penetration of wireless network facilities.
- Deploy external boundary protection, including locking doors and installing video cameras around the perimeter to discourage unauthorized access to wireless network facilities such as access points.

3. RESEARCH METHOD

Multiple-case design is chosen instead of single-case because the evidence from multiple cases is often considered as "being more compelling and the overall study is therefore regarded as more robust" (Yin 1994, p.45).

Two cases were selected from wireless vendors and three organizational user cases were respectively selected from the education sector and the commercial sector. These cases include:

- ***Vendor A***: a leading wireless infrastructure provider. Its main wireless products include access points, wireless bridges, wireless security servers and intrusion detection systems.
- ***Vendor B***: a leading wireless management system provider. Its main wireless products include wireless gateways and wireless intrusion detection systems.
- ***User C***: a New Zealand secondary school
- ***User D***: an international real estate company
- ***User E***: a New Zealand university

Two data collection techniques are adopted: interviews and documentation. Six face-to-face interviews were conducted with IT directors, network administrators

and security consultants coming from vendors and users. All the interviews were audio-taped. When interviewing the vendors, two main topics were discussed:

- Technical products they provide or security technologies they recommend to protect 802.11 wireless LANs .
- Network management practices they perceive to be the must-use practices for organizations.

When interviewing the users, three main topics were covered:

- Motivation for deploying their wireless LANs
- Perception of the main risks associated with their wireless LANs
- Technical and managerial solutions they have adopted to secure their wireless LANs

4. ANALYSIS OF THE CASE STUDY FINDINGS

This section contains a summary description of the five cases. A detailed description can be found in [eliminated for blind peer-review].

4.1 Technical Solutions

As revealed in the case studies, all the technical solutions compiled from the literature review are either provided by the vendors in their wireless products or adopted by the organizational users. The case study also revealed some findings which were not discussed in the literature.

4.1.1 Finding 1: Evaluation of Technical Solutions

As discovered in the case study, both the vendors and organizational users agree on the following issues which need to be considered to evaluate the technical solutions:

- Network infrastructure and security requirements
- Interoperability of the different technical solutions
- Secure roaming across the subnets
- Administration burden
- Ease of use
- Transparency to the users
- Cost

4.1.2 Finding 2: Current Authentication and Encryption Technologies in the Industry

With regards to the technologies that provide authentication and encryption, the two vendors pointed out that SSID, MAC access control lists and WEP are not sufficient for enterprise-level security, because a MAC address is easy to forge and WEP has many fatal flaws. The two vendors suggested that organizations use 802.1x/EAP+TKIP (or AES) or IPsec VPN to provide strong authentication and encryption. As revealed in the case studies, three users are currently using these two technologies. Moreover, the case studies revealed that 802.1x/EAP+TKIP (or AES) can be used when an organization wants both reasonable assurance of confidentiality and a transparent user security experience, while IPsec can be chosen when organizations have utmost concern for the sensitivity of the transported data.

Furthermore, guidelines are suggested by the wireless vendors for choosing the authentication and encryption technologies. Firstly, it is recommended that the authentication should be user-specific not device-specific. Ideally, strong authentication should be tied to the use of multiple factors of information, including something you know (a password), something you have (a hardware token card, a digital certificate) and something you are (biometrics). Secondly, it is recommended that, when evaluating encryption technologies, organizations need to consider ease of use, administration load, CPU/battery load and support for mobility across subnets.

4.1.3 Finding 3: Current Intrusion Detection Technologies in the Industry

As revealed in the case studies, intrusion detection systems and rogue access point detection are already available in current wireless products. Intrusion detection is built into Vendor B's wireless gateway. Vendor A's access point is also capable of detecting rogue access points. Moreover, current wireless products also provide the capability of detecting unassociated clients, ad-hoc networks and interference. Except the detection functions provided by Vendor A and Vendor B, the three organizational users also rely on a third party product. User C utilizes *AirMagnet*, User D relies on *Snort*, and User E uses *Argus*.

Furthermore, it is identified from the case studies that traditional ways of detecting intrusions which are used in wired networks could also be utilized in the wireless environment. For example, in the case of User D, they rely on some traditional ways, such as monitoring log files, to detect wireless intrusions.

4.1.4 Finding 4: Bandwidth Management

As revealed in the case studies, bandwidth management is suggested by Vendor B as one component of the wireless security solution. This solution is available in Vendor B's wireless gateways, enabling network administrator to assign a maximum bandwidth to each user. Two organizational users, User C and D are also running bandwidth management tools to carry out bandwidth management, such as bandwidth differentiation based on the roles of the users.

4.1.5 Finding 5: Authorization

Authorization is another new component of the solutions, which is discovered in the case studies. As a wireless management system provider, Vendor B points out that organizations need to differentiate access to network resources based on each user's role. Therefore, Vendor B has developed role-based access control to provide the correct level of access for each user.

4.2 Managerial Solutions

The solutions found in the literature review suggest seven management practices for organizations to deploy and maintain a secure wireless LAN. Furthermore, the cases studies indicated that the technical solutions and managerial solutions should not be separated from each other. Technologies can assist in some management practices, such as management of access points and security audits. There are plenty of tools available in the market for assisting in the inventory of access points. For example, Vendor A's wireless management solution offers the functions of displaying the location and configuration of each access point. All the three organizational users also use Vendor A's wireless management solution to control the access point reset function.

5. FORMULATION OF THE GUIDELINES

Based on the information gathered from the literature review and the case studies, a set of operational guidelines are proposed to assist organizations in protecting their 802.11 wireless LANs. The proposed guidelines are divided into two parts: technical and managerial.

5.1 Technical Guidelines

Guideline 1: Choose the technical solutions that are suitable for your network infrastructure and security requirements. When evaluating technical solutions, you need to consider interoperability, administration burden, ease of use, transparency to the users, secure roaming across the subnets and cost.

Guideline 2: Have an authentication and encryption solution in place.

- The authentication solution should be user-based, not device-based. Consider deploying authentication that is tied to multiple factors of information, i.e. something you know (username/password), something you have (digital certificate) and something you are (biometrics). Consider user-friendliness when choosing the authentication solution, for instance, the authentication process needs to avoid multiple user steps.
- When evaluating the encryption solution, consider ease of use, administration burden, CPU battery load and support for mobility across the subnets.
- Recommend two solutions: 802.1x/EAP+TKIP (or AES) and IPsec. 802.1x/EAP can be adopted when you want both reasonable assurance of confidentiality and transparent user security experience. IPsec can be adopted when you have utmost concern for the sensitivity of the transported data.

Guideline 3: Have an intrusion detection solution in place. The solution is at least capable of detecting general network intrusions, rogue access points, unassociated clients, ad-hoc networks and interferences.

Guideline 4: Have a solution in place to manage the bandwidth.
- Bandwidth differentiation based on the roles of the users.
- Monitor bandwidth usage of each user.
- Block unneeded applications, such as video.

Guideline 5: Have a solution in place to enable differentiating users' access to your network resources.

Guideline 6: Have a worm-protection solution in place. Install antivirus software on each wireless client if it is feasible. If not, have a solution in place to detect the virus and prevent the virus-infected client from accessing the wireless LAN.

Guideline 7: Separate your wireless LAN from your wired network by using segmentation devices, such as routers, layer 3 switches, VPN concentrators, firewalls, enterprise encryption gateways and wireless gateways.

5.2 Managerial Guidelines

Guideline 1: Control the coverage of your wireless LAN and reduce the leaking of radio frequencies. For doing this, you can adopt the following three approaches:

Approach 1: Conduct a site survey

Approach 2: Place the access points strategically to reduce the radio frequency leakage and focus the majority of the coverage within the building.

Approach 3: Implement radio frequency containment. This can be achieved by:
- Minimizing the transmission power of the access points.
- Modifying the building by installing metallic film or foil under the drywall, applying metallic paint to walls to add layer of attenuation and using metallic window blinds to provide better attenuation.

Guideline 2: Change the default settings of the access points and configure the access points properly. The followings are some guidelines:
- Disable any insecure and nonessential settings.
- Update the default administrator password. Recommend implementing strong passwords with both alphanumeric and special characters and a minimum password length of eight characters. In addition, passwords should be changed regularly.
- Change default SSID.
- Choose strong community strings for SNMP and change them often. Consider using ***SNMP Read Only*** if the management infrastructure allows it.
- Ensure the access points have at least three channels different from any other nearby wireless networks to prevent interference.
- Utilize secure management protocols, such as SSH for web and SSL for telnet, to configure the access points.
- Limit management traffic to a dedicated wired subnet.
- Isolate management traffic from user traffic and encrypt all management traffic where possible.

Guideline 3: Control the reset function of the access points.
- Make sure that only an authorized group of people can reset the access points.
- Have a solution in place that allows the reset access points to restore themselves to the latest security settings.

Guideline 4: Track the locations of all the access points and record the configuration of all the access points to ensure each access point follows the security standards and uses the latest patches. Recommend using vendor-specific tools to do this.

Guideline 5: Establish security policies regarding wireless security. The security policies need to be expressed in a way that everyone can easily understand. Moreover, the security policies are recommended to address the following issues:
- **Wireless users**: Identify who may use the wireless LAN in the organization and specify the acceptable and unacceptable behavior of the wireless users.
- **Wireless communications**: Identify what type of information may be sent over the wireless network and define the security level of the information.
- **Use of wireless devices**: Specify who is authorized to install wireless equipments, such as the access points, the acceptable and unacceptable offsite use of the corporate wireless devices, and the procedures on reporting losses of the wireless devices and security incidents.
- **Network configuration**: Define standard security configurations of network devices, such as access points. Provide guidelines on the use of encryption and other security technologies.
- **Security management**: Define procedures of network security management, including virus control, password management, security upgrades and security audit.

Guideline 6: Regularly check the security patches and only apply the ***needed*** ones. Make sure that the antivirus software has the latest virus definition.

Guideline 7: Conduct a security audit regularly. You may choose the following two approaches to do this:

Approach 1: Use public tools (such as ***NetStumbler***) or vendor-specific tools (such as ***AirMagnet***) to check if access points are transmitting correctly and are deployed on the correct/authorized channel and to check for rogue access points and other unauthorized access.

Approach 2: Ask professional companies to conduct a security audit of your wireless LAN. Usually these companies provide audit services that are more up-to-date on security vulnerabilities than most organisation's IT departments.

Guideline 8: Provide user training for those who operate and manage your wireless LAN. The training at least covers the following areas:
- Make sure the relevant people understand that they have personal responsibility to keep the wireless LAN safe from intrusion.
- Let the relevant people know about the risks associated with the wireless LAN.
- Let the relevant people know about security protocols, why these protocols exist, and how to follow them.

Guideline 9: Cultivate good communication between your IT staff and end users. Encourage the users to consult IT staff if they are uncertain about some computer or network operations.

Guideline 10: Protect your wireless network facilities physically, especially the access points.
- Conduct physical access controls, such as using security cards, to minimize the risk of improper penetration of wireless network facilities.
- Install access points out of the normal reach of people. If possible, conceal the access points from sight.
- Deploy external boundary protection, including locking doors and installing video cameras around the perimeter to discourage unauthorized access to wireless network facilities, such as access points.

6. CONCLUSIONS AND LIMITATIONS

As revealed in this research, 802.11 wireless LANs security must be achieved by the integration of security technologies and good management practices. On one hand, technologies can secure the wireless LANs only when they meet the organizational security requirements, are applied to an appropriate network environment, and are implemented properly. This is actually associated with an organization's security management practices. On the other hand, technologies can assist in good security management practices. With the help of the adequate technology it is easy to carry out good management practices.

This research has three main limitations. Firstly, the findings are only applicable to 802.11 wireless LANs, not to the other types of wireless networks. Secondly, the findings are only suitable for organizational users, not for home users. Finally, the technical solutions proposed in this research do not consider the issue of network performance, which is also an important factor that organizations need to consider when evaluating the possible technical solutions.

REFERENCES

Arbaugh, W. A. (2003). "Wireless security is different." *Computer* 36(8): 99-101.

Benbasat, I., D. K. Goldstein, et al. (1987). "The case research strategy in studies of Information Systems." *MIS Quarterly* 11(3): 369-385.

Cai, Y. (2005). *How to secure your 802.11 wireless LAN.* MCom Thesis, Department of Information Systems and Operations Management, University of Auckland, Auckland, New Zealand,

Gast, M. (2004). The top seven security problems of 802.11 wireless. Retrieved 9 December, 2004, from http://www.airmagnet.com/bitpipe/assets/AirMagnet.Security.WhitePaper25.pdf.

Hassick, B. (2002). "Simple wireless exposures in traditional networks." *Secure business quarterly* 2(1): 2-5.

Karygiannis, T. and L. Owens (2003). Wireless network security 802.11, Bluetooth and handheld devices. Retrieved 09 Nov, 2004, from http://www.netsys.com/library/papers/draft-sp800-48.pdf.

Keenan, K. (2004). What hackers don't want you to know about your WLAN. Retrieved 9 December, 2004, from http://www.airmagnet.com/bitpipe/assets/WLAN_Hacker_White_Paper.pdf.

Mateti, P. (2004). Hacking techniques in wireless networks. Retrieved 5 January, 2005, from http://www.cs.wright.edu/~pmateti/InternetSecurity/Lectures/WirelessHacks/Mateti-WirelessHacks.htm#_Toc77524648.

Maxim, M. and D. Pollino (2002). *Wireless security*. Berkeley, Calif. ; London, McGraw-Hill/Osborne.

Mishra, A. and W. Arbaugh (2002). An initial security analysis of the IEEE 802.1X standard. Retrieved 4 February, 2005, from http://www.cs.umd.edu/~waa/pubs/1x.pdf.

O'Halloran, J. (2004). "Fashion sharpens wireless risk." *Network Security* 2004(8): 2.

Pike, J. (2002). *Cisco network security*. Upper Saddle River, N.J. ; London, Prentice Hall PTR.

Potter, B. (2003). "Wireless security policies." *Network Security* 2003(10): 10-12.

Potter, B. (2004). "Fixing wireless security." *Network Security* 2004(6): 4-5.

Regan, K. (2003). "Wireless LAN Security: Things You Should Know about WLAN Security." *Network Security* 2003(1): 7-9.

Rittinghouse, J. W. and J. F. Ransome (2004). *Wireless operational security*. Burlington, MA, Digital Press.

Solms, v. B. and E. Marais (2004). "From secure wired networks to secure wireless networks - what are the extra risks?" *Computers & Security* 23(8): 633-637.

Walsham, G. (1995). "Interpretive case studies in IS research, nature and method." *European Journal of Information Systems* 4(2): 74-81.

Williams, A. (2004). WLAN security best practices. Retrieved 9 December, 2004, from http://www.airmagnet.com/bitpipe/assets/WLAN_Security_Best_Practices.pdf.

Williams, J. (2002). "Providing for wireless LAN security. 2." *IT Professional* 4(6): 48, 44-47.

Wong, J. (2003). Performance investigation of secure 802.11 wireless LANs: raising the security bar to which level? Retrieved 5th August, 2004, from www.cosc.canterbury.ac.nz/research/reports/MastTheses/2003/mast_0301.pdf.

Yin, R. K. (1994). *Case study research : design and methods*. Thousand Oaks, Sage Publications.

Saving Endangered Species: The Application of Computer-Based Radio Coverage Modelling to Wildlife Telemetry Systems

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ABSTRACT

The research described in this paper is aimed at improving wildlife telemetry systems by the use of computer-based radio frequency (RF) visualization and planning, and enhancing RF coverage by adoption of improved techniques and tactics. The use of a computer-based modelling application has proved to be of benefit in the area of visualisation and planning. Use of this tool and other work in this area has led to the identification of opportunities to improve field practice, including staff training in RF techniques and tactics, selection of optimum receiver sites, improved receive antenna systems, and better planning for airborne monitoring and tracking.

Keywords: Information systems, information systems applications, wildlife telemetry

INTRODUCTION

Kiwi – a New Zealand national icon – is one of several endangered species subject to national conservation and recovery programmes. This paper describes research conducted for the kiwi recovery program of the NZ Department of Conservation (DOC) (Bank of NZ, 2005). During 2004, the author spent some time working as a volunteer with DOC staff at the Moehau[1] kiwi sanctuary, mainly assisting in the location of kiwi to enable the annual change of telemetry transmitter, undertaken because of limited battery life. This process is normally undertaken in the May-June period each year.

While engaged in this work, two issues became apparent. Firstly, the terrain of the Moehau area is very rugged: the northern part of the Coromandel Peninsula is only about 10 km wide, and the main mountain range rises to a height of nearly 1000m. Most of the area is clad with dense primary bush or secondary-growth scrub. The terrain means that vehicle movement is mainly restricted to one road around the coast, foot movement is difficult and radio coverage, which is in the very high frequency (VHF) band (30-300 Mhz) and limited to radio line-of-sight, is also problematical.

Secondly, the majority of work involving monitoring and tracking of birds utilizing telemetry involves long periods of time in the field for relatively few detections. (For example, in one day that the author was out with a DOC team, only one bird was located, and that was found by a trained kiwi dog, rather than using the telemetry system.) Although monitoring and tracking by aircraft is possible (and actually undertaken once or twice a year) the cost makes regular use prohibitive, and the rugged nature of the terrain creates problems even for this mode, as will be outlined later in the paper.

As a result of these experiences, an informal research question was formulated: can improvements (that are cost-effective and practicable to implement) be made to the telemetry system, to enhance the effectiveness of endangered species management and research?

The approach taken to the problem was one of incremental and piecemeal improvement: that is, visualizing the problem, formulating ideas for improvement and then evaluating these ideas from the points of view of functionality improvement potential, economic feasibility and practicality. Lack of resources within DOC meant that a "big bang" approach to upgrade or replace the current system is just not feasible. This paper summarizes work to date - albeit still at an early stage. The results are applicable to any wildlife telemetry scenario that uses RF techniques, not just the kiwi recovery program. The majority of the work can be considered as being in the category of *critical research*: "… the specific purpose of a critical IS research project ranges from creating knowledge as a catalyst for change … to playing an active role in transforming IS practices …" (Cecez-Kecmanovic, 2005). A variety of methods have been employed, including the positivist methods of laboratory and field experiments (Galliers, 1994) and the critical research method of *participatory action research* (Baskerville, 1999).

RADIO COVERAGE MODELLING

Wildlife telemetry has gained increasing prominence in NZ conservation management and research over the past two decades (e.g. Thomas, 1982, Taborsky and Taborsky, 1995, Gibbs and Clout, 2003, Seddon and Maloney, 2004). There is good general coverage of wildlife telemetry systems in the literature (e.g. Mech, 1983, Kenward, 1987, Priede, 1992, Geers et al., 1997, Government of British Columbia, 1998, Mech and Barber, 2002). Most of these references give a high-level overview of RF technology (e.g. frequency bands and their propagation characteristics, and antenna types and characteristics) but there is no in-depth coverage of RF techniques or tactics.[2] Nor does the main wildlife telemetry literature mention the use of RF coverage modeling (either manual or computer-based) to assist in improving detection rates in the field, an approach which could also lead to savings of time and resources.

On the basis that, often, a good start point for solving a complex problem is being able to visualize the problem, the initial step was to carry out some radio coverage modelling over the Moehau Sanctuary area. The first intention was to use an orthodox geographic information system (GIS) application such as ESRI ArcInfo or ArcView. However, these applications support only optical line-of-sight coverage modeling and the incorporation of RF coverage capabilities would have required significant programming effort. Therefore, an off-the-shelf RF coverage planning tool was identified – the *Radio Mapper* application developed for military tactical radio planning at the University of NSW.

Radio Mapper requires Digital Terrain Elevation Data (DTED) to provide the terrain model base for radio coverage modelling. DTED is a well-known topographic data standard that essentially represents terrain as a set of (x,y,z) coordinates. There are three levels, representing different coverage granularities: level 0 has horizontal cell widths of 1 km, level 1 has cells of 90m and level 2 has cells of 25m. An approach was made to the NZ Defence Force Joint Geospatial Support Facility at Devonport Naval Base, who agreed to supply DTED level 2 coverage of the Coromandel area. After assembling the necessary application software, data and hardware, modeling activities commenced in early March 2005.

The initial use of Radio Mapper was to assist in problem visualisation. This is consistent with the use of computer models or simulations in orthodox decision

support applications (e.g. Turban and Aronson, 1998 77). However, the tool proved to be far more effective and useful than originally envisaged, and probably offers the following lessons for IS designers (and educationalists):

- A decision support application can sometimes be utilised successfully in a problem domain significantly different from that for which it was originally intended.
- The use of Radio Mapper, in this instance, has contributed far more to the problem domain than could possibly have been imagined at the outset. In that regard, the tool can be thought of as a key element in a learning process and can be equated to what Papert terms *objects to think with* (Papert, 1993 11).

Figure 1. Radio mapper display showing selected radio sites

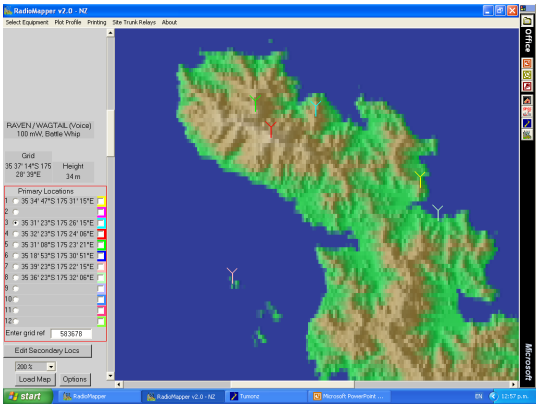
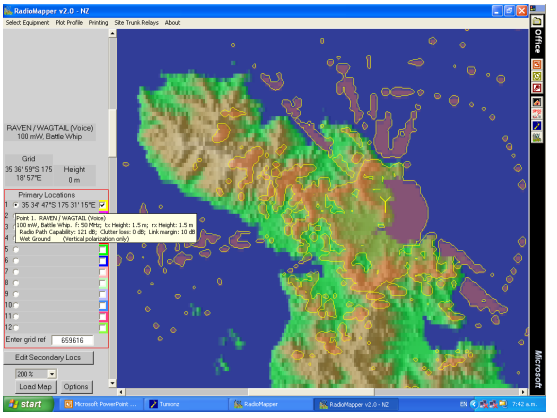


Figure 2. Predicted coverage from a single site



INITIAL RESULTS AND OBSERVATIONS

Radio Mapper is a radio communications path-planning tool that assists planners in predicting performance using both point-to-point and area coverage calculations. Parameters which can be varied include transmitted frequency and power, antenna and antenna feeder gains or losses, receiver sensitivity, ground type (e.g. wet, dry, urban) and transmit and receive antenna heights above ground level (AGL). Modelling can be conducted for any area for which a DTED data set is available. Examples of outputs from Radio Mapper are shown at Figures 1 and 2 below.

As Radio Mapper displays only include terrain-related information (i.e. horizontal coordinates and height), it was discovered that toggling between Radio Mapper and another digital mapping application (in this case TUMONZ[3] was used) allowed selection of likely sites taking into account natural and artificial features such as streams, roads, tracks, built up areas etc not shown on Radio Mapper. At a later stage of the work, Radio Mapper coverage diagrams were able to be geo-referenced, imported into a GIS, and displayed as overlays to topographic maps.

By varying the site locations and other non-constant parameters such as receive antenna height, a "profile" of the sanctuary area was compiled. It was notable that raising the receive antenna height to around 100m had a large effect on coverage - of the order of 7-8 times that obtained at 1.5m, the typical height of a hand-held antenna. This is shown in Figure 3. This result has a bearing on techniques and tactics which could be adopted to improve coverage – some of these are discussed in following sections.

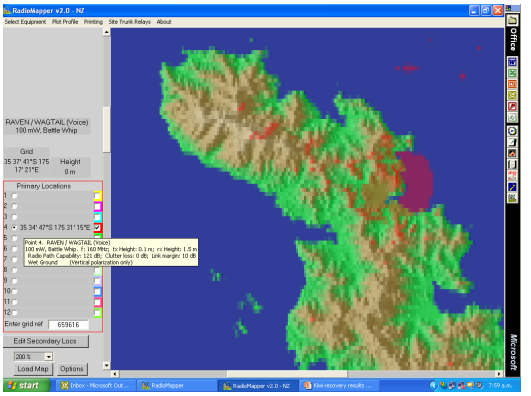
Another interesting result is that Radio Mapper predicts that the whole of the sanctuary area could be covered by five carefully sited receivers, provided the antennas were 100m AGL.

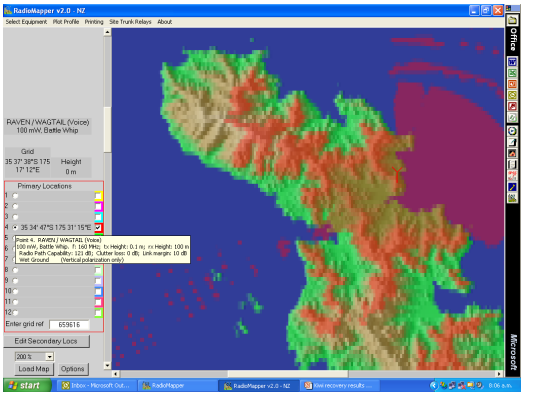
Practical validation of the RF coverage modeling results has been undertaken to a limited extent; for example:

- The tool predicts that receivers active on the high points of the main Moehau Range should be able to pick up transmitters operating on Great Barrier Island (some 25 km to the north east of Moehau) and from the Hunua Ranges (some 50 km south west of Moehau). Practical results have confirmed that that is the case.
- The selection of a migration monitoring site, described in the next section, also confirmed the predictions of Radio Mapper.
- Field trials were conducted over a three day period in the Moehau Sanctuary area. These compared actual radio telemetry coverage with that predicted using Radio Mapper, and very close correspondence was obtained.

Although only limited in-field validation has been conducted, results are sufficient to give a reasonable degree of confidence in the coverage predictions. Validation will be extended as time permits.

Figure 3. 1.5m receive antenna height (on left) compared with 100m receive antenna height





SOME PRACTICAL APPLICATIONS OF RADIO COVERAGE MODELLING

Following presentation of initial results of this work at the national kiwi recovery conference in March 2005, DOC staff met with the author and suggested a number of tasks that could make use of the RF coverage modeling capability:

- Selection of a radio receiver site at the southern end of the sanctuary area where a receiver/data logger could be installed to monitor transmitter-equipped kiwi entering or leaving the sanctuary area.
- Investigation, design and construction of prototype elevated antennas, to improve telemetry coverage.
- Predictions for the best altitude and track to fly while undertaking airborne monitoring.
- Analysis of the telemetry monitoring sites currently used by staff in the sanctuary area, to identify gaps in coverage and possible identification of better sites.
- Enhancing staff tracking performance, by appropriate training in RF techniques and tactics.

Progress has been made in all five of these areas. However, due to space limitations, only the first two are described in this paper. Work was carried out commencing late- 2005 and continues in 2006. The results are reported in the remainder of this section.

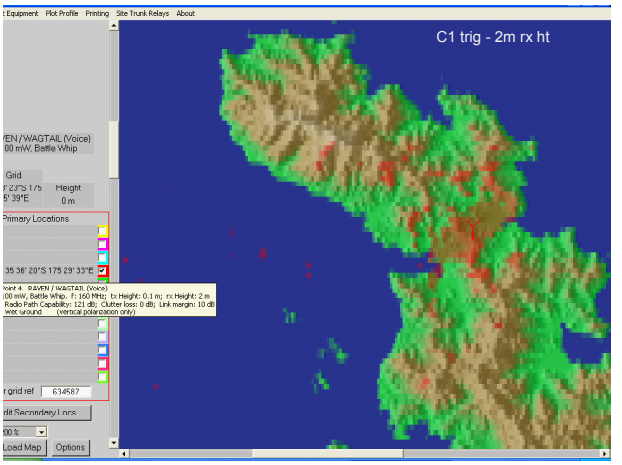
SELECTION OF A MIGRATION MONITORING SITE

The aim of this task was to determine if there are suitable site(s) where a receiver/data logger system could be installed to monitor, on a long-term basis, transmitter-equipped birds entering or leaving the sanctuary area. Experimentation with Radio Mapper identified four possible sites – one to the north of, and three to the south of, the Colville-Port Charles road. Figure 4 below shows predicted coverage from one of these sites. In April 2005, the author and a small group of DOC staff and volunteers undertook a site survey of the three southern sites, to assess their suitability, in terms of access, security, space to erect antennas etc. All three sites proved to be suitable from a practical point of view.

A communications test was also performed from one of the sites. Two people were equipped with telemetry transmitters tied to their bootlaces and they walked from the selected site down to the sea on each side (about 5 km each way). On the hill, staff were able to receive the signals continuously, down to the sea on each side. This demonstrated that the location is viable as a migration monitoring site, and also reinforces confidence in the Radio Mapper tool.

The use of Radio Mapper in the selection of this site and the subsequent communications test indicate that there should not be a significant issue of "false negative" results. That is, transmitter-equipped birds should not be able to move through the monitoring zone undetected, unless there is a failure of the receiver/data logger equipment, which is a separate management issue.

Figure 4. Predicted coverage from selected migration monitoring site



A significant issue, however, is likely to be "false positives" – that is, detection of birds at high points on the main range that are within the coverage of the selected site, who are not actually emigrating from the area. It is considered that this risk can be managed – over time, such birds will be detected within the sanctuary area during normal monitoring operations, indicating they have not emigrated. Similarly, any birds that immigrate would be transmitting on channels not allocated within the Moehau area, so should be able to be located and identified once in the sanctuary area.

During the second half of calendar year 2005, detailed planning, funding approval, system selection and acquisition, installation, and commissioning of the system took place. The telemetry system selected was the Telonics TR5 with the data acquisition option enabled (see Telonics Inc, undated). Funding was provided jointly by the author's university and DOC. The system was installed by DOC volunteers during a weekend in December 2005 and the system went live in early January 2006. Initial results are promising, with up to 10 birds being detected and logged in each 24 hour period. Some of these had not been detected in their normal range for some months, probably indicating they were "wanderers", or in the process of emigrating from the sanctuary area.

At this early stage, careful interpretation of the results is required to avoid false positives – that is, to identify birds that are actually migrating, and not just resident within the coverage area of the receiver. Future enhancements to ease this problem could include things such as: reducing the receive antenna height, or the use of directional antennas oriented east and west, to avoid repeated detection of birds resident in the main sanctuary area.

ELEVATED ANTENNA SYSTEMS

Also in the area of improved techniques, as previously mentioned, Radio Mapper graphically demonstrates the effect of increasing the height of the receive antenna. (Obviously, increasing the height of the transmit antenna would have the same effect, but is not feasible in a wildlife telemetry scenario.) For example, Figure 3 above demonstrates that a receive antenna at 100m AGL would have a coverage roughly 7-8 times that of an antenna at 1.5m AGL. This effect could be exploited by a number of initiatives, for example:

- Investigate the feasibility of mounting a receive antenna under a tethered balloon or in an unattended airborne vehicle (UAV). Limited by payload, the most likely antenna configuration is something simple such as a half-wave dipole or quarter-wave monopole. Bosak (1992 p. 93) provides a design for a lightweight, improvised Yagi that could be mounted on the side of a balloon – the ability to roughly "steer" the balloon by tether ropes at either end could allow a rudimentary direction-finding capability.
- Investigate the feasibility of a quick-erect (e.g. by pneumatic means) antenna mast mounted in the back of a truck or utility vehicle. This would allow utilization of good reception sites accessible by vehicle. This concept is widely used in military tactical communications.
- Design and develop a range of cheap, lightweight, antennas that could be hoisted into tall trees at key reception sites and left there, so that staff could move to them and connect to their receiver on arrival. This concept is also widely used in military tactical communications, particularly for jungle operations. The improvised Yagi design by Bosak (1992) may be viable, and therefore provide a direction-finding capability.

During the second half of calendar year 2005, some research funding was obtained to investigate the third option; namely cheap, lightweight antennas that can be installed around the sanctuary area and left in position. A small number of trial antennas were designed and constructed, mainly consisting of half-wave dipoles, Yagis based on Bosak's design and the commercial Yagi currently used by DoC, elevated by various means.

Limited laboratory testing was undertaken, using the RF laboratory of the author's university, in the absence of an anechoic chamber. The laboratory results demonstrated that the antennas constructed exhibited expected properties: particularly gain (relative to each other) and frequency response.

A field antenna testing range (ATR) was selected in the Moehau area, due to the availability of telemetry equipment from the Moehau Kiwi Sanctuary. The terrain was selected by Radio Mapper modelling, physical reconnaissance and telemetry coverage tests. The actual antenna test site had to have tall trees to achieve appropriate elevation for the antenna under test (AUT), and the terrain ideally had

to provide intermittent coverage over a distance of 5-10 km along a traversable route radiating away from the antenna test site.

Antennas were set up at the test site and a research assistant equipped with a telemetry transmitter moved on foot along the chosen route. Other staff at the antenna test site monitored the RF signals using Telonics TR4 telemetry receivers. Up to three antennas were tested at a time. When a change occurred (e.g. signal was lost or regained) instructions were radioed to the surrogate "kiwi" to change position (e.g. back-track 50m). When it became apparent that a change had actually occurred, the "kiwi" was instructed to take a GPS waypoint of that position and then proceed along the route.

The results were recorded on TUMONZ by plotting the GPS waypoints, which were then linked up by line to show pictorially the coverage achieved for each AUT. The results are shown at Figure5 below. The field results graphically demonstrated the value of increasing receive antenna height to improve reception coverage. (The standard commercial Yagi, at 1.5m AGL, gave the worst performance of all the antennas tested.)

Other conclusions were as follows:

- The commercial Yagi, operated in an elevated mode, was quick to erect (of the order of 2-3 minutes) and provided superior performance, particularly over the same antenna when hand-held (the range obtained was of the order of four times greater, on the particular terrain where testing took place).
- Cheap, expendable dipoles could be erected and left in place in trees at key monitoring points, so that staff can connect to them on arrival. If RF signals are detected on significant channels, the standard commercial Yagi could be substituted for the dipole and hoisted into the tree if direction-finding is required.

The results have been passed to DOC with recommendations for further work and utilisation of the findings.

SUMMARY AND CONCLUSIONS

The research described in this paper is aimed at improving wildlife telemetry systems by means of computer-based RF visualization and planning, and improving RF coverage by adoption of enhanced techniques and tactics. The majority of the work can be considered as being in the category of *critical research.* A variety of methods have been employed, including the positivist methods of laboratory and field experiments and the critical research method of *participatory action research*.

The use of a computer-based modelling application – Radio Mapper – has proved to be of benefit in the area of RF visualisation and planning. It has been recommended that DOC consider acquiring a licence to operate Radio Mapper, or identify and procure a similar RF coverage modelling tool.

Use of Radio Mapper and other work in this area has led to the identification of opportunities to improve field practice: staff training in RF techniques and tactics, selection of optimum receiver sites, improved receive antenna systems, and better planning for airborne monitoring and tracking. It has been recommended that all DOC staff involved in field telemetry work undergo training (of the order of half a day is considered sufficient) in RF propagation techniques and tactics. In the kiwi recovery program, this could be run in conjunction with the annual national conference.

FUTURE WORK

There is considerable potential for further improvements to wildlife telemetry systems arising from the user of a radio coverage modeling tool and improved RF techniques and tactics. These include further work to improve conventional airborne tracking and monitoring (as mentioned in section 3.2); elevated antenna improvements, including vehicle- and ground-mounted masts; the use of alternative airborne platforms such as balloons and un-manned airborne vehicles (UAV); and investigation of automated space- and land-based detection and tracking systems.

REFERENCES

Bank of NZ (2005) *Kiwi Recovery Program website*, http://www.kiwirecovery.org.nz/Home/, Accessed 1 May 2005.

Baskerville, R. (1999) Investigating Information Systems with Action Research, *Communications of the Association of Information Systems,* 2.

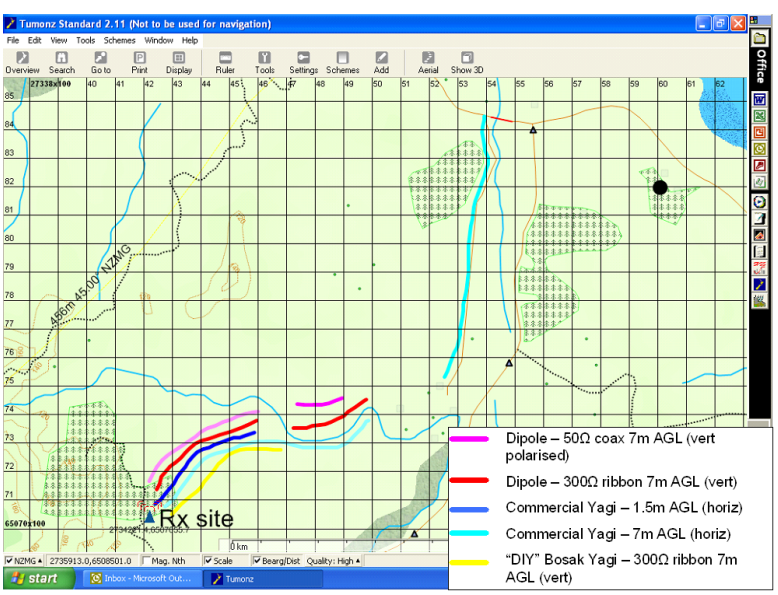
Bosak, A. (1992), "Some new design concepts for simple lightweight radio tracking equipment" in Priede, I. G. and Swift, S. M. (eds.) *Wildlife Telemetry: Remote Monitoring and Tracking of Animals*, Chichester.

Cecez-Kecmanovic, D. (2005) *Critical Approach in IS Research: the Differences that Matter*, 16th Australasian Conference on IS, Sydney.

Galliers, R. D. (1994), "Choosing Information Systems Research Approaches" in Galliers, R. D. (ed). *IS Research: Issues, Methods and Practical Guidelines*, Henley-on-Thames.

Geers, R., Puers, B., Goedseels, V. and Wouters, P. (1997) *Electronic Identification, Monitoring and Tracking of Animals,* CAB International, New York.

Figure 5. Antenna field test results



Gibbs, S. J. and Clout, M. N. (2003) Behavioural vulnerability of juvenile brown kiwi: habitat use and overlap with predators, *DOC Science Internal Series,* 102**,** 1-17.

Government of British Columbia (1998) *Wildlife Radio-telemetry: Standards for Components of British Columbia's Biodiversity No. 5*, http://srmwww.gov.bc.ca/risc/pubs/tebiodiv/wildliferadio.htm, Accessed 22 April 2005.

Kenward, R. (1987) *Wildlife Radio Tagging: Equipment, Field Techniques and Data Analysis,* Academic Press, London.

Mech, L. D. (1983) *Handbook of Animal Radio Tracking,* University of Minnesota.

Mech, L. D. and Barber, S. M. (2002) *A Critique of Wild-life Radio Tracking and its Use in National Parks*, http://www.npwrc.usgs.gov/resource/2002/radiotrk/radiotrk.htm, Accessed 3 May 2005.

Papert, S. (1993) *Mindstorms: Children, Computers and Powerful Ideas,* Harvester Wheatsheaf, Hemel Hempstead.

Priede, I. G. (1992) *Wildlife Telemetry - Remote Monitoring and Tracking of Animals,* Ellis Horwood, Chichester.

Seddon, P. J. and Maloney, R. F. (2004) Tracking Wildlife Radio-tag Signals by Light Fixed-wing Aircraft, *Department of Conservation Technical Series,* 30**,** 23.

Taborsky, B. and Taborsky, M. (1995) Habitat Use and Selectivity by the Brown Kiwi (Apteryx Australis Mantelli) in a Patchy Environment, *The Auk,* 112**,** 680-689.

Telonics Inc (undated) *Telonics TR5 Telemetry Receiver with Optional Data Acquisition System*, http://www.telonics.com/literature/tr-5/tr-5.html, Accessed 1 June 2005.

Thomas, M. D. (1982) A Radio Telemetry System for Animal Tracking in NZ, *NZ Journal of Science,* 25**,** 245-252.

Turban, E. and Aronson, J. E. (1998) *Decision Support Systems and Intelligent Systems,* Prentice-Hall, Upper Saddle River, New Jersey.

ENDNOTES

[1] Located at the northern end of the Coromandel Peninsula, on the North Island

[2] *Tactics*, in this context, are considered to be decisions or actions derived from in-depth knowledge of RF propagation characteristics that allow, for example, selecting the best receiver site(s) to cover a particular area.

[3] The Ultimate Map of NZ: see URL http://www.tumonz.co.nz/ for details

The Relationship Between IS Strategic Planning and Enterprise Architectural Practice: A Study in NZ Enterprises

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ABSTRACT

Modern businesses face increased levels of competitive pressure, and the IT sector is going through a period of rapid change. These issues have resulted in a drive for new approaches to planning and managing IT services. Two approaches that have emerged in different eras are IS Strategic Planning (ISSP) and Enterprise Architectural Practice (EAP). Despite the apparent similarities between these two approaches, neither IS researchers, nor practitioners, have explored the relationship in any depth. This paper investigates the relationship between ISSP and EAP, utilising results from a survey in NZ enterprises.

INTRODUCTION

Modern businesses face increased levels of competitive pressure, and the following factors will influence the nature and duration of current and future strategic planning: (Wagner, 2004)

- Shorter planning and implementation cycles.
- Frequent and rapid environmental changes, possibly with discontinuities.
- Organization units that extend beyond a single company, such as supply chains or virtual organizations.

In addition, the IT sector is going through a period of rapid change, and the rate of change is expected to at least remain steady, if not accelerate. Many commentators regard rate of change as a key issue in the sector (e.g. CCTA, 1999 11). These pressures have resulted in a drive for new approaches to planning and managing IT services.

Within the corporate world and, to a certain extent, government organisations, ISSP was pre-eminent during the 1980s and 1990s. In the latter half of the 1990s, EAP became prominent in the US Department of Defense; a trend which has flowed on to the government and commercial sectors. Some similarities between ISSP and EAP are apparent.

This paper examines the relationship between ISSP and EAP. Such a comparison is made difficult by the large number of approaches towards ISSP and EAP that have emerged (including proprietary and in-house), and the inherent differences in scope and techniques. However, two typical approaches have been chosen, based on their widespread usage, to enable a theoretical comparison between ISSP (the CCTA methodology) and EAP (the US DoD C4ISR Architectural Framework). An empirical comparison, based on a survey of NZ organisations, has also been conducted. The paper concludes that there are strong similarities between the two activities, and that there are, indeed, opportunities to rationalise the two activities, to eliminate duplication of effort and to develop improved IT planning methodologies based on "best-of-breed" techniques from both.

THEORETICAL UNDERPINNINGS

ISSP

In discussing IT strategic planning, it is important to distinguish between *strategic information systems planning* (SISP) and strategic planning for *all* information systems (ISSP), terms often used interchangeably in the literature. The latter term, referring to the strategic planning of an enterprise's entire IT resources, is the term used in this paper. This is consistent with the terminology used by Fitzgerald (1993) and Cerpa and Verner (1998).

The Central Computer and Telecommunications Agency (CCTA[2]) of the UK Treasury highlights the following concerns of ISSP: (CCTA, 1988)

- Understanding the aims and objectives of the business,
- Establishing the information requirements of the business,
- Outlining the systems to provide the information, and determining the role of technology in supporting the information systems,
- Agreeing policies and plans to develop and implement the information systems,
- Determining the role and use of resources to achieve the information systems required, and
- Managing, reviewing and evolving the strategy.

There are numerous techniques, or *methods* that have been used for ISSP, including Critical Success Factors (CSF) (Rockart, 1979), Business Systems Planning (BSP) (Wiseman, 1988), Porter's Competitive Forces Model (Porter, 1980), Porter's Value Chain (Porter, 1985), and Scenarios (Schwartz, 1991). Methods can be grouped together to constitute a *methodology*. Methodologies used for ISSP include those of the CCTA (1988, 1999) and Boar (2001).

Many IT vendors and consultancy organizations use proprietary methods and/or methodologies, some of which are adaptations of open source approaches. Examples are Arthur Andersen's *Method/1* and Coopers and Lybrand's *Summit* (Lederer and Sethi, 1988, Min et al., 1999). It is also well known that organizations often develop their own in-house methodologies, often based on open or proprietary methods or approaches (Earl, 1993, Lederer and Sethi, 1988).

One open source methodology that has been successfully used for IT strategic planning in the government sectors of Australia, UK and NZ is that of the UK government CCTA (1988, 1999). The basic mechanism is a sequence of actions, grouped into the common-sense phases of:

- Where are we now?
- Where do we want to be?
- How do we get there?

The steps include a detailed inventory and cost model of existing systems, a study of business goals and objectives, and a scan of the environment in which the business will operate. Senior management define a vision of where they envisage the organisation will be at the end of the time "window[3]" of the study, both from a business and IT perspective. Options for the provision of systems and services are defined, which are evaluated by a high level steering committee, who decide on the (or a small number of) option(s) to be costed and developed in detail into a strategic plan. The options could include outsourcing, or other innovative approaches to service provision.

In summary, the main strength of CCTA (or a similar strategic planning methodology) is that it gives a methodical, business-driven approach to selecting, funding, operating and managing IT systems. The production of a comprehensive, top-down IT strategic plan represents a low risk approach to any organisation's requirement to manage its IT infrastructure. The existence of a comprehensive strategic plan will allow the organisation to make informed "what if" decisions, such as evaluating the benefits of outsourcing all or part of its IT infrastructure.

Enterprise Architectural Practice (EAP)

Many approaches to ISSP include *IS/IT architecture* as a deliverable of the process (e.g. O'Brien, 2004, CCTA, 1999). However, the scope of "architecture" envisaged in EAP is somewhat more significant – it actually subsumes many of the steps inherent in ISSP.

EAP first became prominent in US government circles. Frameworks include those developed by the US Department of the Treasury (2000) and US Department of Defense (DoD) (1997, 2003). The US Army has developed an extension of the DoD framework, that is described in a separate document (U.S. Army, 1998). Non-government approaches to EAP also exist; e.g. those developed by Zachman (1987), and The Open Group (2003).

The underlying vision of EAP is as follows:

"Architectures are developed to portray the evolution of an IT environment over various points in time, beginning with the baseline, or current situation. ... The architecture envisioned to meet all operational and business requirements is the objective architecture. Migration documents show the progression of architectures from baseline to objective ..." (U.S. DoD, 1997 1-2)

A complementary view of the purpose of EAP is as follows:

"Enterprise architecture is a far-reaching concept that comprises the vision, principles and standards that govern the acquisition and deployment of technology. As such, it provides the foundation for detailed data, application and network architectures. An enterprise IT architecture is a key component of a mature IS organisation that enables alignment of business goals, consistent processes and best practice in software reuse." (Cecere, 1998)

The US DoD framework describes the process of defining an EA in terms of the deliverables; that is, the steps to be undertaken to produce the various elements of the operational, systems and technical architectures. It does not describe in any detail the underlying rationale, or analysis that should be undertaken to produce the various deliverables:

"The situation is further complicated because the framework does not provide a process for generating the products. Thus, an organization developing an architecture that is compliant with the C4ISR Framework could be faced with an unbounded amount of effort." (Barbacci and Wood, 1999)

The opening paragraph of the C4ISR AF (U.S. DoD, 1997) states that: "the application of the Framework will enable architectures to contribute most effectively to building … cost effective military systems" (p. 1-1). However, there is no elaboration of this statement into the development of a business case, or costed options, as is integral to CCTA. There is also no indication in C4ISR AF of any specific time window on which the objective architecture should be based. With rapid advances in technology, it may not be possible to specify a firm objective architecture more than 3-5 years ahead.

THEORETICAL COMPARISON OF ISSP WITH EAP

Even from the cursory descriptions of ISSP and EAP in the preceding sections, there are similarities apparent. A more detailed comparison was conducted by Wilton (2001) who identified the following similarities and differences:

Similarities:

- Basic Intent/Vision: Both are high-level approaches, intended to realize a rational, affordable IT infrastructure that is consistent with business strategy and goals.
- Both include a baseline summary of existing IT infrastructure, and an objective architecture ("where do we want to be?").
- Both establish the information requirements of the business and determine the systems required, to provide and manage the information.
- Both include a financial dimension (however, this is much more heavily emphasized in ISSP).
- Both produce plans/architectures that are dynamic, and need to be reviewed regularly.

Table 1. ISSP and EAP - differences

	ISSP	EAP
Scalability	Tends to be targeted at a single enterprise entity	Can be adapted to fit a multi-level or multi-organisation enterprise (intended to produce nested architectures, or "systems of systems")
Deliverables	Not tightly defined within any particular methodology	Tend to be tightly defined, and grouped as mandatory and optional.
Process	Well defined. Tightly coupled to business strategy and cost effectiveness.	Not particularly well defined
Time window for objective strategy or architecture	3-5 years (limited by rapid advances in IT)	Not specified
Interoperability focus	Not specifically emphasized	Inter - and intra - organisational interoperability is a key focus
Summary of overall approach	Process-oriented	Product oriented

Differences are shown in Table 1.

In summary, the high-level intent of the two approaches is nearly identical, and the general scope and factors considered during the respective processes are very similar. However, the major difference is that ISSP tends to be process-oriented, with relatively little specification of the deliverables, whereas EAP is rather the opposite. US DoD EA practice, as espoused in (U.S. DoD, 1997, U.S. DoD, 2003), does not attempt to define any business processes or models which could be used to derive cost-effective objective architectures. The use of ISSP methods could remedy this shortfall.

The similarities between ISSP and EAP are reinforced by Beveridge and Perks (2003 12-13) who state:

"In many ways there is synergy between the Enterprise IT architecture and the concepts that embodies ... ISSP. Both provide a medium- to long-term vision and framework within which the IT environment is implemented, including people, structure and technologies. Both the ISSP and enterprise architecture provide guidelines for systems to be implemented, technologies to be considered, and information to be gained."

EMPIRICAL COMPARISON OF ISSP AND EAP

In order to compare ISSP and EAP from a more practical basis, a survey was conducted of NZ organisations. A research model was developed, containing the variables that are considered to be of interest in the problem domain and the anticipated inter-relationship between them. Some initial hypotheses were also proposed. These are not included in this paper due to space limitations. A survey instrument was designed utilising constructs and questions derived from the literature where possible. The draft survey was subjected to faculty review (including review by a senior statistics academic) and pilot tested on several large organisations and SMEs then subjected to fine tuning.

It is generally accepted in statistical analysis that a sample of at least 100 valid responses is required to constrain the margin of error to no more than 10%, and

therefore to provide results that can be generalised across the whole population. However, the use of a stratified sample (as used in this survey) introduces a design effect that reduces the likely margin for error to 80-90% of that of a truly random sample (Page and Meyer, 2003 pp.107-108). In this particular survey, there were difficulties in obtaining valid responses, due to the following reasons:

- The length and complexity of the survey instrument, which necessitated the use of a simplified instrument for small and medium organisations.
- The relatively small size of NZ, coupled with the fact that 97% of NZ enterprises are classified as small or medium. (N.Z. Ministry of Economic Development, 2003).

The small number of responses (53), and the even smaller number of organisations (26) which had (or were developing) an IS strategic plan and/or enterprise architecture represents a limitation on this study that must be taken into account when interpreting the results. However, according to the NZ Ministry of Economic Development (2005), as at February 2004, there were fewer than 2000 "large" enterprises in NZ. Therefore, a response by 20 large enterprises represents more than 1% of the population. Further, it is noted that surveys with less than 100 valid responses feature prominently in the IS strategic planning literature, for example: (Lederer and Sethi, 1988 - 80 responses, Flynn and Goleniewska, 1993 - 18 responses).

The small sample size must be regarded as a limitation on generalisability of the results, but does not negate this survey being used as the basis for a preliminary investigation into ISSP and EA practices and issues in NZ enterprises.

SURVEY RESULTS

The survey instrument used was intended to gather a wide variety of data. Only certain key results - those relating to a comparison of ISSP and EAP - are included in this paper due to space limitations. Data from the survey responses was entered into the statistics application *SPSS - Version 13 for Windows*, and processed using appropriate techniques. Results were as follows.

Existence of IS Strategic Plan and/or Enterprise Architecture

Grouping the results according to organisational size (small/medium or large) (see Figure 1), provides an interesting perspective.

All large organisations who responded have an ISSP or one under development, whereas only 87% of large organisations either have an EA (or one under development). A minority (20%) of small or medium organisations have an ISSP (or one under development) and only 17% have an EA (or one under development).

The low proportion of SMEs (20%) that have either an ISSP or EA, and the fact that around 97% of NZ enterprises are SMEs, is noteworthy. While the IT requirements of many SMEs may be relatively modest or simple, it is likely that a significant number of organisations are not realising the full benefits, or potential competitive advantage, that modern IT can offer. This may be having a detrimental effect on the national economy, but that is outside the scope of this research. One approach that could alleviate the situation would be the development of a simple, short-duration IS strategic planning methodology that the owners or staff of SMEs, who generally would not have in-depth IT knowledge, can conduct themselves. This would alleviate the need for costly consultancy services to produce ISSP and/or EA.

Figure 1. Existence of ISSP and/or EA – Small/medium and large enterprises

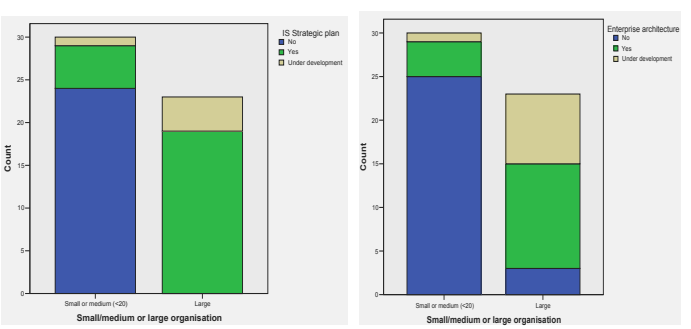

Table 2. Comparison of ISSP and EA development parameters

	Maximum	Minimum	Mean	Median
"Window" of ISSP (years)	10.0	3.0	4.4	3.0
"Window" of EA (years)	10.0	2.0	4.1	3.0
Internal staff effort for ISSP (person-months)	99.0	2.0	16.97	9.0
Internal staff effort for EA(person-months)	420.0	0[1]	38.8	12.0
Direct financial cost of ISSP	$600,000	$0	$66,833	$20,000
Direct financial cost of EA	$130,000	$0	$23,667	$0
Duration of ISSP development exercise (weeks)	52.0	5.0	23.6	24.0
Duration of EA development exercise (weeks)	52.00	0[1]	24.73	24.00

Characteristics of the Development Processes

A set of questions collected data associated with the ISSP and EA development processes, e.g. duration, cost, staff effort. Results are summarised in Table 2.

The mean cost of EA development is less than half that of ISSP, possibly indicating that EA development is not regarded as such a business-critical function as IS strategic planning. The fact that the median cost of EA development was zero (indicating that over half the organisations that had an EA developed it without dedicated funding) and the higher mean (almost double) for staff effort tend to reinforce this observation.

Investigating the Relationship between ISSP and EAP

One of the major goals of this research was to determine the relationship between ISSP and EAP. One of the key indicators of this was a hypothesis which examined the coincidence of topics in IS strategic plans and enterprise architectures:
Topics in ISSP] ∩ [Topics in EA] ≠ 0

To assist in visualising the situation, a comparative table was formed that displays the topics contained in an ISSP or EA (as reported by respondents) displayed as a percentage of organisations with that topic in their ISSP and/or EA. Results are presented in Table 3.

All listed topics (apart from two *other items* in ISSP) were present in both ISSP and EA. The lowest figure in any cell was 28.6%, representing the lowest incidence of topics in either type of document. This indicates a considerable overlap between the topics in ISSP and those in EA.

The results of a Spearman bivariate correlation test produced a correlation coefficient of 0.447, indicating significant correlation at the 0.05 level (two-tailed). Therefore, the hypothesis is demonstrated to be correct.

Another indicator of the relationship between ISSP and EA is a comparison of the ranked lists of objectives for both activities. These are shown in Table 4.

The primary objective is identical for both activities, but there is some variation in objectives 2-4 (in particular, *establish technology path and policies* is ranked 2nd in EA, but 4th in ISSP). Apart from this variation, the lists are identical.

The considerable overlap between the objectives and contents of ISSP and EA suggests that there may be confusion about the role and scope of both activities, and this could lead to a risk of duplication of effort and resources. One possible solution is to combine them into a (conceptually) single activity. This would not

Table 3. Topics included in ISSP and EA

Topic	Included in ISSP	Included in EA
	(% of organisations):	
Business objectives &/or vision	87.5	50.0
Model of the business	56.3	57.1
Business processes	37.5	42.9
Review of the business environment	68.8	35.7
Information requirements &/or flows	62.5	71.4
Enterprise data model	25.0	42.9
IT vision	75.0	71.4
Review of the technology environment	93.8	71.4
Applications portfolio	75.0	66.7
Networking requirements	37.5	57.1
Hardware requirements	31.3	57.1
Requirement for collaboration tools	37.5	28.6
Requirement for decision support tools	37.5	28.6
IT policies &/or procedures	50.0	35.7
IT standards and protocols	56.3	64.3
Security requirements or strategy	37.5	57.1
IT funding requirements &/or issues	62.5	28.6
IT procurement&/or sourcing strategies	56.3	35.7
IT organisation &/or management responsibilities	62.5	28.6
IT projects portfolio	81.3	50.0
IT architecture	68.8	64.3
Other items	12.5	0

preclude an approach where different deliverables are produced in successive phases.

This suggestion is in line with the statement that: "…there are distinct similarities in the objectives and scope of both approaches [ISSP and EA]. … The two approaches can be viewed as complementary, rather than mutually exclusive, and there could well be significant benefits in combining elements of both, to produce a new paradigm in IT planning and management." (Wilton, 2001)

SUMMARY AND CONCLUSIONS

Theoretical and empirical comparisons of ISSP and EAP indicate a strong correlation between these two activities. Organisations that undertake both, as separate activities, incur a risk of overlap, duplication of resources and possible difficulty in obtaining management commitment for both. There is the potential for development of a comprehensive methodology which combines best-of-breed methods from both disciplines. The research conducted in this area to date, has also produced some other significant results, such as the very low incidence of IS strategic plans and/or enterprise architectures in SMEs in NZ. Coupled with the fact that approximately 97% of NZ enterprises are SMEs, this may indicate that a significant number of organisations may not be realising the potential advantages that modern IT offers.

FUTURE WORK

The next stage of the study will consist of detailed Case Studies in a small number of selected organisations. The purpose of the studies will be to obtain detailed information on issues that emerged from the survey: in particular, the attitudes towards ISSP and EA, and detailed reasons why certain paths were followed (or not followed). This includes the low incidence of ISSP and/or EA in SMEs. The final stage will be the development and testing of an improved methodology that includes elements drawn from ISSP and EAP.

REFERENCES:

Barbacci, M. and Wood, W. (1999) *Architecture Tradeoff Analyses of C4ISR Products*, http://www.sei.cmu.edu/publications/documents/99.reports/99tr014/99tr014chap02.html, Accessed 25 April 2001.

CCTA (1988) *Guidelines for Directing Information Systems Strategy,* HM Treasury, London.

CCTA (1999) *IS Strategy: process and products,* Format Publishing Limited, Norwich.

Cecere, M. (1998) *Architecting Architecture*, http://www.cio.com, Accessed 1 April 2001.

Cerpa, N. and Verner, J. M. (1998) Case study: The effect of IS maturity on information systems planning, *Information & Management,* 34**,** 199-208.

Earl, M. J. (1993) Experiences in Strategic Information System Planning, *MIS Quarterly,* 17**,** 1-24.

Fitzgerald, E. P. (1993) Success measures for information systems strategic planning, *Journal of Strategic Information Systems,* 2**,** 335-350.

Flynn, D. J. and Goleniewska, E. (1993) A survey of the use of strategic information system planning approaches in UK organisations, *Journal of Strategic Information Systems,* 2**,** 292-319.

Hulbert, I. and French, J. (2001) The accuracy of GPS for wildlife telemetry and habitat mapping, *Journal of Applied Ecology,* 38**,** 869-878.

Table 4. Key Objectives - ISSP and EA

Key objectives - ISSP	Key objectives - EA
1. Align IT with business needs.	1. Align IT with business needs.
2. Forecast IT requirements.	2. Establish technology path and policies.
3. Gain senior management commitment.	3. Forecast IT requirements.
4. Establish technology path and policies.	4. Gain senior management commitment.
5. Seek competitive advantage from IT.	5. Seek competitive advantage from IT.
6. Revamp the IT function.	6. Revamp the IT function.
7. Other reasons	7. Other reasons

Lederer, A. L. and Sethi, V. (1988) The Implementation of Information Systems Planning Methodologies, *MIS Quarterly,* September 1988**,** 445-461.

Min, S. K., Suh, E. H. and Kim, S. Y. (1999) An integrated approach toward strategic information systems planning, *Journal of Strategic Information Systems,* 8 (1999)**,** 373-394.

N.Z. Ministry of Economic Development (2003) *SMEs in New Zealand: Structure and Dynamics*, http://www.med.govt.nz/irdev/ind_dev/smes/2003/smes-2003.pdf, Accessed 25 February 2005.

N.Z. Ministry of Economic Development (2005) *SMEs in New Zealand: Structure and Dynamics - 2005*, http://www.med.govt.nz/templates/MultipageDocumentPage____2817.aspx, Accessed 17 May 2006.

O'Brien, J. A. (2004) *Management Information Systems: Managing Information Technology in the Business Enterprise,* McGraw-Hill, New York, NY.

Page, C. and Meyer, D. (2003) *Applied Research Design for Business and Management,* Irwin/McGraw-Hill, Macquarie Park, NSW.

Perks, C. and Beveridge, T. (2003) *Guide to Enterprise IT Architecture,* Springer-Verlag, New York.

Porter, M. E. (1980) *Competitive Strategy: Techniques for Analysing Industries and Competitors,* Free Press, New York.

Porter, M. E. (1985) *Competitive Advantage: Creating and Sustaining Superior Performance,* Collier Macmillan, New York, N.Y.

Rockart, J. (1979) Chief Executives Define their own Data Needs, *Harvard Business Review,* 79.

Schwartz, P. (1991) *The Art of the Long View: Paths for Strategic Insight for Yourself and Your Company,* Currency/Doubleday, New York.

The Open Group (2003) *TOGAF as an Enterprise Architecture Framework*, http://www.opengroup.org/architecture/togaf8-doc/arch/, Accessed 8 July 2004.

U.S. Army (1998) *Army Enterprise Architecture Guidance Document*, http://www.army.mil, Accessed 1 March 2001.

U.S. Department of the Treasury (2000) *Treasury Enterprise Architecture Framework Version 1*, http://www.software.org/pub/architecture/teaf.asp, Accessed 8 July 2004.

U.S. DoD (1997) *Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) Architecture Framework Version 2*, http://www.c3i.osd.mil/org/cio/i3/AWG_Digital_Library/index.htm, Accessed 30 Jan 2001.

U.S. DoD (2003) *DoD Architectural Framework Version 1.0*, http://www.teao.saic.com/jfcom/ier/documents/DOD_architecture_framework_volume1.doc, Accessed 17th June 2004.

Wagner, C. (2004) Enterprise strategy management systems: current and next generation, *Journal of Strategic Information Systems,* 13**,** 105-128.

Wilton, D. (2001) The Relationship Between IT Strategic Planning and Enterprise Architectural Practice, *Journal of Battlefield Technology,* 1**,** 18-22.

Wiseman, C. (1988) *Strategic Information Systems,* Irwin, Homewood, Illinois.

Zachman, J. A. (1987) A framework for information systems architecture, *IBM Systems Journal,* 26**,** 454-470.

ENDNOTES

[1] One organisation reported that their EA development had been conducted as part of normal business planning, and therefore reported staff effort and duration of the EA activity as zero

[2] The CCTA is responsible for formulating IT policy, procedures and methodologies for all UK government departments. More recently known as the UK Office of Government Commerce OGC).

[3] Due to environmental volatility, a window of 3-5 years is fairly typical in a commercial organisation

Knowledge Harvesting System for a Business Enterprise

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ABSTRACT

Globalization has created new opportunities for business enterprises and their employees. Employees have started leaving the organization to avail themselves of the opportunities. Consequently knowledge gained and developed by them is lost when they quit the organization. Many business enterprises have started realizing that they need a solid and ongoing system that will capture and store the knowledge of their organizations and employees in information systems. It is required to establish synergy between the concepts of knowledge management and information technology for the creation of knowledge management system. This paper talks about the steps to be followed for incorporating the concept of knowledge harvesting with the human centered component in intellectual capital in business practices of an organization. Further it explains the role of Information and Communication Technologies (ICT) in this process.

Keywords: Knowledge harvesting, Intellectual capital, Knowledge worker, Data ware house, Data mining.

INTRODUCTION

The existing ways of doing business are constantly changing due to rapid changes in global economy. It is apt to recall here the observation of Arnold Kransdorff and Russell Williams(2000) who say that industrial conditions determine the options available and competitive advantage stems from business to it's environment (PP399). It has become a necessity for business enterprises to respond quickly to these changes. Many business enterprises have started realizing that managing knowledge as well as innovative process is the way to remain competitive in the changing business scenario. It is generally perceived by many business enterprises that knowledge management is a technology for preserving and enhancing the knowledge base of an organization. But after a close look at their own organization they may find that many elements related to knowledge management are already available in their own organization itself. In reality they are required to make use of the elements of knowledge source in their organization for their competitive advantage. George Friedman, Meredith Friedman, Colin Chapman, John S Baker Jr. (1997) rightly observe that the geography of information is not quite like a map of New Jersey. Information exists in a Variety of domains, some further away and harder to access, some closer and easily accessible. Further they say that we must draw a peculiar map to describe the geography of information, charting the zones or domains in which information resides (PP46-47). The overall challenge that many enterprises face today is identifying where the knowledge resides and to leverage it across to their organization. In spite of heavy investment in information technology business enterprises seem to think that they are fighting a losing battle. Business success lies in converting the information in their systems into knowledge. Now it has become important that one should use one's own wisdom to convert information into knowledge in the new scenario of business world. Business enterprises also seem to think that 'INTELLECTUAL CAPITAL' and 'KNOWLEDGE MANAGEMENT' are one and the same. The word 'MANAGEMENT' in knowledge management clearly indicates a process whereas 'INTELLECTUAL CAPITAL' is an entity and asset and not a process. This paper recommends a model for a business enterprise to design a knowledge harvesting system with the elements of Intellectual Capital. It comprises of five sections covering (1) Existing Scenario in Business Enterprises (2) Knowledge management and Intellectual capital (3) New Brand of Professionals (4) Steps in creation of knowledge harvesting system and (5) Globalization Scenario.

EXISTING SCENARIO IN BUSINESS ENTERPRISES

The greatest challenge in implementing effective knowledge management is helping employees make the transmission from knowledge hoarders to knowledge sharers. With knowledge comes power and influence in an organization and in today's business scenario one may find most employees working in knowledge hoarder's environment. Many of them also follow the practice of a selective distribution of knowledge. While comparing sharing patterns in knowledge, Melissa M.Appleyard (2002) gives an example of knowledge sharing in semi conductor industry in the US and Japan. Employees in the US semiconductor industry are more likely to rely on private channels of communication than their Japanese counterparts (PP 539). Generally executives do not intend remaining with an organization for long, they do not recognize the value of an accumulated knowledge. All they focus on is completing the tasks assigned to them as soon as possible in order to take on other assignments or leave the organization. This is one reason why they are unable to adapt to the new knowledge management environment. They need to realize that they have to work under competitive pressure in the present globalization scenario. Mary Crossan and John Hulland (2002) state that adjustment and joint action are crucial to the development of shared understanding (PP 714 – 715). This is most relevant in the present business scenario. Janie Nahapiet and Sumantra Ghosal (2002) explain that the cooperation among individuals in the organization will be possible only when individuals and functional experts are structured, coordinated and communicated (PP673). The essence of a knowledge management environment is to manage carefully 'Human centered assets' in business enterprises. What is required is a change in mindset among managers. Managers are expected to act as mentors to help employees change to knowledge workers and make use of the organizational knowledge base. Arjan Raven (2003) rightly points out that instead of looking at individuals as just information processors or decision makers, it is required to understand their work and support for making them feel their importance in the business of the organization (PP 292).

KNOWLEDGE MANAGEMENT AND INTELLECTUAL CAPITAL

Evolution of Knowledge Management

One would know from the study of history of any country that the concept of knowledge management is not new. The only difference one could observe is the methodology followed by them. Emperors of China preferred to have scholars as their advisors than politicians. The services of educated priests were used by Roman emperors like Greeks to know the possible trends in future. It is said that Kings in ancient India were particular mainly about four elements while developing a township in their Kingdom. They were places for worship (DEVALAYA), places for learning (VIDYALAYA), LIBRARIES (GRANDHALAYA) and Hospitals (OUSDALAYA). Indian kings seemed to be concerned with creation of knowledge among people by allocating places for schools and libraries. It may be interesting to note that a British stock broker in 1815 came to know about the defeat of Napoleon at the battle of Waterloo before it was known to others. It is said that this information helped him to make a fortune. In this context Thomas A. Stewart (2001) rightly says that industrial age was knowledge based too and the results of inventions such as steam engines, radio and telephones were based on this concept (PP XI). In the present day scenario these inventions would be classified under human centered assets.

Intellectual Capital

Intellectual capital or Intellectual assets are two words mentioned frequently in the present knowledge economy. The word 'CAPITAL' or 'ASSET' suffix to 'INTELLECTUAL' is not used in strict accounting terminology. It may be noted that the meaning of both the terms is the same. The components of intellectual capital can be classified under four heads. They are 1.Human Centered Assets 2.Intangible Assets 3. Market Assets and 4.Tangible assets. It is apt to recall the observation of Stephen E. Little (2002) on knowledge creation in a global context: "The speed of technical and infrastructural changes in business practice together with a new understanding of the centrality of intangible assets to wealth creation has brought the Silicon valley Paradigm of innovation to prominence (PP 369).

Knowledge Harvesting

The world 'Harvesting' generally applies to agriculture and refers to the practice of increasing the yield of cultivable land. In the same way organizational Intellectual asset is considered as equivalent to Cultivable land, where the employees' wisdom is the 'Manure'. With the help of employees' wisdom, the knowledge management process is developed by making use of the Intellectual assets of an enterprise. 'Knowledge Harvesting' means an integrated set of processes that capture the often hidden insight of human expertise in business. Just as individual skills are acquired through practice over a period of time, so are the skills of an organization developed and sustained only through experience.

Codification of Knowledge

It may be interesting to note that major portion of corporate knowledge is in employees' brains and documents. They are not easily shareable. Knowledge harvesting process is needed for making it shareable. The output of knowledge harvesting is the codification of Human centered assets in business enterprises. This is required to be stored in information systems. This creates value for business enterprises and it belongs to them. Further it has to be used for guidance and decision making. All critical decisions recorded will help to create Meta knowledge for adopting changes in business. The importance of reuse of intellectual capital can be understood from the statement of David E. Smith (2000) who says that reuse of intellectual capital is possible only when leveraging the experience of others who are not on the current team in an organization (PP XI).

New Brand of Professionals

Recent convergence of information and communication technologies has come to be termed as ICT. Professionals associated with these technologies are known as ICT Professionals.

STEPS IN CREATION OF KNOWLEDGE HARVESTING SYSTEM

Case Illustration

ROA Software Ltd was started two decades ago by a group of software professionals at Madras in India. Their area of operation mainly related to development of application software in the financial services sector across the globe. They have specialized in the segments such as Portfolio Services, Financial Services and Risk Management in Financial Sectors. Their approach has been to develop software on the basis of the business practice followed in the financial sector of the country concerned. It is because of this approach the members of the software development team have acquired good knowledge of their software. If any changes had to be carried out for any client, their efforts would be minimum. ROA Software Ltd has been considered as reliable and dependent IT solution provider in the global market. Their market share has been 75% and they were considered as market leaders. The policy of the company has been to group five project teams as one SBU (Strategic Business Unit). There are 7 to 10 such SBU's in every country wherever they have their business. Each SBU has its own team of Domain and Functional experts and software, hardware and telecommunication professionals. It has been the responsibility of the head of SBU to generate income for their operations. Capital Investments decisions are taken at head office and the funds are organized by them for acquisition of assets.

In recent times they have started feeling the impact of competition due to globalization policy followed by many countries. Consequent to this many of their seasoned employees have started leaving them to avail themselves of the various opportunities available in the global market. Knowledge gained and developed by them was lost due to their exit. The management has realized that a solid and ongoing system is required to archive the human centered assets and to have methods in place. This proposed system is expected to help their employees to share the knowledge that has been developed internally over a period of time. The management has created a task force consisting of senior executives who have rich experience in the business related to Portfolio Services, Financial Services and Risk Management in financial sector.

Observations of the Task Force

The task force has studied the existing practices, procedures and methods at various SBUS. They have also assessed the utilization of the resources such as Hardware and Software. They had interaction with the Domain and Functional experts, and ICT professionals at the SBUS. Their observations have been that neither knowledge nor the resources have been shared among the different SBUS in the same country. There has been no method to capture the knowledge and experience of their employees either by manual documents or electronic mode. While explaining culture and its relationship to knowledge Joseph M.Firestone and Mark W.Mcelroy (2004) state that to realize full value of the organizations' knowledge resource, if it is required culture in the organization has to be changed (PP 261).

Action Plan from the Task Force

The task force has created a core team. This team will consist of Domain and Functional experts, Human knowledge codifiers and ICT Professionals. The Core team has initiated the steps for creating knowledge harvesting system by integrating the components of Intellectual capital at ROA software Ltd. Table 1 – explains the components of Intellectual capital at ROA software Ltd. While establishing relationship between knowledge intensity and process complexity, Amrit Tiwana (2001) divides the business process in three phases such as Translation based, Activity based and Knowledge oriented base (PP 45-46). The core team identified the business activities in the countries of their operation as market assets. The three segments of the business activities in the financial sector have been classified under intangible assets. The various experts at ROA software Ltd are

Table 1. Intellectual capital at ROA Software Ltd.

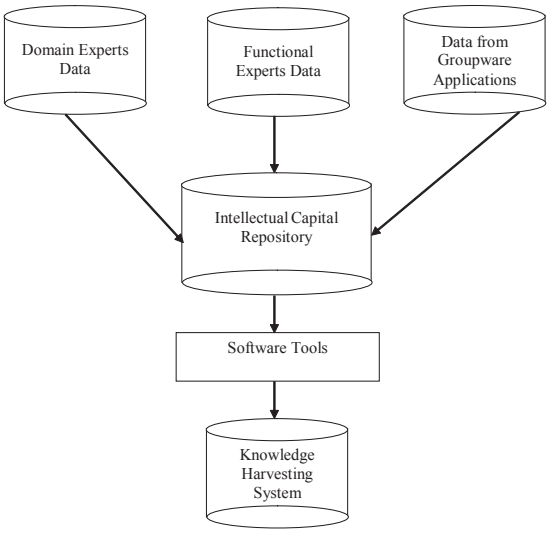
MARKET ASSETS
• BUSINESS ACTIVITIES IN • WESTERN COUNTRIES • ASIAN COUNTRIES • MIDDLE EAST COUNTRIES
INTANGIBLE ASSETS
• PORTFOLIO SERVICES • FINANCIAL SERVICES • RISK MANAGEMENT IN FINANCIAL SECTOR
HUMAN CENTERED ASSETS
• DOMAIN EXPERTS • FUNCTIONAL EXPERTS • KNOWLEDGE CODIFIERS • ICT PROFESSIONALS
TANGIBLE ASSETS
• HARDWARE • SYSTEM SOFTWARE • APPLICATION SOFTWARE

grouped under Human Centered assets. The elements needed for the process of their business activities are considered as tangible assets.

Role of Core Team

While understanding the importance of human-Centered assets, it would be apt to recall the observation of Arnold Kransdorff (1998) on sustaining internal knowledge: "One of the first things to do is to create a simple 'KNOWLEDGE MAP' that identifies an organization's key individuals whose functions and experiences are considered important for the smooth running of the business. In identifying them, the broad rule of thumb is: would we be in trouble if these people fell under a bus? (PP33). The role of Domain experts is to provide inputs for creating database in their areas of business activities at ROA software Ltd i.e.; Portfolio services, Financial services and Risk management. Their inputs will be based on their knowledge and experiences in their areas of specialization. The functional experts will explain the procedures, methods and practices followed in the above business activities and stored in a database. The Core team has decided the employees who are in the middle level management will be designated as knowledge workers. The core team has insisted that all interactions among the knowledge workers, Domain and Functional experts should be stored in a database by using Groupware software. Further the core team selected a group of knowledge workers who have created impact in their area of work have been given the responsibility as knowledge codifiers. ICT Professionals would design a system on the basis of the inputs provided by the other members of the core team. This design is termed as ROA Knowledge Harvesting System.

Figure 1. ROA knowledge harvesting system



System Software for ROA Knowledge Harvesting System

Information Technology is providing many concepts to face the new realities in the present business scenario. Data warehouse and Groupware are among a number of other concepts provided by information technology. Data mining is a software tool needed to make use of Data warehouse. The core team has decided to make use of the above software.

Data Warehouse

There are different definitions of Data warehouse. The essence of these definitions is extraction of the data from the legacy systems in enterprises, integrating it with the external data for analysis purpose. It can be inferred that the purpose of Data warehousing is (1) To slice and dice through data (2) To ensure that past data is stored actually (3) To provide one version of data (4) To operate analytical purpose and (5) To support the decision process. It may be noted that data warehouse is a central store of data that has been extracted from operational data.

Groupware

While describing the groupware applications Kate Ehrlich (2001) says: "Groupware Applications provide computer support for group work. At a general level, group work includes written and spoken communication, meetings, shared information and coordinated work. Some group work occurs where people interact with each other at the same time (SYNCHRONOUSLY). Face-to-face meetings are an example of people working together at the same time and often in the same place. People can also work together at different times (ASYNCHRONOUSLY). Where people leave messages in electronic mail, the communication occurs over a period of time. (PP138).

Data Mining

While explaining about Data mining PIETER ADRIAANS and DOLF ZANTINGE (1996) say that there is confusion about exact meaning of the terms 'DATA MINING' and KDD (Knowledge Discovery in Databases) among many authors and they regard them as synonymous (PP 79 – 81). At the first international KDD conference in MONTREAL in 1995, it was proposed that the term 'KDD' be employed to describe the whole process of extraction of knowledge from data. In this context knowledge means relationship and patterns between data elements. It was further proposed that the term 'Data mining' should be used exclusively for the discovery stage of the KDD process. While talking on KDD process they observe four types of knowledge can be distinguished. They are:

- **Shallow knowledge:** The information can be easily retrieved from databases using a query tool such as Structured Query Language (SQL)
- **Multi-Dimensional Knowledge:** The information that can be analyzed using online analytical processing tools.
- **Hidden Knowledge:** The data can be found relatively easily by using pattern recognition or machine learning algorithms
- **Deep knowledge:** The information stored in the data warehouse can only be located if we have a clue that tells us where to look. It is interesting to note the example given on 'CUE' in knowledge in organization by John Sparrow (1998) who says how courts have tried to formulate definitions of retrieved cues. In legal theory anything that actually refreshes a witness's memory may be used (PP171-172).

ROA Knowledge Harvesting System

Fig 1 –ROA Knowledge Harvesting System gives an overview of the system created by ICT professionals. The knowledge codifiers will coordinate and organize to codify the data from the three databases and store them in Intellectual Capital Repository. Data Warehouse software is used for Intellectual Capital Repository and Knowledge Harvesting System.

The intellectual asset repository is developed from Domain experts' data, Functional experts' data, and data from Groupware applications. This repository is the result of the application of Human centered assets on intangible and tangible assets at ROA software Ltd. The knowledge harvesting system is created by using the Software Tool (Data mining) on Intellectual Capital Repository.

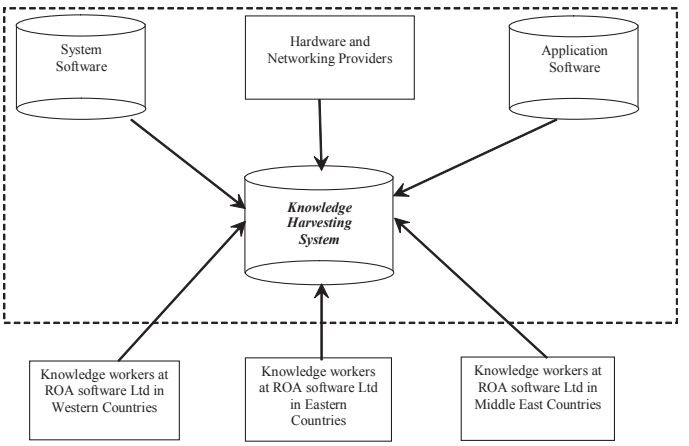
IMPORTANCE OF ROA KNOWLEDGE HARVESTING SYSTEM

The knowledge harvesting system developed at ROA Software Ltd is to facilitate the knowledge workers to understand the business process, procedures, discussions and decisions in their business activities. This system is the result of their knowledge coders who have strong ideas about knowledge to be grouped, classified and defined in their Intangible assets such as Portfolio Services, Financial Services and Risk Management in Financial Sector. The knowledge workers will tend to explore the knowledge in the system in terms of how it can be related in the context of their business activity. Further this system illustrates how business, ICT and human elements are integrated. This system ensures ROA Software Ltd to face the complex situations in the present globalization scenario.

GLOBALISATION SCENARIO

It may me noted that the concept of globalization has created virtual organizations. Further business requirements are also changing at rapid phase. Likewise ICT is also emerging with new concepts with an increase in computing power

Figure 2. ROA resource model



and communication capability. 'Grid Computing' is one more emerging concept provided by ICT. Virtual organization and Networking are the main elements in Grid Computing.

This concept has helped ROA Software Ltd making use of their intangible and tangible assets, and human centered assets across the globe. The knowledge workers have taken advantage of time difference for making use of the resources available at their offices in the respective countries. It enables them in minimizing capital and operational expenditure. The Fig 2 – ROA Global Resource Model explains how the resources at ROA Software Ltd are being used by their knowledge workers from their respective countries. This model facilitates to control and coordinate resources sharing and problem solving among knowledge workers across the countries of their operations. Sharing of resources range from simple file transfer to complex and collaborative problem solving among knowledge workers at ROA Software Ltd. The enormous competitive pressure in the International Market the knowledge workers at ROA Software Ltd can get, is advice and guidance for decision making from the human centered assets from any part of the world through this model.

CONCLUSION

Knowledge Harvesting System is not a Centralized database that contains all the information known by an organization. Business insight comes from capturing knowledge and giving it greater meaning through its relationship to the other information in business enterprises. ROA Software Ltd has illustrated how Knowledge Harvesting System can be developed applying Human Centered Assets in an organization from Tangible Assets. The important elements such as Market Assets and Intangible Assets are described as focal area on which the entire ROA Knowledge Harvesting System relies. It is interesting to note the observation of George Friedman, Meredith Friedman, Colin Chapman, John S. Baker Jr. (1997) who say that: "The core decision in every intelligence project is: How much time do you want to buy – where do you want to be on the knowledge curve?" (PP53).

REFERENCES

1. Amrit Tiwana (2001). Knowledge Enabled Relationship Management, The Essential Guide to Knowledge Management, Addison Wesley Longman (Singapore) Pte Ltd, New Delhi, pp 45 – 46.
2. Arjan Raven (2003). Team or Community of Practice, In Cristina B.Gibson and Susan G.Cochen (EDS), Virtual Teams that work, Jossey – Bass A Willey Imprint, Sanfrancisco, pp 292.
3. Arnold Kransdorff and Russell Williams (2000). Swinging Doors and Musical Chairs in James W. Cortada and John A. Woods (EDS), The Knowledge Management Year Book, 2000-2001. Butter Worth Heinemann, Boston, pp 399.
4. Arnold Kransdorff (1998). How to sustain the Internal Knowledge Chain in a Flexible labour Market, Corporate Amnesia, Butterworth Heinemann, Oxford pp 33.
5. David E. Smith (2000). (ed), Introduction, Knowledge Groupware and the Internet, Butterworth Heinemann, Boston, pp XI.
6. Friso Den Hertog J & Edward Huizenga (2000). Knowledge Development, The Knowledge Enterprise, Imperial College Press, London, pp 87.
7. George Friedman, Meredith Friedman, Colin Chapman and John S.Baker Jr (1997) Space, Time, Money. The Intelligence Edge, Crown Publishers Inc, Random House Inc (published in USA), pp 46-54.
8. Janine Nahapiet and Sumantra Ghosal (2002). Social Capital, Intellectual Capital and the Organizational Advantage, In Chun Wei Choo and Nick Bontis (eds) The Strategic Management of Intellectual Capital and Organizational knowledge, Oxford University press, Oxford, pp 673.
9. John Sparrow (1998). Focusing on specific kinds of mental material, Knowledge in Organizations, Sage Publications Ltd, London, pp 171-172.
10. Joseph M.Firestone and Mark W. Mcelroy (2003). Knowledge Management and Culture, Key Issues in the Knowledge Management, Butterworth Heinemann, Burlington, pp 261.
11. Kate Ehrliceh (2000), Designing Groupware Applications: A work centered Design Approach, Knowledge Groupware and the Internet, Butterworth Heinemann, Boston, pp 138.
12. Mary Crossan and John Hulland (2002). Leveraging knowledge through Leadership of Organizational Learning in Chun Wei Choo and Nick Bontis (Eds), The Strategie Management of Intellectual Capital and Organizational knowledge, Oxford University Press Oxford, pp 714-715.
13. Melissa M.Appleyard (2002). How Does Knowledge Flow? , In Chun Wei Choo and Nick Bontis (Eds) The Strategic Management of Intellectual Capital and Organizational knowledge, Oxford University Press, Oxford, pp539.
14. Pieter Adriaans and Dolf Zantinge (1996). Setting up a KDD environment, Datamining, Addison Wesley Longman Ltd, Harlow, 1996, pp 79-81.
15. Stephen E. Little (2002). Conclusion: Managing Knowledge in a Global Context, Stephen E.Little Paul Quintas and Timray (Eds) Managing Knowledge, Sage Publications Ltd, London, pp 369.
16. Thomas A. Stewart (2001). Forward, the wealth of knowledge, Nicholas Brealey Publishing, London, pp XI.

Information Technology Outsourcing: An Institutional Theory Approach

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ABSTRACT

The study explores factors contributing to adoption of information technology outsourcing (ITO). The focus is on adoption of ITO as a management innovation. The research model is motivated by institutional theory. The model posits that it is the fit among two factors that determines the adoption rate of ITO services: (1) institutional profile- propensity to adopt by a firm is influenced by factors such as prestige level of the firm, educational level, support from senior management and firm size; and (2) field level characteristics such as intensity of competition, density of inter-firm connections, service professionalization, skilled staff availability, knowledge codification in the field, and effort level by intermediaries in promoting legitimacy of ITO.

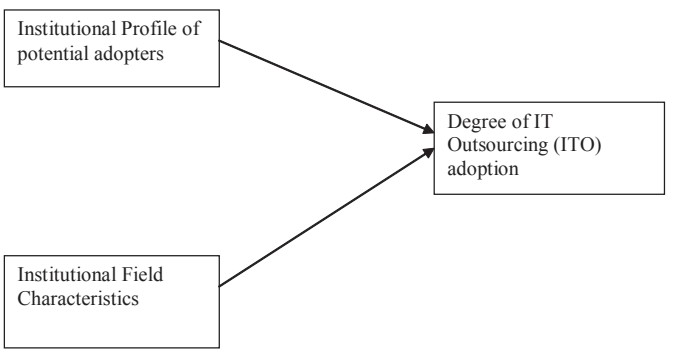
1. INTRODUCTION

Information technology outsourcing (ITO) is the contracting of a specific business task relating to development and management of IT to a third party service provider (Yourdon 2004). The service provider is then responsible for the day-to-day development, management, running and maintenance of the delegated task. The study investigates factors contributing to adoption of ITO. The research model is based on institutional theory (Scott 2001). In the paper, ITO is viewed as a management innovation that incorporates new procedures and routines in the management process (Hamel 2006).

The focus of this research is on adoption of ITO as a new idea. Our model (Figure 1) posits that it is the fit among two independent variables that determines the adoption rate of an innovation- the dependent variable. The two factors are:

1. Institutional profile: Damanpour (1991) listed following positive characteristics- size, professionalism, and specialization. Institutional theory has emphasized prestige level of firms (Sherer and Kyungmook 2002) and CEO background as crucial variables (Scott 2001).
2. Institutional field level characteristics such as competitive intensity, density of inter-firm connections, information flow, and the role of intermediaries such as professional associations, and consultants in promoting the legitimacy (DiMaggio 1991) of ITO as an institutional norm.

Figure 1. The basic model



The rest of the paper is organized as follows. In the next section, we discuss the issue of ITO as a form of management innovation. In section 3, the issue of institutional profile of a potential innovator is discussed. Section 4 outlines the institutional field level characteristics that are relevant for ITO adoption. Finally, we conclude in section 7.

2. ITO AS A MANAGEMENT INNOVATION

Afuah (2003) describes innovation in the context of for-profit firms as "the use of new knowledge to offer a new product or service that customers want". Similarly, according to Porter (1990, pg 780), innovation for for-profit firms is "a new way of doing things that is commercialized". In a more general vein, innovation for organizations has simply been defined as, " the adoption of ideas that are new to the organization" (Downs and Mohrs 1983). Rogers (2003, pg 12) provided a more general definition of innovation in the context of both individuals and organizations as "an idea, practice, or object that is perceived as new by an individual or other unit of adoption."

Hamel (2006) in a current article defines management innovation as a "marked departure from traditional management principles, processes, and practices or a departure from customary organizational forms that significantly alters the way management is performed. Put simply, management innovation changes how managers do what they do". In the context of firms in the western countries, outsourcing strategic IT services (such as new systems development) and functions (such as IT infrastructure management relating to networks and data services) to service providers from developing nations is a departure from what managers are wont to do. Role and responsibilities of managers alter considerably as important elements of management are farmed out to third party vendors abroad. In the context of this paper, outsourcing of services is taken as a form of management innovation on the part of firms as institutions.

3. POTENTIAL INNOVATOR PROFILE OF ITO CLIENTS

In institutional theory, institutions are patterns of social behavior (Breit and Troja 2003). In social sciences, patterns of interest are social norms, routines of behavior, legal regulations and distributional systems of power and resources (Breit and Troja 2003). In this paper, the terms institutions and organizations are used interchangeably.

A basic tenet of institutional theory is that institutions seek "legitimacy" in the eyes of both internal and external stakeholders (Parson 1960). Institutional theory attempts to explain why institutions of the same type, "such as schools and hospitals, located in widely scattered locales so closely resemble one another?" (Scott 2001). A key concept here is that of isomorphism- resemblance among institutions in terms of structures (DiMaggio and Powell 1983). Considerable evidence of such isomorphism has been provided by Slack and Hinnings (1995).

The theory has mostly focused on the "movement towards, and maintenance of, isomorphic institutional environments". Focus on institutional evolution and change has been weak (Powell 1991). However recent studies on birth, evolution, and diffusion of new institutional norms in the business sector have tried to mitigate this (Greenwood et al. 2002, in business services). Even though mimetic, coercive and normative forces drive institutions towards isomorphism, not all organizations in a field are alike.

Kondra and Hinnings (1998) provide a typology of institutions based on their degree of fit and institutionally defined performance norms. Their typology consists of: institutional operators, equifinalists, renegades and dogs.

- Institutions that have a high fit with both norms of operations and performance levels are called "institutional operators". Much of a field is likely to be populated by institutional operators.
- Institutions that operate differently but have performance that are within norms prevalent in the field are called "equifinalists".
- Institutions that are performing well above institutional norms are called "Renegades"
- Institutions performing below institutional norms are called "dogs". Dogs are likely to be weeded out due to lack of legitimacy in the field and are not likely to have any impact on institutional norms. There is no incentive to mimic these organizations.

Renegades according to Kondra and Hinnings (1998) are firms that are performing well above institutional norms. They may include firms that are new entrants to the field, and are able to have a novel operational model as they have not been subject to forces of isomorphism for long. They could also be existing firms that have deviated from norms knowingly (active agency) or unknowingly (passive agency). Organizations that are weakly bound to field norms are more willing to risk transgression of norms and operate in a manner that allows superior performance.

In organizational innovation literature, Rogers (2003, 411) describes organizational innovativeness as a dependent variable dependent on independent variables such as leader characteristics, internal characteristics of an organization such as size, complexity, and similar factors. Our model for predicting organizational propensity to innovate in the managerial field is shown in figure 2.

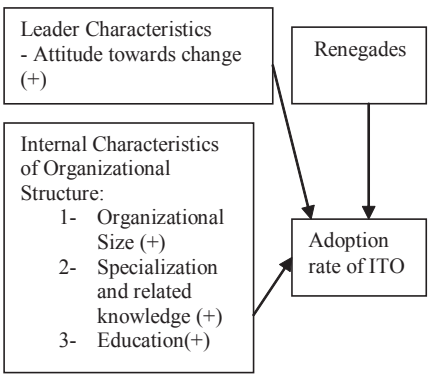
Renegades
By definition, firms that are star performers are likely to be "renegades" as their performance level is above field level norms.

Proposition 1a: Renegade firms are more likely to adopt outsourcing than non-renegade firms, and in turn act as exemplar for others in the institutional field.

Leader's Characteristic: Attitude Towards Change
IS research literature is replete with evidence that top management's support is crucial for technology adoption (Chatterjee et al. 2002).

Proposition 1b: More positive the attitude of top management towards outsourcing, greater the potential adoption rate of ITO related services .

Figure 2. Institutional profile variables related to adoption rate of ITO



Organizational Characteristics—Organizational Size
Mahler and Rogers (1999) found that organizational size, revenue, and people employed are positively correlated with telecommunication technology adoption. Sherer and Lee (2002) show that large law firms are more likely to adopt innovative HR practices.

Proposition 1c: Greater the organizational size, greater the potential adoption rate of ITO related services .

Organizational Characteristics—Specialization and Knowledge Diversity
Kimberely and Evanisko (1981) ascribe innovativeness of organizations to specialization in related activities.

Proposition 1d: Greater the specialization and knowledge employees have related to outsourcing, greater the potential adoption rate of ITO related services.

Organizational Characteristics—Education
Pierce and Delbecq (1977), and Fichman (2001) relate education to professionalism and thereby to ability to innovate.

Proposition 1e: Greater the employee education and training level in the firm, greater the potential adoption rate of ITO related services .

4. INSTITUTIONAL FIELD CHARACTERISTICS

There are three levels of analysis in institutional theory (Chiasson and Davidson 2005). Lowest level is that of a single institution. That is the main focus of institutional theory. The second level is that of population, which is a set of similar institutions that is entities that "produce similar products and services, operate is similar environment, share systems of meaning, and take actions that are influenced by shared normative, cognitive and regulatory structure" (Scott 2001). Then we have the level of institutional field which "includes those organizations that in the aggregate, constitute a recognized area of institutional life; key suppliers, resources and product consumers, regulatory agencies and other organizations that produce similar services and products" (DiMaggio and Powell 1983).

The field constitutes an environment, a material environment and an institutional environment. The material environment and also called the technical environment, provides (Chiasson and Davidson 2005, Scott 2001):

- demand side factors such as complexity, and variation in demand for product and services,
- the supply-side factors provide factors such as scarcity and concentration of key inputs,
- technologies provide skills and knowledge to produce outputs, including material technologies and
- market structure that includes alignment of suppliers and customers that influence flow of resources.

The institutional environment provides (Chiasson and Davidson 2005, Scott 2001):

- Institutional logic, that is, organizing principles underlying practices and belief systems.
- Institutional actors, which includes individuals and organizations that create and enact belief systems
- Governance systems, the system of regulatory and normative control

DiMaggio (1991) characterizes institutional fields in terms of dimensions related to professionalization (Larson 1977), and dimensions related to structuration (Giddens 1979). In terms of professionalization, Dimaggio (1991) listed factors such as (i) creation of body of knowledge, (ii) organizations of professional associations, and (iii) consolidation of a professional elite. He used these factors to demonstrate how the Carnegie Corporation facilitated the development of the organizational field of U.S. Art Museums.

More recently, we have IBM promoting the concept of service and process management and helping universities such as North Carolina State University

to come up with the first MBA program in the field (http://www.mgt.ncsu.edu/news/2006/mba_ssme.php dated 01/31/2006). One of the major sub-field in the proposed area is that of managing vendors engaged in outsourcing activities- "emphasizing the management of relationships between service providers and their clients". IBM had similarly helped consolidate the subject of Computer Science in 1960s, helped develop their many professional associations and encouraged universities to provide degrees in the subject and thus populate the professional world of computer science. This professionalization helped in legitimation of the subject and its subsequent widespread use in sciences, businesses and engineering (previous web site).

Proposition 2a: Creation of a body of knowledge, organization of professional associations and consolidation of a professional elite in the field of IT outsourcing will help in legitimation of the subject and its correspondent institutional forms, which in turn will promote its diffusion.

Motivated by Giddens (1979), DiMaggio (1991) suggested following structuration variables impact the development of an institutional field and its subsequent impact on institutional members: (i) density of inter-organizational contacts, (ii) rate of flow of information, and (iii) emergence of a center-periphery structure. Coleman (1939), showed how increasing contact among member museums led to smaller museums adopting professional methods. Lawrence et al. (2002) and Phillips et al. (2000) show the importance of information flows in fields for institutional effects to occur.

Proposition 2b: Increasing density of contacts, information flow and emergence of center-periphery structure leads to an institutional field exercising more influence on its members in the field of ITO adoption.

Following are the institutional actors in the material environment (Scott 2001) that are of interest to us:

1. Competitors and Customers
   Haveman (1993) and Clemons (1990) point to imitation effect in firm behavior in the airline and banking industry.

Proposition 2c: Greater pressure and influences from competitors and customers will leads to greater adoption rate of ITO services.

2. Suppliers and vendors
   Burt (1982) and Markus (1987) point to pressures from dyadic channel. Teo et al. (2003) find effect of suppliers on a firm's intention to adopt inter-organizational systems.

Proposition 2d: Greater assistance and influence from outsourcing suppliers and vendors will lead to greater adoption rate of ITO services.

3. Government Agencies and Trade Associations:
   King et al. (1994), and Teo et al. (2003) find evidence that participation in industry, trade associations and with government sanctioned bodies constitute pressure on a firm.

Proposition 2e: Greater positive influence from mass media, professional networks, and government agencies will lead to greater adoption rate of ITO services.

5. CONCLUSION

The purpose of this study is to explore factors contributing to adoption of ITO outsourcing (ITO) by firms in western countries. The focus is on adoption of ITO as a management innovation. The research model is motivated by institutional theory (Scott 2001).

The model posits that it is the fit among two factors that determines the adoption rate of ITO services: (1) innovator profile- propensity to adopt by a firm is influenced by factors such as prestige level of the firm, educational level, support from senior management and firm size; and (2) field level characteristics such as intensity of competition, and density of inter-firm connections, and effort level by intermediaries in promoting legitimacy of ITO, professionalization of outsourcing services, availability of managers skilled in ITO vendor management and knowledge codification in the field.

The ITO vendor community has a major role to play in enhancing popularity and legitimacy of outsourcing activity in western countries to third world country vendors. They need to follow IBM's role in this regard. The vendor community should attempt to reduce the initial learning cost in adopting this innovation on the part of customers. There are many steps that the vendor community can take in the country of operations. They can promote courses, programs of study, case studies, and industry projects in the outsourcing field in business schools, universities, and in the training industry. By helping outsourcing management achieve an identity as a subject and specialization, and promoting availability of study and training in the area, they will foster creation of a pool of outsourcing professionals that can be employed in both customer and vendor side. Easy availability of trained staff in outsourcing area will help in reducing initial adoption costs. Availability of courses, seminars, books and cases will lead to outsourcing activity getting legitimized within the community, and thus promoting its acceptability and popularity. ITO vendors are also advised to recruit sales staff from the community they will be selling to, as this will help overcome the initial reluctance on the part of firm owners and managers to deal with people with different cultural background.

REFERENCES

Afuah, Alan (2003), Innovation Management, Oxford University Press, Oxford, UK.

Briet, Heiko and Markus Troja, (2003), Institutional Change and Social Learning in Environmental Contexts: An Introduction, in How Institutions Change-Perspectives on Social Learning in Global and Local Environmental Contexts, edited by Heiko Breit, Anita Engels, Timothy Moss and Markus Treja, Leske and Budrich, Opladen 2003.

Burt, R. S. (1982), Towards a Structural Theory of Action: Network Models of Social Structure, Perceptions and Action, Academic Press, New York.

Chiasson, Mike W. and Elizabeth Davison, (2005), Taking Industry Seriously in Information Systems Research, MIS Quarterly, vol. 29, #4, pp. 591-605.

Chatterjee, Debabroto, Rajdeep Grewal and V. Sambhamurthy (2002), Shaping up for E-Commerce: Institution Enablers of the Organizational Assimilation of Web Technologies, MIS Quarterly, vol. 26, no. 2, pp. 65-89.

Clemons, E. K. (1990), MAC-Philadelphia National Bank's Strategic Adventure in Shared AM Networks, Journal of Management Information Systems, vol. 7, #1, pp. 5-25.

Damanpour, F. (1991), Organizational Innovation: A meta-analysis of effects of determinants and moderators. Academy of Management Journal, vol. 34, pg. 555-590.

DiMaggio, Paul J., (1991), Constructing an Organizational Field as a Professional Project: U.S. Art Museums, 1920-40, in The New Institutionalism in Organizational Analysis, edited by Walter Powell and Paul DiMaggio, University of Chicago Press, Chicago.

DiMaggio, Paul J. and Walter W. Powell (1983), The Iron Cage Revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields, American Sociological Review, vol. 48, pp. 147-160.

Downs, G. W. and L. B. Mohr (1983), Conceptual Issues in the study of innovation, Administrative Science Quarterly, vol. 21, pg. 700-714.

Fligstein, Neil (1991), The Structural transformation of American industry: an institutional account of the cause of diversification of large firms, 1919-1979, in The New Institutionalism in Organizational Analysis, edited by Walter Powell and Paul J. DiMaggio, pp. 311-336, University of Chicago Press, Chicago.

Fichman, Robert, (2001), The role of Aggregation in the Measurement of IT-Related Organizational Innovations, MIS Quarterly, vol. 25, #4, pp. 401-429.

Giddens, Anthony, (1979), Central Problems in Social Theory: Actions, Structure, and Contradictions in Social Analysis, University of California Press, Berkeky, CA

Greenwood, R., R. Suddaby, and C. R. Hinnings, (2002), Theorizing Change: The Role of Professional Associations in the Transformation of Institutionalized Fields, Academy of Management Review, vol. 45, #1, pp. 55-80.

Hamel, Gary, (2006), Why, What and How of Management Innovation, Harvard Business Review, February 2006, pp.72-84.

Haveman, H. A., (1993), Follow the Leader: Mimetic Isomorphism and Entry into markets, Administrative Science Quarterly, vol. 38, #4, pp. 593-627.

Kondra, Alex Z. and C. R. Hinnings, (1998), Organizational Diversity and Change in Institutional Theory, Organization Studies, Winter 1998.

Kimberley, J. R., and M. J. Evanisko, (1981), Organizational Innovation: The Influence of Individual, Organizational, and Contextual factors on Hospital Adoption of Technical and Administrative Innovations, Academy of Management Journal, vol. 24 #4, pp. 689-713.

King, J. L., V. Gurbaxani, K. L. Kraemer, F. W. McFarlan, K. S. Raman, and C. S. Yap, (1994), Institutional Factors in Information Technology Innovation, Information Systems Research, vol. 5, #2, pp. 139-169.

Larson, Magali Sarfatti, (1977), The Rise of Professionalism: A Sociological Analysis, University of California Press, Berkeley.

Lawrence, Thomas B., and Hardy (2002), Institutional Effects of Inter-organizational Collaboration: The Emergence of Proto-Institutions, Academy of Management Journal, vol. 45 #1.

Mahler, Alwin, and Everett M. Rogers (1999), The Diffusion of Interactive Communication Innovations and the Critical Mass: The Adoption of Telecommunication Services by German Banks, Telecommunications Policy, vol. 23, pp. 719-740.

Markus, M. L. (1987), Towards a Critical Mass Theory of Interactive Media: Universal Access, Interdependence and Diffusion, Communications Research, vol. 14, #5, pp. 495-511.

Parsons, Talcott, (1960), A Sociological Approach to the Theory of Organizations, pp. 16-58, in Structure and Process in Modern Societies, edited by Talcott Parsons, Free Press, Glencoe, IL.

Phillips, N., T. B. Lawrence and C. Hardy, (2000), Inter-Organizational Collaboration and the Dynamics of Institutional Fields, Journal of Management Studies, vol. 37, pp. 23-43.

Porter, M. E. (1990), The Competitive Advantage of Nations, Free Press, New York.

Pierce, J. L. and A. L. Delbecq, (1977), Organizational Structure, Individual Attitudes, and Innovation, Academy of Management Review, vol. 2, pp. 23-37.

Rogers, Everett M., (2003, 1965), Diffusion of Innovation, Free Press, New York.

Scott, Richard W., (2001), Institutions and Organizations, Sage Publications, Thousand Oaks.

Sherer, Peter D., Kyungmook Lee, (2002), Institutional Change in Law Firms: A Resource Dependency and Institutional Perspective, Academy of Management Journal, February, vol. 45 #1.

Slack, Trevor and Bob Hinnings, (1995), Institutional Pressures and Isomorphic Change: An Empirical Test, Organization Studies, vol. 17, #5, pp. 803-827.

Teo, H. H., K. K. Wei, and I. Benbasat (2003), Predicting Intention to Adopt Inter-organizational Linkages: An Institutional perspective, MIS Quarterly, vol. 27, no. 1, pp. 19-49.

Yourdon, Edward, (2004), Outsource- Competing in the Global Productivity Race, Yourdon Press.

File Valuation in Information Lifecycle Management

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ABSTRACT

Information Lifecycle Management (ILM) stores files according to their value. Therefore file valuation is a very important task in the ILM environment. In this paper we look at how the value of a file can be measured. Instead of traditional methods leading to a classical decimal-value, the method presented leads to a valuation in terms of a "probability of further use". Feasibility of the new method is verified using an ILM simulator.

1. INTRODUCTION

ILM is based on the idea that in an enterprise different information have different values. Valuable information is stored on systems with a high quality of service (QoS). The value changes over time and therefore migration of information is required to cheaper storage systems with a lower QoS. Automated migration makes ILM dynamic. Such automation requires storage systems to understand what files are important at what time so that right policies can be applied. In this point ILM nowadays lacks information valuation methods and tools.

The question is "How is the value of a file measured?". Storage Network Industry Association (SNIA) proposes measuring the value as an amount of money [1].

Other methods express the value as a decimal-value [2]. In section 3 we show how this type of value can be derived from a set of metadata. This method of valuation depends on different factors and has to be defined accurately. Obtaining metadata is not always easy or even possible. Therefore in section 4 we abandon metadata and show how the value can be derived using a probabilistic method. Here the value of a file is calculated from usage information and expressed as a probability of further use. This is a new method which allows valuation depending on the future importance of a file. Section 5 proves the capabilities of the new method using an ILM-simulator. Section 6 applies and combines both methods. The paper ends with a summary and an outlook on our future work.

The essence of this paper is as follows:

1. We present a new method of file valuation
2. We show that this probabilistic method works for ILM systems
3. We combine the new with an "old" method to optimize the performance.

2. RELATED WORK

Usage information is used for valuation in other system domains as well. Google uses PageRank algorithm to rank the importance of a web page [3, 4]. A page is ranked based mainly on how many other pages are linked to it. Such links represent a form of usage. They indicate how many other pages are using that particular page. Caching algorithms often rely on data usage information to determine what data are important and hence what to cache in buffers in file systems, databases, and storage controllers [5, 6, 7]. These algorithms cannot be directly applied to our problem due to different design purposes and different target data.

Usage was the focus of Strange, too, who examined the long-term access behaviour on files in an UNIX system [8]. His aim was to identify regularities and patterns which can be applied to automated migration strategies for Hierarchical Storage Management (HSM).

Schmitz has also analyzed the access behaviour of files on a supercomputer to be able to derive an optimal migration strategy [9].

Miller and Gibson examined the access behaviour in further studies in UNIX environments and designed a "file aging algorithm" as a migration rule [10].

The self-* storage system at Carnegie Mellon University aims to automate storage management tasks through self-managing techniques [11]. It describes how one can classify files based on the automatic learning of file properties using decision tree algorithms.

Chen focused on the file valuation for ILM. He erects value classes which are characterized by a unique set of attributes [2]. The valuation leads to a decimal value which can be normalized to the interval [0;1].

In contrast to other work the valuation presented in this paper offers a percent value. It demonstrates how great the probability of future accesses on a specific file is. Based on the percent value an ILM system can migrate files when their access probability falls below a predefined threshold.

3. FILE VALUATION USING METADATA

Metadata are data that describe other data. Therefore, in general, for accurate valuation the more metadata is useable the better the valuation will be. Relevant, but not limiting, factors for ILM are [12]:

- Legislation
- Cost
- User
- File size
- File type

This list could be extended to factors representing the value of knowledge and intellectual properties [13, 14]. These business focused valuation methods require intense human interaction and organizational support. Hence they are often hard to implement.

The five factors mentioned above have different characteristics. For example, some are steady others are discrete, some are string variables others are real variables.

To obtain the information a form has to be filled in. This needs human interaction and makes it difficult and expensive to receive the metadata. Nonetheless we discuss the parameters represented as a mapping which can be implemented into an online form. We will now consider each factor.

Legislation: Each file in an enterprise has its own file retention period. In Germany the period can vary between 0 and 10 years. In the American healthcare environment, for example, the period can be up to 100 years [15].

Let L(F) be the file retention period of file F determined by legislation. L(F) is a discrete function:

$$L(F) : F \mapsto L(F) \in \{0,1,2,5,10\} \subset N_0$$

Cost: Each file is important for the enterprise. Its importance is related to the cost originated from the absence of this specific file. Business importance is expressed in a currency (e.g. Dollar or Euro). Either the real value or a relative value is used.

Real values are difficult to obtain. Here the relative value is used. The value might vary between 0 and 10.000.

Let C(F) be the cost originating from the absence of file F. C(F) is a steady function:

$$C(F): F \mapsto C(F) \in [0;10.000] \subset R_0^+$$

User: Each file is intended to be used by specific users within the enterprise. If this factor is to be used for valuation, the users' importance is distinguished between "low", "medium" and "high".

Let U(F) be the intended user group of file F. U(F) is a discrete function:

$$U(F): F \mapsto U(F) \in \{low,\ medium,\ high\}$$

File size: The size of a specific file can be used as a factor for valuation, too. The intention is to reduce the needed space on the expensive storage hierarchies. Therefore there is a special focus on large files which represent a great capacity-saving potential. The file size is finite and varies between the values "small", "medium", "big" and "very big". Depending on the enterprise the thresholds are set, e.g. between "big" and "very big" it can lie at 1MegaByte or much higher [9].

Let S(F) be the size of file F where S(F) is a discrete function:

$$S(F): F \mapsto S(F) \in \{small, medium, big, very\ big\}$$

File type: The file type is determined by the application. In the office environment the most common file types are, for example, "doc", "xls" and "ppt".

A case study conducted in 2004 at an enterprise database identified 21 different file types with the following composition [16].

Let T(F) be the file type of file F where T(F) is a discrete function:

$$T(F): F \mapsto T(F) \in \{doc, xls, ppt, pdf, rest\}$$

Depending on the enterprise other file types like e.g. "jpg" or "mpg" can be assigned, too.

The five factors are summarized to a vector to derive the value of a file. Let V(F) be the value of file F where V(F) is an n-dimensional function (here n=5). It takes into consideration the factors "legislation", "cost", "user", "size" and "type" and determines the value as a decimal figure. The value is used to assign the files to the different hierarchies in an ILM environment.

$$V(F): F \mapsto V(F) =$$
$$V(L(F)\ C(F)\ U(F)\ S(F)\ T(F)) \in R_0^+$$

Currently V(F) is only a theoretical mapping. The definite procedure to derive the value from the vector consists of transformations and normalizations. First the string variables (U(F), S(F) and T(F)) are transformed to real variables. Then the real variables are normalized to [0;1].

At the end the n-dimensional vector is reduced to a one-dimensional figure. This might happen by simple actions like:

$$V^* := \max\ \{L^*, C^*, U^*, S^*, T^*\}^1 \in [0,1] \text{ or}$$
$$V^* := \text{mean}\ \{L^*, C^*, U^*, S^*, T^*\} \in [0,1]$$

This shows that the valuation using metadata works. The advantage of this type of valuation is that no history information is needed. On the other hand, this procedure is neither easy nor cheap.

4. FILE VALUATION WITHOUT METADATA

Instead of metadata we now uses usage information for the valuation process. This procedure results from one of the most intuitive metrics for file valuation "if a file is not used for a long time, it is not valuable".

In a case study on a database we provided following results [16]: There were more than 150,000 files on the system and 89 percent of them were not accessed 90 days after creation (see figure 2).

The intuitive method for valuation would lead to the following policy:

"A file is valuable if it has been accessed during the last 90 days and not valuable otherwise."

This is a simple way of measurement and one often used in HSM (Hierarchical Storage Management) solutions. It demonstrates that a simple history-based valuation without metadata has a wide-spread acceptance.

Nonetheless this method does not fit to ILM because it only focuses on time limits and not whether the file is needed in the business process which is the intention of ILM [1].

Figure 1. Distribution of file types

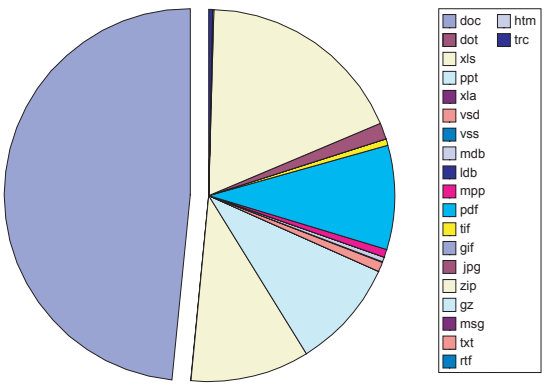


Figure 2. Access probability

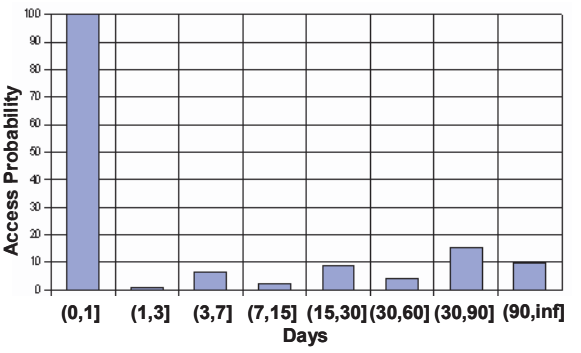


Table 1. Applied distribution functions

Number of accesses / File type	1-6	7-14	15-∞
doc	W(0,35;3,5)	G(0,32;183)	W(0,35;3,5)
xls	W(0,25;1,1)	W(0,25;1,1)	W(0,25;1,1)
ppt	W(0,38;14,3)	W(0,38;14,3)	W(0,38;14,3)
pdf	W(0,35;3,5)	G(0,32;183)	W(0,35;3,5)
other	W(0,46;27,7)	G(0,29;181)	W(0,46;27,7)

4.1 Case Study

We conducted another case study with the intention of obtaining a predictable measurement of whether or the file is needed in the future.

Our aim was to derive mathematical distribution functions for file accesses for several file types.

We took a sample of 1,000 files from a company's database.

Each file was characterized by the number of accesses per file, the size of the files, the size of the accesses, the age of the files, as well as the file types and access methods.

The file types doc, xls, ppt, pdf and zip are contained most frequently in the sample. The file types avi, cfg, csv, cti, dot, exe, gif, htm, jpg, log, mdb, mmap, mmp, mp3, mpg, mpp, pps, pst, rtf, sql, tif, trc, txt, vsd, vss, wav, wbk, wf2 and xml fall into the category "other".

Most accesses to files in the sample, i.e. 46.22 % of 7,911, are of the "version fetched" type. The access types "View" and "Version added" are represented with 19.20 % and 17.60 % at second and third place. Other frequently occurring access types are "Move", "Reserve", "Unreserve" and "Permission changed". The noticeably more seldom access types under "Miscellaneous" are "Attributes Changed", "Rename", "Copy", "Version Deleted", "Alias Created" and "Generation Created".

We derived distribution functions for file accesses in conjunction with the file type and access history [17]. Either the Weibull-distribution (W(α;β)) or Gamma-distribution (G(α;β)) were derived as distribution functions (see table 1).

Using this approach we were able to calculate the future access probability of a file.

The valuation is executed on a percentage basis: "A file is valuable if its access probability is higher than, e.g., 5% and not valuable otherwise".

This is a new quality of valuation using only the file type and the access history. This information is provided by the storage systems and does not need further metadata or user interaction.

5. PROOF OF CONCEPT

We implemented a simulator to analyse that the valuation based on "percentage of further accesses" can be used for ILM. Figure 3 shows an example using 5 hierarchies observed over 4,000 days. The lifecycle is illustrated graphically for one single file.

In figure 3 you can see that between day 1,300 and day 1,500 after generation of the file the access probability sinks remarkably. Therefore the file is moved to the lowest storage hierarchy in several steps. After approximately 1,800 days the file is accessed so that it must be shifted to the highest storage level again.

After about 3,800 days the information is again at the lowest level. The lifecycle follows the typical course of a file with a periodical access sample.

A graphic evaluation does not make sense for the simultaneous analysis of several files. Therefore examination of the relative capacity-need per hierarchy has to be performed.

Figure 4 depicts how an ILM system with 3 hierarchies and the described valuation works.

Figure 3. Migration of a file according to its value measured in "% of further accesses"

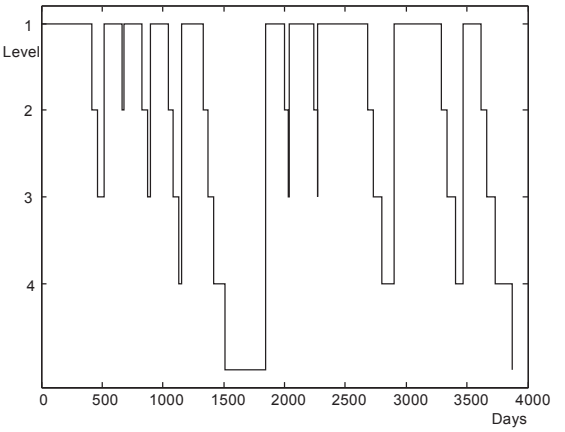
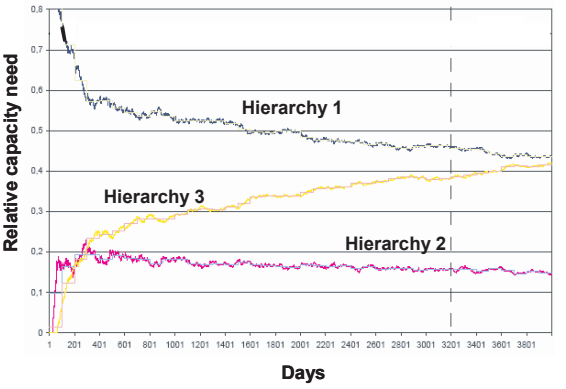


Figure 4. Relative capacity-needs in a 3-dim. ILM system



Since the method looks at the access history, it needs some time to stabilize the capacity-need in an ILM system.

6. COMBINATION OF THE DERIVED VALUATION METHODS

When metadata is available, it is advisable to use it in combination with the probabilistic method. Since the effort in dealing with metadata is quite high, it is advisable to use metadata only for the initiation of an ILM scenario.

There are two options for initiating an ILM scenario (see figure 5):

Option 1: Store all files on the highest hierarchy at the beginning.
Option 2: Valuate all files and presort them into the related hierarchy at the beginning.

Option 1 does not require metadata, of course. The files are stored in the highest hierarchy. Their valuation is done on the basis of file access patterns during the ILM process as shown in figure 4.

The advantage of option 2 compared to option 1 is that the capacity need for hierarchy 1 is below 100% from the beginning. This means that money is saved earlier on.

Figure 6 shows a simulation run in which the files were presorted according to option 2.

We notice that presorting has positive effects on reaching system stability.

Figure 5. Starting options in an ILM system

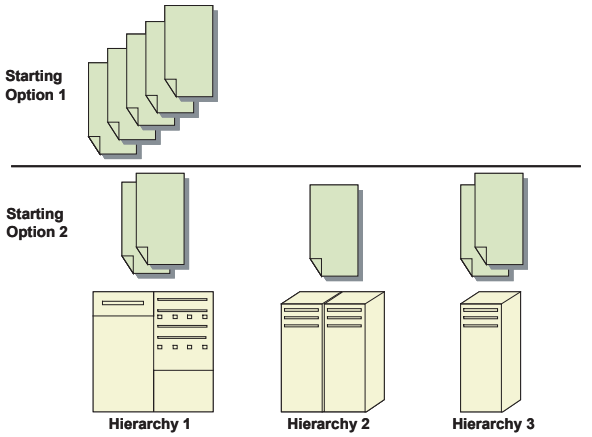
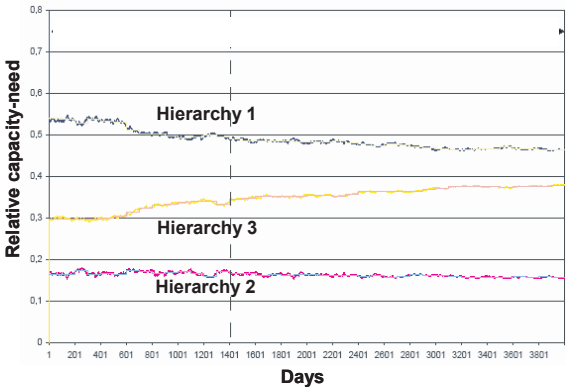


Figure 6: Relative capacity-needs in a presorted 3-dim. ILM system



7. SUMMARY AND OUTLOOK

Proper information valuation is the first step towards ILM automation. Existing valuation methods either use metadata or look at the history and generate a value in terms of "amount of dollars" or "a decimal figure within an interval".

We demonstrated that the future access of a file can be predicted from observed access data and that this can be used as a metric for file valuation.

The value of a file is its percentage of further accesses. This is a new way of valuation. The advantages are that it is simple, does not need metadata and fits to ILM automation. Furthermore it is more sophisticated than the simple HSM-time-limit approach.

Application of the new method was shown by means of an ILM simulator. Therefore the first step towards automation is done.

Since the method looks at the access history, it needs some time to stabilize the capacity-needs in an ILM system.

This period can be shortened by presorting the files over the hierarchies. We showed that in combination with an initial valuation according traditional methods using metadata earlier cost gains in ILM-systems can be achieved.

In our future research we will continue to look at ILM automation. We will focus on the aspect of policy definition. In order to compare different policies, the existing simulator will be optimised.

REFERENCES

[1] Peterson, M.: ILM Definition and Scope - An ILM Framework, SNIA Data Management Forum, Version 2.3, July 2004

[2] Chen, Y.: Information valuation for Information Lifecycle Management. In: Proceedings of the Second International Conference on Autonomic Computing (ICAC'05), pages 135-146, 2005.

[3] Page, L., Brin, S., Motwani, R. and Winograd. T.: The pagerank citation ranking: Bringing order to the web. http://dbpubs.stanford.edu:8090/pub/1999-66, 1999.

[4] Ridings, R. and Shishigin, M.: PageRank Uncovered. http://www.voelspriet2.nl/PageRank.pdf, 2002.

[5] Denning, P. J.: The working set model for program behavior. Communications of the ACM, 11(5), 1968.

[6] Denning, P. J. Working sets past and present. IEEE Transactions on Software Engineering, SE-6(1):64–84, 1980.

[7] Effelsberg, W. and Haerder, T.: Principles of database buffer management. ACM Transactions on Database Systems, 9(4), 1984.

[8] Strange, S.: Analysis of Long-Term UNIX File Access Patterns for Application to Automatic File Migration Strategies. Technical Report UCB/CSD-92-700, EECS Department, University of California, Berkeley, 1992.

[9] Schmitz, C.: Entwicklung einer optimalen Migrationsstrategie für ein hierarchisches Datenmanagement System. Technischer Bericht, Forschungszentrum Jülich GmbH, 2004.

[10] Gibson, T. and Miller E.: An Improved Long-Term File-Usage Prediction Algorithm, 1999.

[11] Mesnier, M., Thereska, E., Ganger, G. R., Ellard, D. and Seltzer, M.: File classification in self-* storage systems. In Proceedings of the First International Conference on Autonomic Computing (ICAC-04), New York, NY, May 2004.

[12] Turczyk, L. A.: Information Lifecycle Management: Organisation ist wichtiger als Technologie, Information Wissenschaft & Praxis 2005, Heft 7, S. 371-372

[13] Sveiby, K. E.: The balanced scorecard (bsc) and the intangible assets monitor – a comparison. http://www.sveiby.com/articles/BSCandIAM.html, 2001.

[14] Strassmann, P. A.: The value of computers, information and knowledge, January 1996.
http://www.strassmann.com/pubs/cik/cik-value.shtml,

[15] Public Law 104-191, Health insurance portability and accountability act, August 1996.
http://www.hipaadvisory.com/REGS/law/index.htm,

[16] Turczyk, L., Gostner, R., , Heckmann, O. and Steinmetz, R.: Analyse von Datei-Zugriffen zur Potentialermittlung fuer Information Lifecycle Management, TU Darmstadt KOM Technical Report 01/2005

[17] Turczyk, L. Groepl, M., Heckmann, O. and Steinmetz, R.: Statistische Datenanalyse von langfristigem Dateizugriffsverhalten in einer Unternehmensdatenbank fuer ILM, TU Darmstadt KOM Technical Report 01/2006

ENDNOTE

[1] * indicates that transformation and normalization have been executed

Enhancing User Interactive Experience Through Diasporic Reception

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ABSTRACT

This paper focuses on the notion of interactivity and how ideas from outside the field of interaction design can expand the understanding and application of interactivity. Interactivity is generally seen as the user's ability to easily access information. For certain writers and practitioners, however, the idea of interactivity extends to user's capacity to shape content and meaning to extend the range of experience in digital media contexts. Using a combination of theoretical discussion, the research explores the second perspective, proposing a mode of interactivity that supports user's capacities for reflexivity and intervention. In the wake of poststructuralism, computer and digitally networked technologies are seen to challenge traditions of stable, a priori authorship by allowing users to construct meaning from the range of available content. Anthony Giddens's writings on human reflexivity support the idea of the 'knowledgeability' of human agents, that is, their capacity to understand the nature of their circumstances and to act upon them. Theories of diasporic reception argue that visualities produced by diasporic individuals reveal critical reflexivity in the mixing of cultural meanings and materials. The research draws on these ideas to suggest the importance of allowing users to experience autonomy, agency and self-determination in digital media contexts.

Keywords: interactivity, digital media, knowledgeability, diasporic reception, agency

INTRODUCTION

Most new media programs promise a high level of interaction and a richness of experience, ranging across animation, graphics, music, sound, text and video. The concept of interaction covers the connection between interface, content, computer and user. Implicit in its meaning is the idea of reciprocal exchange between users and content, suggesting that one will have an effect on the other and vice versa. For the majority of digital media designers, however, successful interactivity comes when design elements enhance browsing experience and access to content. According to Carrie Heeter, for example, design should make interaction an easy rather than a difficult process (Heeter 2003). Although clarity of meaning, accessibility and ease of use are important elements of interaction design perhaps the real promise of interactivity lies in its unpredictable dimensions. Interactivity can represent an open, creative process of content engagement. Navigation systems, for instance, should not force users into a path-following, choice-making state of mind. This represents a loss of self and limits the range of unfolding, on-screen possibilities. By contrast, Nathan Shedroff contends that the ability to formulate new content or new ways of interacting with content is critical to adding a creative dimension to the interactive experience (Shedroff 1999). As technology develops it is likely that many more dimensions of interactivity will become available, allying multimedia products more closely to human creative and conceptual capacities. Moreover, the pace and scale of change in information and communication technologies, combined with the possibility and complexity that comes with media convergence, suggest that although the nature of future technology resists prediction, designers must constantly reflect on their approach to interaction if they wish to harness design to emerging technological capabilities and human needs.

Presently, the fields of usability testing and computer studies, especially Human Computer Interfaces (HCI), dominate investigations into interaction and interface design, using empirical methods to understand user's reactions to interface design and to test the effectiveness of specific products. These fields favour the stringent analysis of phenomena without the intrusion of enquirer's subjective judgments. The rise of scientific methodology in modern, technocratic society has given rise to the tendency to dismiss anything that cannot be open to empirical scrutiny, including aesthetic principles, emotional responses and taste preferences. The broad consequences of this have been the creation of putative rules for interaction design, which insist that designers keep things as simple as possible in the design of the graphical user interface (GUI). Recently, designers including Nathan Shedrofff and John Lenker have advanced the idea of 'experience design', arguing that for design to be effective as mass communication it must offer more than simple, practical approaches to the presentation of information in a digital context by satisfying audiences at an aesthetic, emotional and social level (Lenker 2002). Designer's capacity to invent alternative models of interaction and interface design could open up new possibilities in the use and experience of information technology in an age where knowledge is a vital commodity and society regards the capacity to identify, create and apply useful knowledge as crucial skills.

In seeking to understand the potential of interaction design it is vital not to simply fix and control it, thereby limiting the range of human experiences and capacities in the digital realm. This paper explores how interaction design can create the conditions which allow individuals to experience new levels of engagement with content, shifting the focus from path finding and selection to the user's ability to create content and meaning. It brings multi-disciplinarity to the discussion of interaction design, believing that to develop new design possibilities it is necessary to 'think outside the box' and challenge existing paradigms. Although interactivity should continue to provide effective paths and comprehensible information structures it should also prioritize models that generate meaningful experiences and empower users.

INTERPRETATIVE AUTONOMY AND DIGITAL MEDIA DESIGN

My interest in the interpretative autonomy of users evolved from the idea that audiences, rather than senders, construct meaning. According to Roland Barthes' classic essay 'The Death of the Author', writing transcends the author, focusing on the reader's response, rather than the author's intentions. (Barthes 1977). A founding statement of postmodernism, 'The Death of the Author' overturned common understanding of cultural texts by encouraging open interpretation. Barthes' essay encapsulated many ideological dimensions, arguing that an author is not an integral "person" but a subject, constituted through society and history, which does not exist, outside language. He maintained it is writing—itself a product of society, history and ideology—that makes the author. On this point, Barthes wrote, "The writer can only imitate a gesture that is always anterior, never original. His only power is to mix writings ... in such a way as never to rest on any one of them" (Barthes 1977). Many see the interactive hypermedia environment as realizing Barthes' radical agenda, which liberates meaning from the tyranny of singular authorship. A reader's capacity to follow individual paths, through text and information, which do not conform to linear order, mirrors the way reading affects writing; allowing the user to so engage, suggests empowerment.

Poststructuralism sees meaning as generated within language, which symbolically constructs the reality we experience from a storehouse of existing meanings. Judith Butler describes this conception of language as a process of reiteration (Butler 1993). She accepts that in speaking or writing individuals conform to established meanings, and other rules and conventions of language, reinforcing the semantic construction of the world and the speaking subject. While the subject does not create meaning, and is largely an effect of the language practices used when speaking or writing, Butler identifies the possibility that new or changed meanings emerge in the process. For Butler, reiteration incorporates inherent

contextual shifts of meaning through the specific combinations of meanings and the temporal and social context in which reiteration occurs. She argues that the process of reiteration slowly but inescapably changes meanings, resulting in the continual renovation of language as old meanings adjust and new meanings emerge. For Butler the transformation of language derives from the fact that it is a social system in continuous use, the iteration of meaning through time and space molding the sense of things in ways that nobody can control or predict.

Rethinking interactivity involves developing an expanded concept of receptivity in new media communication. British social theorist, Anthony Giddens' 1984 book *The Constitution of Society: Outline of the Theory of Structuration* offers ideas for rethinking the nature and process of interaction, as well its design concepts and strategies. Giddens emphasizes the capacity of social agents for self-reproduction, self-transformation and self-deconstruction (Giddens 1984). His primary contention is that social patterns and structures do not exist, outside of individual agents, who continually reproduce or change them, making them simultaneously enabling and constraining. He emphasizes the active and reflexive characteristics of human conduct, stressing that in modern society, individuals and institutions encompass high reflexivity. Giddens' theory of modernity sees qualities of reflexivity informing the knowledgeability of human agents, monitoring self-action and correcting self-behavior, which depends on consciousness of complex social relations when judging or adjusting actions (Giddens 1984). For Giddens, this was extended to the way we construct ourselves.

Communications studies, which explores the way users negotiate the media of the World Wide Web through hyperlinks, also advances ideas of active readership and user agency, suggesting that browsing behavior should not be viewed as a passive process. For example Joyce (1995) defines hypertext as a medium that 'embodies information and communications, artistic and affective constructs, and conceptual abstractions alike into symbolic structures made visible on a computer-controlled display'. While these qualities may be implicit in the process of negotiating linked content interaction design has a clear role to play supporting users to initiate a whole range of actions, to structure their own paths following their interests, affecting the unfolding of events.

DIASPORIC RECEPTION

So far I have argued that Roland Barthes's idea of the illusory nature of authorship, Judith Butler's idea that iteration inevitably and inexorably shifts meaning, and Anthony Giddens's idea that individuals have the capacities of reflexivity to understand and act upon the structures they encounter in life, suggest the potential for an expanded view of interactivity in new media contexts. Even though these ideas are not addressed to the subject of interaction and interface design they have challenged me to formulate the fundamental proposition of this research, that to fulfill the promise of interactive multimedia (IMM) products should facilitate diverse modalities of meaning and experience.

Feminist, post-colonial and other theories of identity have valorized the critical and imaginative power of decentered subjectivity. Theories of diasporic reception argue that social and cultural context are basic frameworks of meaning, the translocation of cultural materials across boundaries of space, time, race, culture, language and history actively disrupting meaning. For Kate McFarlane, diasporic experience incorporates qualities of syncretic visuality that 'are multiperspectival and frame-breaking and exist in that provisional and productive site of diasporic in-betweenness.' (McFarlane 2004) She suggests that the reading of culture from different temporal and geographic locations involves the grafting and juxtaposing of multiple modes of visuality. In addition, she argues that 'this syncretic diasporic intervisuality often displays, through its intercultural mixing of modes of visuality, an attitude of irony and critique as regards the relations that exist between power, visuality, ethnicity and nationalism.' (McFarlane 2004) The 'multiperspectival' operations of diasporic cultural reception incorporate a reflexive or creative dimension that shifts ways of seeing and reading cultural objects because the subject is inclined to patterns of interpretation and identification grounded in dialectics of past and present, here and there. The reception of cultural texts particular to diasporic negotiations of cultural identity and meaning reflects the increasing fragmentation and dispersal of points of reference in an era of globalization. Julia Kristeva, in fact, argues 'we are all in the process of becoming foreigners in a universe that is being widened more than ever, that is more than ever heterogeneous beneath its apparent scientific and media-inspired unity' (Kristeva 1991).

Structuration theory and ideas of diasporic visuality, that is instances of critical looking bound up in seeing things from a different cultural context, describe orders of reception that go well beyond the basic idea that all cultural materials are intertextual because audiences filter them through their different experiences and cultural literacies. In highlighting the complexity and ambiguity of contemporary subjectivity and the critical dimensions of cultural syncretism, theories of diasporic reception challenge new media designers to accept the protean nature of meaning production while embracing the creative agency of users in new media contexts as something positive. Designers may agree in principle that interactivity should support a range of on-screen possibilities that shift the emphasis away from fixed outcomes and offer users the freedom to explore in ways that liberate the intellect and imagination. However, the fundamental challenge is to create designs that allow users to understand interaction as productive, to think consciously about the relationships between linked materials and to visualize the unfolding contours of what might be produced.

RESHAPING MEANINGS IN DIASPORA AND HYPERMEDIA ENVIRONMENTS

In an age of globalization meaning is inevitably negotiated between cultures. Globalization challenges designers to draw on the diverse sources of knowledge and understanding encapsulated in different cultures in order to expand on general understandings of design. In 1985 Eisner raised the idea of 'aesthetic modes of knowing', seeing creative activity as a form of reflective practice that allowed people to make sense of things. Diasporic visuality may be a prime example of the effects that Eisner writes of, the work of diasporic visual artists revealing a capacity to reconstitute culture and meaning in critical ways. According to McFarlane (2004), 'diasporic visuality involves the deployment of tactics such as syncretism, irony, juxtapositioning and intercultural aesthetic cross-hatching which operate collectively to enact both the specificities of diasporic cultural identity and a cultural politics which challenges exclusionary norms of nationalist subjectivity and culture.' McFarlane sees cultural identity as being reconstituted in ways that escape contemporary cultural structures and understandings because of their complex and dynamic nature. Diasporic visuality is embedded in interpretative processes where individuals and communities attempt to understand their identity by negotiating a path between their present circumstances and their cultural roots. Consideration of this showed it was possible to develop a critical relationship to identity and this became intrinsic to the form and content of the project, which aimed for a much richer experience of interaction based around reflexive ways of seeing, knowing and understanding.

As Butler suggests, the iteration of meaning is a continual occurrence in a culture and society that produces new cognitive positions and fresh ways to conceive the world. For Butler, iterative processes draws attention to the absence of essential, natural or ideal categories of meaning prior to each appearance within a causal chain, suggesting only continual shifts between pre-existing categories and new representations (Butler 1997). Postcolonial theory and theories of diasporic visuality challenge the division of the world into simple opposites. Both emphasize the individual and the cultural diversity of diasporic and colonized peoples, suggesting that while such individuals may stand apart as a group from their colonizers or from original populations, they are different one from each other despite their shared pasts, and should not be seen in a singular sense.

McFarlane argues that diasporic intervisuality can produce ironic outcomes, critically reflecting on the relationships between power, visuality, ethnicity and nationalism (McFarlane 2004). The dimension of 'play' challenges traditional ways of seeing and reading in digital media environment, positioning the user as an active producer of content. For McFarlane, diaspora can be experienced both as a dynamic tension and as a space of opening in which issues such as the narratives and visualizations of nation and the politics and stylistic consequences of diasporic interventions into cultural practices can be explored (McFarlane 2004). The potential of interactive multimedia to facilitate multiple viewpoints, double consciousness, differential pathways and in-betweenness is high if designers move beyond the current paradigm of clear communication and efficiency of use, replacing hierarchical patterns of use defined by the designer with interpolating experiences based around provisionality of meaning and the productiveness of users.

CONCLUSIONS

This paper has sought to redefine the nature and purpose of interactivity in digital media contexts, principally by thinking about the idea of user power. In this it has drawn substantially on theoretical ideas concerning the reflexivity of social subjects, especially the critical imagination bound up in diasporic visuality. Arjun

Appadurai (Appadurai 1996) characterizes the workings of the contemporary imagination as both a form of labour and a potential conduit for individual resistance, arguing:

No longer mere fantasy (opium for the masses whose real work is elsewhere), no longer simple escape (from a world defined principally by more concrete purposes and structures), no longer elite pastime (thus not relevant to the lives of ordinary people), and no longer mere contemplation (irrelevant for new forms of desire and subjectivity), the imagination has become an organized field of social practices, a form of work (in the sense of both labor and culturally organized practice), and a form of negotiation between sites of agency (individuals) and globally defined fields of possibility. (Appadurai 1996)

In an age of mass information and communications, individual acts of the imagination are routinely mediated by digital technology while the use of information and communications technology is more or less synonymous with citizenship in many nations. Developments of this scale reinforce the need for interface and interaction designers to keep pace with social and technological change on at least two levels. At the most basic, *inter*active mediums imply input and effort on the part of the user that product developers need to harness in the most effective ways. The question that I have pursued in this study is whether the empirical concepts of effectiveness delivered to design from the fields of usability and HCI should be supplanted by more complex models of the role of the user that merge consumption with production and understand effectiveness more in the sense of whether the interactive experience is compelling.

In redefining the potential for user agency in IMM contexts, new media designers could do well to take account of evolving concepts of the audience in media studies, where, as Elihu Katz (Katz 1996) argues, New theories of the audience maintain that viewer's add value to what they view. Going far beyond functional theories of media use, they proclaim the competence and creativity of the individual. They suggest that viewers do work—not just by staying awake, but by investing effort, by being critical, by making "public" (Katz 1996). This research has speculated on the potential for this to happen through the theoretical discussion from different field of studies, outlining the current limitations in the understanding of interactivity and then using ideas of critical reflexivity and diasporic visuality to encourage designers to unleash the potential creativity and productivity implied in user interaction processes.

REFERENCES

Appadurai, A. (1996) *Modernity at Large: Cultural Dimensions of Globalization*, , University of Minnesota Press, Minneapolis .

Barthes, R. (1977) 'The Death of the Author' in Stephen Heath trans. *Image-Music-Text*, Fontana Paperback, Fontana.

Butler, J. (1993) *The Psychic Life of Power: Theories in Subjection*, Stanford University Press, Stanford.

Eisner, E. (1985) 'Aesthetic modes of knowing', in E. Eisner, (ed.), *Learning and teaching the ways of knowing: Eighty-fourth yearbook of the National Society for the Study of Education*, Chicago University Press, Chicago.

Giddens, A. (1984) *The Constitution of Society: Outline of the Theory of Structuration* ,Polity Press, Cambridge.

Heeter, C. (2003) 'Interactivity in the Context of Design Experiences', *Journal of Interactive Advertising*, vol. 1, no. 1, [online], http://jiad.org/vol1/no1/heeter/

Joyce, M. (1995) *Of two minds: Hypertext pedagogy and poetics*, University of Michigan Press, Ann Arbot.

Katz, E. (1996) 'Viewer's Work' in James Hay, Lawrence Grossberg and Ellen Watella (eds.), *The Audience and its Landscape*, Boulder, Westview Press, pp. 9-21.

Kristeva, J. (1991) *Strangers to Ourselves*, quoted by Zhang, 'Identity in diaspora and diaspora in writing: The poetics of cultural transrelation', *Journal of Intercultural Studies*, vol. 21, no. 2, August 2000, p. 137.

Lenker, J. C. (2002) *Train of Thoughts: Designing the Effective Web Experience*, New Riders, Indianapolis.

McFarlane, K. (2004) 'Diaspora, cultural Practice and Syncretic Visuality', *Journal of Intercultural Studies*, vol. 25, no. 2, p. 175- 184.

Shedroff, N. (1999) Information Interaction Design: A Unified Field Theory of Design' in Robert Jacobson (ed.) *Information Design*, The MIT Press, Cambridge.

ENDNOTE

[1] For a more developed discussion of this see Huyssens, 'Back to the Future: Fluxus in Context', in Armstrong and Rothfuss, In the Spirit of Fluxus, Minneapolis, Walker Art Center, 1993, pp. 140–151.

IT Educational Challenges for the Internet Generation

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INTRODUCTION

The Net (Internet) generation generally refers to those children born between 1986 and 2000. Although there are different opinions on the exact current age range of the Net generation, it is well accepted that the first waves of these youngsters are already on university campuses (Internet Generation, 2006). The Net generation is expected to trigger major challenges in the educational process, especially in IT education.

The Net generation has been brought up among edutainment, and expects learning to be fun. They are avid users of computer and Internet, and are much less tolerant of boredom than previous generations. They exhibit no fear for computers and feel no need for computer literacy training. They probably have experienced and even master technology that baffles many instructors of the current generation. They are accustomed to search information on their own and expect instant feedback. They learn just in time, and are less willing to memorize information as a necessary part of the leaning process. They will not hesitate to turn to powerful computational machines to complete tasks, and they are well aware of the limitation of textbooks. The Net generation will be less inclined to follow a curriculum, simply digest bundled knowledge, and equate hard work with learning (Hay, L.E. (2000).

EDUCATIONAL CHALLENGES FOR THE NET GENERATIONS

The Net generation grew up with technology, and in certain ways more technically savvy than instructors who are slowly adapting to the "new" technology. They were accustomed to high-speed interactive communication, and quickly lose interest in the gradual dispensation of small doses of knowledge. The instructional method of sequential presentation of information embedded in traditional textbook could be ineffective for this generation.

Members of the Net Generation acquired keen ability to find resources on the Internet. They were equally at ease at the crafty assembly of freely adopted excerpts from the web toward the formation of research reports (Smith, 1999). Many perceived the web as the whole of Internet and the world of network computing. They also inclined to believe that the Web holds the entire knowledge depository. As such, they habitually based their learning experience outside of the traditional scope of academic knowledge domain, prompting challenges to instructor roles and relevancy of learning goals.

The Net Generation was accustomed to networked microcomputers with little appreciation for the professional computing technology in the world of mainframe and data communication. As end-users of powerful 4GLs, they would amplify the recent trend towards user-developed applications, posting risks in design, development, maintenance, and infrastructure supports for information resources (Barker, 2002). For this new generation, programming is neither desirable nor challenging. The knowledge gap posted threat to the support and usage of core information technology.

Being very comfortable with mobile communication and wireless services, with the broad availability of software and hardware, the Net Generation no long value a full service central computing facility. Many of this generation either own microcomputers, or have easy access to technology. A new challenge in academic computing support shifts to the orchestration of linking compatible technology rather than ensuring the accessibility of standardized technology.

CHANGING IT EDUCATIONAL ENVIRONMENTS

The Net Generation grew up among technology long before they began formal education. Very often, the introductory IT training in school paled in comparison to the sophisticated technology penetrating households. The vigorous disciplining of IT training lost ground to multimedia e-learning. An overabundant supply of technology distorted the perceived needs for further information system development. The Net Generation was more interested in end-user IT issues, than business issues on IT management. A mass failure of IT ventures followed by off-shore outsourcing of technical positions erased the attractiveness of IT careers, draining potential talents from the IT fields.

The widespread availability of application software based on 4GLs drew great interests in end-user IT training. E-learning technology greatly promoted the training opportunity for non-IS professionals, and these end-users eventually assumed primary development responsibility for computer-based applications. Corporate training programs and private trainers filled the void of training needs unfulfilled by university IS programs, which were slow to retool to meet demands for end-user computing training.

On university campuses, multiple disciplines were eager to offer their versions of IT training, leading to the dilution of resources as well as student pool. Indeed, students unprepared for the more vigorous IS program would flee to other programs. The educational attention was shifted from the quality of IT education to the relevancy of IT training. Debates began to arise surrounding standards for technology, rather than the effectiveness of IT education. In many cases, group and department secured exclusive rights to selected areas of IT trainings, feuding and fighting over shrinking student interests.

The diversification of technology deployment in organizations also made it more difficult to train students to meet the expectation of recruiters. Increasingly, firms turned to internal training programs to inject the needed IT skills to the new recruits, thus decreasing the value of IT training from university programs. Changing funding and reward practices drove innovation out from university campuses to high technology industries, widening the technology gap.

New requirements on program assessment prompted IT curricula changes to align instructional activities with measurable student learning outcomes. An effective IT educational program must begin to build on top of the existing skills and knowledge of students. A new generation of technologically literate students challenged the educational effectiveness of existing IT courses.

With an increasing recognition of IT as an essential communication skill, a new influx of demand arose from non-IS students, who were less motivated, and less prepared for vigorous IT training. IS programs encountered new challenges to retool to meet the demands for cross disciplinary IT training.

IT AND KEY EDUCATIONAL OUTCOMES

The Association of American Colleges and Universities specifies five key educational outcomes (Ehrmann, 2004):

1. Strong analytical, communication, quantitative, and information skills
2. Deep understanding and hands-on experience
3. Intercultural knowledge and collaborative problem-solving skills
4. Sense of responsibility
5. Thinking mind and knowledge transfer skills

Information technology assumes a critical role providing tools to facilitate information gathering, analysis, aggregation and finally sharing information with others through various communication channels. It is no longer a specialized tool reserved for the IS professionals, but an essential component in supporting the primary educational outcomes.

IT enhanced problem visualization represents efforts to promoting deep learning in many disciplines. Simulation provides realistic environment for training, and for complex skills development. Digital e-learning tools increase opportunity for hands-on experience at affordable costs. IT tools allow students to be in charge of exploratory learning experience, rather than being constraint to pre-defined, instructor-led, exposure to a limited domain of knowledge.

Powerful networks and conversion tools bring the world to students through their communication devices. IT helps to overcome geographical barriers, national boundaries and cultural presuppositions, supporting free exchanges of ideas and knowledge across the world in matters of seconds. Knowledge and technology transfers enhance a growing trend towards multicultural collaboration.

IT promotes free speech and free communication. New forms of communication channel expose social challenges; increase awareness, thus enhancing informed choices. It is much easier to keep informed about world events, and participate in social activities. Electronic forums and messages are leveling the playing field to allow easy access to a global audience, bypassing intermediaries and filters, providing a far richer communicative environment.

IT ties groups and disciplines together through common tools and communicative habits. Knowledge sharing enhances multidisciplinary approaches to problem solving. The continuous growing deposits of knowledge bases enhance just in time learning, bridging knowledge gaps resulting from specialization and fragmentation of organizations and societies. At the same time, it is challenging for the IS professionals to morph from being IS service providers to become members of learning communities.

IT EDUCATIONAL CHALLENGES

There is a need for IT educators to reexamine the current environment, and refresh IT educational goals. The emerging roles of IT educators can be roughly divided into three areas.

1. Preparing future IS professionals as effective IT providers
2. Nurturing the next generation of IT innovators
3. Training technically savvy IT end-users

Different programs, depending on their available faculty resources, institutional resources, industrial relationships, and ability to attract student talents, may have to make hard choices and begin retooling the IS programs for the Net Generation and future generations of students. For many institutions, the emerging demands for IT training may gradually shift to the last category of training IT end-users.

Preparing the Net Generation for IS Professions

Many IS curricula have been designed to train IS students to develop and construct information systems. The Net Generation will face a world with an over abundant of information systems. There is a great need for skillful workers to adapt existing information systems to support the integration of functional applications. It will be challenging to support training for the large variety of programming languages, especially those for maintaining open source systems. In the future, IS professionals will need to be resourceful besides mastering basic computer skills. On the other hand, the Net Generation, while resourceful, is more inclined to use 4GLs, ignoring the role of basic programming skills and efficient coding. The new generation will be impatient with research methods, and problem solving methodology, quickly turning to powerful information searching tools, and experiential problem solving – trail and error approach.

Many IS programs have invested substantial resources in constructing computer labs and training facility. However the Net Generation is a highly mobile group. The plummeting of computer prices allows many of the new generation to haul around their laptop computer and mobile devices. They have a strong preference for using their own personal computing device for learning and rebel against the restrictive time and location of centralized computing facilities.

The Net Generation arrives college with substantial computing experience, thus shows little interest in the basic computing concepts. They are motivated by the sophisticated applications such as simulations and multimedia tools, which are seldom included in college level curricula. Their prior computing experience could create motivation problems and distort the assessment of learning outcomes.

The lack of knowledge and lack of interest about computing technology outside of the microcomputer based technology present a major challenge to prepare students for workplace where they have to work with those technology. There are limited opportunities for students to gain hands on experience with high-end systems such as ERP, SCM and CRM. The Net Generation could totally ignore the relevancy of these integrative information systems because of the vagueness of these concepts in comparison to attractive simulation and virtual reality gaming software. The knowledge gap limits the career options for the future generation of IS students, who at the same time are expected to spend an increasing portion of their college experience in non-technical studies.

Increasingly, an effective IS professional must be competent in interpersonal communication, organizational management, and the business processes. Numerous IS projects must support initiatives such as those in human resource development, organizational reengineering, and business process improvement. With the increasing integration of IT into the business process, there are increasing needs to address IT strategy and the design of IT architecture. Case studies, project management, system integration, collaboration, multi-cultural team, security and social issues, are examples of the numerous challenges for IS programs to recruit motivated students and produce IS graduates that can quickly fit into the work environment.

Preparing the Net Generation to be IT Innovators

Historically, businesses are the leaders in IT adoption, and thus the driving forces behind IT innovation. IS curricula train students to support the numerous IT projects of business corporations, and maintain their IT assets. IS graduates contribute to centralized IS supporting services. The widespread available of web technologies and inexpensive, yet powerful computers decentralized IS services. Increasingly, businesses realize that it is insufficient to draw customers through powerful technology; they must also learn to accommodate customers who own sophisticated technology and expect businesses to support their IT applications. Many successful business ventures prove that non-technical innovations are just as important as basic IT innovation.

The Net Generation is well tuned in with the recent technology innovation. Early habits of self-reliance make them good candidates for problem-based learning, where they learn by exploration. The potentially richer learning environment can better prepare the Net Generation to be life-long learner, rather than swallowing down blocks of textbook based knowledge. There is the need to equip students with problem solving skills, beyond concepts of system designs.

It will be difficult for the typical IS program to find sufficient funding to provide the IT architecture and technical supports to nurture students to be IT innovators. Many IS programs will have to turn to alliances with businesses to gain access to the expensive IT infrastructure to properly train the next generation of IT innovators. Increasingly, instructors will become coaches or mentors, guiding the learning paths of students, instead of the actual dispensing of IS trainings to students. A new challenge will be for higher educational institution to recognize the new roles of faculty as facilitators. Even more challenging will be to find ways to document student accomplishments, much of which will be proprietary information due to corporate sponsorship.

The traditional assessment methods of testing and quizzing will lose effectiveness, since it will be difficult to find effective measurement for innovative ideas, which take long period of time to prove their value, or the lack of it. The sole assessment by course instructor will also be an incomplete measurement of student growth, especially when students start to work on projects outside of the campus environment. However, these challenges should not prevent the development of new curricula to better align academic and industrial resources to prepare the next generation of IT innovators.

Preparing the Net Generation to be Savvy IT End Users

The widespread adoption of IT creates a new wave of demand for IT education. These are the end-users who do not plan to become providers of IS services, but

have strong interests in IT skills to open up career opportunities, or to prepare themselves for their career of choice. The traditional IS program must compete with other programs sharing the interests in providing IT education. However, IS program could benefit from its current availability of IT resources and IT staffs, supporting easy transition to meet the emerging IT educational needs.

It is challenging to design curricula for end-users. The end-users tend to be practically oriented, and demonstrated little interest in computational theory. A lot of end-users could have prior exposure to application software, and developed bad habits that must be undone through the training process. The end-users come from all backgrounds, and show limited interest in training materials that are designed for business applications. The end-users tend to learn at a slower pace, testing the patient of IS instructors. Lastly, the end-users arrive with different level of computing experience, and expectation, thus requiring flexibility in the curriculum design to accommodate the broader range of prior experience and capabilities. A lot of end-users have work experience, or currently working in an official environment with exposure to IT. The end-user experience challenges the adequacy and currency of IT contents in courses, and requires careful selection of IT architecture and technical supports. The Net Generation exhibits characteristics of end-users.

The Net Generation is intolerant of inferior technology, and antiquated software, which unfortunately remain as the core IT technology for many IS programs due to budgetary constraints. The Net Generation wants mobility, and prefers to center their learning and works around their personal computing devices. A new challenge involves placing software in the computers of the Net Generation at affordable costs. The rapid changing technology also prompts many institutions to take a serious look at refreshing the campus IT technology in short cycles, demanding close coordination between campus technology and academic programs.

The profuse availability of online resources and training opportunities poses another challenge for preparing IT education for the Net Generation. The Net Generation is resourceful enough to find resources superior to contents of most basic textbooks. The IT education of the Net Generation must incorporate Internet resources, and adopt pedagogical approach that takes advantage of the Internet skills of the Net Generation. At the same time, the challenge remains to prove to the Net Generation that core IS theories are necessary components in preparing them to become effective, and technically savvy end-users.

Perhaps one of the greatest challenge yet is to demonstrate to the end-users that college level IS training is delivering additional value beyond the proliferation of IT training opportunities from self-learning tools, online programs, workshops, short courses, and on the job training. This is especially true when students enrolling in IS courses may arrive with expectation inconsistent with the learning objectives of the courses, thus evaluating their learning experience based on the perceived benefits of the course, rather than the achievement of course goals that they are least concern about. As a result, the learning assessment should measure value delivery as well as the relevancy of goals set by the faculty curriculum committee.

Although IS programs can choose not to service the end-user IT educational market, they risk the alienation of end-users who eventually will become the decision makers on IT adoption, and setting paths for the future development of IT. There is a need to bridge the knowledge gap between IT end-users and the IS professionals, so that a healthy collaborative relationship will be maintained, and the IS program can remain its influence on the proper approach to IT education for the future generations.

New challenges arise to position IS programs not merely to prepare providers of IS services, but also as agents to ensure the proper implementation of IT to support educational outcomes, to promote deeper understanding of natural and social phenomenon, to bridge cultural gaps, to expand the scope of learning experience, to enrich insight on relationships and social concerns through IT, and to stimulate thinking and expand knowledge through IT applications

MEETING THE IT EDUCATIONAL CHALLENGES

After the selection of program goals and target student markets, each IT program must also tackle important challenges in five major areas:

a. Curriculum design
b. IT architecture for technical support
c. Pedagogical approach
d. Assessment method
e. Bridging to Workplace competency expectation

A brief discussion of these challenges will follow, and the interested reader is referred to the abundance of literatures in these areas. IS programs is facing the challenge of embracing cross disciplinary IS curriculum design, recognizing that IS innovations could emerge from multiple disciplines. The core IT architecture needs to emphasize connectivity standards rather than maintenance of physical facilities. Learner-based pedagogical approaches will be desirable, and learning outcome assessment will be expected. Students and recruiters will demand relevancy of IT education, and the tight integration of theory with practical applications.

CHALLENGES TO IS PROGRAM TRANSFORMATIONS

Embracing change is a difficult experience, but change is inevitable. There are numerous responses of IS programs to the IT educational challenges. Proposals on IT educational challenges are often reactive to emerging problems. The following discussion will address some of these efforts, and emerging new challenges.

Expansion of Program Offerings

Some IS programs enrich their curricula with new courses, providing more tracks of specialized training for student pursuing different IS careers. However, waning student interests in the IS fields strain the resources of the programs with small enrollments. The increase in the assortment of courses may be insufficient to address a fundamental educational issue – The Net Generation is expecting learning to be fun, meaningful and with immediate success. Some programs turn to Distance Education to attract a broader student base, only to find out that they are attractive students with "Net expectations" – highly competitive costs, customized services, fast response, continuous interaction and sophisticated information supports. Many IS programs and their faculty members underestimate the "Net Challenges".

Merging of Academic Programs

Some institution merged IT related academic programs, consolidating the student pools. The merging of technical programs under one roof could reduce administrative overhead, and eliminate duplication. However, the reorganization may have little impact on promoting cross-disciplinary IT training. Students are merely allowed to select from a consolidated menu, but the Net Generation expects flexible and ubiquitous computing, prompting the reengineering of the educational process. In some cases, merging IS programs into other programs could limit innovation and growth of the IT educational curricula, further widening the gap of technology relevancy of these programs.

Corporate Alliance

A newly rekindled interest in collaboration between academic institutions and business corporations could revive the support for IT education. However, the challenge remains on the acceptance of business sponsored training and research as legitimate academic exercises. Corporate alliance requires the diversion of valuable faculty resource to nurture the relationship, which may interfere with other academic missions, and requires a strong organizational infrastructure to support and sustain. On the other hand, corporate alliance could serve to draw student talents to the IS programs, but at the same time, requiring a shift in the role-play of the IS programs. A key issue is to find a delicate balance in the mix of knowledge versus relevant skills in an academic program.

CONCLUSION

IT education is no longer merely for a small group of individuals seeking careers in IS professions. The omnipresence of IT creates great demand for IT education for people from all walks of life. The Net Generation represents the first wave of students who expects a richer and interesting learning experience. Thus the challenges in IT education are no longer about incremental adjustments of the IT curricula. A fundamental rethinking of IT educational goals, and bold reengineering of the educational process will prepare IS programs for emerging opportunities and new missions for IT education. The globalization process will hasten changes and create multiple missions for IT education for different regions of the world. The Net Generation will not hesitate to seek alternative channels to fulfill educational needs, including crossing the geographic boundaries of IT educational services.

REFERENCES

Barker, S. K. (2002). Training Business Students to be End-User Developers: Are Case Studies the Best Option?, In Khosrow-Pour, M. ed. Issues & Trend of Information Technology Management in Contemporary Organizations, Hershey: Idea Group Publishing, 2002, pp. 62-65.

Ehrmann, S. C. (2004). Beyond Computer Literacy: Implications of Technology for the Content of a College Education, AAC&U. Retrieved September 18, 2006, from http://findarticles.com/p/articles/mi_m0NKR/is_4_90/ai_n1380100

Hay, L.E. (2000). Educating the Net Generation – educational planning for technology-knowledgeable students, American Association of School Administrators. Retrieved September 18, 2006, from http://findarticles.com/p/articles/mi_m0JSD/is_4_57/ai_77204709

Internet Generation. (2006). Retrieved September 18, 2006, from http://en.wikipedia.org/wiki/Internet_generation.

Schlenker, L. H. (2002). The Challenges Facing Higher Education in Training the European Workforce for the Information Society. In Khosrow-Pour, M. ed. Issues & Trend of Information Technology Management in Contemporary Organizations, Hershey: Idea Group Publishing, 2002, pp. 1095-1097.

Smith, C. & Phillips, C. (1999). Are Our Academic Libraries Ready for the Internet Generations?, CAUSE/EFFECT journal, 22(1), 1999.

Portals as a Multidisciplinary Field

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INTRODUCTION

Portals often fall into two major categories: as gateways purposed to consolidate services or applications, or to assist in community building. In the latter case, extensive communication tools (such as instant messengers, event calendars, and forums) facilitate and build networks within the community. It must be noted that these suggested categories do not assume exclusivity – and there are increasing instances of portals that are built for multiple purposes.

Various cases of portals have been studied with their technological applications, software, and business applications for communities and organisations. The portals that have emerged on the web, such as Smart Mobs (http://www.smartmobs.com) and YouTube (http://www.youtube.com), reflect communal identities of communities. There is often a core group of people identifying themselves as part of that community, and a mechanism for contributions from community members, which act to cement the communal identities that people in the community share with one another. This paper argues that the emergence and popularity of portals is not driven by technologies, but more by this sense of communal identity within communities.

Its broader goal is to identify a research agenda for the Community Informatics Research Network (CIRN) in the Asia-Pacific region, using the case of a portal informed by structuration theory and the notion of the knowledge commons, here considered as a virtual space dedicated to the sharing of understanding, memory, and practical know-how.

Through Giddens' structurational theory (1986), the paper first demonstrates how portals provide a sense of collective identity for communities and thereafter cultivate a knowledge commons space within the portal. Using this discussion, research dialogues are introduced to demonstrate the multidisciplinary nature of portals. The paper then presents a case study of a portal that is being developing for the upcoming Beijing Humanistic Olympics, and focuses on the role of that portal in contributing to the establishment of the knowledge commons.

STRUCTURATION THEORY AND PORTALS

Giddens (1984) offers the insight that

> *The best and most interesting ideas in the social sciences (a) participate in fostering the climate of opinion and the social processes which give rise to them, (b) are in greater or lesser degree entwined with theories-in-use which help to constitute those processes and (c) are thus unlikely to be clearly distinct from considered reflection which lay actors may bring to bear in so far as they discursively articulate, or improve upon, theories-in-use (Giddens, 1984, pp 34).*

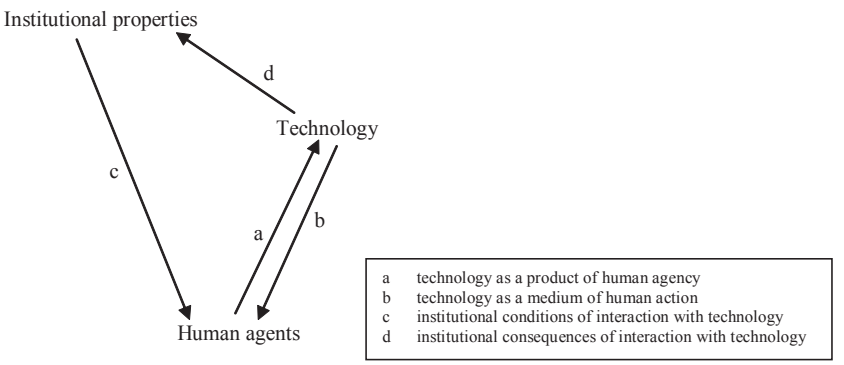
This insight implies the interdependencies of meanings, actions, and structures. The cumulative effect of people's living and working within social frameworks (through a dynamic that Giddens calls structuration) is the production and re-production of culture. According to Giddens, community cultures are generated and re-generated through the interplay of action and structure. Social structure both supports and constrains the endeavours of individuals, communities and societies. Giddens' theory of structuration is the cornerstone concept for this paper.

In Giddens' theory of structuration, he proposes what is known as the 'duality of structure', where human actions create structure or institutional properties of social systems, which in turn shape human actions (Giddens, 1986). It recognises that 'man actively shapes the world he lives in at the same time it shapes him' (Giddens, 1984). Information technology is well posited in the theory of structuration – its very nature reflects an underlying structurational duality: where human actions, the needs, wants, skills, and collaborative tasks of communities create requirements for technological systems, and with these structures, shape human actions.

Portals, when considered as an object of study, require constantly renewed effort at definition -- depending on context. It is now a reality of the techno-social condition that people need to grapple continuously with the multiple personae projected by portals and their enabling functions. It is worth explaining this interaction with portals. Orlikowski (1992) depicts a recursive model of information technology using structuration theory, applied to a vision of portals in this paper (figure 1).

The recursive nature of technology based on structuration theory is reflected in the structurational properties of portals as being created and changed by human action; but also supporting and constraining such actions. Through such interplays, memories of people are cultivated within portals.

Figure 1. Structurational model of technology (Orlikowski, 1992)



PORTALS PURPOSED FOR KNOWLEDGE CREATION

Pearce (2003) noted that portals have evolved and are expected to perform a number of diverse functions, including the access, storage, and organisation of information, gateway to enterprise applications, communication, and so on. Strauss (c.f. Pearce, 2003) suggested a trend of 'portalization', where organisations 'are rushing to produce portalware and portal-like Web pages without fully understanding the scope of a portal undertaking'.

This paper argues that the sustainability and usefulness of portals lie in the dynamics of the user communities and, in the same way, portals function as an important platform for the sustainability of communities. 'Community' as used here is intended in its widest sense, and includes communities of practice, communities of interest, and both local and virtual communities (Wellman and Haythornthwaite, 2000; Wenger and Snyder, 2000). Thus the scope of a community includes not only corporate-based communities, but also the vast variety of communities that make up the civil society as defined by the World Summit on the Information Society (Schauder, Johanson, Taylor 2005).

Figallo (1998) argues that a true community exists when 'a member feels part of the larger social whole', when 'there is ongoing exchange between members of commonly valued things', when there is an interwoven web of relationships between people, and when these relationships last through time, creating shared meanings and histories. Thus, the ties that bind people together transcend their formal tasks and work practices. As noted by Figallo (1998), this view of communities is altogether dialectic and multifaceted.

Behind the knowledge commons lies the memory of community for the common good: humans hunting together for food and developing conventions for shared use of grazing lands. Benkler and Lessig (c.f. Levine, 2002) defines a 'commons' as resources that are not possessed or controlled by any one individual, company, or government. The commons is rooted in communities of social trust and cooperation (Bollier, 2004) and is distinct from the market. Active defenders of the commons, such as the Friends of the Commons (2004) refer to the commons as 'a generic term which embraces all creations of nature and society that we inherit jointly and freely, and hold in trust for future generations'.

Such defenders regard it as critical that we make distinctions between what is shared and common to the society – so as not to allow market forces to create fragmentations caused by social differences such as income and literacy. The current movement of the knowledge commons focuses on knowledge-creating communities using technologies to empower or constrain their shared spaces and resources.

However promising it may sound, sceptics have referred to this concept as merely a metaphor – and regard it as risky to guide decisions based just on a metaphor. Others defend it fiercely – arguing that without it resources would be taken over by market forces (Bollier, 2004). Hardin (1968) writes about the tragedy of the concept of the commons, based on the assumption that equitable access and use would result in the degrading of quality, and emptying of resources. This suggested tragedy is based on the idea that in the commons, where lemming-like, 'every man is locked into a system that compels him to increase his herd without limit – in a world that is limited. Ruin is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons. Freedom in a commons brings ruin to all.' (Claude, 2002).

This paper argues that such ideas may be invalidated due to the changing nature of participative technologies, contemporary media scenarios, and the applicability of portals as a form of both structure and agent to sustain the commons within a specific community. Massimo (2006) further supports this claim, by stating that 'there is no common without community within which the modalities of access to common resources are negotiated' (Massimo, 2006).

Portals are gateways and central points of access to applications, services, and more importantly, networks of people within the community. Belonging and having access to a portal allows members to feel part of the community, to contribute and exchange commonly valued knowledge and resources with one another. In this way portals present an opportunity for a true community to exist. It must be emphasised that the communal identity does not imply compromise with the self. The portal as a participative and mediating technology allows for both the construction of self and communal knowledge of individuals and their communities. In fact, knowledge of both the self and the community are mandatory for each other to exist. The emergence and popularity of portals might be argued as evidence of a desire of people in a community to connect with the like-minded, alongside with the need to construct self-knowledge. This desire, or innate nature of people, is described by Calhoun (c.f. Castells, 2003):

We know of no people without names, no languages or cultures in which some manner of distinctions between self and other, we and they, are not made ... Self-knowledge – always a construction no matter how much it feels like a discovery – is never altogether separable from claims to be known in specific ways by others. (Calhoun c.f. Castells, 2003)

Castells (2003) argued that the construction of self-knowledge is an inevitable process when people come together as a community. In the process of constructing self-knowledge, one makes sense of existence, presence, and roles in the world. In doing so, people in communities make sense of their relationships with other people, and end up with multiple associations with various communities. Very often, the behaviour and roles they eventually take up in different communities are not independent of each other. Because there is such a multiplicity of intertwining of community consciousness in people, it is not possible to only include one aspect of a community without considering all of aspects.

People try to make sense of their identities in multiple communities, reducing the tensions between identities, and eventually it results in a glut of communities trying to collaborate within and with each other. As a result of such courses and discourses, it is necessary for technology, spaces, and other resources to be utilised.

Web portals present an interesting contemporary media environment which is a remarkably different state of the knowledge commons that Hardin (1968) spoke against. Equitable access that was thought by Hardin (1968) to be disastrous is now extremely easy within a web portal, as an individual frequently moves from creating his own knowledge to sharing it with others. The distinctions between knowledge for oneself and for collective action are often blurred, as individuals move back and forth within those realms. In the portal, knowledge that is produced also has the characteristic of increasing in value as it is used and shared. There are many examples such as Wikipedia (http://en.wikipedia.org), a web-based encyclopaedia leveraging the collective knowledge and collaboration of many people, not all experts. In this way, web portals present structure and agency properties as suggested by Giddens' structuration theory (adapted by Orlikowoski, 1992 in figure 1), and potentially a discourse against the suggested tragedy of the commons (Hardin, 1968).

Portals provide access to information technologies, resources, and contexts of use – they also provide a method by which multiple layers of identities, memories, and knowledge can be construed by communities. In examining the social reality of portals, they are regarded as forms of structure (Orlikowski and Robey, 1991) – created by and shaping human actions. Together with a vision of portals informed by structurational theory, this paper presents a snapshot of a case and examines the research dialogues which it stimulates.

THE CASE OF THE BEIJING HUMANISTIC OLYMPICS (2008)

The case study presented has been commissioned by the Humanistic Olympics Studies Centre for Beijing Olympics 2008, co-funded by the Chinese Ministry of Education, and with support from China State Administration of Radio, Film and TV (SARFT).

With the successful bid to hold the 2008 Olympics in Beijing, a team in CUC (Communication University of China), also a member of METIS Global Network (www.metis-global.net), the cross-cultural research organization in multimedia studies, began working on the project of producing an 'advertainment' (so called because the production would implicate the purpose of entertainment and advertising, whether commercial or not) portal for use in the Beijing Olympics.

The broad goal of the portal is to allow volunteers, spectators, and other participants in the Beijing Olympics to upload self-directed pictures, stories, video clips, and relevant advertisement clips associated with either the event itself or the lead-up to it, and to interact with one another within the portal. There are various reasons for them to do so – most of which are associated to their sense of belonging to the event. Access to these resources is open to these communities and facilitated through a web interface in the portal. This also includes business sponsors.

A prototype of this portal is being developed at present, optimised for streaming media content delivery. As informed by structuration theory and the recursive nature of technology, user studies were carried out iteratively with observations made in tandem in the manner of arrows a, b, and c of Figure 1. With the portal still in its prototyping stage, it has not yet been possible to study any possible institutional consequences.

The notion of 'advertainment' as the emphasis of the portal presents a case of an innovative portal that is born out of an age of convergence – as described by Price Waterhouse Coopers (2006) -- to refer to the ability of different network platforms to implement different services and the merger of consumer devices. In the case of the portal, this translates into layers of meanings and constructions contained in information objects. This in turn, results in the special treatment of information objects being deployed and redeployed in the functions of the website. The requirement imposed on the portal is a demonstration of institutional conditions that are reflected in the interaction between institutions and technology.

Each content object potentially belongs to, or can be used by more than one entity. From the user studies, it was found that different observers or users would evaluate the same content object based on diversified experience and knowledge, resulting in inconsistency in the interpretation of content features (Pang, Cao and Schauder, 2005). For example, users from diverse backgrounds and cultures, of various religions, and disparate social classes, could view a same colour with dissimilar sentiments. This finding, along with other findings from iterative user studies, was used to revise the functional specifications of the portal.

A strategy has been adopted to reinforce one of the preconditions of the commons – the idea that no resources are owned or controlled by a single entities but are shared by people in communities. The approach to developing metadata for information objects and resources has also been intricately designed to allow users to define their own tags to the multimedia objects they create and share, while including them in the description model of the portal's infrastructure, to manage uncertainties in such metadata.

This rationale is also based on the assumption that resources in the knowledge commons should not be controlled or manipulated by any one entity alone. Further user studies (Pang, Cao and Schauder, 2005) support the multifaceted meanings embedded in multimedia objects such as videos and pictures, which were expressed and categorised differently by users. As a medium of human action, the portal acted as a facilitator and repository where such meanings were exchanged, shared, and stored. At the same time, interactions also result in the shaping of the portal design, where humans act as the main agents.

As reflected in the recursive interactions between the portal and user groups, one of the main foci of the portal lies in the sharing of resources by the community. This is designed with the intention to cultivate shared memories of the event: public video captures of various members are shared with others, and through these shared resources, the sharing of stories on viewing the same event in the Olympics are elicited. At the same time, advertising videos are put up and shared by the business stakeholders, facilitating further identifications with the event as a whole, and cultivating further memories of the event as a community.

PORTALS AS A MULTIDISCIPLINARY FIELD: RESEARCH DIALOGUES

The focus of the project on the design, development, implementation and use of the portal has led to several multidisciplinary research ideas. The lens of the knowledge commons that has been borrowed to study the portal has been very useful to contribute to emerging dialogues. Development of the project that is ongoing has served to demonstrate that the study of portals is a multidisciplinary field.

The Case for the Knowledge Commons

The idea of having a portal advocating advertising values may trigger arguments that advertising and commercial sponsorship are opposed to the development of the commons (Levine, 2002). However, Bollier (2004) highlights that the commons is not necessarily unsympathetic to the market, pointing out both are needed to 'invigorate each other' or, in other words, to inspire and supplement each other. In the example of the open source versus proprietary software, while one encourages creativity, learning, and accessibility to knowledge, the very culture of such environments inspires and permits marketability. Even so, examples that could demonstrate the co-existence of both the market and the commons are few and far between, making this case study seem somewhat unique. Online donations to non-government organisations via a portal as a means of fund-raising may be another (Johnson and Johanson 2005).

In the case discussed, the notion of 'advertainment' is one that seeks to advocate a 'healthy' infusion of market forces. Information objects are seen to include advertising or entertainment (or possibly, both) values; and whether they originate from commercial sources are considered of little importance. The emphasis in this portal lies in the sharing of memories of the event from cross-cultural communities, of which commercial entities are a part, either as communities of business providers, or of consumers.

The paper has so far discussed a view of portals that is necessary for their sustainability – one that sees portals as not being driven by technologies or even accessibility, but sees portals as driven by the identities, resources, and spaces which people in communities share with each other. This concept of sharing and inclusion of community dialogue is congruent with the concept of the knowledge commons.

Communities are seen working and coming together for the production of knowledge, using portals (as viewed through the lens of structuration theory) as tools to facilitate the construction of knowledge and cultures. As with the knowledge commons, communities see themselves not merely as users and exchangers of information, but in themselves coming together to contribute to the knowledge commons belonging to the community. Portals provide such a space for this interplay and interaction; and in the process, establish a knowledge commons space consisting of both physical and virtual dimensions.

Research Dialogues

As a result of the ongoing work, a field trip was made to Beijing in July 2006, where researchers from Australia and China came together to study the development of the portal, and to reflect on the larger changes that were happening (such as the development of the Olympics venue, changes to the infrastructure of the city of Beijing, and the emergent social agendas in Beijing and other parts of China). Research interests emerging in China that were relevant to the project's work in developing the portal were also identified.

The outcome of such dialogues has been the identification of a number of themes that could form the basis of a research agenda for a CIRN (Community Informatics Research Network) group in Asia-Pacific, guiding cross-cultural perspectives in a field that has become multidisciplinary in nature. Some of these themes are:

- Digital storytelling and the use of communicative technologies.
- The capture, representation, sharing, and shaping of artefacts.
- Human-computer interaction of portals.
- Collaborative and commons-based design for cultural communities.
- New business models in the contemporary media environment.
- Search and retrieval of rich indigenous media objects.
- Research annotations and the making of meaning by communities.
- Issues around design and use of digital repositories for communities.

CONCLUSION AND FUTURE WORK

The project discussed has been concerned about the making, conservation and the transmission of community and individual knowledge, identities, and memories within a community bounded by a significant event.

Using the concept of the commons, the paper has demonstrated how portals can be used as a structure and agent to sustain communities and their resources. Although the concept of the knowledge commons is not new, there has been a considerable amount of interest in looking at it as a framework for considering the dynamics of communities and the successful design (and redesign) of technological applications and workspaces. More research findings from empirical case studies are desired. The knowledge commons movement also calls for radical rethinking of design methodologies to guide the design and developments of portals and informational resources accessed through portals.

This paper has also discussed the key features of the portal, designed to capture and share stories of the event, and cultivate memories for cross-cultural communities. The inclusion of collaborative tasks is another key feature of the portal that lends supports to the larger goal of cultivating cohesiveness and establishing a commons within the diverse communities of the Olympics.

This approach has assisted in the setting up of a research agenda for a CIRN group in Asia, set to convene in 2007. Such dialogues are ongoing, and raise

opportunities for future work in developing research around portals and their implementations.

REFERENCES

Benkler, Y. (2003). The political economy of Commons. Upgrade: The European Journal for the Informatics Professional, 4(3), 6-9.

Bollier, D. (2004). Why We Must Talk about the Information Commons. Law Library Journal, 96(2), 267-282.

Castells, M. (2003) The power of identity. Malden: Blackwell Publishing.

Claude, G. (2002) Goatherds in pinstripes. Mute, 1(23), 33-37

Figallo, C. (1998) Hosting Web Communities. New York: John Wiley & Sons.

Friends of the Commons. (2004) The State of the Commons: A Report to Owners. New York: Tomales Bay Institute.

Giddens, A. (1984) The constitution of society: outline of the theory of structuration. Berkeley: University of California Press.

Giddens, A. (1986) The constitution of society. Berkeley: University of California Press.

Johnson, K., and Johanson, G. (2005) Donations over the Web: collecting for Australian non-profit organizations. Third Sector Review, 11(1), 19-36.

Levine, P. (2002). Democracy in the Electronic Era: Building the Electronic Commons. The Good Society. 11(3), 3-9.

Massimo, A. D. (2006). On the "tragedy of the commons" (that is, the tragedy of commons without communities). Retrieved 4 December, 2006, from http://www.commoner.org.uk/blog/?p=79

Orlikowski, W.J and Robey, D. (1991). Information Technology and the Structuring of Organisations. Information Systems Research, 2(2), 143-169.

Pang, N., Cao, S., and Schauder, D. (2005). A Hybrid Approach in Applying Usability Evaluation: A case study of the MAMS platform in Olympics 2008. In X. He, T. Hintz, M. Piccardi, Q. Wu, M. Huang & D. Tien (Eds.), Third International Conference on Information Technology and Applications. (Vol. 1, pp. 82-87). Sydney, Australia: IEEE Computer Society.

Pearce, L. (2003) . Institutional Portals: A Review of Outputs. The New Review of Information and Library Research, 2003, 61-84.

Pricewaterhouse Coopers. (2006). The Rise of Lifestyle Media: Achieving Success in the Digital Convergence Era. A Report by Technology Centre, Pricewaterhouse Coopers, United States of America: Pricewaterhouse Coopers International Limited.

Schauder, D., Johanson, G., and Taylor, W. (2005) A diversity of voices: framing ICT policy for civil society, in Proceedings CIRN2005 Conference, Cape Town, South Africa, 24-26 Aug 2005. Retrieved 11 November, 2006, from http://infow3@cput.ac.za

Schauder, D., Stillman, L., and Johanson, G. (2005) Sustaining a community network: the Information Continuum, E-Democracy and the case of VICNET, The Journal of Community Informatics, 1(2), 79-102.

Wellman, B. and Haythornthwaite C. (2000). The Internet in Everyday Life, 2000. Blackwell: Oxford.

Wenger E. and Snyder, W. (2000) Communities of practice: the organizational frontier. Harvard Business Review, 78(1), 139–145.

State Portals: Empowering E-Government via Software Engineering

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ABSTRACT

In an effort to deliver efficient and effective e-government services State portals are playing a prominent role. Software engineers are able to facilitate the convergence of politics and administration. On November 8, 2000, U.S. voters received conflicting media projections, but the Secretary of State's Office in Florida was able to provide them with that state's most timely election counts. With this example, software engineering factors, such as the use of dynamic web programming, can suddenly spring to the forefront of attention. For almost all federated entities, the establishment of state portals has become an advanced stage of e-government. Most states now have them and they can provide a wide variety of public services. Portals can be used as a gateway or central access point, but to appear coordinated, they should be based on a sound software engineering framework. This article presents the convergence of advanced software engineering practices with the empowerment of public administration standards and the swift enabling of public policy via state portals.

INTRODUCTION

Years ago many government agencies progressed from simply republishing forms on a front-end website. However, fewer have advanced to developing back-end web applications. Advanced portal features can now be extended and implemented to include more file-intensive processing. Because software is a form of organizational memory, it has been called a type of federated governance (Strassmann, 1995). E-government portals now include self-service applications and may enable the ability to initiate government contacts, interactivity and consultation (Curtin, Sommer & Vis-Sommer, 2003; Sharma & Gupta, 2003; Thomas & Streib, 2003; West, 2004; Aitkenhead, 2005). Further, citizens will demand more of these interaction capabilities in the future (Thomas & Streib, 2003). It is prudent for the chief executive, or his/her designee, to take control of such developments. Factors to consider among agencies would include the quality, accessibility, privacy and security of their website functions.

In theoretical terms, the concept of a state provides for a framework for analyzing the organizational and ethical complexities of life. Further, a state can provide a unity of attention amid a diversity of details and speculation (Farr, 1993). Using software engineering principles, a new focal point of contact can be achieved. As a minimum, a government-wide portal should provide links to various applications on the Internet "…organized in a way that makes the site easy to navigate and desired links easy to locate" (Edmiston, 2003, pp. 23-24). A state portal is a specific form of government portal. In almost all instances, there are one-to-many states, and within those states there may be one-to-many disparate functions. Yet, a government portal should be fully executable with integrated online services offering considerable convenience to its visitors (West, 2004). This attribute is desired for most of the organizational entities, even those at a peer level. In short, government portals are "…the entry point for business and citizens to access information or services that are for the good of the community" (Aitkenhead, 2005, p. 214) and, like with software engineering, state portals should attempt to have replicate functionality.

Various types of portals have been categorized (Tatnall, 2005) and a state variety could be thought of as being a General/Mega type. While vigilantly considering the needs of state constituents, these portals try to be a "one-stop" source for services, thus the mega description. It is also hoped that the user would return to the same portal for yearly government renewals. Examples may include intermittent visits, such as the payment of parking tickets, or yearly visits, like the payment of taxes or motor vehicle fees (Johnson, 2002). A uniform belief is that these fee-based interactions would be considered encroachments on a constituent's time and resources. As such, states do their utmost to make the experience politically acceptable.

A common goal for state portals is for the web-enabled services to have a similar look and feel. The front-end graphical user interface (GUI) should not be a source of client frustration. This goes for both functionally specific and centralized processing agencies. Resources may vary from state to state as each provides a wide variety of services. However, most want their constituents to be comfortable with the use of their website. Factors of consistency and application reuse are primary among the various organizations of a state. A well-designed enterprise framework, similar to those crafted by software engineers, may be the best way to ensure that consistency.

PUBLIC ADMINISTRATION

The Weberian notion of a bureau maintaining files is at the crux of public administration. Very publicly, a state's web portal has the ability to greatly increase agency efficiency. Standardization, a form of coordination, was identified by Weber as a form of rationalization and is still essential to bureaucracies. Most agencies are rule bound, but presenting their regulations via the web is transformational. Due to information and communication technology (ICT), it has been said how the implementation of law has been virtually perfected (Bovens & Zouridis, 2002). Inter-organizational exchanges are now quite commonplace and state portals provide a focal point for individual government entities to provide their services and information.

This is especially so if one or more agencies have the same types of files or database management systems (DBMS). The software engineers for those agencies play a huge role. For a front-end developer in a functionally specific agency, it may be easy to post regulations in a hypertext markup language format. However, in more file-intensive bureaus, and to incorporate conditional processing, sophisticated back-end programmers or engineers may be required. Regardless of agency size, client views of agencies are more likely now to originate from the web.

Shrewd public administrators may obtain or borrow parts or wholly functional enterprise frameworks while striving to develop greater efficiencies. For instance, e-payment options may be transferable within a state between various state agencies. In much less frequent (but notable) instances, entire software engineering frameworks have been ported to other state jurisdictions. The enabling factor may have been the ability of the designers to distinguish between functionally specific attributes of a state and core features when the base-classed functions appeared to be the same. Ask seasoned programmers and, if they have worked with government projects, see if they are aware of adaptations involving intra- or interstate endeavors.

POLITICS

For the usability reasons above, the chief executive of a state may want a prominent role in the portal's capabilities, development and content. This is because e-government "…is as much about politics as it is about government…" (Curtin, Sommer & Vis-Sommer, 2003, p. 14). That individual should be able to enlist (or coordinate) staff from executive branch agencies. It is less likely that a software engineer would reside in peripheral agencies as these entities usually hire specialists and/or programmers. However, without proper planning, the developers would still need to converge to ensure that their efforts yield a uniform look and feel. Thus, the administration of software engineering and standardization between agencies becomes key.

Exceptions may pertain to autonomous elected officials positioned below the chief executive. They may choose to be less standardized. These offices often have links from the main portal, and those officials may or may not follow standardization attempts as closely. They may try to look similar if they are from the same party as the chief executive; if not, they may try to differentiate themselves. In some instances, the autonomous offices employ their own programming, networking and/or outsourced staff. The degree of uniqueness may be an attempt to contrast with the chief executive's site, but seldom is an elected official's website less usable. Sometimes, due to the nature of those elected offices, they may have less budgetary oversight and more specialized features.

INFORMATION TECHNOLOGY STANDARDS

The technical standards regarding web development have evolved a great deal. This pertains to both hardware and software engineering. In terms of telecommunications and networking techniques, it has been recognized that lesser developed states often borrow standards from others. However, in a collaborative way, they too must provide input to achieve full participation (Chauvel, 2003). This includes interactions with other federated entities. In terms of e-accessibility, the state portal host and sponsors will not want any weak or inconsistent links.

In contrast to modular software and programming practices, which have been in place for decades, the most popular client services often have links originating directly from a state's homepage. Facilitated by the portal, this is often the case regardless of government entity. By utilizing cascading style sheets (CSS) and other common techniques, the same GUI can be achieved. Large and established software frameworks such as Microsoft's .Net and Java Community Process' J2EE may be utilized. Regardless of the state's framework of choice, the standards of web services need to be employed to achieve a common communications infrastructure (Williams, 2003). This may facilitate greater inter-organizational exchanges, whether they originate publicly or privately.

INFORMATION RESOURCE MANAGEMENT

Some have recognized how "[m]ulti-organizational collaborations need an institutional framework" (Dawes & Prefontaine, 2003, p. 42) and it is the state's portal that provides one. Teams within a state, regardless of executive department, may be enlisted in the development of a state's portal or web architecture. This is also an overseeing function of information resource management (IRM) entities. The teams that participate early may have greater influence as their ideas and practices would be foundational. However, if the back-end programs are long-linked and/or lack modularity, the ability to extend and reuse the code may be limited. It may be necessary to have software engineers and object-oriented programming experts as part of a design team(s) as they begin to discern the capabilities (or restrictions) of such code.

For instance, one agency's programming staff, having more technical skills than others, may provide an interface to a back-end DBMS. This is commonly referred to as middleware and some database vendors can provide it. Once those interfaces are achieved, the success may be disseminated among state entities, and soon implemented by the agencies. If agencies use the same DBMS, such as those with centralized systems, they may be able to reuse the code objects, segments or libraries. Thus, the encapsulation, extensibility and documentation of such code becomes key. Through the use of secure web services, units may also gain the ability to seamlessly access and display other agency's data.

CONTROL AND COORDINATION

Both control and coordination should occur when administering state portals. For some staff, a state portal may be their first attempt at information technology (IT) and/or front-end application development. With the use of electronic templates, the scope of administrative discretion has been reduced (Bovens & Zouridis, 2002). A simple web page has content, but when forced to integrate that information into the format of a state portal, some advanced software engineering techniques may be required. An IRM entity may be responsible for coordinating that integration. Even the use of CSS may be beneficial when considering simple application code reuse. The dissemination of at least some documentation should occur in preparation for agencies to assimilate clients from the state's portal (Oliveira, Alencar, Filho, Lucena & Cowan, 2004), and many states provide that guidance.

More so than in the private sector, state representatives must be aware of the digital divide or how some individuals are either new to computing or have no access to networked systems. Broadband versus dial up modem accessibility is a common issue. In the private sector, an unavailable website means lost sales, whereas in the public sector, it could mean lost votes. According to one researcher, most state and federal government sites had not made much progress at incorporating democracy-enhancing features (West, 2004), although lower level browser versions try to be accommodated. For instance, agencies should be aware of the browser capabilities of Internet Explorer, Netscape, Navigator, Mozilla, Firebird, Camino, OmniWeb, Opera, Lynx and others. This is because constituents may be using Windows, Macintosh, Unix/Linux or other operating systems. Further, they should encourage technologies that facilitate Internet use by the handicapped. State representatives may require a minimum level of quality, accessibility and privacy as a prerequisite to having an agency's website linked to the portal.

BUDGETARY BENEFITS

By charging convenience fees and reducing staff, state agency revenues and expenditure savings can be substantial. As mentioned above and if enabled by law, convenience fees may be charged. Waiting lines could be reduced, and in areas where population growth is occurring, capital expenditures may be saved. Although constituents can usually find and download forms without a state portal, as advertised by the agency or documented in correspondence, more personalized documents with agency planning can sometimes be obtained.

In public organizations normally known for growth, increased staffing can be curtailed. Along with the development of seemingly personal information, the agency can develop a queuing sequence of events for whenever the client arrives or connects. In some instances the client interfaces the information, not a clerk. For instance, with pre-assigned access numbers or barcodes, an efficient delivery of services may result. Such numbers would originate from a holding table or database, ready to initiate a set of processes when the client keys, swipes or pays. Be it a web, interactive voice response, e-payment or web service transaction, a pre-established number would be anticipated and foreknown by the originating agency.

It may seem to the client that delivery is different, but deep within the back office processes, the sequential numbering of transactions is very likely the same. This, along with stringent DBMS table designs, could reduce the likelihood of redundant data and, as a result, promote more efficiency. With pre-established information the clients can be better prepared before accessing a government website, and the portal support staff can be better prepared (if necessary) to serve them. To the casual user, this might not be entirely evident; however, in a well-designed system, hidden access codes can provide a great deal of functionality, security and personnel savings.

COMMON ELEMENTS

Beyond a search engine and a gateway to sites of a jurisdiction, a state portal should provide access to all network-accessible resources. These include intranets, extranets and the Internet. Table 1 lists a few of the most prominent state portal features.

FUTURE TRENDS

Future trends include facilitating web-enabled voting, the use of inter-organizational transactions and vigilant security. As opposed to yearly transactions, voting periodicity may be as needed, biennially or once every four years. So timed, the stakes and risk can be quite high. To prevent duplicate votes, at least some association should be done between the interfacing voters, their domains and electoral choices. Jurisdictions may be overwhelmed with the coordination of electronic voting systems, and systems would need to be certified by the state (Deutch & Berger, 2004). Even though e-voting may be routed through the state portal, a specific office may head up this responsibility. To instill confidence in voting, the level of transactional integrity needs to be high as well as secure. As such, verifications of voter registrations may be increasingly been done between agencies.

As in the past, state organizations will try to integrate the Internet services of subunits within and between each other. It has been recognized how this trend will require oversight institutions to use more horizontal forms of management (Fountain, 2001). But web-enabled transactions usually start under the domain of a single agency and are not fully integrated into the holistic government structure (Sharma & Gupta, 2003). An example of these types of transactions may be found

Table 1. Common state portal features

Alphabetic list of executive departments and agencies[1]
Links to the legislative branch
Links to judicial entities
Lists of councils, committees and boards
Lists of political organizations outside of the executive domain
Executive press releases
Maps of government service locations
State phone/e-mail directories[2]
Links to peer level states[3]
Access to the other states entities[4]
Links to laws
State calendars
Language translations
Business
Education
Employment
Public assistance
Tourism
Emergency and safety

[1] The names of the departments and common abbreviation often follow in parentheses.
[2] A central payroll entity may maintain employee phone numbers and e-mail addresses.
[3] The sub-domain suffix or domain extension will be similar (such as *.gov.uk).
[4] For example, Germany has all of portals listed, accompanied by supporting maps.

with the need to process bad debt payments and their subsequent collections. Transactionally, one agency may attempt to encumber a client's interaction with another. The use of sequentially assigned numbers, as described above, could provide needed tracking. This is so regardless of service delivery technique and may be inter-organizational as long as the jurisdictional boundaries and accountability remain clear. Data intensive collaborations, such as those associated with state portals, usually face issues of data ownership (Dawes & Prefontaine, 2003) and this becomes increasingly so as one or more agencies access or process the data of another. The privacy of constituents, whether election-related or not, is of primary importance. State portals should collect, store and redistribute private information only to the extent required for their proper application (Felten, 2005). Although all agencies must be vigilant in terms of security, the use of a state portal can have a focusing effect on those efforts.

Of the utmost importance to each state, now and in the future, is security. An IT, IRM or public safety agency may be directed to control and coordinate this effort. Because a state portal is often associated with an IRM agency, they usually take the lead. This is especially so with the establishment of firewalls and other advanced security. Intranets are often established to allow access within and between agencies. Users accessibility may be the same within a portal, but restrictions may reduce the hazards of full Internet access. By having an IRM agency as the state's lead, the portal usability trends and security may be forecast, budgeted and planned.

CONCLUSION

Software engineering innovations represent challenges to organizations when they consider IT standards, IRM and the need for coordination and control. But opportunities can exist with a state portal as they have been known to influence government budgets, public administration and public policy. As software engineering innovations are developed, communicated and subsequently discovered by the sub-agencies of a state, they may be shared between entities within a state framework. Inherently, they are borrowing from core software engineering and object-oriented principles. Code reuse, especially in the form of accessing a large DBMS, could help agencies bring more transactional and inter-organizational applications to the web. This interlacing enables sound public administration standards and the timely implementation of public policy. State portals can encourage a vibrant development environment, facilitated by an extendable software engineering framework, for the creation, maintenance and accessibility of secure websites.

REFERENCES

Aitkenhead, T. (2005). Web portals in government service. In A. Tatnall (Ed.), *Web portals: The new gateways to internet information and services* (pp. 212-229). London: Idea Group.

Bovens, N., & Zouridis, S. (2002). From street-level to system-level bureaucracies: How information and communication technology is transforming administrative discretion and constitutional control. *Public Administration Review*, *62*(2), 174-184.

Chauvel, Y. (2003). Standards and telecommunications development: Where are we going? *International Journal of IT Standards & Standardization Research*, *1*, 50-53.

Curtin, G., Sommer, M., & Vis-Sommer, V. (2003). The world of e-government. In G. Curtin, M. Sommer & V. Vis-Sommer (Eds.), *The world of e-government* (pp. 1-16). New York: Haworth.

Dawes, S., & Prefontaine, L. (2003). Understanding new models of collaboration for delivering government services. *Communications of the ACM*, *46*(1), 40-42.

Deutch, H., & Berger, S. (2004). Voting system standards and certifications. *Communications of the ACM*, *47*(10), 31-33.

Edmiston, K. (2003). State and local e-government: Prospects and challenges. *American Review of Public Administration*, *33*, 20-45.

Farr, J. (1993). Political science and the state. In J. Farr & R. Seidelman (Eds.), *Discipline and history* (pp. 63-79). Ann Arbor, MI: University of Michigan.

Felten, E. (2005). DRM and public policy. *Communications of the ACM*, *48*(7), 112.

Fountain, J. E. (2001). *Building the virtual state: Information technology and institutional change*. Washington, DC:Brookings.

Johnson, C. L. (2002). The structure of portal revenue and prices. In *State web portals: Delivering and financing e-service*. Arlington, VA: PricewaterhouseCoopers.

Lewis, B., Snyder, C., & Rainer, R. (1995). An empirical assessment of the information resource management construct. *Journal of Management Information Systems, 12*(1), 199-244.

Oliveira, T., Alencar, P., Filho, I., Lucena, C., & Cowan, D. (2004). Software process representation and analysis for framework instantiation. *IEEE Transactions on Software Engineering*, *30*(3), 145-159.

Sharma, S., & Gupta, J. (2003). Building blocks of an e-government—a framework. *Journal of Electronic Commerce in Organizations*, *1*, 34-48.

Strassmann, P. (1995). *The politics of information management: Policy guidelines*. New Canaan, CT: Information Economics Press.

Tatnall, A. (2005). Portals, portals everywhere. In A. Tatnall (Ed.), *Web portals: The new gateways to internet information and services* (pp. 1-14). London: Idea Group.

Thomas, J., & Streib, G. (2003). The new face of government: Citizen-initiated contacts in the era of e-government. *Journal of Public Administration Research and Theory*, *13*, 83-102.

West, D. (2004). E-government and the transformation of service delivery and citizen attitudes. *Public Administration Review*, *64*, 15-27.

Williams, J. (2003). The web services debate: J2EE vs. .Net. *Communications of the ACM*, *46*(6), 59-63.

Researching the Portal

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ABSTRACT

The Web portal is now ubiquitous, and a considerable amount of research has now been done into portal technology and applications. In this paper we will argue that research in portal applications should adopt a socio-technical stance, and should see the portal as an innovation which must be adopted before it can be used. We distinguish between inventions and innovations and argue that there is nothing automatic about adoption of an innovation, and that this can best be investigated through the lens of innovation theory. The paper also points out that from a socio-technical perspective some portal adoptions have had positive consequences while others have been negative. To fully appreciate all the human and non-human influences involved, research into the applications of portal technology should adopt a socio-technical approach that considers positive and negative consequences of this technology. We argue that a good way to do this is by considering the portal as an innovation and considering its adoption using the theory of innovation translation, informed by actor-network theory.

WHAT IS A WEB PORTAL?

Most people have a idea of how to answer this question, but not all the answers would be the same – there are many views on what constitutes a web portal. The term 'Web portal' is rather overused and takes on a somewhat different meaning depending on the viewpoint of the people involved in the discussion. Some people define a portal quite tightly suggesting, for example, that it must be customisable by the user or that it must have certain specific features (Tatnall 2005c). Although there are many different definitions, some simple and some quite technical, we will use a simple definition that suggests that as in general terms a portal is just a gateway, a web portal can thus be seen as a gateway to the information and services on the Web. More than this, a Web portal should be seen as providing a gateway not just to useful sites on the Web, but to *all network-accessible resources* whether they involve intranets, extranets, or the Internet (Tatnall 2005a). In other words a portal offers easy centralised access to all relevant network content and applications.

The first Web portals were designed by companies like Yahoo, Excite and Lycos to act as general jumping-off points to the contents of large parts of the Web. An early classification of portals had them being either horizontal or vertical (Lynch 1998). The original portal sites mentioned above would have been considered as horizontal portals because they were used by a broad base of users, whereas vertical portals were focused toward a particular audience. Davison, Burgess and Tatnall (2004) offer the following list of portal types: General Portals, Community Portals, Vertical Industry Portals, Horizontal Industry Portals, Enterprise Information Portals, e-Marketplace Portals, Personal/Mobile Portals, Information Portals and Niche Portals. A major problem, however, is that new types and categories of portal are appearing all the time, portal types are re-classified, and most classification schemes include overlapping categories. Even given the difficulty in classifying portals or attempting to count the numbers of each type, it has become clear that specific, rather than general portals are very much the topic of interest around the world (Tatnall 2005c).

THE GROWING IMPORTANCE OF WEB PORTALS

A crude measure of the growing importance of the portal comes from a Google search of the World Wide Web. In September 2006 this search produced ***1.5 billion*** entries relating to Portals. A similar search performed in October 2005 produced 425 million entries, and in December 2003 only 35.6 million. This measure is rather crude as definitions change and some entities that were not previously called portals now are. It is also the case that some of these entries refer to other types of portals, such as those providing entrance to medieval cathedrals. It is nevertheless clear that web portals have become an important topic for discussion, and one that is becoming more important as time goes on.

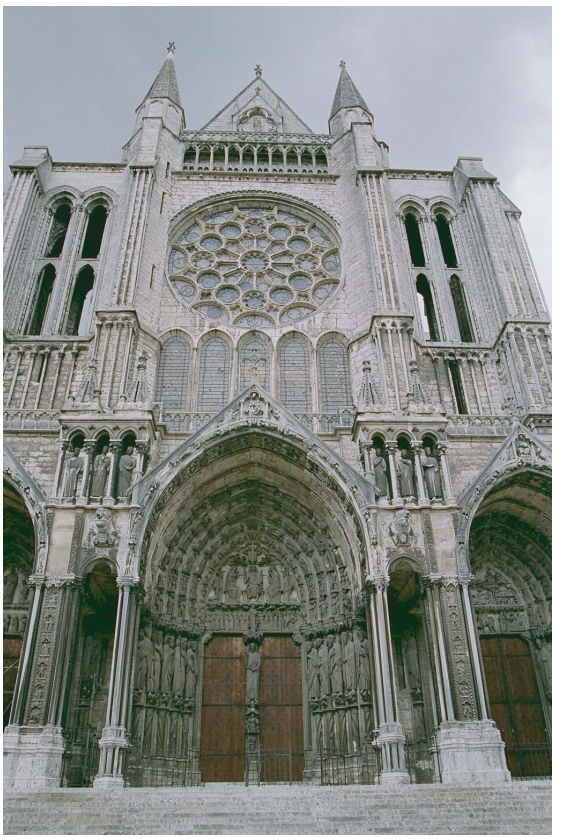
Portal research can be conveniently broken down into research on portal technology, and research on portal applications (Tatnall 2007 forthcoming). In this paper we will concentrate on portal applications.

RANGE OF PORTAL APPLICATIONS

Articles in the Encyclopaedia of Portal Technology and Applications (Tatnall 2007 forthcoming) cover a wide range of topic, ranging from the complex to the very simple. One area of research discusses the nature, characteristics, advantages, limitations, design and evolution of portals, while at the other end of the spectrum several investigations centre around semantic portals and some philosophical portal issues.

A major user of portal technology around the world is governments and the public sector. A large research effort describes and discusses public sector, education and government portals, while social and community-based portals are not forgotten. At the personal portal level, research is conducted in topics including Weblogs, widgets and MP3 players. Medical, health and bio-informatics portals form another significant group of applications.

Figure 1. The Great Portal, Chartres Cathedral, France



Another important research area is in the business and industrial sectors. This research investigates organisational and management issues regarding portal use, enterprise information portals, human resources portals, portals for small to medium enterprises and more specific topics including shopping, the automotive industry and wine industry portals. The economics of setting up and using these portals is also discussed, as are issues of strategic planning, user acceptance, security and the law.

Portal technology itself has been researched by many scholars, especially those involved in the design and implementation of portals. One important consideration is whether certain implementation factors are more likely to lead to successful adoption of portal technology than others. The design and development of portals is an issue, and applications and technologies such as business intelligence, artificial intelligence, semantic portals, intelligent agents and mobile technology are discussed.

TWO SIDES TO THE STORY

Research into adoption of portals has shown that there is a potential for both detriment and benefit to society from this wide range of portals applications. Sentences that start "all freedom loving people …" have been used over the years to justify everything from gun ownership to invasions of foreign countries. An argument for free exchange of information should not need to be made, but the complete licence of the Wild West should also be seen as potentially harmful. In this paper we will examine both sides of the freedom/licence question that have been researched in medicine, democracy and government, and intellectual property piracy. In each case we examine the research to show the dichotomy of the benefits of opening global communications through portals and the potential problems that can arise in an uncontrolled space.

Portals and Medicine

Medical portals abound on the internet. Almost every major disease is represented by at least a support group portal. These portals offer everything from emotional support, through possible treatment advice to contacts within the medical community.

(Lewis 2006) suggests that while the medical literature has a rather pessimistic take on issues like online health consumption, debates over cyberchondria and cyberquackery are underpinned by a recognition that doctors are no longer necessarily the sole holders of health knowledge and that many consumers are now increasingly taking control over their own health care management. Thus the 'quality' debate within the medical literature on online health consumption is underpinned by anxieties over what gets counted as legitimate health knowledge today. The penetration of the Internet into provision of medical information is startling. An independent US study conducted in 1999 found that 31 percent of respondents under the age of 60 had sought health information on the web (Brodie, Flournoy, Altman, Blendon, Benson and Rosenbaum 2000). In 2002 Harris Interactive, conducted a study in (Taylor 2002) whose key findings included the information than 80% of all adults who are online (i.e. 53% of all adults) sometimes use the Internet to look for health care information. A December 2005 survey found that 20% of online Americans said the Internet has greatly improved the way they get information about health care (Madden and Fox 2006), while in Europe a survey by market research company Datamonitor of over 4500 adults in France, Germany, Italy, Spain, the UK and the US, found that 57% of respondents had consulted Internet sources when looking for health information (BBC 2002).

Two reported problems with all this health information available through the various portals are: social alienation, and problems with the quality of health information available. Shields (Shields 1996) finds that one of the dominant popular discourses around web use is that it produces or worsens processes of social alienation, the argument being that it is possible for interaction through computer to replace person to person contact. Theodosiou and Green (Theodosiou and Green 2003) identify five important problems with patients using medical portals to satisfy their needs:

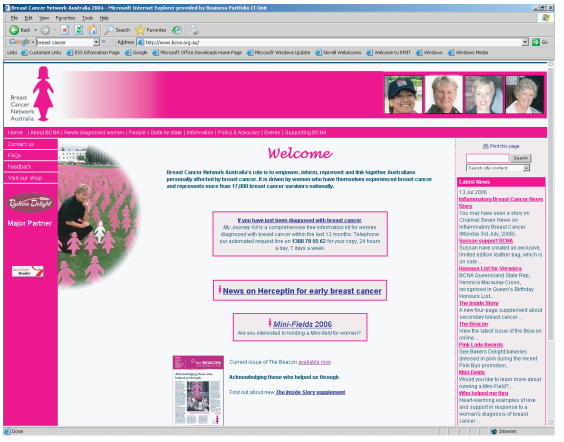
- Potentially dangerous drugs and other substances may be bought by individuals for themselves or their children
- Individuals can spend a lot of money on products or diagnostic procedures that have no scientific backing or benefit
- The information may be more negative than the reality of the situation
- Individuals may abandon treatment programmes of proven efficacy to pursue less-mainstream approaches
- Users' sites (e.g. for families affected by autism) may contain advice or opinions of questionable ethics (e.g. non-mainstream treatments that are intrusive or punitive)

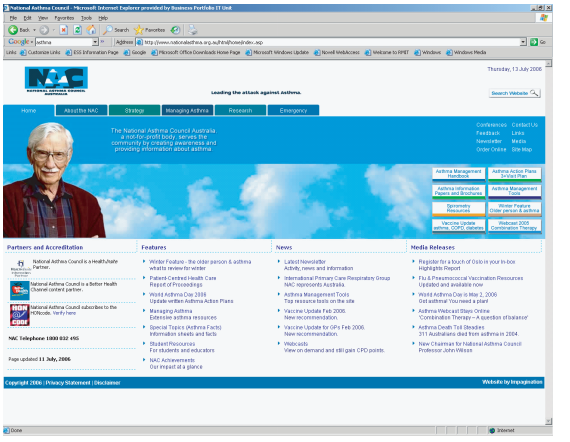
Portals and Democracy

Commentators are split on the issue of the Internet and democracy. For instance George (George 2005) asks "Does the internet democratize communication?" This is one of the big questions that has guided a decade of inquiry within media studies, political science, sociology and other disciplines. George suggests that the relationship between new media and political factors is far too dynamic and interdependent to be reduced to simple causal statements. The less democratic the society, the more attractive the Internet looks as an emancipatory medium – but the more likely radical Internet use will be blocked or punished. Furthermore, the Internet cannot be treated as an independent variable as the technology has been, and will continue to be, shaped by political and economic forces.

Studies of Internet use in Asia find the interaction between economic and geographical forces to be complex. A detailed study of Korea undertaken by Woo-Young (Woo-Young 2005) found Citizen e-participation in Korea is characterized by: (1) convenient access to detailed information, (2) free expression and exchange of opinions, (3) online activism led by politicized agenda, and (4) active formation of cyber groups. The Korean case shows that the electronic participation of citizens may even develop into off-line social mobilization.

Figure 2. Medical portals





Portals and Intellectual Property

Some researchers have evidence that the issue of piracy shows that lobby groups have criminalised the practice and are intent on confusing discussion of the issues in order to try to control activities on the Internet. (Yar 2005) finds two useful ways of looking at exchange of electronic information: "The first mode, proceeding in a largely 'realist' manner, sees the 'rise of piracy' as the outcome of a range of social, economic, political and technological changes that are radically reconfiguring the global political and cultural coordinates within which the consumption of media goods takes place. From this point of view, globalization, socio-economic 'development' and innovation in information technology help to establish the conditions for expanded production and consumption of 'pirate' audio-visual goods. However, the second mode, juxtaposed to the first, proceeds in a 'social constructionist' mode to view the emergence of the 'piracy epidemic' as the product of shifting legal regimes, lobbying activities, rhetorical manoeuvres, criminal justice agendas, and 'interested' or 'partial' processes of statistical inference." Yar sees the expansion of proprietary copyrights, and the criminalization of their violation, is part of a larger 'game' in which struggles to dominate the uses of information are being played out within the new 'knowledge economy'. Rather than taking industry or government claims about film 'piracy' (its scope, scale, location, perpetrators, costs or impact) at face value, we would do well to subject them to a critical scrutiny that asks in whose interests such claims ultimately work.

SOCIO-TECHNICAL RESEARCH ON PORTAL APPLICATIONS

The mixed outcomes illustrated by research into portal applications points to a need to develop a research approach that will bring more understanding of the mechanisms that lead to either great benefit or considerable risk to those exposed to the ubiquity of portals. Recent success in socio-technical approaches to this type of research point a way forward.

Just because a portal exists it cannot be assumed that organisations or individual people will want to adopt or use it. A portal will only be adopted if potential users make a decision to do so, and adoption of technological innovations, such as a portal, occurs for a variety of reasons. The first step to researching the use of a portal by an organisation (or individual) though is to investigate why it was adopted. The remainder of this paper will consider the portal as a technological innovation and consider portal adoption through the lens of innovation theory.

It is important to distinguish between *invention* and *innovation*. Invention refers to the construction of new artefacts or the discovery of new ideas, while innovation involves making use of these artefacts or ideas in commercial or organisational practice (Maguire, Kazlauskas and Weir 1994). Invention does not necessarily invoke innovation and it does not follow that invention is necessary and sufficient for innovation to occur (Tatnall 2005b). Clearly the portal can be seen as an invention, but the point here is that it will not be used unless it is adopted, and that means looking at it also as a technological innovation. Of course, the application of innovation theory to the adoption of a technological innovation assumes that the potential adopter has some choice in deciding whether or not to make the adoption. In the case of an organisation or individual considering the adoption and use of a portal, however, it is difficult to see any reason why they would not have a large measure of choice in this adoption decision. This makes the application of adoption theory quite appropriate when considering the use of Web portals.

INNOVATION TRANSLATION

Compared to the better known innovation approaches of Diffusion of Innovations (Rogers 1995) and the Technology Acceptance Model (TAM) (Davis 1986), an alternative view is that of Innovation Translation proposed in actor-network theory (ANT). This approach considers the world to be full of hybrid entities (Latour 1993) containing both human and non-human elements. It offers the notion of heterogeneity to describe projects such as the adoption of portal technology which involves computer technology, the Internet, the Web portal, broadband connections, Internet service providers (ISP) and the individual or organisation considering the adoption. More specifically though, ANT makes use of a model of technological innovation which considers these ideas along with the concept that innovations are often not adopted in their entirety but only after 'translation' into a form that is more appropriate for the potential adopter.

The core of the actor-network approach is translation (Law 1992), which can be defined as: "... the means by which one entity gives a role to others." (Singleton and Michael 1993 :229). Rather than recognising in advance supposed essential characteristics of humans and of social organisations and distinguishing their actions from the inanimate behaviour of technological and natural objects (Latour, Mauguin and Teil 1992), ANT adopts an anti-essentialist position in which it rejects there being some difference in essence between humans and non-humans. ANT makes use of the concept of an actor (or actant), that can be either human or non-human, and can make its presence individually felt by other actors (Law 1987).

It is often the case that when an organisation (or individual) is considering a technological innovation they are interested in *only some aspects* of this innovation and not others (Tatnall 2002; Tatnall and Burgess 2002). In actor-network terms it needs to *translate* (Callon 1986) this piece of technology into a form where it can be adopted, which may mean choosing some elements of the technology and leaving out others. What results is that the innovation finally adopted is not the innovation in its original form, but a translation of it into a form that is suitable for use by the recipient (Tatnall 2002).

RESEARCHING THE ADOPTION OF WEB PORTALS

Adoption of a portal is not a straightforward process and researching this adoption is particularly complex when the topic is determining detriment or benefit to society. By its very nature such an investigation must involve both humans and technology and be treated as a socio-technical study. We suggest that innovation translation (and actor-network theory) has many advantages as an explanatory framework over both Innovation Diffusion and TAM in socio-technical studies like this.

Both Innovation Diffusion (Rogers 1995) and TAM (Davis 1986) suggest that adoption decisions are made primarily on the basis of perceptions of the characteristics of the technology concerned. Using an Innovation Diffusion approach a researcher would probably begin by looking for characteristics of the specific portal technology to be adopted, and the advantages and problems associated with its use. They would think in terms of the advantages offered by portals in offering a user the possibility of finding information, but would do so in a fairly mechanistic way that does not allow for an individual to adopt the portal in a way other than that intended by its proponent – it does not really allow for any form of translation. If using TAM this researcher would similarly have looked at characteristics of the technology to see whether the potential user might perceive it to be useful and easy to use.

A researcher using an Innovation Translation approach to studying innovation, on the other hand, would concentrate on issues of network formation, investigating the human and non-human actors and the alliances and networks they build up. They would attempt to identify the actors and then to follow them (Latour 1996) in identifying their involvement with the innovation and how they affect the involvement of others. The researcher would then investigate how the strength of these alliances may have enticed the individual or organisation to adopt the portal or, on the other hand, to have deterred them from doing so (Tatnall and Gilding 1999; Tatnall 2002) (Tatnall and Burgess 2006). Especially in investigations involving interaction of humans and non-humans (technical artefacts) such an approach has much value.

CONCLUSION

Web portals are now quite ubiquitous and researching their use in organisations and by individuals is an important aspect of Information Systems research. It is useful to consider the portal as a technological innovation and to research it using an approach based on innovation theory.

While there is a significant amount of research into impacts of the use of web portals, the outcomes of much research are inconclusive when attempting to explain the uptake of the technology. It seems clear that a socio-technical perspective is need in the research effort. ANT provides a perspective that can produce resolution of the conflicting research results and provide an explanatory system.

REFERENCES

BBC. (2002). "Health Websites Gaining Popularity'." Retrieved July, 2006, from http://news.bbc.co.uk/2/hi/health/2249606.stm.

Brodie, M., Flournoy, R. E., Altman, D. E., Blendon, R. J., Benson, J. M. and Rosenbaum, M. D. (2000). "Health Information, the Internet, and the Digital Divide." *Health Affairs* **19**: 255-266.

Callon, M. (1986). Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St Brieuc Bay. *Power, Action & Belief. A New Sociology of Knowledge?* Law, J. London, Routledge & Kegan Paul**:** 196-229.

Davis, F. (1986). A Technology Acceptance Model for Empirically Testing New End-User Information Systems: Theory and Results. Boston, MIT.

Davison, A., Burgess, S. and Tatnall, A. (2004). *Internet Technologies and Business*. Melbourne, Data Publishing.

George, C. (2005). "The internet's political impact and the penetration/participation paradox in Malaysia and Singapore." *Media, Culture & Society* **27**(6): 903–920.

Latour, B. (1993). *We Have Never Been Modern*. Hemel Hempstead, Harvester Wheatsheaf.

Latour, B. (1996). *Aramis or the Love of Technology*. Cambridge, Ma, Harvard University Press.

Latour, B., Mauguin, P. and Teil, G. (1992). "A Note on Socio-Technical Graphs." *Social Studies of Science* **22**(1): 33-57.

Law, J. (1987). Technology and Heterogeneous Engineering: The Case of Portuguese Expansion. *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*. Bijker, W. E., Hughes, T. P. and Pinch, T. J. Cambridge, Ma, MIT Press**:** 111-134.

Law, J. (1992). "Notes on the Theory of the Actor-Network: Ordering, Strategy and Heterogeneity." *Systems Practice* **5**(4): 379-393.

Lewis, T. (2006). "Seeking health information on the internet: lifestyle choice or bad attack of cyberchondria?" *Media, Culture & Society* **28**(4): 521-539.

Lynch, J. (1998). Web Portals. *PC Magazine*.

Madden, M. and Fox, S. (2006). "Finding Answers Online in Sickness and in Health." Retrieved July, 2006, from http://207.21.232.103/pdfs/PIP_Health_Decisions_2006.pdf.

Maguire, C., Kazlauskas, E. J. and Weir, A. D. (1994). *Information Services for Innovative Organizations*. Sandiego, CA., Academic Press.

Rogers, E. M. (1995). *Diffusion of Innovations*. New York, The Free Press.

Shields, R. e. (1996). *Cultures of Internet: Virtual Spaces, Real Histories, Living Bodies.* London, Sage.

Singleton, V. and Michael, M. (1993). "Actor-Networks and Ambivalence: General Practitioners in the UK Cervical Screening Programme." *Social Studies of Science* **23**(2): 227-264.

Tatnall, A. (2002). Modelling Technological Change in Small Business: Two Approaches to Theorising Innovation. *Managing Information Technology in Small Business: Challenges and Solutions*. Burgess, S. Hershey, PA, Idea Group Publishing**:** 83-97.

Tatnall, A. (2005a). Portals, Portals Everywhere ... *Web Portals: the New Gateways to Internet Information and Services*. Tatnall, A. Hershey, PA, Idea Group Publishing**:** 1-14.

Tatnall, A. (2005b). To Adopt or Not to Adopt Computer-Based School Management Systems? An ITEM Research Agenda. *Information Technology and Educational Management in the Knowledge Society*. Tatnall, A., Visscher, A. J. and Osorio, J. New York, Springer**:** 199-207.

Tatnall, A. (2005c). *Web Portals: from the General to the Specific*. 6th International Working for E-Business (We-B) Conference, Melbourne, Victoria University.

Tatnall, A., Ed. (2007 forthcoming). *Encyclopaedia of Portal Technology and Applications*. Hershey, PA, Idea Group Reference.

Tatnall, A. and Burgess, S. (2002). *Using Actor-Network Theory to Research the Implementation of a B-B Portal for Regional SMEs in Melbourne, Australia*. 15th Bled Electronic Commerce Conference - 'eReality: Constructing the eEconomy', Bled, Slovenia, University of Maribor.

Tatnall, A. and Burgess, S. (2006). Innovation Translation and E-Commerce in SMEs. *Encyclopedia of E-Commerce, E-Government and Mobile Commerce*. Khosrow-Pour, M. Hershey, PA, Idea Group Reference**:** 631-635.

Tatnall, A. and Gilding, A. (1999). *Actor-Network Theory and Information Systems Research*. 10th Australasian Conference on Information Systems (ACIS), Wellington, Victoria University of Wellington.

Taylor, H. (2002). "The Harris Poll #21: Cyberchondriacs Update." Retrieved July, 2006, from http://www.gsbc.com/harris_poll/index.asp?PID=299.

Theodosiou, L. and Green, J. (2003). "Emerging challenges in using health information from the internet." *Advances in Psychiatric Treatment* **9**: 387-396.

Woo-Young, C. (2005). "Online civic participation, and political empowerment: online media and public opinion formation in Korea." *Media, Culture & Society* **27**(6): 925-935.

Yar, M. (2005). "The global 'epidemic' of movie 'piracy': crimewave or social construction?" *Media, Culture & Society* **27**(5): 677-696.

Implementing E-Procurement Systems: The Promise, Reality, and Lessons Learned

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INTRODUCTION

For most of the 20th century, the housing and auto industries were the key drivers of the United States economy. By the late 1990's, information technology (IT) accounted for a quarter to a third of economic growth. The increased productivity resulting from this IT growth, combined with the trend of globalization, together spawned what was coined as the "new economy."

THE PROMISE

A 1997 *Business Week* editorial touted that IT "boosts productivity, reduces costs, cuts inventories, and facilitates electronic commerce. It is, in short, a transcendent technology--like railroads in the 19th century and automobiles in the 20th [1]." There is little doubt that ease of access to the World Wide Web over the Internet was the catalyst of this "transcendent" technology. Businesses saw the potential for greatly increased markets, with significantly increased efficiency and productivity – a truly revolutionary development in the world of commerce.

One of the first and most obvious applications of B2B eCommerce was in the common function of corporate procurement. eCommerce was not new in this arena. Electronic Data Interchange (EDI) transactions over Value-Added Networks (VAN's) had been conducted since the 1970's as a technology that evolved completely separate from the Internet. These transactions, however, proved to be costly, required significant configuration, and forced trading-partner relationships that were formed out of convenience rather than for sound business decisions.

Commerce One, Ariba, and FreeMarkets were some of the more prevalent B2B eProcurement dot.com startups that promised to make the new economy a reality. They enjoyed double-digit daily stock price gains while maintaining negative cash flows and earnings in the dot.com frenzy. They developed their own "standards" such as xCBL (Commerce One's XML Common Business Language) and cXML (Ariba's commerce XML). Both "standards" claimed to constitute the XML schema, which would define how procurement transactions (and eventually all business transactions) would be defined over the web. As customers realized the challenges of these marketplaces and of complex integration requirements with suppliers, sales fell off sharply by 2001. Today Commerce One is an obscure part of Perfect Commerce, a $13 Million company that focuses on Supplier Relationship Software and the Open Partner Network electronic Marketplace. xCBL has evolved into an open source eCommerce standard (xCBL.org), and has become the baseline for the evolving standard Universal Business Language (UBL).

What are the lessons to learn from Commerce One? As early as 2001, Commerce One was feeling its troubles: Commerce One must continue to innovate if it hopes to stay ahead of enterprise resource planning vendors such as Oracle Corp., SAP AG and i2 Technologies Inc., all of which continue to invade its turf [5]. It's refocusing on procurement rather than marketplaces. it really got involved with all these marketplaces that were popping up and took its eye off the procurement ball. The e-marketplace stuff was at a roadblock.

Ariba was Commerce One's main competitor in the dot com era. Ariba developed the Commerce Services Network electronic marketplace. In contract to Commerce One, Ariba's more conservative approach to providing "sourcing solutions" ensured its vitality and survival. Ariba has enjoyed a trend of increased revenues since 2002. In its Fiscal Year ended 2005, Ariba recognized $323 Million in revenues, of which $151 Million was in services (up from $84 Million in services in 2004). Although revenues are growing, so are expenses, to the point where Ariba has yet to recognize a net gain. Since 2001, net losses have ranged from $2.6 Billion in 2001 to $349 Million in 2005.

The following stated in Ariba's Annual Report's requisite risk factors, is true not only to Ariba but a reflection of the industry. It also sheds another view on the fate of its one-time competitors: "The markets in which we compete are characterized by rapid technological change, evolving customer needs and frequent introductions of new products and services. As we adjust to evolving customer requirements and competitive pressures, we may be required to further reposition our product and service offerings and introduce new products and services. We may not be successful in developing and marketing such product and service offerings, or we may experience difficulties that could delay or prevent the development and marketing of such product and service offerings, which could have a material adverse effect on our business, financial condition or results of operations [6]."

THE POTENTIAL

Supply-side B2B eCommerce was born. New web procurement specialists such as aforementioned Commerce One, Ariba, and FreeMarkets emerged. These startups offered procurement software, and fought for dominance to provide "the" web standard for electronic procurement.

Electronic Marketplaces including MarketPlace.net, Global Trading Web, Covisent, the Commerce Service Network, and scores of vertical marketplaces evolved. Many were created by and for software vendors, while others were created by and for specific industries. The goal was to increase the number of suppliers and the number of buyers. The concept being that more traders would yield higher volumes of transactions. With lower transaction costs, and exponentially higher sales volumes, lower margins could be accepted. Lower margins would yield lower prices and cyclically increased volume.

Long-time Enterprise Resource Planning (ERP) vendors including SAP, Oracle, PeopleSoft, Baan, I2, and JD Edwards scurried to update their application offerings and their technology platforms to be able to accommodate the web based eCommerce requirements of their procurement customers. Each of the ERP providers worked rapidly to re-engineer its products to work on a web services based platform. Many formed strategic partnerships with web services companies, others tried to develop their own. Thus emerged new solutions from the ERP players including Oracle 11i eApps, MySAP from SAP, PeopleSoft version 8 with "no code on the client", and JD Edwards OneWorld. The products were different in approach, but they all were leveraging web services in one way or another so not be overtaken by their low capital high promise startup rivals.

On the eProcurement front, these ERP stalwarts also needed to devise their own applications, and quickly. For example, PeopleSoft and SAP took turns having partnerships with Commerce One. SAP is attributed to contributing to the demise of Commerce One by draining Commerce One of its intellectual capital [7]. The partnership kept SAP in the game in the short-run, while they were able to invest their significant resources into developing their own web based solutions for the long run. Today, SAP, Oracle, and Microsoft each continue to offer eProcurement solutions. These solutions unlike their standalone competitors have the ERP advantage of full-integration of eProcurement to supply chain management (SCM), supplier relationship management (SRM), financials management systems (FMS),

and enterprise performance management systems (EPM).

THE REALITY

A March 2001 study from Gartner Group reported that there is no first-mover advantage in eProcurement. The study reported "being a pioneer in this market is a huge hassle" since "projects grow out of control, the software vendors are immature, the e-procurement software itself is immature, and very few consultants have much experience with it." The study also pointed out that "early adopters of e-procurement are likely to have to educate many of their suppliers," and that "those who expect a rapid return on investment are in for a big disappointment [2]".

However, not all analyst outlooks' were as bleak as Gartner's. In a 2002 study, IDC analysts observed "The extensive conversion of existing EDI systems to an Internet foundation will be the primary force behind the continued expansion in e-procurement." [3] By late 2003, the purchase of direct materials over the web surpassed the purchase of indirect materials for the first time, according to a study by Forrester Research Inc. Forrester attributed this increase to the number of available software tools available for companies to use for online procurement and an increased level of comfort with buying direct materials over the Internet. The study identified Ariba Inc., SAP AG, Oracle Corp. and PeopleSoft Inc. as top tools vendors in the e-procurement business. These software providers were applauded for providing eProcurement solutions that could focus on the intensive sourcing process involved with direct materials [4].

CASE ANALYSIS

Case 1: Department of Defense

The Department of Defense (DOD) announced in January of 2002 that it would integrate its own internal marketplace and procurement system with Ariba's Commerce Services Network. The integration efforts were being managed by webMethods. The plan was that "DOD workers will be able to search for goods using keywords, manufacturer names or Universal Product Code numbers. The webMethods technology would let them see all relevant product information on a single screen instead of having to separately look through multiple online catalogs." Plans were in place to add additional vertical marketplaces so that "data will be boiled down to provide easy access for end users" [8]. However, the project was halted soon after the project started, after facing harsh criticism from the Government Accountability Office (GAO). In 2004, the GAO reprimanded the DOD for not adhering to US Government best practices in its system implementation, and "made 14 recommendations aimed at strengthening the Pentagon's acquisition policies for business systems as well as its controls for ensuring that proper procedures are followed." [9]

By September, 2005, DOD was on its way to revamping its procurement problems, both technical and policy related. The technical problems stemmed from failed software integration efforts to back-office systems. The majority of the user systems were client/server, and not web based. The revamping effort included a radical overhaul of its integration strategy by establishing XML standards to eliminate hand coding, and creating automatic tools to assist in documentation and development, to assist in the shift to being fully web based. The new web based system was anticipated to be in production in late 2006.

Some valuable lessons to consider from the DOD project include:

1. **Synergize**: The 2002 integration to electronic marketplaces was completely independent of the longer-term procurement project, which was halted by GAO. Although the marketplace solution met the short-term need of part of the organization, its implementation could have provided valuable resources and lessons to the overall procurement project. The marketplace effort should have been included as a component of the larger procurement solution.
2. **Identify standards up-front.** Part of the procurement overhaul was defining XML standards to replace manual coding for each integration effort. Since there were hundreds of integration efforts, a standard and scalable model is essential. The lack of standards encountered by DOD caused each integration to be handled as a separate, sequential project.
3. **Continuously evaluate technology.** The timing of this project was at a time of the most significant changes in the IT industry – between the end of client/server and the beginning of web services. As web services started to grow in the marketplace, DoD under the enforcement of GOA was forced to re-evaluate the project technology, and make the changes accordingly.
4. **Involve end-users early and often.** This is a critical success factor of any change in any organization, particularly in the area of IT.

Case 2: United Nations Development Program

In September 2003 the United Nations Development Program (UNDP) Agency scrapped their legacy system in favor of PeopleSoft ERP in a $27.5M global rollout, including eProcurement. The New York-based UNDP fights poverty and diseases such as AIDS and helps countries stricken by crises such as the December 2004 tsunami in Southeast Asia.

The motivation for this change was that the UNDP's processes were supported by a hodgepodge of homegrown legacy systems, including 21 separate human resources, payroll and procurement applications. That myriad of software prompted the UNDP in 2002 to choose the centralized PeopleSoft system and have Unisys Corp. manage it [10].

By November of 2005 the agency entered "Wave II" of the implementation, now a $59 million rollout, and now Oracle Corp.'s PeopleSoft applications. In September, the UNDP began implementing PeopleSoft's eProcurement application, which would be deployed in the Americas, Asia, Europe and Africa by the end of the first quarter of 2006. The eProcurement module automated requisitioning processes, cutting the time between procurement and payment by 10% [10].

Although it is another large political organization similar to DOD, the UN approach varied for several reasons. The lessons learned include:

1. **Think Big Picture**. The UNDP's implementation of eProcurement was not a standalone project, but one component of a greater global ERP system rollout. The economies of scale of resources, and the implementation knowledge base attained and transferred were applied across multiple module rollouts. Extensive monitoring, status, and documentation of project benefits and challenges were critical to this success.
2. **Plan, Plan and Plan**. The UN took its time to evaluate, analyze, and setup a realistic, phased timetable for its ERP project. It documented and evaluated progress each step of the way. It didn't hop on the eProcurement bandwagon during its short ride, but patiently waited out the temptation. It effectively planned to implement the system to best compliment its current system and meet its business objectives.
3. **Management Sponsorship, End User Ownership, and Consistent Messaging from the top down.** The implementation not only had management sponsorship, but ownership at every level. The needs, challenges, proposed solution, and plan to implement those solutions were clearly identified, and clearly communicated to all the project stakeholders.

Case 3: Ford

Similar to the UN Project, Ford Motor Company made the effort to implement a procurement system built around an ERP Vendor's eProcurement system. In 1999 Ford undertook a project appropriately named Everest, and started to go live in 2000 and continued with a "rolling launch."

Despite four years in production and an investment of millions of dollars, by Q3 2004, Ford decided to abandon Everest, which was built around Oracle Corp.'s 11i E-Business Suite of applications. Sources indicated that Everest was hampered by poor performance [11]. Ford's next plan was to migrate any relevant new features from Everest to its legacy system using its house development staff. Apparently, the mainframe procurement software continued to run in coexistence with Everest, and company suppliers used both sets of applications to handle procurement transactions.

A June 2001 assessment in Automotive Manufacturing and Production suggests that procurement in the automotive industry has the most complex procurement requirements of any industry. The article points out how "current procurement practices are rife with inefficiencies, complexities, and costly procedures" and that "A lack of standardization and its extraordinary complexity preclude any simple fix." The charge is made that IT vendors underestimate the challenges in providing software solutions in this space [12].

Dave Stephens, a former Oracle iProcurement developer shed some light on the Everest project at Ford, summarizing that the project was over-ambitious, with lofty goals including the desire to "unify dozens of legacy procurement systems, - standardize procurement methodology across its feudally-run, fiercely independent plants, take on direct, indirect, and MRO at the same time, and

- rationalize its supply base while putting in the new system." [13]. Here are the lessons learned from Ford:

1. **Prioritize Solutions and Implement Accordingly**. Ford was attempting to solve all of its procurement issues with one monumental effort. These included systems and non-systems issues, supplier, buyer and management issues. The eProcurement initiative and rollout to its end users got lost in the "big bang" approach of the Everest project.
2. **Align the Technology with the Business Need.** The timing of the rollout of Everest (1999) was prompted by the Web Revolution. Given the haphazard approach to the project and ultimate failure, it would have been in Ford's best interest to address its business process needs, and determine how the web can best help it meet those needs. Although this effort was made, it obviously was not given due diligence.
3. **Have appropriate expectations when entering a software partnership.** Ford attempted to implement an off the shelf ERP system that had very little automotive industry specific functionality. As with any vendor solution, nor did it offer any Ford specific business processes. The integration and customization effort was so huge, that the software was modified beyond the point where it could be upgraded. Undoubtedly, this contributed to the ultimate result. Ford should have expected that it would be making significant modifications.
4. **Get Back to Basics**. Emphasizing focus on the core information of the business, and how that core information is used to accomplish overall corporate strategy. This also implies the opposite, get away from anything that is not basic, or core, to the overall corporate strategy.

THE NEW WAVE

Many eProcurement providers have learned from the mistakes of the past, and have invested time and resources in creating world-class software solutions. They also promise realistic savings in the 10-15% range, rather then revolutionizing and reshaping the business world. For example, PurchasingNet, Inc claims over 1400 satisfied customers. With the self-nomenclature of "PNet," the company's focus is to streamline the procurement process in medium to large organizations. The Procure to pay solution consists of three primary modules: eProcurement, ePayables, and Financial Management. The differentiator of PNet compared to its progenitors is that it claims on its website that it can be implemented in less than 5 weeks. Another claim, also justified through a marketing case study is its ability to be easily implemented with legacy systems.

In a case study citing Countrywide Mortgage services, PNet is attributed to allowing Countrywide to continue to grow at a rapid pace, while keeping procurement costs under control. The study claims an ROI in 18 months, that 98% of spend is managed through PNET (approximately 3400 Purchase Orders per month), and that there is a 65% reduction in Accounts Payable manpower [14].

Although PurchasingNet has maintained eProcurement as one of its three solutions, other providers prefer to nestle eProcurement into the confines of "Spend Management Solutions." Ketera claims to be "The Proven Spend Solution" with a products focusing on spend analysis, sourcing, contract management, procurement, invoice management and supplier connection [15]. The company has enjoyed quarter-to-quarter growth over the past 14 quarters, with an optimistic outlook.

Another example is SciQuest, Inc. The company features many pharmacutical, as well as higher education institutions as having successfully implemented and gain cost benefits from implementing its products. Glaxo Smith Kline (GSK) opted for SciQuest's Spend Director products which enhance existing procurement systems with content to increase on-contract spending, which was a business challenge at GSK). After implementing the product, GSK realized an improvement in contract compliance of over 20%, with 50% of all of its indirect purchases through the SciQuest product. It has also allowed GSK to integrate directly to their suppliers (over 200) avoiding a wholesales middleman, saving an additional $500,000 a year.

The aforementioned New Wave of eProcurement providers have some key differences from the DotCom era eProcurement vendors. First, they all try to cleverly minimize the 'eProcurement" term as a buzzword. Second, none are publicly trade. Third, each focuses on procurement and procurement related business objectives. Although some expand into materials management (SciQuest) and others in integrated Financials Management (PNet), each knows its limits and has developed and implemented ERP integration points. Finally, each focuses on the solution being one of enabling users to make more efficient and effective procurement choices. The focus on the earlier eProcurement vendors was on how technology would enable efficiency and effectiveness, grossly underestimating the critical need to incorporate the users as the key catalysts of change.

CONCLUSION

The philosophies, approaches, successful and failed eProcurement efforts over the past seven to eight years, are as various as the combined number of vendors and customers who have dabbled in or delved into eProcurement. However, the past in this case is not a clear indication of the future. Instead, the past offers many lessons learned from successes and failures that can serve as guiding factors for future implementations.

A December, 2005 Aberdeen Group study on eProcurement best practices sites [16]. The study claims there is now resurgence in eProcurement systems, and that the reasons for this resurgence include:

- Continued cost pressures, especially due to outsourcing
- Compliance issues that suppliers enforce compliance with purchasing contracts
- Advances in supplier enablement make it easier for more suppliers to be on board; including proliferation of supplier networks and catalog hubs
- Advances in eProcurement system functionality including integration and reporting
- New pricing models have made eProcurement more affordable for mid and small market companies.

The resurgence and noted successes of eProcurement in its second "wave" of less hype and greater returns is a testimony to the inherent human factors of competently addressing change management and project management. The cited critical lessons learned in this study are not unique to eProcurement, but are generally practiced for any successful change management or project implementation effort:

- Executive sponsorship has a direct relationship on the success of the project. Higher sponsorship yields greater chances for success.
- End-user involvement early and often has been cited as a critical success factor. This also involves extensive training of the system.
- Planning accordingly should be obvious, but especially in the dot com hype planning often took a back seat to the industry generated fear of being left behind.
- Putting company strategy first and IT strategy aligned with the company strategy should also be obvious, but also suffered during the dot com hype
- Consistent messaging across divisions, especially for large-scale projects, is critical for success. This can be hindered by poor planning and poor strategy alignment as well.

These human factors, combined with the fact that eProcurement systems involved people - lots of people – emphasize that it is truly the people that are the key implementation success factor, and not the technology. The implementers, the back-office experts, the systems experts, the supplier representatives, and thousands of potential end uses are all involved; each contributes and each makes a difference.

REFERENCES

(1) Shepard, Steven B. "The New Economy: What it Really Means"; Business Week, Nov. 17, 1997
(2) "Business Pioneers, E-Procurement: OK to Be No. 2", Computerworld, March 12, 2001
(3) Hamblen, Matther, "After the Hype", Computerworld, December 23, 2002
(4) Weil, Nancy, "Forrester: 'Nuts and Bolts' Buying up on Internet", July 13, 2003
(5) Meehan, Michael, "Commerce One Refocuses on Procurement", Computerworld, June 22, 2001
(6) Form 10-K, United States Securities and Exchange Commission, September 30, 2005
(7) Shread, Paul, "Time Running Out for Commerce One", Internetnews.com, September 23, 2004
(8) Havenstein, Heather, "DOD Revamps Troubled Procurement Software", Computerworld, September 26, 2005
(9) Songini, Marc L., "Pentagon Urged to Fix Procurement Processes", Computerworld, August 9, 2004

(10) Songini, Marc, "UN Updating Oracle ERP Rollout", Computerworld, November 28, 2005
(11) Songini, Marc, "Ford Abandons Oracle Procurement System", Computerworld, August 23, 2003
(12)Piszczalski, Martin, "The Promise of eProcurement", Automotive Manufacturing & Production, June 2001
(13) Stephens, David, "Marv Adams, Ford CIO and Ruminations about Project Everest", Wordpress: Procurement Central, March 24, 2006
(14) "Financials Services Giant Realizes Significant Reduction in Costs", PurchasingNet, Inc. http://www.purchasingnet.com
(15) "Identify, Capture, and Sustain Spend", Ketera Technologies, Inc.(http://www.ketera.com)
(16) "Best Practices in E-Procurement", Aberdeen Group Report, December 2005.

Design of Web Information System Process-Oriented

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ABSTRACT

Modern Web Information System must answer "on the fly" to the company's change requirements. To do this, companies left the vertical vision that locates business logic in functional areas orienting them toward a transversal vision that, according to the process logic, tries to improve the management exploiting as much as possible the existing resources. Process vision seems a good way to guarantee to the manager a full business activity control and to increase the flexibility degree in the IS management in order to apply immediately changes. To reach a good flexibility level a company "process vision" is not enough: it is very important that processes are explicitly taken in consideration in the Information System and not hidden in the code. In this paper, our goal is to provide a methodological approach to the design of Web Information System in order to obtain a good flexibility level. We consider the two main aspects of the Web Information System that is the management of the user experience (a typical web application problem) and the design of the business process already made by business experts and we try to integrate them through methodological guidelines.

Keywords: Business Process Management, BPMN notation, Web Information System

1. INTRODUCTION AND BACKGROUND

Companies have abandoned a functional logic that provide a vertical vision and they are moving towards a horizontal vision that allows, thank to a correct use of business process, to provide the appropriate flexibility level to the Information System. This involve a change to the companies' Information Systems but, because the Information Systems are now oriented to the web (WIS-Web Information Systems) it is important to consider not only the process aspects (the business processes must be considered in a explicit way in order to reach a good flexibility level) but also the web application paradigm that is the information, navigation and the transactional aspects typical of Web Applications. According to these requirements, the WIS became more complex and they need a careful design phase made up by ad-hoc methodologies to manage the complexity.

In the traditional design and development of an Information System, it is important to consider two kinds of actors: internal actors and external actors. Today, because Information System is delivered on the web, this distinction is still important:

- *Internal actors* interact with the WIS through intranet considering the Information System as a job tool needful and irreplaceable.
- *External actors* (as an example customers or suppliers) take advantages of Information Systems only through Internet.

The two kinds of user and the two platforms (Intranet and Internet) share the same characteristics: the application implements one or more process in order to drive the user to execute them. The main difference is that the internal users actions are essentially process driven while, when external users interact with the application, they need information not strictly related to the processes (such as marketing information) that make easy the process execution by the final user.

Therefore, there are several approaches (methodological and technological) to follow in the design and implementation of a WIS process-oriented and the main difference concerns the necessity to manage or not the user experience (UX). The UX design is the design of the information and navigation aspects in a user centred style focusing on the dialogue between user and application so the information are presented to the user in order to facilitate this dialogue avoiding the user to lose in the web application.

We focus in this paper on the WIS design for the external actors, so we consider both the UX design and the business process design linking together the know-how coming from these two research area. We deal in the intranet design problems in a separate paper where we describe a methodological approach focused on the portlets.

Several methodologies attempt to solve the WIS design problem for external actors.

WebMl [1] is a web application design methodology: to support processes authors made an extension to meta-data and add the concept of interface in order to provide to the final user the interface to execute process. The authors of WebMl state that the methodology is not efficient when process hide sophisticated business logic.

UWE[2] start from an UML class diagram and from a process design made up by an UML activity diagram. The design methodology is made up of several steps starting from a refinement of the conceptual model adding new attributes in order to take in consideration the process logic. In the navigational model, the extension for business process adds new access structure (in order to support business process) and the rules of their use.

WSDM [3] extend itself in order to support processes with a first integration with the information aspect of the methodology: this integration is made up by a design of the information needed in each process task. In the Task Navigation Model, in order to complete the design, WSDM add the *process logic link* that express the link between tasks and semantic link.

Each methodology has its strengths and weaknesses; for example, all these methodologies are user-centred but just UWE provides support in order to stop the process execution and continue its execution later. Only few methodologies support a standard notation to design process and it is not always possible to make a clear distinction between process link and semantic links.

Our research work, starting from a Web Application design methodology that, focusing on the dialogue between user and application and using well-known techniques for process analysis, design and representation, defines methodological guidelines that drive the designer towards the design of complete WIS.

We selected IDM [4][5] as web application design methodology. IDM seems a good methodology to manage the UX aspects of WIS and we implemented, for IDM, a code generator [6] considering IDM as the domain specific language to design the web application. The code generator allows us to obtain in a few minutes the final application. Today, IDM does not provide guidelines about the integration with business processes.

Regarding business process design, we select BPMN [7] an OMG standard notation simple and effective.

In IDM, the main concepts are: *Topics* and *Relevant Relation*. Topics are made up by *Dialogue Acts* that are information unit of the main topic. The access structures express how the final user can reach and use the information. Each topic may be related to one or more *Introductory Act* that is the entry point to the topic's information. Furthermore, IDM provides the possibility to indicate that the topic

is related to an operation using the *Operation Act* but IDM does not provide any detailed description about the operation. IDM provides a specific design for each user and each device. Information contents are organized in page (*P-IDM*). Screens with input and/or output information contents make up each page; each screen has its own layout and belongs to a screen template. Pages are grouped in view; each view focuses on a specific aspect: the *structural view*, for example, represents the navigation within the same topic; the *association view*s represent the navigation between topics.

In this paper, we present in the section 2 the open issues in the WIS process-oriented design and in the section 3, we present the integration guidelines between IDM design and the business process. In section 4 we apply guidelines to a real world case study, finally, we present in section 5 conclusions and future works.

2. WEB INFORMATION SYSTEMS PROCESS-ORIENTED: OPEN ISSUES

Before to define the methodological guidelines we present here some open issues. We know that other works deal with the same open issue [8] but here we refer to a specific design methodology focused on the UX and not on a general UML-based methodology.

Several Types of Information in the Same Web Application

A traditional web application has the main goal to provide the user with information using a well-defined plan close to the user's expectation. The introduction of process logic, adds process information to typical web application information. In a WIS process-oriented, we can see three different kinds of information:

- Information used by process task: for example input and output data of each task.
- Information related to the process already finished;
- Hypermedia information that are data not related to the process: for example marketing information are related to a specific process but are not input and/or output information of the process task.

Information related to the UX design and information related to the process are not disjoint: it is possible that a UX information hide information related to one or more process tasks; in the same way, a process task may hide information related to different UX information unit.

Navigation Design

The navigation design plays a very important role in the web application design. In the WIS process-oriented, it is hard to make the navigation design because the final user must follow several steps coming from process logic in a well-defined order. We observe that process links (links coming from process design) must be related to the semantic links: an inconsistence between process link and semantic link warns the designer about the possibility of an error in the process and/or in the UX design.

Process State

The user during the task execution may want to exit from the process in order to read marketing information or information related to process instances yet finished. The user wants to continue the process later exactly where he/she leaves from. This is not only an implementation problem but this is a design problem: at design level, it is important to provide information about the process state in order to provide dynamically generating access structures that allow the user to continue the process execution.

Web Page for Task Execution

In the web page design, it is important to define if the process uses just one page or multiple pages. We observe that there is not a rule to assign a well define number of pages to a task: it depends on the graininess level of the process design. Sometimes a task execution ends in one page; sometimes the task execution require several pages, other times a task is an automatic task so web pages are not required.

3. WEB INFORMATION SYSTEM PROCESS-ORIENTED: GUIDELINES

To approach the open issues presented in section 2 we provide not a design methodology but integration guidelines: in this way the know-how coming both from web application design and from business process design are related in order to not lie the designer to many restrictions. In the guidelines definition our attention was oriented to the *traceability requirement*: in the web application process-oriented design, it is important to follow the process flow. In this way, it is simple to obtain quickly changes in the web application process oriented when a change in the business process happens: very often companies change their business process in order to answer to the companies' requirements changes.

Type of Users

There is a natural mapping between web application type of users and business process actors: each pool and each lane of pool can be mapped to a web application user. This is not a general rule; in fact, in BPMN notation it is possible to represent with pool and/or lanes non-human actors that are not related to a specific web page; pools can be black box (when they represent external institution related to the company but not directly involved in the process).

Mapping Between Process Information and UX Information

Starting from IDM design it is possible to identify topics, dialogue acts and slots belonging to the process. It is possible that information related to only one topic are enough to execute the process but it is also possible that information needed to execute the process are in several IDM topics. So, it is impossible to define a general rule in order to identify the information helpful to execute process starting from the UX design; in the same way it is impossible to define a general rule in order to identify where process information are located in the process depending on the specific case study.

Operations

Operations are very often not taken into consideration from design methodologies: operations are, instead, a key aspect to integrate process design and UX design but it is important to define the operation properties. For each process task, it is important to see if it requires one or more operations, a simple navigation or both. The operation act (the IDM element that defines the operation) may be related to a topic or to a dialogue act but may be related neither to a topic nor to a dialogue act. For example, if we think to an operation related to a message exchange the operation is not lies to any elements of the UX design. The operation act properties that we define are:

- *Name*: the same to the task related to the operation act (when exist);
- *Process name*: the name of the process;
- *Task:* the task related to the operation act (when exist);
- *Implementation*: the reference to the code that implements the operation;
- *Pre-condition*: the condition need to execute the task (when exist);
- *Output*: the output of the task related to the operation act (when exist);
- *Gateway*: is defined only if the operation is related to a gateway. It expresses the condition related to the gateway ;
- *Kind of topic*: identify the kind of topic where information are located;
- *Dialogue act*: identify the dialogue act where information are located;
- *Slot*: identify the slot where information are located;

Traceability Between UX Design and Business Process Design

As we state before, it is very important to provide traceability between UX design and business process design. We add to the IDM design the operation strategy ⇧ (to show the dialogue act or topic where the process starts) and the intermediate strategy ⇮ (to show a pause in the process execution) that is related to an intermediate event. Another important aspect is the introduction of the *process link*: it links together two operation acts in order to trace the process flow. The name of the process link is the name of the target operation act.

Access Structures

Access structure allows the user to access the web application. In the web application without business process, access structure allows to access to the information

Table 1. IDM extension

IDM extension for Business process integration	Comments
Structure of operation act	To provide the right structure to operations (very important in the process)
Intermediate strategy	Answer to the traceability requirement
Operation Strategy	Answer to the traceability requirement
Process link	To separate the free navigation from the navigation coming from the process logic
Specific access structure for process	User must be able to execute a task of the process
Management of the state of the process	Allow to stop and re-start process
Input form	Allow to insert input data in order to execute a process task
Screen with input form (<<P>>)	Answer to the correspondence requirement
Process view	Answer to the traceability requirement

according to the UX design; when the web application hides a business process, it is important to add access structures in order to allows the user to start the process and to continue its execution when he/she stop the process. We advise to define an access structure for each operation act.

Page Structure

The page structure design changes when we integrate the business process design in the UX design. In P-IDM each topic produce a structural view made up by screens aggregate to contents (in order to show information) or screens aggregate to an input form (in order to insert information). When the process design is taken into consideration, the same information may be, depending on the process state, input information or output information. We state that in the page design level must coexist both input form and content: the input form or the content will be dynamically presented to the final user depending on the *process state:* the screen has also information about the state. The input screen related to a process will be show with a <<P>> symbol.

If the information of the same topic is useful in order to execute two or more operation, the related screen will be linked together with a process link. In the structural view, we define the *intermediate link* in order to represent the intermediate strategy.

Regarding to the *template view*, it is important to define links that allow the user to continue the process: the state of the process allows to dynamically activate the correct link.

We recommend to add a process view in order to design in a single view all the process screens. The process view is useful when the information needed to execute a process are in several topics in order to understand how the process flow moves towards information. If the information to execute process is all in the same topic the process, view is the same of the structural view.

We summarize in table 1 the IDM extension proposed.

4. GUIDELINES IN PRACTICE: A CASE STUDY

We apply the guidelines proposed in section 3 to two different research project founded by Italian government: one project is related to the management of environment domain and another is related to the commerce of the wheat.

We present here the first project born with the goal to design and implement a family of web application compliant with European standard related to the environment. From this family it will be possible to obtain specific web application for several public administrations with different competencies and responsibilities. Obviously, the web application family will consider both the UX and the process aspects.

Figure 1. IDM design of the management flora and fauna census

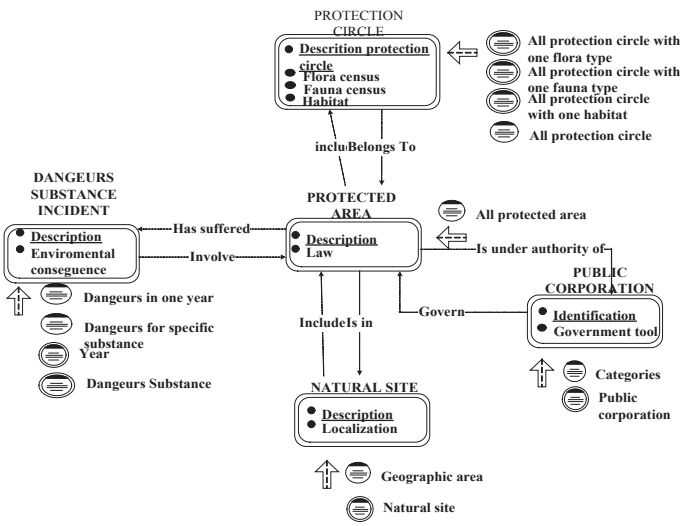
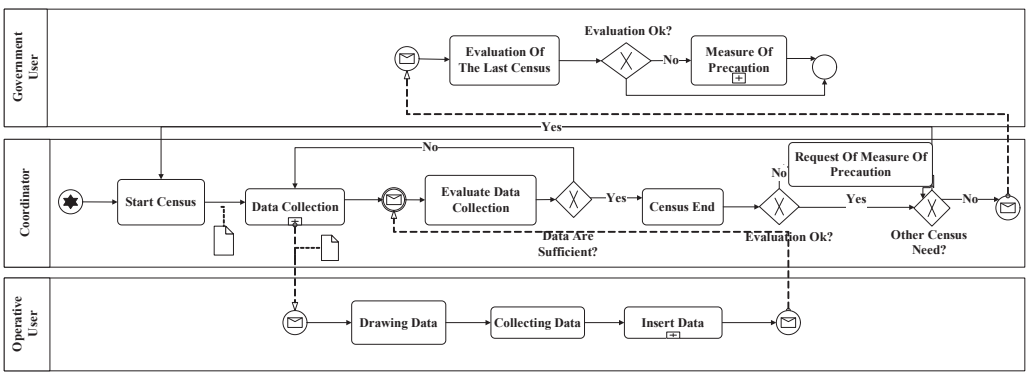
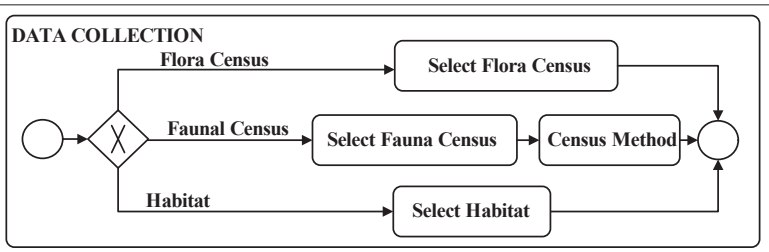


Figure 2. BPMN design of the management flora and fauna census process





In this project business experts and IT experts' teams design, in a separate way, both the UX and the business process of the overall information system (Fig. 1 and Fig. 2).

We present here, due to space limitations, a fragment of the overall Information System: the management of flora and fauna census. The sub-process "data collection" considers three kinds of census but we are interested only to "faunal census".

In fig. 2 we can immediately observe three kinds of user one for each BPMN pool: we focus only on the coordinator user.

A careful analysis of the process design and of the UX design helps to select the process information defined also in the UX design. We observe that all process tasks refer to one dialogue act: "*faunal census*". Each task is related to a different slot of the dialogue act. As an example the task "*Start Census*" is related to the slot "*Description*" and "*Start date*" while the task "*End Census*" is related only to the slot "*End Date*".

The task "*Request Of Measure Of Precaution*" is not related to any slot: this task is the request of a precaution made up by the coordinator user to the government authority, so it does not require neither to write nor to read any slot.

In fig. 3 we show the process start on the integrated design with an *operation strategy* near to the dialogue act related to the first process activity (the first operation act).

We define now the operation act (in this case study all the operation act are on the topic *Protection circle*). In fig. 3 we show only the properties of the operation act related to the "*Start Census"* but all operation acts have its own structure. We

Figure 3. IDM Process of the management flora and fauna census process

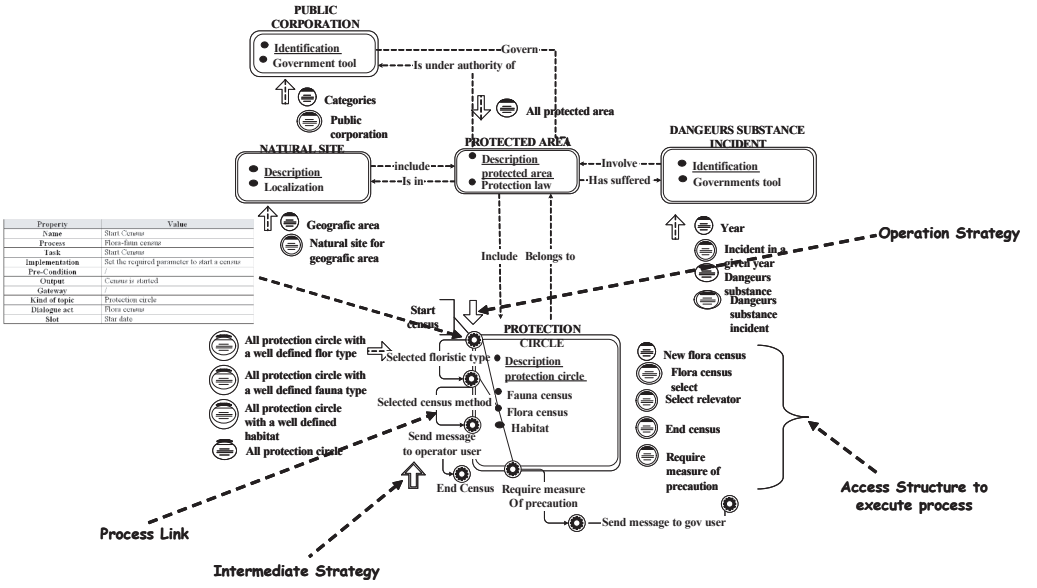
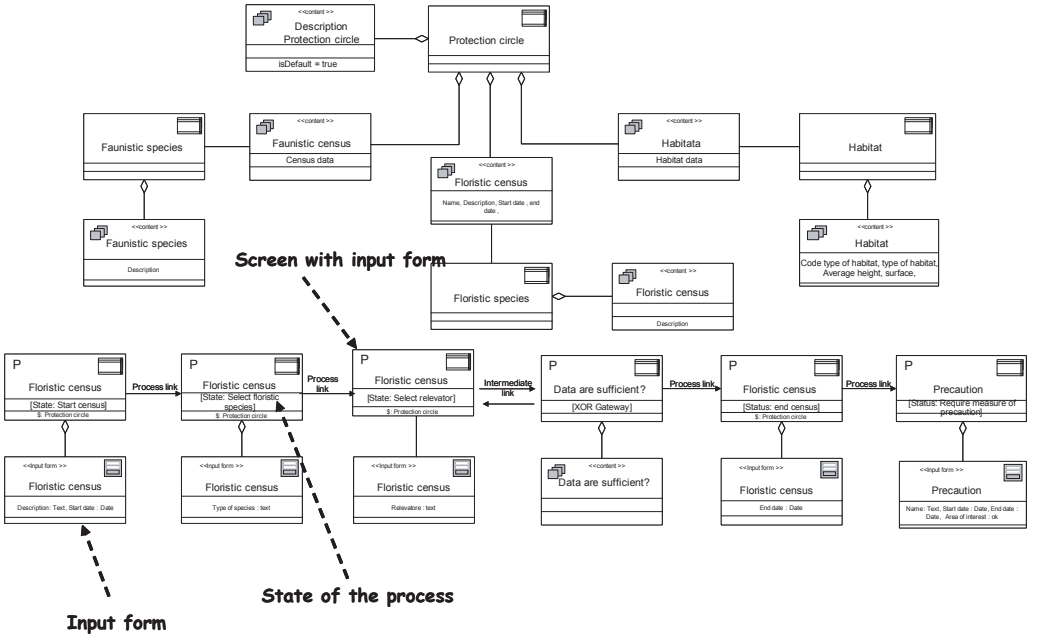


Figure 4. Structural view



can see that there is an operation act related to each process task also for the task related to operation not directly related to the information.

At this point, we design the process link that links together, in a well-defined order and according to the process flow, the operation acts. The name of the process link is the name of the target operation act.

We define now the access structures (in IDM methodology named introductory act) in order to start a new process or to continue the process. There is an introductory act for New Flora Census that allows to make a new process instance; in the same way, we define an introductory act for each operation act. If the operation act represents only a message exchange there is not an access structure related.

Regarding the page design, we consider the structural view related to the *Protection Circle* Topic (Fig. 4). We can see that the screen related to each dialogue act has both content and input form. Process screens are marked with a <<P>> on the top and contain information about process state. *Process link* links together the process screens according to the process flow. We highlight that the process screen related to the gateway is related with content and not with an input form: a gateway does not require input data (defined through slot) but only an answer to a well-defined question. The slots needed to execute task are shown in the input form.

In the *page template view* (not shown here for space reasons) there are links that brings to the process screens. These links do not appear in all the pages but they will be dynamically generated depending on the process state and allow the user to start or to continue the process exactly where he/she left.

Finally, the process view contains the entire process screens and their relationships: in this case study the process view is the same of the structural view because all the information need to execute process are in the same topic.

5. CONCLUSIONS AND FUTURE WORK

To achieve the goal of the flexibility in the modern WIS process-oriented, it is important to think to a design methodology that links together the know-how coming from the UX design and the know-how coming from the process design. In this paper, we defined an integrated methodology focusing on the differences between kinds of information and between free navigation and navigation process-driven. We apply the guidelines to a real case study with good results. The buyer was very happy because it is possible to trace, in the final design, both the UX and the process design. Processes, was, also, defined by their business expert so, the final WIS matches exactly their needs with an added value. Public administration, that is the final user of the WIS, was very happy to work with a WIS where all the information are really where they need and are reachable exactly as they need. In addition, developers have a clear documentation.

Naturally, the implementation actually is made by hand but we are planning to extend our code generator in order to support also the introduction of these guidelines.

REFERENCES

[1]S. Ceri, P. Fraternali, A. Bangio: Web Modeling Language: a modeling language for designing web sites, WWW9 Conference, Amsterdam, May 2000

[2] N. Koch, A. Kraus, C. Cachero and S. Meliá, Integration of Business Processes in Web Applications Models. Journal of Web Engineering, Rinton Press, Vol. 3, No. 1, May 2004, 22-49

[3] O.M.F. De Troyer, S. Casteleyen, Modeling Complex Processes for Web Applications using WSDM, 3rd Int. Workshop on Web-Oriented Software Technology, Oviedo 2003

[4] Paolo Paoline, Luca Mainetti, Davide Bolchini: "Progettare Siti Web e applicazioni mobili" McGraw- Hill, 2006

[5]Perrone, V., Bolchini, D., Paolini; P.:A stakeholders centered approach for conceptual modeling of communication-intensive applications. 23rd annual international conference on Design of communication: documenting & designing for pervasive information Conventry (2005)

[6] R. Paiano and A. Pandurino, "WAPS: Web Application Prototyping System" - Web Engineering 4th International Conference, ICWE 2004, Munich, Germany, 2004, Springer ISBN 3-540-22511-0.

[7] OMG, BPMN 1.0, (2006). Final Adopted Specification, February 6, 2006 Retrieved April, 2006, from www.bpmn.org

[8] Vidgen, R., Avison, D., Wood, R., and Wood-Harper, A.T. Developing Web Information Systems, London, UK, 2002

Exploring Knowledge Management Success

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ABSTRACT

Discussions at previous HICSS conferences have shown that there is no general agreement on definitions of Knowledge Management (KM) and Knowledge Management Systems (KMS) success. A deep understanding of these concepts would help to design and implement efficient KM initiatives and systems. We present an exploratory research study to begin and facilitate a debate that will hopefully lead to a consensus definition of KM and KMS success. We chose an expert panel approach followed by an exploratory survey to approach the KM and KMS success definition. The research shows only a few points of consensus. However, we present some areas of agreement as well as of disagreement, which are a good starting point for further discussions on KM and KMS success.

1. INTRODUCTION

Knowledge Management (KM) and Knowledge Management System (KMS) success is an issue needing to be explored. The Knowledge Management Foundations workshop held at the Hawaii International Conference on System Sciences (HICSS-39) in January 2006 discussed this issue and reached agreement that it is important for the credibility of the KM discipline that we be able to define KM success. Additionally, from the perspective of KM academics and practitioners, identifying the factors, constructs, and variables that define KM success is crucial to understanding how these initiatives and systems should be designed and implemented. It is the purpose of this paper to initiate discussion on this topic and present results of a survey looking at how KM practitioners, academics, and students view what constitutes KM success. The paper presents some background on KM success and then a series of perspectives on KM/KMS success. These perspectives were derived by looking at responses to questions asking academics and practitioners how they defined KM/KMS success. The paper then concludes by presenting the results of an exploratory survey on KM/KMS success beliefs and attitudes. It is hoped that this paper will begin the debate that will lead to a consensus definition of KM/KMS success.

2. BACKGROUND ON KM SUCCESS

Jennex (2003) summarized various definitions of KM to propose that KM success be defined as reusing knowledge to improve organizational effectiveness by providing the appropriate knowledge to those that need it when it is needed. KM is expected to have a positive impact on the organization that improves organizational effectiveness. DeLone and McLean use the terms success and effectiveness interchangeably and one of the perspectives proposed in this paper does the same for KM (DeLone and McLean, 1992 and 2003).

Jennex and Olfman (2005) summarized and synthesized the literature on KM/KMS critical success factors, CSF, into a ordered set of 12 KM CSFs. CSFs were ordered based on the number of studies identifying the CSF. The following CSFs were identified from 17 studies looking at over 200 KM projects:

- A Knowledge Strategy that identifies users, sources, processes, storage strategy, knowledge and links to knowledge for the KMS.
- Motivation and Commitment of users including incentives and training
- Integrated Technical Infrastructure including networks, databases/repositories, computers, software, KMS experts
- An organizational culture and structure that supports learning and the sharing and use of knowledge
- A common enterprise wide knowledge structure that is clearly articulated and easily understood
- Senior Management support including allocation of resources, leadership, and providing training
- Learning Organization
- There is a clear goal and purpose for the KMS
- Measures are established to assess the impacts of the KMS and the use of knowledge as well as verifying that the right knowledge is being captured
- The search, retrieval, and visualization functions of the KMS support easy knowledge use
- Work processes are designed that incorporate knowledge capture and use
- Security/protection of knowledge

However, these CSFs do not define KM/KMS success; they just say what is needed to be successful. Without a definition of KM/KMS success it is difficult to measure actual success.

3. PERSPECTIVES ON KM/KMS SUCCESS

The KM workshop at the 2006 HICSS found that there were several perspectives on KM success. This section briefly summarizes these perspectives.

3.1. KM Success and Effectiveness

One perspective on KM success is that KM success and KM effectiveness are interchangeable and imply the same construct or variable. This is based on the view that effectiveness is a manifestation of success.

An example would be increasing decision making effectiveness to generate a positive impact on the organization resulting in successful KM. This perspective uses both process and outcome measures.

3.2. KM and KMS Success as Interchangeable

Another perspective is that KM and KMS success is interchangeable. KMS success can be defined as making KMS components more effective by improving search speed, accuracy, etc. As an example, a KMS that enhances search and retrieval functions enhances decision making effectiveness by improving the ability of the decision maker to find and retrieve appropriate knowledge in a more timely manner. The implication is that by increasing KMS effectiveness, KMS success is enhanced and decision making capability is enhanced leading to positive impacts on the organization. This is how KM success is defined and it is concluded that enhancing KMS effectiveness makes the KMS more successful as well as being a reflection of KM success. The Jennex and Olfman (2006) KM Success Model, based on the DeLone and McLean IS Success Model (2003), combines KM and KMS success and utilizes this perspective.

3.3. KM and KMS Success as Separate

As opposed to the previous section, this perspective views KM and KMS success as separate measures. It is based on a narrow system view that allows for KMS success that does not translate into KM success. KMS are often seen as a subfunction of KM comprising technical and organizational instruments to implement KM. Thus, KMS success addresses implementation and operation factors in terms

of system or process metrics whereas KM success is an assessment of the value that these systems and processes provide to an organization. KM focuses therefore more on the outcome, while KMS focus more on the process. These perspectives are introduced in the following sections.

3.4. KM Success as a Process Measure

This perspective views KM success as a process measure. KM success could be therefore described in terms of the efficient achievement of well defined organizational and process goals by means of the systematic employment of both organizational instruments and information and communication technologies for a targeted creation and utilization of knowledge as well as for making knowledge available. KM is a support function to improve knowledge-intensive business processes. An example would be supporting the technology forecasting process in an IT consulting firm by technical components of a KMS [6]. Complementary, the effective implementation of knowledge processes (i.e. acquisition, creation, sharing, and codification) is seen as a part of KM success. This perspective focuses therefore on measuring how much KM contributes to improving the effectiveness of business and knowledge processes.

3.5. KM Success as an Outcome Measure

In contrast, this perspective views KM success as an outcome measure. KM success is therefore seen as a measure of the various outcomes of knowledge process capabilities existing within an organization as a result of undertaken KM initiatives. Typical outcomes in terms of organizational performance are the enhancement of:

- product and service quality,
- productivity,
- innovative ability and activity,
- competitive capacity and position in the market,
- proximity to customers and customer satisfaction,
- employee satisfaction,
- communication and knowledge sharing, and
- knowledge transparency and retention.

3.6. KM Success as Combined Process and Outcome Measures

The last perspective views KM success as a combination of process and outcome measures. Respective descriptions of KM success focus on improved process effectiveness (cf. section 3.4.) as well as on achieving actionable outcomes (cf. section 3.5). Sections 3.1 and 3.3 contain examples for this combined approach.

4. METHODOLOGY

This paper is exploratory research with the goal of guiding the KM community towards a consensus definition of KM success. To achieve this, base data was obtained through an exploratory survey. The exploratory survey was generated through an expert panel approach. The 30 members of the editorial review board of the International Journal of Knowledge Management were asked to provide their definitions of KM success. Thirteen responses were received. These responses were used to generate an exploratory survey on KM success. The exploratory survey used 5 point Likert scale items to solicit agreement on various perspectives and proposed KM success definitions. The perspectives were generated by analyzing the responses of the expert board. These responses were found to be grouped two ways. The first grouping of responses looked at the measures used to determine KM success. Three groupings were observed: process based measures, outcome based measures, and combined process and outcome based measures. The second grouping of responses was in two groupings: those that combined KM and KMS success measures and those that viewed KM and KMS success as separate measures. A final observation was that many proposed definitions used success and effectiveness interchangeably.

The exploratory survey also collected data on the KM expertise and focus of the respondent. Also, the survey had text boxes that allowed for free form input on additional KM success factors or measures, KM success definitions, and thoughts on differences between KM and KMS success.

The exploratory survey was administered using a web form with data collected and stored automatically. Survey respondents were solicited via broadcast emails to the ISWorld and DSI email list servers, to lists of KM researchers maintained by the authors, and to the editorial review board and list of authors for the International Journal of Knowledge Management. An initial request was sent followed by a second request approximately one week later.

One hundred and three usable survey responses were received. Thirteen were from KM practitioners, 70 were from KM researchers, 6 were from KM students, and 14 were from academics interested in KM but not active KM researchers. Likert items were analyzed using means and standard deviations as no hypotheses have been proposed and need testing.

The results of the exploratory survey were used to generate a second survey. This survey presented a composite definition of KM success and a set of measures for each of the indicated dimensions. A 7 point Likert scale was used to solicit agreement on the composite definition and each set of measures. Additionally, as in the exploratory survey items were provided for collecting data on KM expertise and respondent focus. Also, each set of measures had boxes where respondents could indicate measures they would add or remove from each set of measures.

The second survey was also administered using a web form with respondents solicited in the same manner as the exploratory survey. One hundred and ninety-four usable survey responses were received. Sixteen were from KM practitioners, 114 were from KM researchers, 23 from KM students, and 41 were from others including academics interested in KM but not active KM researchers. Likert items were analyzed using means and standard deviations as no hypotheses have been proposed and need testing.

5. FINDINGS

There was little consensus on KM success perspective or definition from the first survey while we did find agreement on a definition of KM success and measures of success in the second survey. The results of the first survey are summarized in tables 1-3 while the results of the second survey are presented in Table 4. Table 1 looks at opinions with respect to the perspectives on KM success. The only perspective that tends to have any consensus agreement is that KM success is a combination of process and outcome measures and is NOT just process or just outcomes. We are undecided if success and effectiveness are equivalent measures and tend to be undecided to slightly against the idea that KM and KMS success are equivalent.

Table 2 summarizes opinions on five suggested components of KM and KMS success definitions. There appears to be consensus on using organization specific subjective measures derived for KM process capabilities. Examples of these capabilities include knowledge reuse, quality, relevance, effectiveness of acquisition, search, and application of knowledge, etc. There also appears to be consensus that any KM success definition should include providing the appropriate knowledge when needed. Additionally, there is consensus that use is not a good measure of KMS success. It is interesting to note that practitioners and students support the use of

Table 1. Opinions on KM success perspectives, mean (std dev)

	Overall	Research	Practice	Academ	Stud
Success = Effectiveness	3.1 (1.4)	3 (1.4)	3.3 (1.3)	3.2 (1.5)	3.7 (0.5)
KM = KMS Success	2.6 (1.5)	2.5 (1.4)	3.2 (1.6)	3.4 (1.5)	2.2 (1)
KM = KMS Measures	2.6 (1.4)	2.4 (1.4)	3.2 (1.6)	3 (1.4)	2.4 (0.9)
KM Success = Process	2 (1)	1.9 (0.9)	2.2 (1.1)	1.9 (0.8)	3 (1.3)
KM Success = Outcomes	2 (1)	2 (1)	2.2 (1.4)	1.7 (0.8)	2.3 (1)
KM Success = Process & Outcomes	**4** (0.9)	3.9 (1)	3.8 (1)	**4.3** (0.6)	**4.2** (0.8)

Overall n = 103, researcher n = 70, practitioner n=13, academics n=14, and student n=6

Values are rounded to 2 significant digits

Table 2. Opinions on KM and KMS success definition components, mean (std dev)

Overall	Research	Practice	Academics	Students
Subjective measure of various outcomes of KM processes capabilities" should be included in a definition of KM success				
4.1 (0.8)	**4** (0.9)	**4.3** (0.8)	**4.2** (0.9)	**4.5** (0.8)
Achieving direct returns from learning and projection" should be included in a definition of KM success				
3.8 (1)	3.7 (1)	3.6 (1)	**4** (1)	**4.3** (0.5)
Success of KMS should be measured in terms of pure usage statistics" should be included in a definition of KM success				
2.5 (1.2)	2.5 (1.2)	2.2 (1.1)	2.6 (1.2)	2.8 (1.2)
Success of KMS should be measured in terms of "firm performance" should be included in a definition of KM success				
3.7 (1)	3.6 (1.1)	**4.1** (1)	3.5 (0.8)	**4** (0.9)
Providing the appropriate knowledge when 'needed'" should be included in a definition of KM success				
4.2 (0.9)	**4.2** (0.9)	**4.3** (0.9)	**4.4** (0.6)	**4.3** (0.5)

Overall n = 103, researcher n = 70, practitioner n=13, academics n=14, and student n=6

Values are rounded to 2 significant digits

firm performance measures as indicators of KM success while there is less support for these measures from researchers and academics. It is also interesting to note that academics and students tend to support the use of measures reflecting direct returns from organizational and individual learning and application of knowledge while researchers and practitioners are less favorable to them.

Table 3 summarizes opinions on five suggested definitions of KM and KMS success. There appears to be little consensus on these definitions other than a general neutrality on KM success as the flow of knowledge and KMS success as improving effectiveness of the KMS components. However, there are some interesting observations. KM success as the ability to leverage knowledge resources to achieve actionable outcomes is overall supported with the strongest support coming from practitioners. This is interesting but not surprising as practitioners tend to favor definitions and measures that are objective, readily measurable, and have an obvious impact on the organization. This is also why practitioners favor KM success as reusing knowledge to improve organizational effectiveness and KM success as the efficient achievement of well defined organizational goals for targeted creation and utilization of knowledge.

Table 3. Opinions on KM and KMS success definitions, mean (std dev)

Overall	Research	Practice	Academics	Students
KMS success can be defined as making KMS components more effective by improving search speed, accuracy, etc.				
3 (1.2)	2.8 (1.1)	3.6 (1.2)	3.1 (1.1)	3.2 (1)
KM success is the ability to leverage knowledge resources to achieve actionable outcomes.				
4 (1)	**4** (1)	**4.3** (0.9)	3.9 (0.9)	3.7 (1)
KM success is reusing knowledge to improve organizational effectiveness by providing the appropriate knowledge to those that need it when it is needed.				
3.9 (1)	3.8 (1.1)	**4.4** (0.91)	**4.1** (0.7)	3.8 (0.4)
KM success is knowledge - tacit and explicit alike - circulates freely throughout the organization, with no debilitating clumping, clotting or hemorrhaging.				
3 (1.2)	2.8 (1.2)	3.2 (1.5)	3.4 (0.8)	2.7 (1)
KM success is the efficient achievement of well defined organizational and process goals by means of the systematic employment of both organizational instruments and information and communication technologies for a targeted creation and utilization of knowledge as well as for making knowledge available.				
3.7 (1.2)	3.5 (1.3)	**4.2** (1.1)	3.8 (0.9)	3.8 (1.2)

Overall n = 103, researcher n = 70, practitioner n=13, academics n=14, and student n=6

Values are rounded to 2 significant digits

Table 4. Opinions on KM and KMS success definition and sets of measures, mean (std dev)

Overall	Research	Practice	Academics	Students
KM success is a multidimensional concept. It is defined by capturing the right knowledge, getting the right knowledge to the right user, and using this knowledge to improve organizational and/or individual performance. KM success is measured using the dimensions of impact on business processes, strategy, leadership, efficiency and effectiveness of KM processes, efficiency and effectiveness of the KM system, organizational culture, and knowledge content.				
5.4 (1.4)	5.3 (1.5)	6.1 (1.4)	5.6 (1.4)	5.5 (1.2)
Impact on business process measures.				
5.5 (1.3)	5.3 (1.4)	5.8 (1.4)	5.7 (1.2)	5.7 (1.0)
Strategy measures				
5.3 (1.4)	5.1 (1.6)	6.1 (0.6)	5.3 (1.4)	5.7 (1.0)
Leadership measures				
5.2 (1.5)	5.1 (1.5)	5.3 (1.5)	5.3 (1.3)	5.4 (1.6)
KM process effectiveness and efficiency measures				
5.7 (1.3)	5.5 (1.4)	6.2 (0.8)	5.8 (1.3)	5.7 (1.4)
KM system effectiveness and efficiency measures				
5.6 (1.3)	5.5 (1.4)	6.0 (0.7)	5.8 (1.2)	5.4 (1.3)
Learning culture measures				
5.6 (1.2)	5.5 (1.4)	6.0 (0.8)	5.7 (1.1)	5.6 (1.2)
Knowledge content measures				
5.4 (1.4)	5.2 (1.5)	6.0 (1.0)	5.7 (1.2)	5.5 (1.3)

Overall n = 194, researcher n = 114, practitioner n=16, others n=41, and student n=23

Values are rounded to 2 significant digits

Table 4 summarizes opinions from the second survey on a proposed success definition generated from the first survey and sets of measures for the dimensions listed in the proposed definition. There appears to be some level of consensus on the proposed definition and measures. However, we don't consider it strong consensus given that the mean response is between agree and somewhat agree. Still, this is considered a strong beginning to establishing a common definition and set of success measures.

6. DISCUSSION

This is exploratory research so few conclusions can be drawn. However, using two surveys has allowed us to reach some consensus on a KM success definition and set of success measures. The consensus KM success definition is:

"KM success is a multidimensional concept. It is defined by capturing the right knowledge, getting the right knowledge to the right user, and using this knowledge to improve organizational and/or individual performance. KM success is measured using the dimensions of impact on business processes, strategy, leadership, efficiency and effectiveness of KM processes, efficiency and effectiveness of the KM system, organizational culture, and knowledge content."

Also, there are a few points of consensus that can be identified from the initial survey:

- KM success and KMS success may not be the same thing.
- Usage is not a good measure of KM or KMS success.

Additionally, it is possible that there is a different focus on KM success between practitioners and researchers. Researchers do not seem to have a clear idea of KM success while practitioners appear focused on KM success as being tied to its impact on organizational performance and effectiveness. This can't be stated conclusively, the number of practitioner responses are too low (n=13) making this supposition. However, it isn't unexpected that practitioners would have a focus on organizational impact as a measure of KM and KMS success. Given that KM is an action discipline; researchers should accept this focus and incorporate it into their investigations.

There are some limitations to this research. It is quite possible that the reason little consensus has been observed is because KM and KMS success are complex constructs that are multi dimensional. It may be that KM and KMS success includes outcome measures, quality of knowledge, how well the KM processes function, organizational culture measures, usability measures, and strategy measures. This is consistent with the DeLone and McLean (1992, 2003) model of Information Systems success and there is much empirical evidence to support the correctness of this model. This model is also the basis of the Jennex and Olfman (2006) KM success model. It is quite likely that the exploratory survey used for this research, while generated using an expert panel, probably did not capture the multidimensional nature of the provided KM success definitions and therefore made it difficult for respondents to find statements they fully agreed with. This limitation was considered when generating the second survey and it appears that this has improved consensus with the KM success definition generated from the first survey.

7. CONCLUSIONS

It is difficult to reach any conclusions with this research; no hypotheses were proposed or tested. This is okay as the purpose of this paper is to start a focused discussion on KM and KMS success. The response to the exploratory survey shows this will happen as well as the minitrack focused on KM and KMS success and measurement at the Hawaii International Conference on System Sciences, HICSS.

To begin this dialogue it is important to identify areas of consensus and areas of disagreement. The following points are areas of agreement:

- KM and KMS success are likely different definitions (note that at least one of the authors greatly disagrees with this point).
- Use is a poor measure of KM and KMS success.
- KM success is likely a multidimensional construct that will include process and outcome measures.
- A base definition of KM success is: KM success is reusing knowledge to improve organizational effectiveness by providing the appropriate knowledge to those that need it when it is needed.

Additionally, a base definition of KM success can be established:

"KM success is a multidimensional concept. It is defined by capturing the right knowledge, getting the right knowledge to the right user, and using this knowledge to improve organizational and/or individual performance. KM success is measured using the dimensions of impact on business processes, strategy, leadership, efficiency and effectiveness of KM processes, efficiency and effectiveness of the KM system, organizational culture, and knowledge content."

Some areas of disagreement are in further need of discussion:

- KM success and effectiveness are likely the same and will be able to use the same measures.
- KM and KMS success are essentially the same (in deference to the authors and consistent with a Churchman view of a KMS and DeLone and McLean [1], [2]).
- The role of learning and firm performance in KM success.
- The role of outcome measures such as speed, accuracy, amount of knowledge stored and used, etc. in KM and KMS success.

It is expected that it will take a great deal of research before consensus is reached on what KM and KMS success is. It is concluded that this paper and these findings from an exploratory survey are a good starting point for this discussion.

8. REFERENCES

DeLone, W.H. and McLean, E.R., (1992). "Information Systems Success: The Quest for the Dependent Variable", Information Systems Research, 3, pp. 60-95.

DeLone, W.H. and E.R. McLean, (2003). "The DeLone and McLean Model of Information Systems Success: A Ten-Year Update", Journal of Management Information Systems, 19(4), pp. 9-30.

Jennex, M.E., (2005). "What is Knowledge Management?" International Journal of Knowledge Management, 1(4), pp. i-iv.

Jennex, M.E. and Olfman, L., (2005). "Assessing Knowledge Management Success", International Journal of Knowledge Management, 1(2), pp. 33-49.

Jennex, M.E. and Olfman, L., "A Model of Knowledge Management Success", International Journal of Knowledge Management, 2(3), 2006, pp. 51-68.

Turban, E. and Aronson, J.E., (2001). "Decision Support Systems and Intelligent Systems", Sixth Edition, Prentice Hall, Upper Saddle River, NJ.

Effects of Individualism-Collectivism in Computer Supported Collaborative Learning

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ABSTRACT

There are few explorations of the effects of cultural orientation (collectivism vs. individualism) on users' perceptions in computer supported collaborative learning in spite of the increasing research attention received. This study investigates the differences in perceptions between collectivists and individualists regarding collaborative learning systems in facilitating collaborative learning, group wellbeing and member support. The effects of these user perceptions on the intention to use are also explored. An experiment involving seventy-three subjects from Asian as well as European countries was conducted to test the hypotheses. The study provides important guidelines in both theoretical and practical forms for future collaborative learning system design and usage.

1. INTRODUCTION

Collaborative learning is regarded as an important information processing activity in e-collaboration. Members learn from one another by actively engaging in exchanging knowledge and information based on their understanding as well as individual experiences (Leidner & Jarvenpaa, 1995). Growing interest in supporting the needs of active learning, along with concurrent improvements in computer networking technology, have prompted research on Computer Supported Collaborative Learning (CSCL). These systems enable effective learning to be achieved related to interactive communication and teamwork.

Individual members' cultural backgrounds influence how members collaborate and communicate (Feldman, 1984). Oetzel (2001) has identified the importance of a member's cultural orientation in influencing his/her participation in the groups that is undergoing adverse conditions. National cultures have been distinguished along a variety of dimensions (Hofstede, 1991). Arguably, the dimension of individualism- collectivism has received the most attention by psychologists specializing in cross-cultural research, particular in the context of group collaboration (Goncale & Staw, 2006). Most of the research on the individual-collectivism dimension has found that growing up in a particular country shapes the person's perceptions, and this element can be used to predict behaviors across a wide variety of situations (Brockner, 2003).

Relatively speaking, people from collectivistic cultures are presumed to care for the development of other members, whereas individualists care more for their self-development (Hofstede, 1991). Members with collectivistic culture background value greater the group needs and goals, social norms, and group cooperation (Cox et al., 1991). In contrast, members with individualistic culture background emphasize on self-interest and belief. They tend to value more personal time and freedom (Massey et al., 2001). Comparing the two types, collectivists are motivated to find a way to fit into the group, and in general become part of various interpersonal relationships (Goncale & Staw, 2006).

The cultural orientation impacts participants' perceptions, which in turn determine the intention to use a technology; this chain of relationships highlights the potential and importance of designing culturally appropriate systems in CSCL. This study concentrates on four common system features which are, according to literature and previous studies, very likely to trigger different perceptions between collectivists and individualists (Marcus & Gould, 2000; Massey et al., 2001); these features include template in posting, post statistics, personal contribution history, and synchronicity of communication.

Table 1. The constructs of PCL, PGW and PMS

Constructs defined in this study	Corresponding constructs in Dennis and Reinicke's (2004) work
Perceived facilitation of collaborative learning (PCL): This construct measures learners' perception of the effectiveness and efficiency of a CSCL feature in facilitating collaborative learning.	**Perceived task performance:** This factor inherited the common presumption of the construct perceived usefulness in literature; it refers to users' perception regarding the effectiveness and efficiency of the system in terms of performance.
Perceived facilitation of group wellbeing (PGW): This construct measures learners' perception of the effectiveness and efficiency of a CSCL feature in facilitating the socialization and relationship building in groups.	**Group wellbeing:** This factor measures users' perception of the ease of socializing and building relationships among members.
Perceived facilitation of member support (PMS): This construct refers to how learners perceive how a CSCL feature can facilitate them to be understood and known by other group members.	**Member support:** This factor refers to how the users perceive themselves are being understood by other group members and hence able to build network with others.

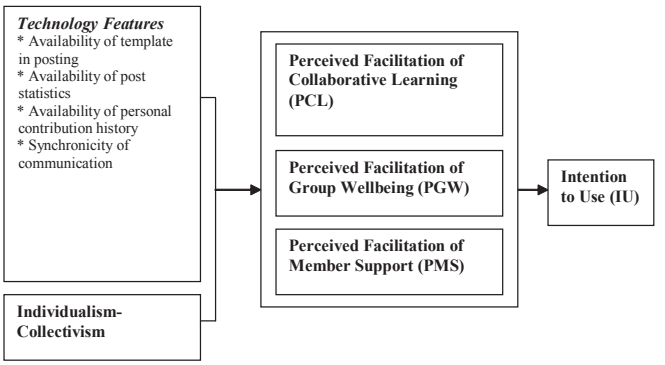
In line with Dennis and Reinicke's (2004) extended Technology Acceptance Model (TAM) in investigating the adoption behaviors of collaborative technologies, This study proposes an adoption model in CSCL by incorporating perceived facilitation of collaborative learning (PCL), perceived facilitation of group wellbeing (PGW) and perceived facilitation of member support (PMS) as antecedents of *perceived usefulness* (Davis, 1989), which in turn affects the intention to use (IU). We adopt these constructs in Dennis and Reinicks' (2004) work (see Table 1); the salient difference is that the current study focuses on the (perceived) effectiveness of the collaboration learning technologies.

This paper highlights the importance of culture sensitivity in CSCL design, which would cater to the cultural orientation, i.e., collectivism or individualism. Section 2 proposes an adoption model for CSCL. The next sections describe an experimental study and the data analysis. Findings are next discussed and implications are drawn.

2. PROPOSED MODEL AND RESEARCH HYPOTHESES

The diagram (Figure 1) depicts the theoretical model to be examined in this paper. The hypotheses are derived in the remaining of the section.

Figure 1. Research model



2.1 Availability of Templates in Posting

Previous instructional research has shown that providing students with templates in answering questions can guide the cognitive process and in turn enhance the learning (Cinneide, 1998). In CSCL, the templates can make the idea exchange among users easier because the flows of the posts are similar. However, individualists may tend to see a template is hindering uniqueness and creativity. Individualistic cultures encourage uniqueness; in contrast, uniqueness can be viewed as a threat to harmony in collectivist cultures (Goncale & Staw, 2006). The underlying psychological reason is that individualists are in favor of being unique and distinguished from other people; however, collectivists value their group as a whole and they generally tend to avoid being unique (Markus & Kitayama, 1994). In this connection, collectivists tend to appreciate the templates provided in the system more than individualists, because they tend to perceive the template as an easier way to achieve the group goal, and communicate with group members.

H1a. *Collectivists will report higher perceived facilitation of collaborative learning to the availability of templates in posting than individualists.*

H1b. *Collectivists will report higher perceived facilitation of group wellbeing to the availability of templates in posting than individualists.*

H1c. *Collectivists will report higher perceived facilitation of member support to the availability of templates in posting than individualists.*

2.2 Availability of Post Statistics

Some bulletin boards and discussion forums inform publicly the statistics regarding the responses to each post. Through this feature, users could gain a better sense of the degree of the consensus concerning a particular topic. Also the statistics reflect the social support among group members (Marcus & Gould, 2000). Collectivists are more incline to follow the consensus so as to promote feelings of harmony and cooperation (Kanter, 1988). This tendency is motivated by their concern for the well being of the larger social group.

However, because individualists tend to resist following the majority if majority's opinion is different from their preferences (Fiske et al., 1998); they are likely to be consistent in their views and maintain them in the face of opposition. As a result, the number shown in the statistics about the responses would not have as much effect on individualists as that on collectivists.

H2a. *Collectivists will report higher perceived facilitation of collaborative learning to the availability of post statistics than individualists.*

H2b. *Collectivists will report higher perceived facilitation of group wellbeing to the availability of post statistics than individualists.*

H2c. *Collectivists will report higher perceived facilitation of member support to the availability of post statistics than individualists.*

2.3 Availability of Personal Contribution History

Some systems allow users to search others' posts using the user login names, i.e. the personal contribution history of every individual is accessible to all users. The purpose of having this feature is to enable users a better understanding of others' arguments or ideas. However, the effects of this features triggers differently on users' emotion. Collectivists' self-esteem is not derived from calling attention to their own abilities or contributions; instead, their prime interest is to promote group interests (Wink, 1997). Thus, they tend to perceive the personal contribution history to be more useful in understand others' contributions rather than making themselves understood. Contrarily, in general, individualists tend to perceive that their contributions could arouse attention (Goncale & Staw, 2006); consequently, they are expected to perceive this function as a mechanism to promote themselves and consequently perceive greater member support from the other members.

H3a. *Collectivists will report higher perceived facilitation of collaborative learning to the availability of personal contribution history than individualists.*

H3b. *Collectivists will report higher perceived facilitation of group wellbeing to the availability of personal contribution history than individualists.*

H3c. *Individualists will report higher perceived facilitation of member support to the availability of personal contribution history than collectivists.*

2.4 Synchronicity of Communication

According to Dennis and Valacich (1999), communication media in CSCL may be differentiated in terms of their synchronicity (or lack of). For example, real-time text communication (e.g. chat) is a highly synchronous communication medium, while message board (e.g., bulletin board and discussion forum) are asynchronous media in which a discussion is carried over time (Bafoutsou & Mentzas, 2002). Generally, collectivists prefer the asynchronous media which allow them more time to compose messages and explain themselves; therefore, they tend to perceived asynchronous communication more helpful in facilitating learning than the synchronous communication (Massey et al., 2001). Collectivists also tend to prefer to reach decisions through indirect communication with a calculated degree of vagueness to avoid conflicts (Goncalo & Staw, 2006).

However, individualists generally prefer to reach decisions through synchronous communication that may invite debates - a practice not easily enacted to asynchronous groupware. The explanation here is that individualists value frankness and perceive conformity negatively, as compared to collectivists (Markus & Kitayama, 1994). Studies have shown that learners of individualistic cultures are generally more assertive than others (Goncalo & Staw, 2006).

H4a. *Collectivists will report higher perceived facilitation of collaborative learning to asynchronous medium than synchronous medium; individualists will report higher perceive facilitation of collaborative learning to synchronous medium than asynchronous medium.*

H4b. *Collectivists will report higher perceived facilitation of group wellbeing to asynchronous medium than synchronous medium; individualists will report higher perceived facilitation of group wellbeing to synchronous medium than asynchronous medium.*

H4c. *Collectivists will report higher perceived facilitation of member support to asynchronous medium than synchronous medium; individualists will report higher perceived facilitation of member support to synchronous medium than asynchronous medium.*

2.5 Relationships Between Perceived Facilitation and Intention to Use

Perceived usefulness has been studied widely in Information Systems literature as an important factor having a positive relation with users' intention to use (Lim & Bebhasat, 2000). Aligning with Dennis and Reinicke's (2004) work, perceived facilitation of collaborative learning, perceived facilitation of group wellbeing, and

perceived facilitation of member support are considered to be important aspects of perceived usefulness. Therefore, we expect they are positively related user's intention to use the technology features.

H5a. *Perceived facilitation of collaborative learning is positively related to intention to use.*

H5b. *Perceived facilitation of group wellbeing is positively related to intention to use.*

H5c. *Perceived facilitation of member support is positively related to intention to use.*

3 RESEARCH METHODOLOGY

3.1 Subjects and Manipulation Check

An experiment was conducted which involves seventy-three undergraduates participated in this study. For the collectivistic condition, forty subjects were recruited from Asian countries including China, Malaysia and Vietnam. For the individualistic condition, subjects were from European countries, mainly Sweden and Germany. Participation to this study was on a voluntary basis. Comparative research on Asian and European cultures suggests that the two cultures represent well the collectivistic and individualistic cultures respectively (Hofstede, 1991). Manipulation check was conducted by using Hofstede's scales to test subjects' cultural orientation in terms of individualism-collectivism, and it was found successful ($p < 0.01$).

3.2 Experimental Procedure

Prior to the experiment, all participants completed a questionnaire to assess their experience in exploring sites and links, participating in online chat, posting in forum, and visiting the websites relating to their courses. Also subjects were assessed for their experience in collaborative learning. No significant differences were reported between the individualists and collectivists. Further, all subjects reported that they had previously participated in all the activities mentioned. Variables PCL, PGW, PMS and IU were measured through questionnaire items adapted from Dennis and Reinicke's (2004) work (see Appendix).

Table 2. Descriptive statistics: mean and standard deviation

Cultural Orientation	Functions	PHCL	PGW	PMS	IU
Collectivists	Templates in posting	3.53 (0.81)	3.23 (0.79)	3.28 (0.79)	3.30 (0.95)
	Post statistics	3.02 (0.75)	3.13 (0.81)	3.02 (0.73)	3.29 (0.82)
	Personal contribution history	3.51 (0.77)	3.54 (0.69)	3.54 (0.72)	3.66 (0.85)
	Asynchronous comm. (Forum)	3.72 (0.56)	3.73 (0.79)	3.71 (0.67)	3.75 (0.82)
	Synchronous comm. (Chat-room)	3.43 (0.78)	3.53 (0.89)	3.50 (0.90)	3.65 (0.82)
Individualists	Templates in posting	3.33 (0.88)	3.07 (0.91)	3.02 (1.02)	2.95 (1.03)
	Post statistics	2.59 (0.81)	2.73 (0.86)	2.89 (0.91)	3.05 (0.98)
	Personal contribution history	3.03 (0.87)	3.02 (1.00)	3.18 (1.03)	3.45 (0.92)
	Asynchronous comm. (Forum)	3.78 (0.64)	3.78 (0.67)	3.75 (0.81)	3.77 (0.81)
	Synchronous comm. (Chat-room)	3.41 (0.82)	4.05 (0.75)	4.03 (0.89)	3.76 (0.90)
Total	Templates in posting	3.44 (0.84)	3.16 (0.84)	3.16 (0.90)	3.15 (0.99)
	Post statistics	2.83 (0.89)	2.96 (0.85)	2.97 (0.81)	3.18 (0.89)
	Personal contribution history	3.30 (0.85)	3.32 (0.87)	3.39 (0.88)	3.57 (0.88)
	Asynchronous comm. (Forum)	3.74 (0.59)	3.75 (0.73)	3.73 (0.73)	3.76 (0.81)
	Synchronous comm. (Chat-room)	3.42 (0.79)	3.75 (0.87)	3.73 (0.93)	3.70 (0.85)

Table 3. Summary of hypotheses test results

H1, H2, H3 and H4				
Functions	Constructs	Hypothesis	ANOVA / T-test	Hypothesis supported?
Templates in posting	PHCL	Collectivists > Individualists	F = 0.91 , p = 0.35	H1a: No
	PGW		F = 0.42, p = 0.52	H1b: No
	PSS		F = 1.01 , p = 0.31	H1c: No
Statistics about the responses to posts	PHCL	Collectivists > Individualists	F = 0.03, p =0.86	H2a: No
	PGW		F = 3.15, p = 0.08	H2b: No
	PSS		F = 0.37, p = 0.55	H2c: No
Personal contribution history	PHCL	Collectivists > Individualists	F = 5.12 , p =0.03	H3a: Yes
	PGW		F =5.81 , p = 0.02	H3b: Yes
	PSS	Individualists > Collectivists	F =2.22 , p =0.14	H3c: No
Degree of synchronicity in communication	PHCL	Collectivists: Asynchronous>Synchronous	t = 1.25 , p = 0.22 t = 1.43 , p = 0.16	H4a: No
	PGW	Individualists: Synchronous>Asynchronous	t = 2.08, p = 0.04 t = 4.67, p = 0.00	H4b: Yes
	PSS		t = 2.23 , p =0.03 t = 4.01, p = 0.00	H4c: Yes

H5						
	Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Hypothesis supported?
	B	Std. Error	Beta			
PHCL	0.18	0.03	0.28	7.03	0.00	H5a: Yes
PMS	0.20	0.07	0.18	2.92	0.00	H5b: Yes
PGW	0.30	0.07	0.27	4.34	0.00	H5c: Yes

We used a web-based learning environment, Future Learning Environment (FLE), to support collaborative learning among participants in this experiment (Leinonen et al., 2003). In the FLE, a course about the solar system was constructed. The subjects were informed that there were a total of 15 users (including the experimenter). These phantom users were played by the experimenter, who also served as the facilitator. Posts (by virtual participants) were pre-created and made identical for all experimental conditions.

Detailed instructions were provided to guide subjects to use the corresponding system features in performing a series of activities. Subjects were first asked to read through the materials as well as the posts in the system. Next, they were requested to compose in a forum two posts in two separate threads regarding two topics covered in the materials. In one thread, all posts were supposed to adopt a specific template. In the other thread, posts were composed without any templates. To combat any order effects in the experiment, the sequence of the two posting activities was randomly assigned to subjects. When the two posts were completed, subjects were asked to try out the chat-room feature, while the experiment administrators took the time to post replies to subjects' posts using the names of virtual participants. The subjects were next asked to check the response statistics about their posts, and access their own personal contribution history and also histories of other percipients in the forum. The relevant instrument was administrated at the appropriate point in time after the corresponding function was attended to.

4. DATA ANALYSIS

Factor analysis and reliability tests show that the instruments are suitable (see Appendix). The ANOVA model was used to detect significant effects; a 5% level of significance was used in all tests. Due to the different number of subject involved in the experimental conditions, steps have been taken prior to the analysis to ensure the satisfying of the three assumptions underlying the ANOVA model, namely homogeneity of variance, independent sample, and normality of error terms. Further, subjects have reported no significant differences in terms of computer experience and collaborative learning experience between the two experimental conditions; these factors are not included as covariates in the analysis. Next, linear regression model is used to test the relationships between the perception variables (PCL, PGW and PMS) and the intention to use (IU). Table 2 reports the descriptive statistics. Table 3 summarizes the results of the hypotheses testing.

5. DISCUSSION AND IMPLICATION

This study has the following limitations. First, the users have used the system for a relative short time. The time limitations could have affected the behaviors of members. This calls for longitudinal studies in future. Next, the relatively small number of subjects should be noted when interpreting the results. Lastly, the use of voluntary subjects in an optional course which may be quite different from the setting in a compulsory course; this may account for most of the unsupported hypotheses regarding the perceived facilitation of collaborative learning.

In terms of theoretical contributions, this exploratory study has examined the effects of culture orientation on perceptions pertinent to the collaborative learning, and how these perceptions affect the intention to use. In this research, the individualism-collectivism culture dimension was of focus. Future research could look into other dimensions such as power distance and uncertainty avoidance. The joint effects of culture and other factors are of interest; these factors include communication style, task nature and gender (Simon, 2000). For example, Chang and Lim (2003) also stated that gender effects may become salient only in individualists in online setting.

This study also highlights the importance of designing culturally sensitive system to facilitate CSCL. For users from collectivistic culture background, systems could include functions which facilitate social support to increase users' incentive and intention to use of the system.

6. CONCLUSION

This study investigates the differences in perceptions between collectivists and individualists regarding collaborative learning systems in facilitating collaborative learning, group wellbeing and member support. The effects of these user perceptions on the intention to use are also explored. An experiment involving seventy-three subjects from Asian as well as European countries was conducted to test the hypotheses. The study provides important guidelines in both theoretical and practical forms for future collaborative learning system design and usage.

REFERENCES

Bafoutsou, G. & Mentzas, G. (2002). Review and functional classification of collaborative systems. *International Journal of Information Management*, 22, 281-305.

Brockner, J. (2003). Unpacking country effects: On the need to operationalize the psychological determinants of cross-national differences. *Research in Organizational Behavior*, 25, 333-367.

Chang T.T. & Lim (2002). Cross-cultural communication and social presence in asynchronous learning process. *e-Service Journal*, 3(1), 83-105.

Cinneide, B.O. (1998). Proposed enhancement of the contribution of the teaching note to the case writing process. *Journal of European Industrial Training*, 22(1), 28-32.

Cox, T., Lobel, S., & McLeod, P. (1991). Effects of ethnic group cultural differences on cooperative and competitive behavior on a group task. *Academy of Management Journal*, 34(4), 827-847.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13(3), 319-340.

Dennis, A.R. & Reinicke, B.A. (2004). Beta versus VHS and the acceptance of electronic brainstorming technology. *MIS Quarterly*, 28(1), 1-20.

Dennis, A.R. & Valacich, J.S. (1999). Rethinking media richness: Towards a theory of media synchronicity., In *Proceedings of 32nd Hawaii International Conference on System Sciences*, Hawaii, 1999.

Feldman, D.C. (1984). The development and enforcement of group norms. *Academy of Management Review*, 9(1), 47-53.

Fiske, A.P., Kitayama, S., Markus, H.R., & Nisbett, R.E. (1998). The cultural matrix of social psychology. In D.T. Gilbert, S.T. Fiske, & G. Lindzey (Eds.), *The Handbook of Social Psychology* (4th ed., 915-981). New York, NY: McGraw-Hill.

Goncale, J.A. & Staw, B.M. (2006). Individualism-collectivism, and group creativity. *Organizational Behavior and Human Decision Processes*, 100, 96-109.

Hofstede, G. (1991). *Cultures and organizations*. Berkshire: McGraw-Hill Book Company Europe.

Kanter, R.M. (1988). When a thousand flowers bloom: Structural, collective and social conditions for innovation in organizations. In B.Staw & L.L. Cummings (Eds.) *Research in Organizational Behavior* (10, 169-211). Greenwich, CT: JAI Press.

Leidner, D. & Jarvenpaa, S.L. (1995). The use of information technology to enhance management school education: a theoretical view. *MIS Quarterly*, 19(3), 265-291.

Leinonen, T., Giedre, K., Tarmo, T., & Janne, P.(2003). *Learning with Collaborative Software - A guide to Fle3*. Helsinki, Taideteollinen korkeakoulu: University of Art and Design Helsinki.

Lim, K.H. & Benbasat, I. (2000) The effect of multimedia on perceived equivocality and perceived usefulness of information systems. *MIS Quarterly*, 24(3), 449-471.

Marcus, A. & Gould, E.W. (2000). Crosscurrents: Cultural dimensions and global web user-interface design. *Interactions*, July+August, 32-46.

Markus, H. & Kiayama, S. (1994). A collective fear of collective: Implications for selves and theories of selves. *Personality and Social Psychology Bulletin*, 20(5), 568-579.

Massey, A., Montoya-Weiss, M., Hung, C., & Ramesh, V. (2001). Cultural perceptions of task-technology fit. *Communications of the ACM*, 44(12),83-84.

Oetzel, J.G. (2001). Self-construals, communication processes, and group outcomes in homogeneous and heterogeneous groups. *Small Group Research*, 32(1), 19-54.

Simon, S.J. (2001). The impact of culture and gender on web sites: An empirical study. *The Data Base for Advances in Information Systems*, 32(1) 18-37.

Wink, P. (1997). Beyond ethnic differences: Contextualizing the influence of ethnicity on individualism and collectivism. *Journal of Social Issues*, 53, 329-349.

APPENDIX MEASUREMENT ITEMS (5 POINT SCALES)

Perceived Facilitation of Collaborative Learning (PCL) (Alpha = 0.96)

PCLE1: Using <This function> enhances the quality of the message I composed. (loading = 0.92)

PCLE2: Using <This function> make the message easier to compose. (loading = 0.91)
PCLE3: Using <This function> is a good way to share my information with other users. (loading = 0.94)
PCLE4: If other users use <this function>, I can understand better their idea in the message. (loading = 0.92)
PCLE5: If other users use <this function>, I can improve my learning in CLS. (loading = 0.91)

Perceived Facilitation of Group Wellbeing (PGW) (Alpha = 0.87)
PGW1: <This function> is a good way to help all users to socialize and develop relationships. (loading = 0.84)
PGW2: <This function> is a good way to build and maintain all users as intact and continuing social group. (loading = 0.88)
PGW3: <This function> contributes to the cohesiveness among all users. (loading = 0.78)

Perceived Facilitation of Member Support (PMS) (Alpha = 0.76)
PMS1: <This function> is a good way to let other users in the system understands me more. (loading = 0.79)
PMS3: <This function> is a good way to create and maintain my role among all users. (loading = 0.75)

Intention to Use (IU) (Alpha = 0.93)
IU1: I intend to use <this function> for learning in CLS. (loading = 0.82)
IU2: Assuming I have access to <this function>; I predict that I would use it for learning in CLS. (loading = 0.82)
IU3: I plan to use <this function> to learning in CLS in future. (loading = 0.85)

Challenges in Building and Maturing of a Telecommunications Business Intelligence Solution in a Developing Country

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ABSTRACT

South Africa as a developing country has since 1994 gone through a process of privatisation of some of the state departments. The Department of Post and Telecommunications was one of those departments. During this transition period, data warehousing and business intelligence has played a critical role in measuring the performance of the new telecommunications company against targets set by government. This new telecommunications company had to meet the targets set while also preparing for competition. This paper will describe the challenges that were faced during the privatisation. It will also describe a new business intelligence literacy and cultural maturity model and a new data warehouse lifecycle model that evolved from the struggle to overcome the challenges that existed.

1. INTRODUCTION

In 1994, just after the privatisation of the Department of Post and Telecommunication, the new democratic government of South Africa was the sole shareholder of the only landline telecommunications company in South Africa. The Government had vibrant discussions with all the relevant parties on how telecommunications might be restructured to create an even distribution of access to telecommunications services to all the people in the country. This resulted in a White Paper on Telecommunications policy which was released in March 1996 (Anon, 1996).

The major proposal contained in the White Paper was that the owner and operator of the fixed telephony infrastructure would be granted a limited period, the so-called exclusivity period, of monopoly in the provision of basic telecommunication services. This exclusivity period was to last for five years, until May 2002, but could be extended to six years, if the telecommunication operator met network rollout and service targets. The rollout targets included doubling its subscriber access lines by 2.7million; installing 120,000 new public telephones; connecting 3,200 villages for the first time and providing service to more than 20,000 priority customers such as schools and clinics. The exclusivity period was intended to allow them to expand the network as rapidly as possible in order to facilitate universal access and to move towards universal service. The agreement left the telecommunications provider with the challenge to plan and manage the implementation targets set by government while at the same time preparing for competition once the exclusivity period expired.

This paper will firstly provide a background of the status of business intelligence in the telecommunications company. That will be followed by challenges faced in building and maturing a business intelligence solution in the company. The paper will then conclude with two models that resulted from the challenges.

2. BACKGROUND

The new company already had a Data Mart (DM) on infrastructure information. Although the DM was in place it was not used at all. The main reason was that people did not know how to use it, simply because of the lack of technical knowledge and a lack of training on the business intelligence tools available to the business. The legal requirement to manage the agreement with government has forced the company to start using available data. When people started asking for information concerning spare infrastructure it was realized that the required information was available in the DM. However, people did not know how to access and/or use the information. The lack of knowledge on how to use the DM has resulted in sales people selling telephone services in areas where there was no infrastructure.

Williams and Williams (2004) stated that, historically, many data warehousing (DW) and business intelligence (BI) initiatives have been IT-driven, and much of the focus within the industry has been on the technical aspects of delivering information to the BI user community. Having arrived at a point where many of the technical challenges and trade-offs were at least well understood, more attention was needed on how BI can be used to deliver business value. The BI user is not interested in the technical working of the DW and BI solution. They are more interested in the value that it adds to the business. Does it create the right business questions and does it facilitate the correct answers to the critical business questions to ensure the competitive advantage? In the case of South Africa and the sole provider of telecommunications in the country, it was at that stage important to start using the DW and BI tools that were already available in the company.

3. CHALLENGES

3.1 BI literacy and culture

To be able to use the information and data available in the DM brought the company to a point that management had to make a decision between the following alternatives:

1. Train all the business people on the existing BI tool (Business Objects)
2. Implement a new BI tool which also needed training
3. Create a new division that will fill the gap between the technical working of the data warehouse (ICT) and the business.

The first two options were seen as expansive, risky and very time-consuming, as there was no culture for the use of electronic information in the company. Business people would have access to electronic information, but would print it out before using it. When going to a meeting managers would print reports and take a hardcopy with them to the meeting. Dashboards were on paper against the wall. Secretaries printed out the new information every day and stuck it on the wall. So, training alone would not be sufficient for the company and therefore it made sense to take the third option.

The third option was selected because it was seen as the quickest solution and also a steppingstone to get the BI literacy and cultural maturity level of the company to a level to use electronic information. In BI it is hard to split literacy from culture. Bodly (1994) believes that culture involves at lease three components: what people think, what they do, and the material products they produce. Literacy is considered as the ability to locate, evaluate, use and communicate. It was difficult to split the two realities, because the one could be the result of the other and that leaded to business not using the DW and BI solution.

A new division was consequently created to fill the gap between the ICT and business. The company was divided into six regions to render a telecommunications service in South Africa. A decision was taken to use that same regional approach to implement this new division called Knowledge and Information Management (KIM). One manager per region was appointed with between three to five knowledge

workers depending on the size of the region. Knowledge workers were people with a combination of ICT and business skills.

3.2 Plan and Manage the Implementation Targets Set by Government

The fact that a DM and BI solution was already in place as well as the establishment of the KIM division have helped a great deal in implementing and managing the targets set by government. South Africa has a 41% rural population and these rural communities have access to schools and clinic's which were also in the rural areas where there was no infrastructure. To start off with the urban schools and clinics was easy, but that would not fulfill the additional requirement for services to the priority customers. The same applied to prepaid phones. To install a payphone (coin or card) was also a way of taking a telephone service to these rural communities.

Therefore, to be able to start working on the targets set by government, the first step was to determine the spare infrastructure in order to send the sales teams to sell where there was infrastructure available. Otherwise sales personnel would have sold in areas where there was no infrastructure and that would result in customers waiting for their services while the company has to plan and build that infrastructure. Building the infrastructure could take months or years depending on the size of the project.

A report on infrastructure was initiated by the KIM division. The infrastructure consisted of two network areas:

1. Core network (exchanges and transmission systems)
2. Access network (cables to the different houses, coin phones and businesses)

Figure 1 below is a high-level graphical representation of the network of a landline telecommunications company.

On the core network each connection needed a telephone number and a port on the exchange. On the access network, each connection needed the following positions on the network:

1. strip and line on the Main Distribution Frame (MDF)
2. an exchange and distribution point position on the Street Distribution Cabinet (SDC)
3. one position on the Distribution Point (DP)

A sales list with the spare infrastructure was provided to the sales division in the different regions. Sales lists were made available on weekly basis. From the dimensional model in figure 2 below, it is clear that there were no facts; the information consisted of a combination of dimensions. Therefore a factless fact (Kimball, 2002) was used.

After the sales team went out and sold telephone services to these addresses, it was important to track the orders through the order system. Not only has the number of orders in the order system increased rapidly, it was also important to get the orders through the system as soon as possible to ensure that the services were provided to the customer to achieve the targets set by government.

3.3 The Order Process

The order process consisted of the following steps:

1. Capturing paper order on the system
2. Credit vetting of new customer
3. Allocate access network

Figure 1. Landline telecommunications network

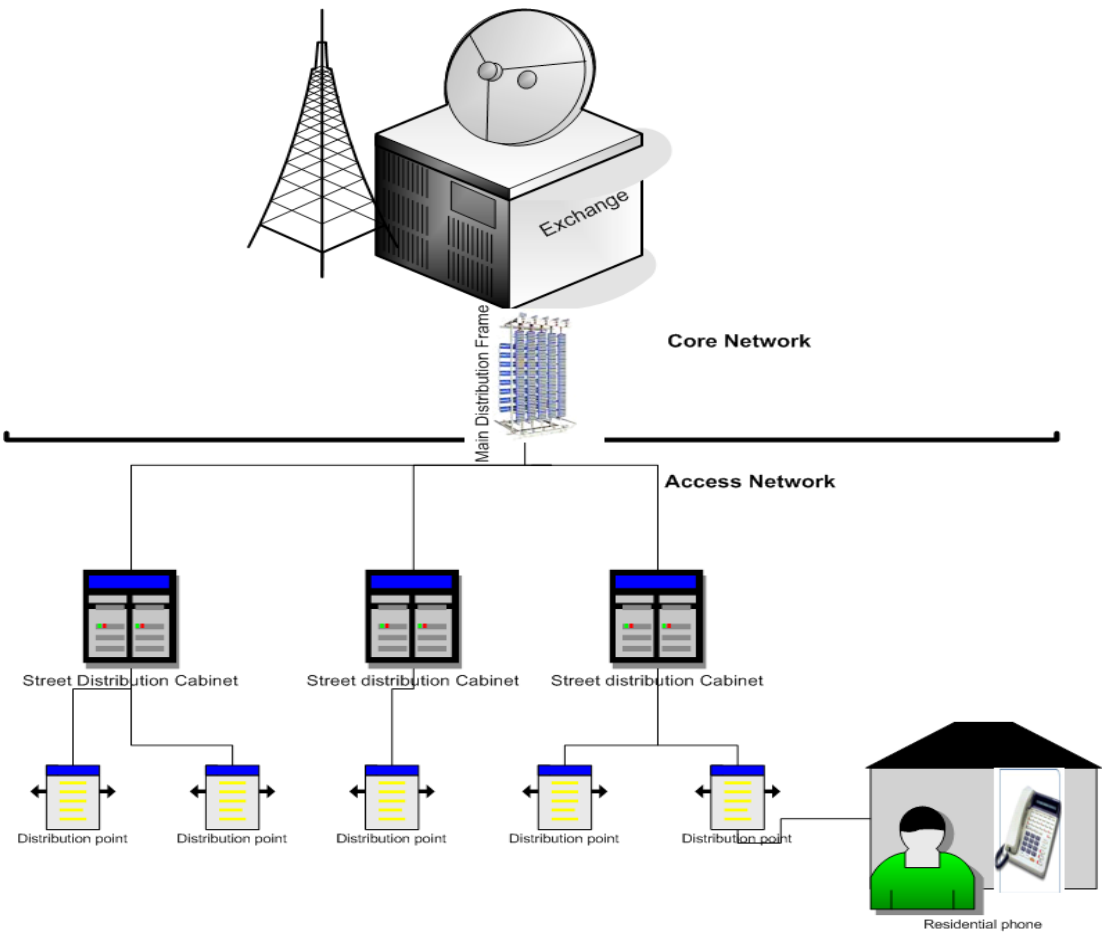
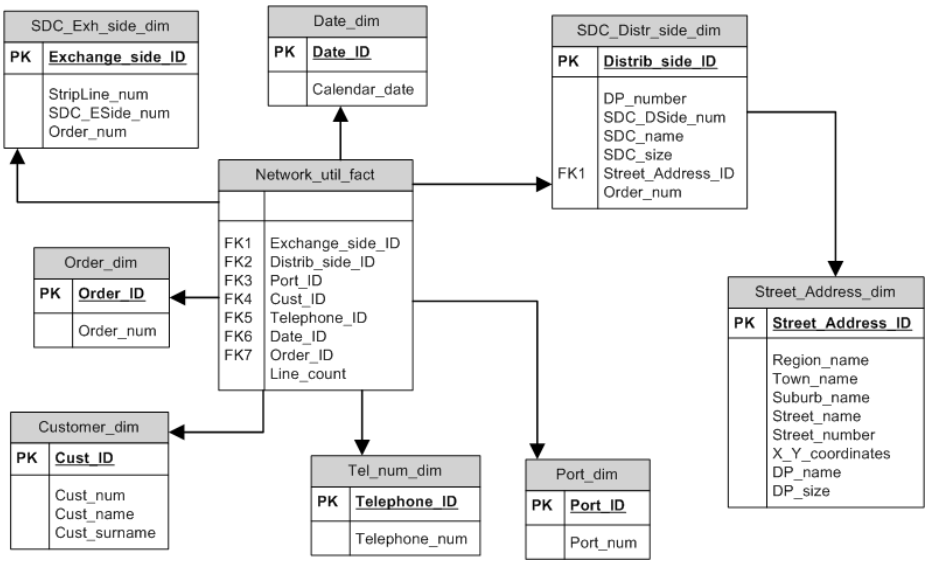


Figure 2. Infrastructure dimensional model

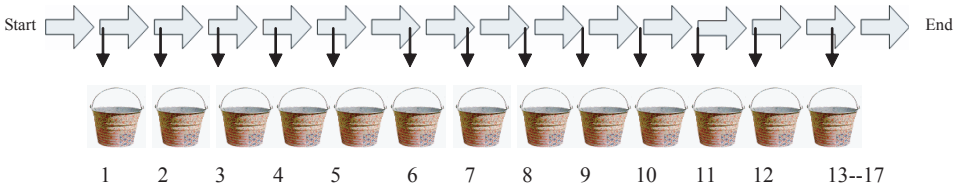


4. Allocate core network
5. Receive connection fee
6. Order sent to exchange to create a new port and telephone number
7. Order sent to main distribution frame for cross connection
8. Order sent to technical team for installation
9. Finished order sent to billing team to start the billing process

The nine step process would have been sufficient in the perfect world, but all orders could not go through the process without getting stuck somewhere in the process. These orders were dropping off the "order pipeline" and therefore the orders that got stuck in the system were grouped into, what was called buckets. Some examples of these drop-off conditions were as follow:

1. sometimes addresses were incorrect on the paper order and the capturing of the order could not be finished,

Figure 3. Bucket system



Bucket number	Bucket description
1	Street address or X and Y coordinates not completed
2	Postal or Billing address not completed
3	Wait for credit vetting results
4	Credit vetting score lower than required score, send letter to customer
5	Waiting for payment
6	Waiting to allocate access network
7	No distribution side access network available
8	Waiting to allocate exchange side network
9	No exchange side access network available
10	Waiting for cable repairs
11	Waiting for allocations of a port on the exchange
12	Waiting for telephone number to be allocated.
13	No core network available at the exchange
14	Waiting to run cross connection on the main distribution frame
15	Waiting for installation
16	Customer not at home
17	Installation completed, wait for billing

2. the information on the network was incorrect and no network existed for the address,
3. the customer was not available for the installation of the service, etc.

To make provision for all these conditions, the following process was modeled and all the different drop-out conditions were called buckets. Figure 3 represents the business requirement.

When the requirement occurred to track the orders through the OLTP system, the orders were already in the system. That meant that it was a business critical information requirement. There was no time to go through the data warehouse development lifecycle. A solution was needed immediately. The KIM section consequently designed the front-end solution for the order-tracking system and called it the bucket system.

The data warehouse Extract Transform and Load (ETL) team was asked to provide the information required in a flat file. The ETL process transformed the different conditions into buckets . That meant that depending on the order's condition, a bucket number was placed next to the order in the flat file. This bucket number was known as the current bucket and the snapshot date was known as the date that the order went into the particular bucket. This was only for the first run of the flat file. For the second run there were a current bucket and previous bucket and the number of days spent in the current bucket. The number of days in a bucket was calculated day by day from the first snapshot date that an order went into a specific bucket. This flat file was accessed by an excel pivot table. The advantage of this flat file was that it could be used while the bucket process was refined. Changes that occurred because of the refinement were easy to handle because it did not require a total redesign of the dimensional model. It required only small changes to the ETL and the flat file which could be done in minutes.

This bucket process was helping business to concentrate on orders that were longest in a particular bucket. The orders were also divided amongst the different sections. Core network sections were responsible for core network buckets, the access network sections were responsible for the access network buckets and finance was responsible for the financial buckets, etc. The responsible section would log into the order system and attend to the order. This bucket system was not only used to follow the orders through the order system, it was also used in the call centre for people phoning to find out where their orders were in the process.

After this bucket system was in place for a month and the KIM section was happy that all information needed was included and correct, the process was started to model this system into a proper dimensional model and business intelligence solution. The advantage of this quick Business Critical Information Solution (BCIS) was that the requirement was now understood very well and there was a proper interim solution in place that fulfilled the immediate need.

The flat file was modeled into a proper dimensional model and the ETL-process was now changed to load the tables of the dimensional model. Documentation was then done on the ETL and dimensional model. All of this was done without the user knowing that it happened. The only thing that could not be done without the user knowing or being interrupted was the user interface BI tool. Excel was used as the BI tool and it had to be changed with Business Objects (BO). The BO front-end was done in parallel and after it was completed the Excel front-end was switched off.

The question could be asked; why is a new solution built while the interim solution is working well. The answer is simple. With the interim solution the focus is on delivering the information and not to optimize the solution. It is for instance not possible to put indexes on a flat file.

4. BUSINESS INTELLIGENCE AND DATA WAREHOUSING MODELS

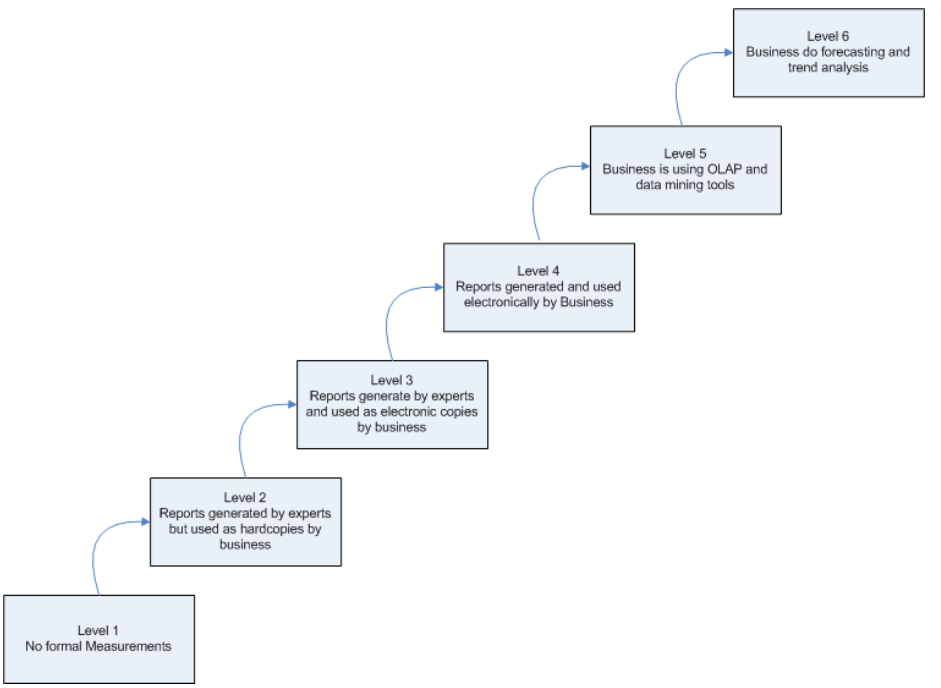
From this exercise the following two models resulted:

1. BI Literacy and Cultural Maturity Model
2. The data warehouse lifecycle model for Business Critical Information Solution called the Double Wave Data Warehouse Lifecycle Model.

4.1 BI Literacy and Cultural Maturity Model

Eckerman (2004) has developed the Data Warehousing Maturity Model. This model focuses on the maturity of the data warehouse. It consists of the following six stages: 1. Prenatal (System), 2. Infant (Individual), 3. Child (Department), 4. Teenager (Division), 5. Adult (Enterprise), 6 Sage (Internal enterprise). The Data Warehouse Maturity Model represents the incremental growth of the data warehouse. It enables an organization to know how mature the technical side of the data warehouse is. As we have mentioned earlier in this document, Williams and Williams (2004) stated that, historically, many data warehousing and business

Figure 4. BI literacy and culture maturity model



intelligence (BI) initiatives have been IT-driven, and much of the focus within the industry has been on the technical aspects of delivering information to the BI user community. The real success of the data warehouse and business intelligence of today lies in how well it is utilised by the business. How "BI literate" the business is, is important information for businesses. A BI Literacy and Cultural Maturity Model is needed to measure the literacy of the business users. This model also suggests ways to increase the maturity level of BI literacy in an organisation. An organisation can have the best DW with the best BI tools, if it is not used; it means nothing for the organisation.

From this study six maturity levels for BI literacy and culture materialized (*See Figure 4*).

Level 1: No formal Measurement
Level 1 does not appear in most new companies and is normally not a level that last very long in bigger companies because it is very hard to manage any organization without any form of measurement. The business management team therefore plays a major role in putting measures in place to manage the performance of the organization. Reports are in some instances built into OLTP systems and therefore results in a lack of integration in all business information.

Level 2: Reports Generated by Experts but Used as Hardcopies by Business
Business people in a company at this level are used to the fact that information is right in front of them on the wall. To run and use reports electronically forces people to change their comfort zone. This is a cultural change and this cultural change could be initiated and improved by creating a new section of people with both ICT and business skills (knowledge and information management section) as mentioned earlier in this document. The business people receive training to use the electronic reports and the Knowledge and Information Management (KIM) section is available to assist with any problems that might be experienced by the business people.

Level 3: Reports Generated by Experts and Used as an Electronic Copy by Business
This level is very prominent in organizations in developing countries where the ICT skills level amongst business people is low. The low ICT literacy could be as a result of the culture that exists in the organization. In companies at this level a culture exists that only ICT people are responsible to use ICT tools and can therefore not be addressed only by the provision of IT training to the business people. To get to the next level a new culture is needed where business people are responsible to use ICT tools and ICT people only maintain these ICT tools. This new culture need to be driven by the business management team which should lead by example. Business management should use electronic reports when doing management meetings. Using electronic reports would be difficult at first but the KIM team can play a huge role in educating business people in these meetings.

Level 4: Reports Generated and Used Electronically by Business Users
This level takes the longest to reach because it is not only dependent on the PC skills of the business people. Previously it was done by someone else, now they should do it for themselves. One way to get to this stage quicker is by only building BCIS that is needed urgently or by using this information for performance appraisals. The business people receive training to generate or run the reports with a proper BI tool and the KIM section is available to assist with any problems that might be experienced by the business people.

Level 5: Business is Using OLAP and Data Mining Tools
Moving from the use of reports to the use of online analytical processing (OLAP) could mean a lot to the business. This is the first step towards a complete business intelligent solution. This level of maturity within the business requires that The Data Warehousing Maturity Model (Ackerman 2004) is at level 5 (Adult). Data mining could result in new information that could be modeled back into the BI and DW solution. This level require creative KIM analysts who are very well equipped with both OLAP and business skills.

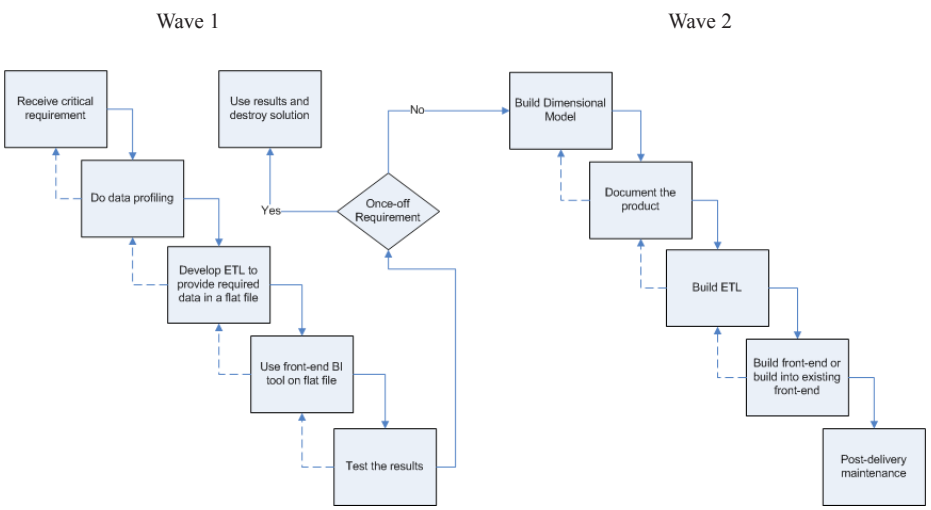
Level 6: Business Does Forecasting and Trend Analysis
Level 6 is to a certain degree not dependent on the literacy of the business people, it is a strategic decision made by top management and therefore dependent on the appointment of statisticians in the company. The approval of these statisticians is normally dependant on the value created by the BI solution up to level 5.

4.2 The Data Warehouse Lifecycle Model for Business Critical Information Solution

The Double Wave Data Warehouse (DWDW) lifecycle model consists of two iterations for the development of a BI and DW solution (*See figure 5*). Wave one concentrates on the rapid implementation of a BCIS. Wave 2 concentrates on modeling the ongoing requirement into a permanent dimensional model. The dimensional model leads to database optimization opportunities, because the dimensional model is a database design that supports extractions of large SQL queries and online analyses. Kimball (1998) has developed "The Business Dimensional Lifecycle diagram" that focuses on the development of a complete solution where there is enough time available for a complete solution.

The DWDW lifecycle model was created to build the BI and DW solution incrementally.

Figure 5. The double wave data warehouse lifecycle model



Information in business is often needed for a "window of opportunity" or legal requirement which cannot wait for a project to finish. When this need arise, there is often not enough time to go through a full software development lifecycle. The requirement can also sometimes be a once-off requirement and the information will not be used in future again. In this case it doesn't make sense to model it into the data warehouse. It is safer to wait for a BCIS to arise and build the BI solution the less expensive way. As soon as this interim solution satisfies the need of the customer, then a proper model can be built and integrated with the exiting BI and DW solution.

5. CONCLUSION

This paper discussed some of the challenges faced by developing countries in building and maturing a telecommunications business intelligence solution. The Double Wave Data Warehouse Lifecycle Model was created to construct a robust source (Data warehouse) for the electronic information in an organization while the BI Literacy and Culture Maturity Model was created to monitor and grow the BI maturity of the organization. The first wave of the Double Wave Data Warehouse Lifecycle Model enable the BI team to deliver business critical information to the business in the shortest possible time with the main focus on delivering the information, while wave two is focused on ensuring the robustness of the solution.

The BI Literacy and Culture Maturity Model ensures that the technical part of the BI solutions grows at the same pace as the human (soft) part of solution. A BI solution that is not used by the business cannot be described as a successful BI solution even though it is technically sound.

REFERENCES

Anon. (1996). White Paper on Telecommunications Policy, http://www.polity.org.za/html/govdocs/white_papers/telewp.html?rebookmark=1

Bodley, J. (1994). *An Anthropological Perspective.* http://www.wsu.edu:8001/vcwsu/commons/topics/culture/culture-definitions/bodley-text.html

Eckerson, W. (2004). *Gauge Your Data Warehouse Maturity.* http://www.dmreview.com/article_sub.cfm?articleId=1012391

Kimball, R., Reeves, L., Ross, M. and Thornthwaite, W. (1998). *The Data Warehouse Lifecycle Toolkit: Expert Methods for Designing, Developing, and Deploying Data Warehouse*s. New York: John Wiley

Kimball. R. (2002). *The Data Warehouse toolkit Second Edition: Developing and Deploying Data Warehouses*. New York: John Wiley.

Williams, S. & Williams, N. (2004). *The Business Value of Business Intelligence*, Business Intelligence Journal. Vol. 1, Page 1

Firm-Level Determinants of Business Process Outsourcing Decisions

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ABSTRACT

Although there are numerous contributions why firms outsource IT activities, research on Business Process Outsourcing (BPO) decisions is scarce. As BPO might affect outsourcer's core, decisions are likely to be taken on firm level. We therefore aim at answering the following research question: What is the impact of firm-level characteristics on the decision to outsource business processes? Using publicly available data we analyze BPO decisions in the German banking market. Our findings show that BPO is perceived to provide significant strategic value for outsourcers. We provide evidence that large and diversified banks with low cost efficiency are more likely to outsource. Contradictory to prior research findings we further demonstrate that more activities are sourced out, if outsourcer's profit increases. Further research is suggested to explain BPO success using publicly available data.

Keywords: Business Process Outsourcing, outsourcing decision, firm characteristics, banking, JEL Classification: G21, G34

1. INTRODUCTION

The examination of outsourcing — the purchase of a good or service that was previously provided internally (Lacity and Hirschheim (1993)) — has been a domain of IS research for several years now. When considering outsourcing, most of the academic discussions have addressed the questions of "why", "what", "which" and "how" to outsource (Dibbern, Goles, Hirschheim and Jayatilaka (2004)). As several motives for outsourcing have been analyzed in prior IT outsourcing research, little is known in the context of Business Process Outsourcing (BPO) (Dibbern et al. (2004)). This is especially surprising as BPO is a fast growing area in the outsourcing market (Gartner (2004)). One of the unique characteristics of BPO seems to be its proximity to outsourcer's core: several researchers (see e.g. Rouse and Corbitt (2004); Franke and Wüllenweber (2006); Gewald (2006)) showed that benefits and risks of BPO are closely related to firm-level objectives and strategic directions. However, these findings provide an incomplete picture as they are drawn from empirical studies with process owners and thus provide only a process-level perspective. Taking a firm-level view, we therefore aim at answering the following research question:

What is the impact of firm-level characteristics on the decision to outsource business processes?

To answer our research question, we first review prior studies on business process outsourcing and motives for outsourcing decisions (section 2). In section 3, we derive our hypotheses and explain the methodology used. Section 4 presents descriptive statistics of our data. The results of our study are given in section 5. Finally, we summarize our findings and discuss further research (section 6).

2. LITERATURE REVIEW

In the last two decades academic research on outsourcing, especially IT-outsourcing, has evolved rapidly. According to Dibbern et al. (2004) most researcher have focused on determinants and motives to outsource IT operations. As current outsourcing literature provides for very few comparative studies, differences between IT outsourcing and business process outsourcing have been suggested as promising research path (Dibbern et al. (2004)). However, little is known on BPO motives at all. Gewald (2006) as well as Gewald, Wüllenweber and Weitzel (2006) outline BPO's strategic importance. The authors analyze potential BPO benefits and risks as perceived by German bank managers. Focusing on core competencies has been identified in these studies as most important benefit associated with BPO. From the risk perspective, process's closeness to outsourcer's core was amongst the most significant inhibitors as BPO may result in substantial loss of know-how and innovative capabilities.

Besides these studies, empirical evidence is rare. Thus, we draw on prior research analyzing firm-level financial characteristics of companies involved in IT outsourcing arrangements. Loh and Venkatraman (1992) find that high overall costs as well as high IT costs and a poor IT performance are significantly correlated with outsourcing. Smith, Mitra and Narasimhan (1998) concluded that low overhead costs, low cash reserves, high debt, and declining growth rates determine outsourcing decisions. Hall and Liedtka (2005) demonstrate that IT outsourcing is determined by poor performance, poor cost control, and short term cash needs of the firms. Ang and Straub (1998) show that IT outsourcing is best explained by high production costs. The authors further outline that outsourcer's size is negatively related to outsourcing.

As the above studies focus on outsourcing decisions, there are several contributions on the firm-level effects *after* outsourcing. Most studies find outsourcing influencing firm's performance negatively Kotabe, Murray and Javalgi (1998); Görzig and Andreas (2003), marginally D'Aveni and Ravenscraft (1994) or having no significant effect (Gilley and Rasheed (2000)). Holzhäuser (2006) find that banks benefit from either a very high or a low vertical integration. Studying the influence of outsourcing on productivity, Girma and Gorg (2004) find labor productivity and total productivity growth positively related to outsourcing.

None of the literature we reviewed was attributed to pre-event firm characteristics of business process outsourcing. Within this paper, BPO is defined as the delegation of one or more entire business processes to third party providers, including the software and hardware that support those processes Halvey and Melby (2000). A business process is defined as a "set of logically related tasks performed to achieve a defined business outcome" (Davenport (2005)). Thus, BPO is the combination of application development/maintenance outsourcing, IT infrastructure outsourcing and the outsourcing of business activities which are not IT supported like business process re-design.

3. RESEARCH MODEL AND METHODOLOGY

3.1 Hypotheses

Following the studies outlined in section 2, we look at three categories of firm characteristics that might influence the BPO decisions: outsourcer's size, firm performance, cost efficiency, and degree of diversification.

Size. Concerning the outsourcer's size ambiguous explanations can be found in the literature. Ang et al. (1998) as well as Girma et al. (2004) argue that it is more difficult for smaller firms to achieve economies of scale and therefore outsource their operations. However, only Ang et al. (1998) confirm this hypothesis. Smith et al. (1998); Girma et al. (2004) as well as Hall et al. (2005) find a positive relation

of firm size and outsourcing as the absolute amount of outsourcing deals should be greater in larger firms than in smaller firms. We follow the later argument and propose that larger outsourcers tend to outsource business processes as for smaller outsourcers the efforts to monitor and control outsourced processes will exceed cost savings. In addition to firm size, we look at firm growth to account for size changes. Smith et al. (1998) find that declining growth rates entail outsourcing. They argue that firms who are lacking growth opportunities focus on cost reduction strategies and therefore tend to outsource.

H1: Firm size is positively, growth rates are negatively related to the decision to outsource business processes.

Firm performance. Hall et al. (2005) suggest that poorly performing firms are more prone to outsourcing as they will try to increase their short term performance. Outsourcing contracts can especially help to increase reported earnings in the year of the outsourcing event by selling their assets through the transfer of operations to the insourcer above book value. Loh et al. (1992) argue that under conditions of poor business performance firms seek to streamline their operations. Kotabe et al. (1998) postulate that outsourcing is negatively related to financial performance as it can be seen as a strategic reaction to declining competitiveness.

H2: Firm performance is negatively related to the decision to outsource business processes.

Cost efficiency. Most research articles on outsourcing show that firms outsource part of their operations, if cost efficiency is low. Hall et al. (2005) as well as Loh et al. (1992) find that high administrative costs and operating expenses – used as a synonym of low cost efficiency - are positively associated with outsourcing. In particular, we will draw special attention to wage levels as Girma et al. (2004) show that firms with high labor costs are more prone towards outsourcing in order to gain cost reductions.

H3: Cost efficiency is negatively, wage levels are positively related to the decision to outsource business processes.

Diversification. In the outsourcing literature hardly any study discusses the influence of diversification on outsourcing decisions. Only Holzhäuser (2006) find that diversified banks tend to operate at a lower level of vertical integration. However, empirical studies show that diversification is associated with higher costs (Holzhäuser (2006)). Thus, diversified banks will have a greater need to reduce costs and will purse cost cutting strategies including BPO.

H4: Diversification is positively related to the decision to outsource business processes.

Finally, we control whether the banks are a savings institute ('Sparkasse'). In Germany, these institutes are institutionally tied and might decide within their group that all institutes source out. In this case, we would have to reduce our sample to count all 'Sparkasse' outsourcing deals as one single outsourcing event. To control for this effect we use a dummy variable which is set to one, if the bank is a savings bank and zero otherwise.

3.2 Methodology

We chose to analyze BPO arrangements in the German banking area. As IS research should account for industry-specific results Chiasson and Davidson (2005), we selected the financial services sector as research object, since it is the second largest buyer of outsourcing services Gartner (2004). We use publicly available accounting data to explain outsourcing decisions as audited financial data provide a more objective evaluation of a firm's performance than the perception-based intermediate metrics typically used in case studies (Smith et al. (1998)). Further, respondents answers in surveys may by self justifying (Ang et al. (1998)).

To derive factors explaining outsourcing decisions we compare firm characteristics of banks where we observed BPO the year prior to the outsourcing event to the characteristics of the control group without BPO in the same year. We apply nonparametric tests to analyze the influence of each variable identified on the outsourcing decision as described by Smith et al. (1998) as well as Hall et al. (2005) and control for multivariate effects of our variables using a logistic panel regression model Hall et al. (2005):

$$\eta\left(\frac{\pi_{i,t}}{1-\pi_{i,t}}\right) = \beta_0 + \beta_1 \cdot SIZE_{i,t-1} + \beta_2 \cdot GROWTH_{i,t-1} + \beta_3 \cdot ROA_{i,t-1} + \beta_4 \cdot CIR_{i,t-1} + \beta_5 \cdot COSTASS_{i,t-1} + \beta_6 \cdot EMPLCOST_{i,t-1} + \beta_7 \cdot DIV_{i,t-1} + \beta_8 \cdot SPARKASSE_{i,t-1} + \varepsilon_{i,t}$$

where $\pi_{i,t} = p(BPO_{i,t} = 1)$ BPO is one, if bank i has sourced out a business process in year t, and zero otherwise. The independent variables are described in Table 2. The measure of diversification is taken from Elsas, Hackethal and Holzhäuser (2006).

4. THE DATA

The information on outsourced business processes was retrieved from a survey, which was sent out in May 2005 among the 200 largest banks in Germany. Responses from 126 banks were received resulting in a response rate of 63%. Twelve responses were anonymous and therefore had to be excluded. To obtain the accounting data we used Fitch IBCA Bankscope. Due to limited availability of accounting data before the year 1997 we had to restrict our study on outsourcing deals that occurred between 1998 and 2005, as we are interested in the accounting data the year before the outsourcing. We included all banks in our sample where at least one year of accounting data in the range between 1997 and 2004 were available. In addition, we excluded all banks that had any process sourced out before 1998 or where the accounting data in the year before the BPO were not available. This selection process reduces our sample to 101 banks for which we obtained 743 years of accounting data over the years between 1997 and 2004.

In this sample we find 41 BPO events. Three banks sourced out two processes in the same year, which we counted as one outsourcing event in the respective year, which leaves us with a total of 38 outsourcing events for our observed time frame (Table 1).

5. STATISTICAL ANALYSIS

5.1 Non Parametric Analysis

Starting with the results of the median difference test (Table 4) we observe the univariate influence of the variables on the decision to outsource business processes. A positive value in the median difference column indicates a positive effect of the variable on outsourcing, while a negative value indicates that the variable has a negative effect on the outsourcing decision.

The variable SIZE is positively correlated to outsourcing and the Wilcoxon test shows significance at the 1% level, indicating that larger bank tend to source out business processes more likely than smaller banks. The median difference for GROWTH is slightly positive but not significant. The same applies for ROA

Table 1. Sample

Year	Number of banks with BPO event	Number of banks in control group	Total
1998	2	76	78
1999	1	90	91
2000	1	91	92
2001	5	89	94
2002	5	90	95
2003	4	94	98
2004	6	92	98
2005	14	85	99
Total	38	707	745

Table 2. Definition of variables

Variable	Description	Definition
SIZE	Size	Logarithm of total assets of the bank
GROWTH	Annual growth of total assets	Total assets divided by total assets of previous year
ROA	Return over assets	Net income divided by total assets of the bank
CIR	Cost-to-income ratio	Total operating costs divided by total operating income of the bank
COSTASS	Total operating cost/total assets	Total operating costs divided by total assets of the bank
EMPCOST	Cost per employee	Wages and salaries plus social security contributions plus pension contributions divided by number of employees
DIV	Diversification	$DIV = 1 - \left(\left(\frac{INT}{TOR} \right)^2 + \left(\frac{COM}{TOR} \right)^2 + \left(\frac{OTI}{TOR} \right)^2 \right)$ INT =interest revenue; COM =net commission revenue, OTI =all other net revenue; TOR=sum of the absolute values of INT, COM, and OTI. DIV increases in the degree of revenue diversification. By definition DIV can take on values between 0 (the bank is fully specialized on one revenue source) and 0.75 (the bank generates a fully balanced revenue mix from all four revenue sources).
SPARKASSE	Dummy for Sparkasse	Binary dummy variable: 1 for state owned, 0 for privately owned

Table 3. Characteristics of independent variables

Variable	N	Mean	Median	Std. Dev.	Min.	Max.
SIZE	745	9.0809	8.5767	1.3885	6.0154	13.1690
GROWTH	644	1.0663	1.0405	0.2528	0.6237	6.7580
ROA	744	0.2118	0.1900	0.3657	-6.0300	4.3500
CIR	744	64.6929	65.1750	14.8277	18.3300	177.0300
COSTASS	744	0.0168	0.0185	0.0088	0.0005	0.1076
EMPCOST	742	0.0557	0.0478	0.0239	0.0145	0.3393
DIV	744	0.1790	0.1741	0.1004	0.0011	0.6026
SPARKASSE	745				0	1

Table 4. Median difference test

		Wilcoxon signed rank test	
Variable	Median Difference	Z-statitic	p-value
SIZE	0.775	2.632 ***	0.009
GROWTH	0.046	0.049	0.961
ROA	0.163	-0.341	0.733
CIR	4.530	1.994 **	0.046
COSTASS	0.002	1.835 *	0.067
EMPCOST	0.014	2.748 ***	0.006
DIV	0.059	3.009 ***	0.003

*=significant at the 10% level, **=significant at the 5% level, ***=significant at the 1% level

which measures the return over assets and is our proxy for the performance of the banks. The variables that measure cost efficiency are higher for the banks with BPO than the median of the peer group at a significance level of 5% (CIR) and 10% (COSTASS). Hence we conclude, that banks with a high costs and a low cost efficiency tend to source out business processes. The same applies for the wage level (EMPCOST) which is higher for the outsourcing banks at a significance level of 1%. Finally, a higher diversification can be observed for banks that have sourced out than for the industry control group (at a 1% significance level).

5.2 Logistic Regression Analysis

We tested several models in our logistic regression analysis. Correlation among the independent variables does not allow including all variables in one model. The

results from the regression mainly support the findings of the univariate median difference test. Only the variable for return over assets (ROA), which was not significant in the median difference test, is significantly positive related to outsourcing in our regression analysis. All other variables show the same influence on business process outsourcing in both the univariate and the multivariate analysis. The dummy variable SPARKASSE, controlling for the firm being a German savings bank does not show significant influence on outsourcing in any model.

Table 5. Regression results

				Independent variables								
No	N	χ^2	Cons. (z-value)	SIZE (z-value)	GROWTH (z-value)	ROA (z-value)	CIR (z-value)	COSTASS (z-value)	EMPCOST (z-value)	DIV (z-value)	SPARKASSE (z-value)
1	644	1.71	-4.401 ***	0.149	0.156						
			(-3.47)	(1.29)	(0.29)						
2	742	15.70 ***	-5.844 ***			1.152 ***	0.030 ***		10.919 **		
			(-6.34)			(3.00)	(2.64)		(2.16)		
3	742	13.11 ***	-4.448 ***			0.749 **		35.805 **	12.258 **		
			(-8.26)			(2.21)		(2.05)	(2.41)		
4	744	11.72 ***	-4.056 ***							4.786 ***	0.283
			(-8.72)							(3.41)	(0.79)
5	744	19.75 ***	-6.903 ***	0.194 *		0.958 **	0.020			3.229 **	
			(-5.22)	(1.76)		(2.25)	(1.48)			(2.19)	
6	744	11.83 ***	-4.388 ***				0.006			4.595 ***	0.275
			(-5.5)				(0.52)			(3.14)	(0.77)
7	742	20.85 ***	-5.802 ***			0.872 **	0.022 *		10.380 **	2.927 **	
			(-6.13)			(2.16)	(1.75)		(2.02)	(2.09)	
8	742	13.11 ***	-4.448 ***			0.749 **		35.805 **	12.258 **		
			(-8.26)			(2.21)		(2.05)	(2.41)		

*=significant at the 10% level, **=significant at the 5% level, ***=significant at the 1% level

5.3 Discussion

Our first hypothesis is partly supported by our findings. We can provide evidence that firm size is positively related to BPO. Research provides findings on 'diseconomies of scale" where coordination and control costs exceed cost savings retrieved from the utilization of economies of scales (Graves and Langowitz (1993); Zanger (1994)). If this is the case, firms tend to focus on core competencies (Prahalad and Hamel (1990); Cross (1995); McFarlan and Nolan (1995)) and outsource non-core activities. Our results contradict prior research findings (e.g. Ang et al. (1998)) as this tradeoff (economies vs. diseconomies of scale) entails that large firms engage in outsourcing activities more often than small firms. We conclude that the processes analyzed here do not belong to bank's core. Thus large banks are not willing to bear high coordination and control costs for those activities which do not provide any value for the firm, if they are internally produced. On the other hand, we did not find a significant influence of growth rates on BPO. Thus, we presume that BPO is not perceived as short-term instrument to improve profitability.

Our second hypothesis is contradicted by our findings: the more profitable a bank operates, the more likely it will engage in BPO activities. To our knowledge, this relation has not been shown in prior outsourcing studies. Firms are only able to invest in new business opportunities, if profit increases. Thus, our data provide evidence that BPO is not only perceived as cost reduction instrument but also as strategic instrument through leveraging the capabilities of the service provider. This finding is in line with outsourcing research where outsourcers gain or sustain competitive advantage through the use of vendor's resources (Lacity and Willcocks (1998); Quinn (1999); Goles (2003); Lammers (2004)).

Nevertheless, BPO seems to be part of cost cutting strategies as our third hypothesis is fully supported by our data. Thus, poor cost efficiency entails BPO. In particular, banks with high wages levels tend to outsource more often than banks with lower wage levels. In the case of high wage levels, it is believed to be easier for the insourcer to provide the services at lower cost as the difference of personnel expenses between the outsourcer and insourcer is larger.

Finally, our data support our fourth hypothesis that the degree of diversification is positively related to BPO. Thus, banks try to streamline their operations and thereby reduce operating costs while still benefiting from diversified revenue. This finding supports prior findings in outsourcing research and transfers them to BPO context (Prahalad et al. (1990); Cross (1995); McFarlan et al. (1995)).

Our control variable for 'Sparkasse' does not show any significance. Thus, we are allowed to count each 'Sparkasse' separately.

5.4 Limitations

As our findings provide for interesting insights on BPO decisions, several limitations have to be considered. First, we rely on those data which are publicly available and cannot account for internal matters. For example, if the bank sourced out to improve process quality, we will not be able to reproduce this parameter as there is no quality measure available. Second, due to limited availability of older accounting data, we only use data from one year prior to outsourcing. Although this is a valid approach used in other research studies (e.g. Smith et al. (1998)), more data would be appropriate to strengthen our results.

6. CONCLUSIONS

This paper empirically addresses the factors that influence BPO decisions. As BPO is considered as strategic instrument through leverage of vendor's capabilities, we advocate a firm-level instead of a process-level analysis. In addition, we aim to overcome respondent's biases from case studies and survey data and therefore rely on publicly available data.

Our findings are somewhat contradictory to current outsourcing research and emphasize the strategic value of BPO. As large banks with high performance tend to outsource more activities, we conclude that BPO is seen as strategic instrument to sustain or further gain competitive advantage. Since especially diversified banks are not able to generate these advantages with internal resources, they are interested in accessing vendor's more specialized resources to complement their resource portfolio. Nevertheless, potential cost savings seem to be a relevant motive for BPO as especially high wages could be reduced significantly (similar findings in Gewald (2006)).

From our data, we were not able to identify whether potential process improvements is the reason why firms outsource their business processes. However, as this has been shown as important factor influencing the outsourcing decision (e.g. Gewald (2006)), further research might analyze the importance of quality from the firm-level perspective. In addition, since our research focus on decision criteria prior to outsourcing, it would be interesting to see if these 'predictions' hold for the future. Thus, publicly available data should be used *after* outsourcing to analyze *achieved* benefits from BPO.

7. REFERENCES

Ang, S. and D. W. Straub (1998). "Production and Transaction Economies and IS Outsourcing: A Study of the US Banking Industry." MIS Quaterly **December**.

Chiasson, M. W. and E. Davidson (2005). "Taking industry seriously in information systems research." MIS Quarterly **29**(4): 591-605.

Cross, J. (1995). "IT Outsourcing: British Petroleum´s Competitive Approach." Harvard Business Review **May-June**: 94-102.

D'Aveni, R. A. and D. J. Ravenscraft (1994). "Economies of Integration versus Bureaucracy Costs: Does Vertical Integration Improve Performance?" Academy of Management Journal **Vol. 37**(No. 5): pp. 1167-1206.

Davenport, T. (2005). "The coming commoditization of processes." Harvard Business Review **June**: 100-108.

Dibbern, J., T. Goles, R. Hirschheim and B. Jayatilaka (2004). "Information Systems Outsourcing: A Survey and Analysis of the Literature." The DATA BASE for Advances in Information Systems **Vol. 35**(No. 4).

Elsas, R., A. Hackethal and M. Holzhäuser (2006). "The Anatomy of Bank Diversification." University of Munich, Munich School of Management, Discussion Papers in Business Administration.

Franke, J. and K. Wüllenweber (2006). The Impact of Potential Flexibility Gains and Losses on the Intention to Outsource Business Processes. Proceedings of the 14th European Conference on Information Systems (ECIS06), Göteborg, Sweden.

Gartner (2004). Forecast for IT Outsourcing Segments Shows Strong Growth. Gartner Dataquest Alert.

Gewald, H. (2006). Assessing the Benefits and Risks of Business Process Outsourcing in the German Banking Industry. Frankfurt am Main.

Gewald, H., K. Wüllenweber and T. Weitzel (2006). „The Influence of Perceived Risks on Banking Managers' Intention to Outsource Business Processes - A Study of the German Banking and finance Industry." Journal of Electronic Commerce Research **7**(2): 78-96.

Gilley, K. M. and A. Rasheed (2000). "Making More by Doing Less: An Analysis of Outsourcing and its Effects on Firm Performance." Journal of Management **Vol. 26**(No. 4): pp. 763-790.

Girma, S. and H. Gorg (2004). "Outsourcing, Foreign Ownership, and Productivity: Evidence from UK Establishment-level Data." Review of International Economics **12**(5): 817-832.

Goles, T. (2003). "Vendor Capabilities and Outsourcing Success: A Resource-based View." Wirtschaftsinformatik **45**(2): 199-206.

Görzig, B. and S. Andreas (2003). "Outsourcing and Firm-level Performance." German Institute of Economic Research (DIW), Discussion Paper(90).

Graves, S. and N. Langowitz (1993). "Innovative productivity and returns to scale in the pharmaceutical industry." Strategic Management Journal **14**(8): 593-605.

Hall, J. A. and S. L. Liedtka (2005). "Financial Performance, CEO Compensation, and Large-Scale Information Technology Outsourcing Decisions." Journal of Management Information Systems **Vol. 22**(No. 1): pp. 193-221.

Halvey, J. K. and B. M. Melby (2000). Business Process Outsourcing - Process, Strategies and Contracts. New York, John Wiley & Sons.

Holzhäuser, M. (2006). "The changing boundaries of banking firms." Dissertation Thesis: Frankfurt am Main, Germany.

Kotabe, M., J. Y. Murray and R. G. Javalgi (1998). "Global Sourcing of Services and Market Performance: An Empirical Investigation." Journal of International Marketing **Vol 6**(No. 4): pp. 10-31.

Lacity, M. and L. P. Willcocks (1998). "An Empirical Investigation of Information Technology Sourcing Practices: Lessons from Experience." MIS Quaterly **22**(3): 363-408.

Lacity, M. C. and R. Hirschheim (1993). "The Information Systems Outsourcing Bandwagon." Sloan Management Review **Fall**: 73-86.

Lammers, M. (2004). "Make, Buy or Share - Combining Resource Based View, Transaction Cost Economics and Production Economies." Wirtschaftsinformatik **46**(3): 204-212.

Loh, L. and N. Venkatraman (1992). "Determinants of Information Technology Outsourcing: A Cross-Sectional Analysis." Journal of Management Information Systems **Vol. 9**(No 1): pp. 7-18.

McFarlan, F. W. and R. Nolan, L. (1995). "How to Manage an IT Outsourcing Alliance." Sloan Management Review **Winter**: 9-23.

Prahalad, C. K. and G. Hamel (1990). "The Core Competence of the Corporation." Harvard Business Review **May-June**: 79-91.

Quinn, J. B. (1999). "Strategic Outsourcing: Leveraging Knowledge Capabilites." Sloan Management Review **40**(4): 9-22.

Rouse, A. C. and B. Corbitt (2004). IT-supported business process outsourcing (BPO): The good, the bad and the ugly. Eight Pacific Asia Conference on Information Systems, Shanghai, China.

Smith, M. A., S. Mitra and S. Narasimhan (1998). "Information Systems Outsourcing: A Study of Pre-Event Firm Characteristics." Journal of Management Information Systems **15**(2): 61-93.

Zanger, T. (1994). "Understanding organizational diseconomies of scale in R&D: agency problems and the allocation of engineering talent, ideas, and effort by firm size." Management Science **40**: 708-729.

Evaluating E-Business Applications Priorities: The E-Business Planning and Analysis Framework

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ABSTRACT

An e-business planning framework is proposed here which links both strategic and operations management to improve the online service quality of a manufacturing SME. A standard systems development lifecycle has been used in the overall approach. However, the initial 'systems analysis phase' of this a unique combination of analytical tools draws upon the Balanced Scorecard (BSC), Value Chain Analysis (VCA) and Quality Function Deployment (QFD) which are integrated into a new practical 'e-business analysis framework'. The paper explains the use of the framework by using a practical case study based upon a manufacturing SME based in the UK. The company realised that information technology can have a great impact on their business, especially on the potential benefits that e-business applications can offer. In light of this the company reviewed the value proposition it deliver to offered its customers and business partners; its internal resource base; its levels of process maturity and the supporting information and technological systems by using the 'E-Business Planning and Analysis Framework' (E-PAF). The result of this research gives a set of recommendations to help the company grow and become more customer focused whilst simultaneously increasing revenue and profitability principally via the deployment of new customer relationship management (CRM) technologies.

Keywords: e-business, analysis and planning framework, systems development lifecycle, manufacturing SME, customer relationship management, quality function deployment

INTRODUCTION

Since the early 1990s, much had been expected in engaging the Internet as a platform for business transactions and business management. However, it was only in the late 1990s that the terms e-business and e-manufacturing began to appear on management agendas, probably due to the phenomenal growth of 'dotcom' companies (Cross, 2000; Gromov, 2000; KPMG Consulting, 2000; Lang et al., 2001; Forrester Research, 2002; Cheung and Huang, 2003; Chen, 2003). Although SMEs realised the need to develop sustainable business models and intermediate into established business sectors to survive, many of them are not able to manage this transition effectively as it requires not only technical knowledge but also a social, economic, political and legal awareness. Whilst a successful implementation could enable the SME to create competitive advantage, a failed implementation could be fatal for the business.

The aim of the paper is to illustrate how an established manufacturing SME based in the UK has analysed and improved the quality of its online services through a structured approach. This paper will provide an in-depth account of that unique analysis framework and demonstrate how it may assist SMEs in e-business analysis. This includes an overview of the 3 existing techniques that are integrated to form the analysis framework. These 3 techniques are Quality Function Deployment (QFD) (Akao, 1972), Balanced Scorecard (BSC) (Kaplan and Norton, 1992) and Value Chain Analysis (VCA) (Porter, 1985). A case study using this approach is presented in detail in this paper based upon an established manufacturing SME based in the UK.

CHARACTERISTICS OF A GOOD BUSINESS FRAMEWORK

Wu (1992) stated that good frameworks should be able to guide managers towards a method or solution uniquely suitable to a particular situation in question. On the whole, frameworks should not be too complex to use and information interaction within the framework should be clear and concise to avoid information overload.

IDEF (U.S. Air Force, 1981) is one potential analytical framework for processes, but is often thought of as too complex and time intensive for small or rapidly developing situations. In contrast, Lee and Ko (2000) proposed a strategic framework for strategic business analysis, by integrating SWOT (strengths, weaknesses, opportunities and threats) (de Witt and Meyer, 1998), Balanced Scorecard (BSC), Quality Function Deployment (QFD) and 'Sun Tzu's the art of business management strategies' techniques. These frameworks demonstrate the value of integrating different analysis tools. Similarly, the authors use a different combination of analysis tools to produce another analysis framework, for a different purpose (i.e. e-business planning).

Whilst many analytical techniques such as the SWOT, SLEPT (political, economic, social, technical and legal) (Op. Cit.:135) and the BSC analyses can be used to identify the strategic needs of an organisation, none provide a direct mechanism to prioritise the needs and convert them into operational processes, or to then translate those processes into a specification that can be used to develop or acquire supportive software systems. In contrast, other analytical techniques such as Porter's Value Chain Analysis (VCA) (Porter, 1985) facilitates the analysis of processes within a company but does not provide an easy mechanism to link these to high level business objectives.

One analytical tool that does provide the ability to convert high level business objectives ('what' the business wants), into processes ('how' the business delivers those 'what's') is QFD, which has had these benefits discussed widely by Akao (1972), Mazur (1992) and more recently by Ko and Lee (2000); and Lee et al. (2000), However, QFD has its own weaknesses; two of these lie in the initial generation of the 'what's' and 'how's'. The analytical framework presented in this paper deals with the weakness of QFD directly by integrating QFD with two other complementary analytical techniques. These are to use the main strengths of the:

- BSC to generate a set of high level business objectives, targets, measures and initiatives for finance, internal operations, learning and growth and customer satisfaction. The outputs from this analysis become the 'what's' in the initial QFD analysis.
- VCA to generate detail about operational processes. The outputs from this analysis become the 'how's' in the initial QFD analysis.

It is through this complementary use of the existing BSC, VCA and QFD that a new successful analytical framework has been produced for analysing and designing the e-business process re-engineering of an established manufacturing SME in the UK. The analysis framework developed by the authors is now outlined within the context of the wider systems development lifecycle. Further details can be found in earlier publications by the authors (Tan et al., 2004).

THE E-BUSINESS ANALYSIS FRAMEWORK FOR MANUFACTURING SMES

An 8-step approach was developed to assist in the understanding and creation of the analysis framework as shown in Figure 1 (Tan et al., 2004). The 8 steps are identified as:

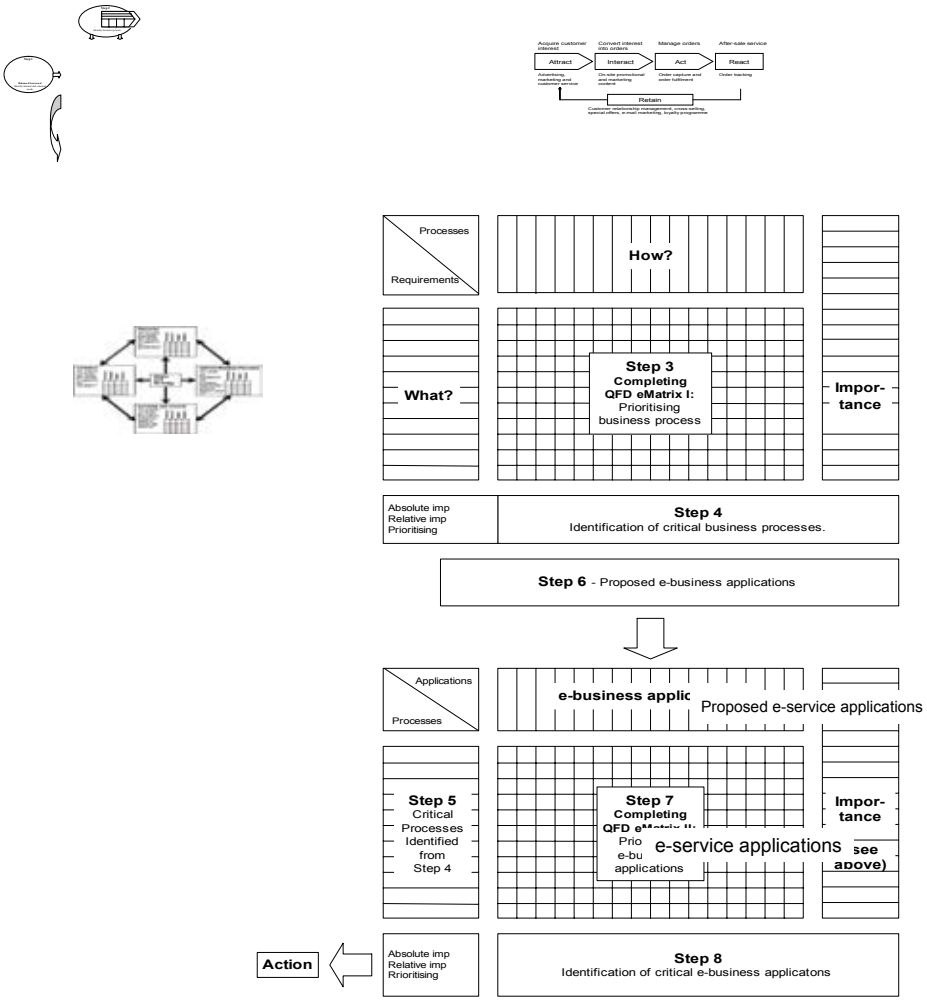
- Step 1 – Using BSC to develop the 'what's' for QFD Matrix I
- Step 2 – Using VCA to develop the 'how's' in QFD Matrix I
- Step 3 – Completing the interrelationships of QFD Matrix I
- Step 4 – Identification of critical business processes from QFD Matrix I
- Step 5 – Inputting critical business processes to the 'what's' of QFD Matrix II
- Step 6 – List of e-CRM (e-Customer Relationship Management) applications to the 'how's' of QFD Matrix II
- Step 7 – Completing the interrelationships of QFD Matrix II
- Step 8 – Identify the most suitable e-CRM solutions from QFD Matrix II inter-relationships.

The analysis framework was first presented as a prototype utilising a data set from the case study on Marshall Industries, US (Olofson, 2000). The purpose of this paper is to illustrate the use of the analysis framework for implementation in an established manufacturing SME. The paper now presents the findings from the case study company – MT Mounts (the name is a pseudonym in order to preserve the sensitive nature of the information disclosed in this paper). MT Mounts is an established manufacturing SME in the UK specialising in the manufacturing of shock and anti-vibration mounts. It should also be noted that all of this analysis is contained within the initial part of the systems development lifecycle (i.e. the 'systems analysis phase').

CASE STUDY: MT MOUNTS – A MANUFACTURING SME

The management at MT Mounts recognise the importance of I.T. to improve its business and has successfully implemented an in-house system for: order entry and processing; accounts (customer and purchasing); stock control and production planning. As a result of these systems, tasks have been improved in terms of time, cost and usability. In addition, MT Mounts had also begun to develop a

Figure 1. E-business analysis framework (source: Tan et al.)



number of supporting I.T. applications to provide more functionality to the sales and marketing activities. However, at the moment the company's presence on the Web is barely visible as it is part of the MT Group's website, and is mainly only informational. The only interactive element was a downloadable form for potential customers to make enquiries. Therefore, the main driving force behind any new investment at MT Mounts is to generate more sales and interface with their customers better.

Due to the R&D culture of the MT Group, most of investments have been going towards product development and design. The challenge was therefore to convince to the MT Group management team towards investing further in online customer interfacing processes. Besides recognising the need to upgrade current e-business applications, MT Mounts also recognised that there was no available in-house resource to conduct such an analysis. Thus, the authors were approached to take up the role of expert consultants to research and create a report on applying customer interfacing processes for MT Mounts.

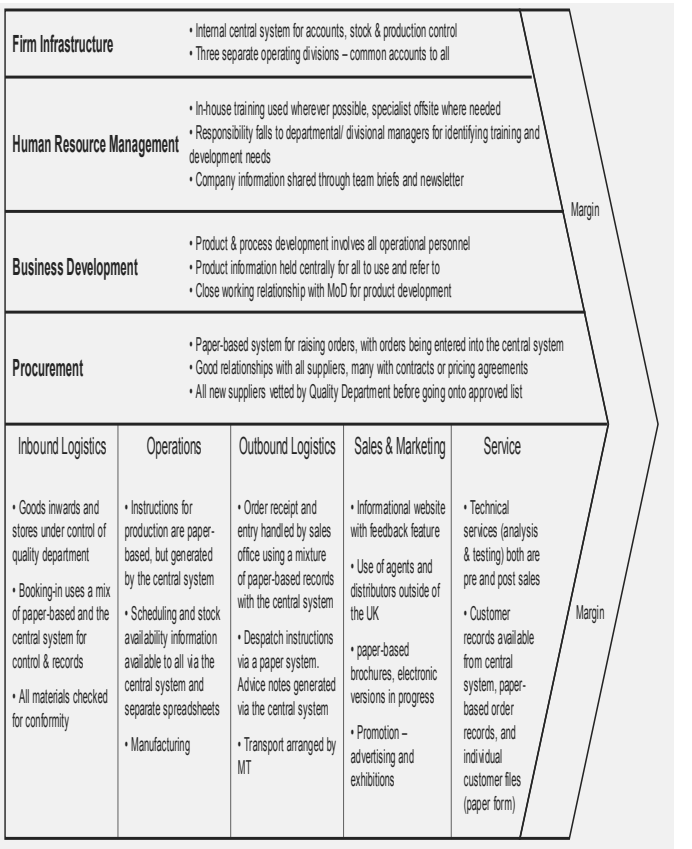
Generating the Balanced Score Card for MT Mounts ('what's')

The first step of the E-PAF is to establish the company's Balanced Scorecard (BSC) to generate a list of 'what's' for QFDI Matrix. The vision of MT Mounts was clearly stated as "to be the number one manufacturer and service provider of vibration, shock, and noise control products in the world". It is therefore important for the business to build sustained growth and ongoing innovation. A summary of the BSC analysis can be seen in Table 1. Expert advice from senior managers with extensive industrial experience, assisted in the ranking of these initial 'what's': the 'what's' deemed most important were awarded the highest points, and the lower scored were given to those which were felt to be of lesser importance.

Table 1. Summary of the BSC analysis

	Objectives	Measures: Target	Initiatives	Weight (1 low, 5 high)
Financial	Sales growth	Turnover: Year on year growth of 10%	• New products • Improvements to existing products • New markets	5
	Product profitability	Profit margin: Average of 30% or better across whole product range	• Improvements to production processes • Involve suppliers to reduce material costs	3
	Minimise costs	Administrative costs, consumables costs, equipment costs: Reduction year on year of at least 10%	• Streamline/ automate administrative processes • Identify and reduce costly consumable use • Reduce prices of items • Improvements to existing processes • Introduce new processes	3
Customer	High retention	No. of repeat orders and new enquiries: obtain enquiries from > 90% of current customer base, and >90% orders.	• Regular contact with entire customer base through various means	5
	Customer satisfaction	Number of complaints: Zero complaints	• Ensure that requirements are fully understood and communicated throughout the company • All problems (or potential problems) to be discussed with customers before escalating	5
	Market share	Number of new customers: Growth of 20 new customers each year	• Targeting specific customers • Advertising	3
Internal Business Process	Product quality	% of rejected production: Zero %	• Improvements to production processes • Improvements to supplied materials	5
	Product cycle time	Direct labour time: Labour times to be reduced by 10%	• Improvements to production processes	3
	Production planning	Waiting time and number delays: Reduce all idle times to minimum, target at 10%	• Coordinate production stages • Improve suppliers coordination	3
	On-time delivery	Number of days late: All orders to be delivered within 5 days of customer due date	• All quoted lead times to be realistic • Improvements to internal processes to reduce lead times • Involve suppliers , reduce leadtimes	5
	Process reliability	Number of machine breakdowns, downtime due to breakdowns: No breakdowns	• Preventive maintenance routine to be set up • Operators training for correct use and routine maintenance	3
Learning and Growth	Staff training	Number of staff involved in training: 100% of all junior staff and 50% of all senior staff	• Examination of skills matrix • In-depth discussion during appraisal	3
	New products and services	Introduce more new products and services: At least five viable new products to be suggested each year	• Suggestion scheme • "Innovation" competition	3
	Employee satisfaction	Staff retention level: No staff leaving due to dissatisfaction	• Staff feedback system	3

Figure 2. Value chain analysis for MT mounts



Generating the Key Business Processes of MT Mounts with the VCA ('how's')

Using the VCA, the authors are able to identify the main categories of business processes and critical customer interfacing activities within the company. The VCA for MT Mounts is shown in Figure 2.

QFDI Matrix

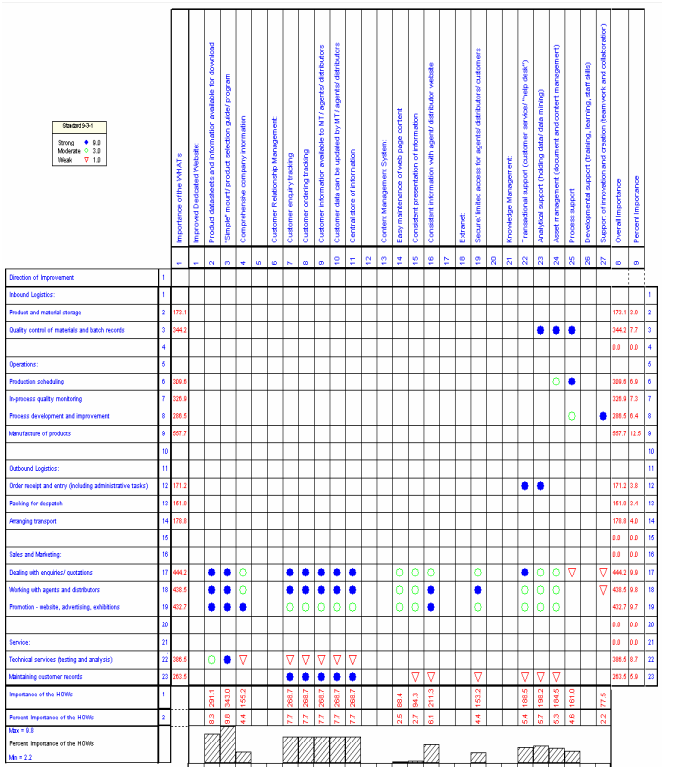
The list of 'what's' and "how's' as generated in the previous steps, are entered into the QFDI Matrix. Expert insight was again sought from MT Mounts at this step to determine the strengths of the relationships between the 'what's' and "how's'. Once these ratings were allocated they were keyed into the QFD/CAPTURE™ software; the software automatically prioritised each key business processes ('how's') in order of importance, according to the capability of each process to meet the requirements of the 'what's' (that were rated in importance). Therefore, the more relevant the business process was in meeting the requirements of the higher ranked 'what's', the higher the business process is prioritised.

The fact that the QFDI matrix showed manufacturing to be the most important process is not surprising since the business is built around producing products and these processes are currently well supported. However, the next four processes are all related to customers in a sales and marketing capacity, the technical services are also tied into sales both before and after a sale has been made.

QFDII Matrix

The 'what's' inputted into the QFDII matrix were transferred from the results of QFDI matrix. The important point to note is that the prioritised scorings of the business processes from QFDI matrix were entered as the rating scores for the business processes (as the business processes are now serving the function of 'what's' in QFDII Matrix).

Figure 3. MT mounts QFDII matrix



The results of this analysis found the following e-business support application to be the most important:

1. Manufacturing of products with a score of 557.7.
2. Dealing with enquiries/ quotations with a score of 444.2.
3. Working with agents/ distributors with a score of 438.5.
4. Promotion (advertising, website, exhibitions) with a score of 432.7.
5. Technical services (testing and analysis) with a score of 386.5

These scores are obtained for each e-business support application by the following formula:

$\sum$ (importance weight of the business objectives x prioritisation score given in QFDII x prioritisation given in QFDII).

Since MT Mounts is not cash rich, it was only practical to focus on one or two e-business implementations. These results indicate that the use of a dedicated and improved website, together with better Customer Relationship Management would be the most important and most suitable (non direct manufacturing) e-business applications to apply in order to achieve the overall company vision. The provision of simple product selection tools and product data availability came in first and second respectively, while all aspects of a CRM system came in jointly third. The QFDII matrix can be seen in Figure 3.

The findings gained by applying this planning and analysis framework were numerous. A dedicated website would allow MT Mounts to showcase their products and services offered to provide a clearer identity, separating them from other divisions of the MT Group that are not related to shock and vibration equipment. Providing data on the web for immediate download after registration will enable customers to review information immediately, before deciding whether or not to make further enquiries. Gathering customer registrations will in turn provide MT Mounts with new market intelligence, customer profiles and increased response rates.

Having technical information available freely also encourages equipment designers to incorporate MT's products into their designs. An improved website will also help to speed up the enquiry process by providing simple mounting selection tools, though this will only be appropriate for very simple selection and more detailed analysis has to be referred back to MT Mounts. A more detailed "technical form" can also speed up the enquiry process by making the customer think about their application before contacting MT Mounts.

Central to a CRM system is a single database that stores all of the customer information collected together from the various communication channels. This database provides complete visibility of customers to employees. Web-log activities can therefore be collected from the website to allow MT Mounts to track the frequency of the items being looked at, the patterns on which the products are viewed and then enquired. This information can thus also be used for further development to improve the website. A centralised CRM system will also allow all relevant staff within MT Mounts and its overseas agents and distributors access to information with increased speed and accuracy. This will reduce duplication of activities such as MT Mounts and their agents responding to the same customer enquiry, saving both time and effort, and increasing professionalism.

A CRM system can also allow MT Mounts to get more information and feedback on the activities of its agents, which has been lacking and may be one of the contributing factors to relatively poor performance by agents in certain areas. Greater visibility will allow MT Mounts to identify and address trends where quotes have been unsuccessful, perhaps through a price reviews or by offering further technical assistance. With an increasingly global marketplace, a CRM system can help to minimise instances where MT Mounts spends money to 'compete' with its own agents to get first contact, which may be counter-productive. For that reason, records contained within CRM could provide the necessary evidence for making the decision process easier.

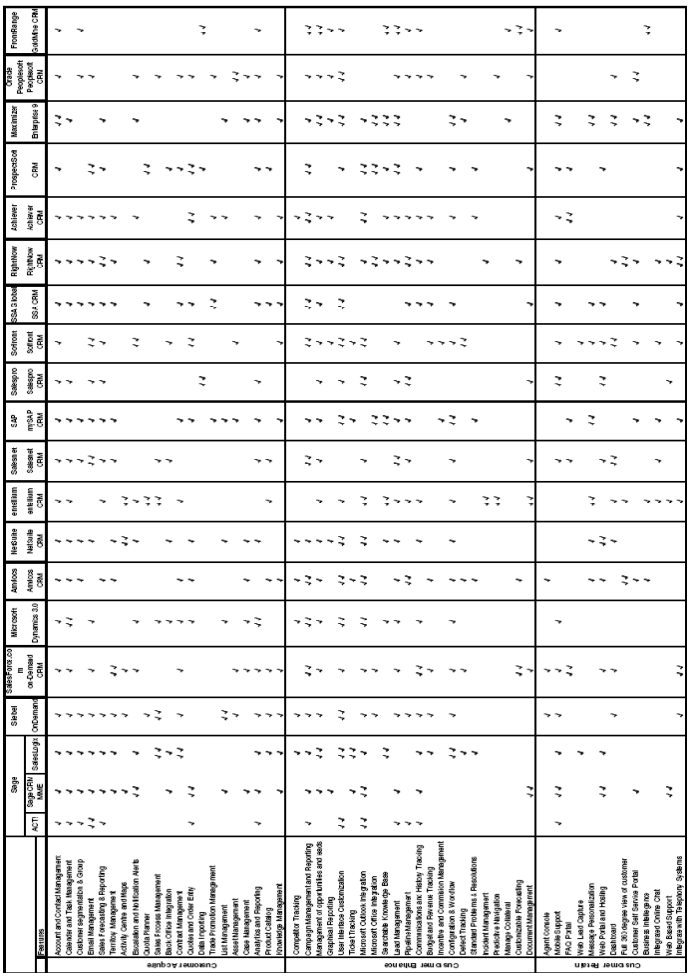
However, there are many CRM vendor solutions from about 18 different leading companies currently available on the market. Therefore, in order to assist MT Mounts further in choosing the right vendor solution, there is a need to provide more in-depth analysis in order to highlight the differences between the software on the three pre-determined features that are significant to MT Mount on its needs to employ a CRM system. These features are divided into customer acquiring, customer enhancing and customer retaining (Table 2). The methodology used to analyse the vendor solution's strength on the feature being looked at are determined to be (a) 2 ticks for a particular feature that is a present and highly sought after; (b) 1 tick for a particular feature present in the vendor solution regarded as desirable; and (c) no tick means the feature is not present in the evaluated vendor solution. Thus, from Table 2, it can be seen that further study may still be required to determine the right CRM vendor solution for MT Mounts.

CONCLUSION AND FUTURE WORKS

The academic contribution that this paper has made has been to select and implement three complementary tools, the Balanced Scorecard (BSC), the Value Chain Analysis (VCA) and Quality Function Deployment (QFD) to provide a comprehensive approach to analysing a business from both a strategic and operational point of view which can define and prioritise actions for process development and the implementation of candidate software solutions to support them. The strengths of the BSC allowed the generation of 'what's' for the initial QFDI matrix. The strengths of the VCA enable the initial 'how's' for the QFD to be generated. An interesting observation was that coupled with the measurement functions typical of any BSC, the QFD becomes more robust by incorporating the 'voice of customer' generated from the BSC. This can eliminate the need for customer surveys, which are mostly vague in their findings, since these 'voices' can now be constructed by using the BSC framework. The QFD can therefore provide integration between top-level objectives and operational-level activities, a major deficiency in the typical BSC approach, by making it possible for managers to prioritise needs while taking into account the business processes, ultimately providing a blueprint for e-business planning. QFD can also facilitate planning at the lowest level of implementation through the deployment of multi-level matrices as deemed necessary by the company for the specific e-business planning.

By using the balanced scorecard technique both internal and external 'what's' for QFDI Matrix were collected. The value chain analysis provided an analysis of the business processes of the company and gave the foundations for the generation of 'how's'. By entering the data through the balanced scorecard and the value

Table 2. Summary of vendor e-business solutions analysis



chain analysis into the quality function deployment matrices managers were able to prioritise the business processes according to the ability of the process to meet both internal and external needs. Once this is achieved, the potential e-business applications can be identified.

The practical contribution that this research has made to MT Mount has been to highlight the internal resource based factors of the company and the industrial scenario in which it is currently operating. The research has also given direction to future developments that the company should take if it is to stay competitive and continue to grow amidst competition. For example, the research has highlighted 'what' is important from the customers' point of view and 'what' is important from a business' point of view for the future, and then 'how' those issues should be delivered through new processes, new software application types and even to propose specific candidate solutions.

Future work planned by MT Mounts will be the implementation of these solutions after approval has been given by MT Group management. Further academic work will continue to deploy this framework in other industrial scenarios to increase its robustness and generic applicability.

REFERENCES

Akao, Y. (1972), "New product development and quality assurance: system of QFD, standardisation and quality control", *Japan Standards Association* 25, 4, pp. 9-14.

Chaffey, D. (2004),*E-Business and E-Commerce Management*. 2nd edn, Harlow: FT Prentice Hall. pp. 188-245.

Chen, S. (2003), "The real value of "e-business models"", *Business Horizons*, Nov./Dec., pp. 27 – 33.

Cheung, W.M. and Huang, W. (2002), "An investigation of commercial usage of the World Wide Web: a picture from Singapore", *International Journal of Information Management*, Vol. 22, pp. 377 – 388.

Cross, G.J. (2000), "How e-Business is Transforming Supply Chain Management", *Journal of Business Strategy*, March/April, pp. 36 – 39.

Couldwell, C. (1998), "A data day battle". *Computing* Vol. 21, pp. 64–66.

Damanpour, F. (2001), "E-business e-commerce evolution: perspective and Strategy", *Managerial Finance,* Vol. 27, Iss. 7, pp. 16–33.

de Wit, B. and Meyer, R. (1998), *Strategy, Process, Content and Contex",* 2nd edn, London: Thomson Learning. pp 30-31.

Dubelaar, C., Sohal, A. and Savic, V. (2005), "Benefits, impediments and critical success factors in B2C E-business Adoption", *Technovation*, Vol. 25, pp. 1251-1262.

Forrester Research, http://www.forrester.com/Products/Product/0,4681,121,FF.html. Accessed on December 2002.

Gromov, G.R. (2000), "History of Internet and WWW: The Roads and Crossroads of Internet History", http://www.internetvalley.com/intvalstat.html. Accessed on December 2001.

Kalakota, R. and Robinson, M. (2001), *e-Business 2.0: Road to Success, 2nd ed.* Harlow: Addison Wesley.

Kaplan, R.S. and Norton, D.P. (1992), "The Balanced Scorecard: Measures that drive performance", *Harvard Business Review* Jan-Feb, pp. 71-79.

Ko, A.S.O. and Lee. S.F. (2000) "Implementing the strategic formulation framework for the banking industry of Hong Kong", *Managerial Auditing Journal* 15, 9, pp. 469-477.

KPMG Consulting (2000), "Companies still hanging back over e-business", *Journal of Management Accounting*, Vol. 78, Iss. 3, pg. 7.

Lal, K. (2005), "Determinants of the adoption of e-business technologies", *Telematics and Informatics,* Vol. 22, pp. 181-199.

Lang, N. S., Michael, D. C. and Sutherland G. (2001), "Digital Dragons - How Asia-Pacific's Large Companies Can Generate Real Value from Consumer E-Business", *Boston Cousulting Group Publications*, http://www.bcg.com/publications/files/Digital_Dragon_7_01_summary.pdf, Accessed on June 2002.

Lee, S.F. and Ko, A.S.O. (2000) "Building balanced scorecard with SWOT analysis, and implementing "Sun Tzu's The Art of Business Management Strategies" on QFD methodology", *Managerial Auditing Journal* 15, 1/2, pp. 68-76.

Lee, S.F., Lo, K.K., Leung, R.F. and Ko, A.S.O. (2000) "Strategy formulation framework for vocational education: integrating SWOT analysis, balanced scorecard, QFD methodology and MBNQA education criteria", *Managerial Auditing Journal* 15, 8, pp. 407-423.

Lord, C. (2000), "The Practicalities of Developing a Successful e-Business Strategy", *Journal of Business Strategy* Mar/Apr, pp. 40-43.

Mazur, G. (1992) "Voice of the Customer Table: A Tutorial", *The Fourth Symposium on Quality Function Deployment*, Michigan: Novi.

Olofson, C. (2000) "Marshall Industries", in Rayport, J.F. and Jaworski, B.J. (eds.), *Cases in e-Commerce: International Edition*, London: McGraw Hill.

Op. Cit. pp. 135.

Porter, M.E. (1985), *Competitive Advantage: Creating and Sustaining Superior Performance*, New York: Free Press.

Porter, M.E. (2001), "Strategy and the Internet", *Harvard Business Review* 79, 3, pp. 63-78.

Stevens, R., Brook, P., Jackson, K, and Arnold, S. (1998), *Systems Engineering: Coping with Complexity*. Europe: Prentice Hall, pp. 262-263.

Tan, B.L., Tang, N.K.H and Forrester, P.L. (2004) "Application of QFD for e-Business Planning", *Production Planning and Control* 15, 8, pp. 802-818.

U.S. Air Force (1981) *Integrated Computer Aided Manufacture (ICAM) Functional modelling Manual (IDEF0)*, Ohio Air Force Laboratory: Wright Patterson AFB, Report # AFWAL-TR-81-4023.

Wu, B. (1992) *Manufacturing Systems Design and Analysis*. London: Chapman and Hall.

The Influence of Culture on Enterprise Portal Design in a Global Environment

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ABSTRACT

Enterprise portals collect and synthesize information from various systems to deliver personalized and highly relevant information to suppliers, customers and employees. While enterprise portal design and portal applications have been widely discussed in the literature, the implications that arise when the scope of such portals is global have not yet been explored. Thus, this paper aims to highlight the implications and the opportunities of enterprise portals for international, transnational and multinational businesses, paying special attention to the influence of culture on portal design. More specifically, we argue that culture has a significant influence on a number of important portal design considerations—including color, icons, symbols, language use and portal layout.

INTRODUCTION

Sifting through voluminous amounts of Internet and intranet information to find relevant material is a daily nuisance for people all over the world. General search engines provide quick results, but one is very dependant on finding just the right combination of keywords, and, even for the best search engine the coverage of its search index is no more than 16% of all the material available on the Internet (Lawrence & Giles 1999). A number of strategies have been employed to reduce this nuisance, including the use of categories, filter sites and the grouping of results according to content—e.g. sports, tourism, finances, news, culture, etc. Functionality has also been expanded to include membership in virtual communities, real time chats, personalized search engine interfaces like My Yahoo and My Excite, and access to specialized commercial content. This aggregation and bundling of information, distributed to various users by a single access point - be it through intranets, extranets, or the Internet – is commonly referred to as a portal (Tatnall 2004). Our definition of a portal is: an integrated and personalized web-based application that provides the end user with a single point of access to a wide variety of aggregated content anytime and anywhere using any web-enabled client device.

The evolution of portal applications has attracted the attention of the business world, because the same underlying technology can also be adopted to manage, structure, and facilitate access to enterprise information as well. Most contemporary organizations use portals to identify, capture, store, retrieve or distribute great amounts of information from multiple internal and external information sources. Portals are used to deliver information and applications to their employees (Counsell, 2004; Daniel & Ward, 2003); to provide staff with job- or task-related information and knowledge (Detlor, 2004; Terra & Gordon, 2003); and as a way to enable collaboration and interaction with external business partners (Detlor, 2000; Dias, 2001). Portals not only deliver information, but improve the usefulness of the information itself by tailoring it according to the role, location or interest of the individual user (Ben-Arieh & Pollatscheck, 2002).

With the continuing rapid development of internet technology, portals have emerged as one of the most promising opportunities in the management of enterprise information—including information dissemination, information access, information sharing, and information exchange (Collins, 2002; Terra and Gordon, 2003; Detlor, 2004). Numerous 'enterprise portals' have been developed, including employee portals, e-market portals, enterprise collaboration portals, enterprise knowledge portals, and others. Research on enterprise portals is also abundant, but most studies have concentrated either on enterprise portal design (Detlor, 2000; Bock, 2001; Ben-Arieh & Pollatscheck, 2002), enterprise portal applications (Dias, 2001; Collins, 2002; Terra and Gordon, 2003; Daniel and Ward, 2003, Detlor, 2004) or on content management and the customization or personalization according to portal-users' roles and information requirements. Whereas portals provide great opportunities to business, *global* portals provide even larger opportunities due to the larger scale, but also the larger diversity of the information represented. Thus, an important yet under-represented area in research to date is culture, and specifically the influence of culture on enterprise portal design. The purpose of this paper is therefore to fill this research gap and highlight the implications and the opportunities of enterprise portals for international, transnational and multinational businesses, paying special attention to the influence of culture on portal design in a global environment. We will show how culture influences several factors of the design, implementation and usage of portals in a global context. This study should be of benefit to managers, educators, and students involved in international business intelligence, information systems management, information resource management, and knowledge management. The structure of the paper is as follows: First, we draw attention to the opportunities enterprise portals provide for improving the daily information flows within an enterprise. Then, we discuss the influence of culture on global enterprise portal design by means of five elementary points. The final section then summarizes our key findings and highlights important implications for management and research.

BUSINESS OPPORTUNITIES FOR ENTERPRISE PORTALS

By serving the needs of large and diverse number of users, enterprise portals can be extremely helpful in the alignment of business and IT. This is not an easy task as the portal must integrate information from a large number of different functions, including purchasing, R&D, manufacturing and production, finance, sales and marketing, etc. The enterprise portal delineates and explicates the internal collaborations and interoperability requirements among these various functions and collaborating groups. Since an enterprise portal offers a single point of access and a single point of information interchange (Hazra, 2002), an enterprise portal could integrate business events across existing information systems and departmental boundaries thus facilitating the internal collaborations and promoting interoperability among the different departments within the enterprise.

Furthermore, the enterprise portal can help employee to be highly productive and competitive. Those capabilities of an enterprise portal give employees a resourceful and aspiring role in the organization because they could personalize information for business decision making. Meanwhile, the personalized information allows employees to find high quality information without having to spend copious amounts of time browsing. It also reduces massive quantities of information into the customized set. The effective information acquisition and utilization make employees more productive in doing their job and thus businesses more competitive.

In addition, the enterprise portal introduces business information management for enterprises with an extension to reach the customers, suppliers, and business partners in their network. In this way, the enterprise portal can support supply chain management and customer relationship management for both businesses and customers. In practice, business relationships evolve in multiple directions

in which buyers, sellers, and brokers of goods and services come together to exchange information, obtain specific knowledge, and conduct transactions. An enterprise portal could extend to potential customers worldwide as well as in the search for optimized suppliers by comparing supplier offerings and prices instantly in a real-time manner. Additionally, the collaboration relationship with suitable business partners is possible, such as collaboratively designing products, matching and responding to customer demands by the entire value chain players, etc. Accordingly, an enterprise portal can provide enterprises with a genuine capacity to enable real-time, interactive exchange of business transaction information and integration of business processes in a network; e.g. of trading partners, buyers, sellers, brokers or intermediaries, and e-business service providers.

The enterprise portal and its various applications shown above strongly suggest that an enterprise portal can contribute to both internal and external integration of enterprise businesses. The internal integration includes the back-end processes required for complete fulfillment of customer requests, which may involve the major customer-client interactions (such as registration, marketing, payment, and so on) and management of customer transactions (such as accommodating requests from the website for products and services, or integration of the vast amounts of customer information). The external integration combines services from multiple providers (such as partners of a supply chain) to support extended transaction management, information exchange, coordination, and collaboration along the entire business value chain. In addition, personalization can help in providing more relevant information, as opposed to more information.

CULTURAL INFLUENCES ON THE DESIGN OF ENTERPRISE PORTALS

From a technical point of view, extending an enterprise to global scale presents challenges, but none that cannot be overcome. But what of the users? Global scale also brings different languages, different life styles and different cultures, all of which affect the perceptions and expectations of users (Ruta, 2005). Two users may have completely different interpretations of a single message displayed on a portal. What are the portal design factors that are influenced by culture, and what are the possible differing perceptions, expectations and interpretations of international portal-users? We highlight five design factors that need to be considered. Next to language differences, important roles are also played by color, icons, symbols, and layout (e.g. Choong & Salvendy 1998; Del Galdo, 1990; Fang & Rau, 2003; Ossner, 1990; Rau, Choong & Salvendy, 2004; Spencer, 1988; Tractinsky 2000).

Language-differences between countries are one of the more obvious hurdles that global portals must overcome. The differences require more than just translation of text, but call for consideration of the meaning and implications attached to words and phrases and how those meanings and implications vary across borders (see for instance the UNESCO B@bel initiative). There are technical considerations as well, such as the difference between single- and double-byte characters for Western and Chinese text, respectively. But in addition to the more obvious language differences, we like to draw attention to numerous other, often overlooked yet important factors that also differ by country and must be considered when designing portals that are global in scope. The factors include color, the use of icons, symbols and portal layout. We consider each of these in turn.

Color is a useful and important consideration, as it both catch and hold the user's attention. It can also help to sustain, reinforce and enhance a positive experience during searching or browsing. However, in a global context, colors connote very different meanings. For instance, colors that are sacred differ between Judeo-Christian West (red blue, white, gold), Buddhist (saffron yellow) and Islamic (green) traditions. Subdued Finnish designs for background screen patterns might, or might not be suitable in Mediterranean climates (Marcus, 2003). Based on Russo and Boor **(1993) s**ome significations of colors related to several countries are adopted, and presented below in table 1.

As shown in table 1, a single color will have very different meanings from country to country; while similar meanings may be represented with completely different colors. For example, red means happiness, prosperity, and success in China, and is the most preferred color for celebrations, such as weddings. It is also often used to decorate festivals sites, important events, or to welcome very important persons. Nevertheless, red color represents danger for Anglo-American, anger for Japanese, and death for Arabs. A similar example is white color, which represent purity for Anglo-American and is commonly used for weddings, but represents death for Chinese and is normally used during funerals. Thus, in a global environment, differences in color go deeper than just appearance, and the selection of colors can be a difficult and sensitive decision for designers of global portals.

Table 1. Colors related to some countries--adapted based on Russo and Boor (1993)

Color / Country	Red	Green	Yellow	White
Anglo-American	Danger	Success; Safety	Coward	Purity
French	Aristocrat	Crime	Lucky; Temporary	Neutral
Chinese	Happy; Success	Life; Hope	Wealthy; Powerful	Death
Japanese	Anger; Danger	Young; Energetic	Grace; Nobility	Death
Arab	Death	Fertile; Strong	Happy; Wealthy	Joy
Indian	Life	Wealth; Fertile	Success	Death

Similar to color, the meaning of *icons* also varies from one country to the next. Icons that represent everyday objects or functions in one country may be perceived as obstacles by users in another country. Nielsen (1999) suggested that, in general, hands or feet as icons should be avoided. Additionally, animal icons may have subtly different meanings by country. For instance, an owl represents wisdom in many western countries but implies something evil in some eastern countries. To most westerners, the dragon is a fearsome mythical animal, but to the Chinese, the dragon has a more positive and mythological connotation. Chinese people considered the dragon as a representative of wisdom and a source of blessings. Another example is that a dog can be a lovely image in some countries, but it is seen as the lowest form of life in some other countries. Some icons may convey meanings that are not only different, but contradictory. Sabre's Planet Sabre, one of the world's largest extranets, whose UI+IV was designed by the authors' firm, uses multiple variations of icons for an e-mail 'mailbox,' to account for national differences (Marcus, Armitage, Frank & Guttman, 1999).

Symbols are also commonly used for international communication, but similarly to colors and icons, the meanings of symbols are country and culturally specific. One example to consider is whether selecting symbols such as the "X" or check marks convey the correct distinctions as to 'selected' or 'de-selected. Looking again to China, an "X" is most commonly used to cross out what is not desired rather than indicating what is to be selected, which is precisely the opposite in many western countries.

Regarding the *layout of portals,* reading direction across the world can be generally divided into three types, the most popular being left-to-right, and row-by-row, from top to bottom. However, in some regions people read from *right-to-left*, and row-by-row, from top to bottom. Moreover, a third way to read is from right-to-left and *column-by-column*, such as in traditional Chinese layout that is still very popular in Taiwan, Hong Kong and certain locations in mainland China. Obviously, left-to-right sequencing may be inappropriate or confusing for use with right-to-left reading scripts or with icon layout. Studies have shown how pictorial information should be presented and organized for scanning on a display according the direction the script flows naturally in the user's first language (Badre, 2000). The early version of a website called Arabia.On.Line, for example, intended to be a place where western readers could learn about Arab countries, mistakenly laid out its contents as though the text were written in Arabic, for Arabic readers. The result was an arrangement of icons that was misleading for the (Western) viewer's eye, and led them in directions inconsistent with that intended by the designers (Marcus, Armitage, Frank & Guttman, 1999). As a final, somewhat humorous example, consider a billboard where a woman on the left is shown unhappy, next to a pile of dirty laundry, while the woman on the right of the billboard is shown smiling, next to clean laundry and holding a certain brand of washing powder. Now imagine how the message might change for viewers who are accustomed to reading from right to left!

CONCLUSION

In this paper we have focused on the business opportunities for enterprise portals and subsequently the influence of culture on enterprise portal design. Enterprise portals can help in integrating internal as well external information flows. Internally, to be effective, enterprise portals require seamless information flows across the organization. When enterprises are bold enough to provide their employees such broad access, cross-linking between all sorts of departments becomes possible. Employees are enabled to consider issues and opportunities—and potentially adding value—well beyond their own functional domain. Similarly, external integration can lead to the development of value networks which extend beyond enterprise boundaries, linking together the information systems of supplies and customers, to minimize order-to-cash, production, and other key cycle times. Furthermore, personalization can enhance the productivity of employees as information is filtered for relevance and the effectiveness of search results—and the work that depends on them—is improved. Capturing these benefits for global enterprise portals, however, requires careful consideration of the influence of culture. Not only language, but also color, icons, symbols and layout—these are examples of portal design considerations that are relatively simple, but that have a strong impact on the successful deployment of an enterprise portal in a global environment (Fang & Rau, 2003).

Managers and portal designers need to consider that enterprise portals will only be successful when a portal can provide most of the services, information, and links that users want (Tatnall, 2004). Nonetheless, portal design has been limited to portals providing user-customizable access to information and applications through a browser (White, 2000). In other words, user-customization does not yet include personalizing the cultural factors, e.g. color, icon, symbol, language, and layout, when portal-users are granted access to portals. To meet the requirements of international portal-users, portal designers should be sensitive to such user-customization in a global context. Next to improving portal design, this knowledge can also be used to improve portal utilization. When enterprise portals are used much less in certain regions than in other regions, perhaps the designers should look for possible conflicts in the meaning of colors, icons, symbols, language and layout.

Finally, we propose that future research be directed at studying various cases of portal design and use and verify how the influence of culture affects portal design and use in a global environment. It would be particularly meaningful if the study results could indicate specifically which factors most influence portal utilization across national borders. The findings of case studies would greatly contribute to the international portal design and development. To satisfy a wider range of users in different locations globally, future research efforts are needed for portal products that can be further customized or personalized. Although portals currently allow users to customize the applications and information they need, the customization should go further in a global environment to include personalization of appearance as well. For example, investigation of "reusable libraries" in which various optional and pre-configured packages or palettes of colors, images, icons, symbols, languages, templates, etc. may prove useful. These optional components are reusable and can be seen as building blocks, which could better fit specific national and/or cultural requirements. Only after consideration of these cultural influences can enterprise portal design become truly global.

REFERENCES

Badre, A. (2000). The effects of cross cultural interface design orientation on World Wide Web user performance. GVU Technical Report, GIT-GVU-01.03, 1-30.

Ben-Arieh, D. & Pollatscheck, M.A. (2002). Analysis of Information Flow in Hierarchical Organizations, *International Journal of Production Research*, 40(15), 3561-3573.

Bock, G.E. (2001). Enterprise portals promise to put an end to corporate intranet chaos. Enterprise Application Webtop, 440,132-133.

Collins, H. (2002). *Enterprise Knowledge Portals*, New York: Amacon.

Choong, Y.Y. & Salvendy, G. (1998). Designing of icons for use by Chinese in Mainland China, *Interacting with Computers*, 9, 417-430.

Counsell, A. (2004). Opening the Door to Collaboration. *Financial Times IT Review*, March 31st.

Daniel, E.M. & Ward, J.M. (2003). Enterprise Portals: Improving Service Delivery in Local Government. Proceedings of the UK Academy for Information Systems Conference, Warwick, UK, April 9-11, 1-16.

Del Galdo, E. (1990). Internationalization and translation: some guidelines for the design of human-computer interfaces, in J. Nelsen (ed.), *Designing User Interfaces for International Use*, (New York: Elsevier), 1-10.

Detlor, B. (2000). The corporate portal as information infrastructure: towards a framework for portal design. *International Journal of Information Management*, 20(2), 91-101.

Detlor, B. (2004), *Towards Knowledge Portals: From Human Issues to Intelligent Agents*, The Netherlands: Kluwer Academic Publishers.

Dias, C. (2001). Corporate Portals: A Literature Review of a New Concept in Information Management, *International Journal of Information Management*, 21(4), 269-287.

Fang, X. & Rau, P.L.P. (2003). Culture differences in design of portal sites, *Ergonomics*, 46(1-3), 242-254.

Hazra, T. (2002). Building enterprise portals: principles to practices. Proceedings of the 24th International Conference in Software Engineering, 623-633.

Lawrence, S. & Giles, C.L. (1999). Accessibility of information on the web (commentary), *Nature*, 400(6740), 107-109.

Marcus, A., Armitage, J., Frank, V. & Guttman, E. (1999), Globalization of User-Interface Design for the Web, Proceedings of 5th Conference on Human Factors and the Web, June 3 1999, Retrieved January 4, 2006 from http://zing.ncsl.nist.gov/hfweb/proceedings/marcus/index.html

Marcus, A. (2003). Cross-cultural user interface design for work, home, play, and on the way. 10th International Conference on Human - Computer Interaction, Crete, Greece, June 22-27, 2003. Retrieved December 15 2005 from http://www.hcii2003.gr/program/tutorials/t10.asp

Nielsen, J. (1999). *Designing Web Usability*, New Riders Publishing, Dec. 1999.

Ossner, J. (1990). Transnational symbols: the rule of pictograms and models in the learning process. In J. Nielsen (ed.), *Designing User Interfaces for International Use*, (New York: Elsevier), 11-38.

Rau, P.L.P., Choong Y.Y. & Salvendy, G. (2004). A cross cultural study on knowledge representation and structure in human computer interfaces, *International Journal of Industrial Ergonomics*, 34, 117-129.

Russo P. & Boor, S. (1993). How fluent is your interface? Designing for international users. INTERCHI'93 Conference Proceedings, ACM, 342-347,

Spencer, R.H. (1988). Translatability: understandability and usability by others, *Computers in Human Behavior*, 4, 347-354.

Tatnall, A. (2004). Portals, Portals Everywhere. In Arther Tatnall (Ed.), *Web Portals: The New gateway to Internet Information and Service*. Idea Group Publishing.

Terra, C. & Gordon, C. (2003). *Realizing the Promise of Corporate Portals*, New-York: Butterworth-Heinemann.

Tractinsky, N. (2000). A theoretical framework and empirical examination of the effects of foreign and translated interface language, *Behaviour & Information Technology*, 19(1), 1-13.

White, M. (2000). Enterprise Information Portals. *The Electronic Library*, 18(5), MCB University Press.

Challenges in Developing a Data Warehouse to Manage the Rollout of Antiretroviral Therapy in a Developing Country

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ABSTRACT

With a global HIV/AIDS epidemic, developing countries are facing an enormous challenge in combating the disease. Public health will be placed under severe pressure in providing treatment such as highly active antiretroviral therapy to all its HIV infected patients. This paper will describe the challenges involved in establishing a data warehouse to provide strategic information during the rollout of antiretroviral therapy (ART). The construction of a Human Resources Data Mart, which is critical to the successful rollout of antiretroviral therapy in South Africa, will be discussed in detail. Special attention will be given to extraction, transformation and loading, slowly changing dimensions type 2 and materialized views.

Keywords: Data Warehousing, Healthcare, Human Resource Data Mart, Antiretroviral Treatment, Developing Countries.

1. INTRODUCTION

The HIV/AIDS epidemic is a global crisis which threatens development gains, economies and societies. At the end of 2004, the total number of people worldwide living with HIV/AIDS was estimated to be just under 40 million. In South Africa the estimated number of AIDS related deaths in 2003 ranged anywhere between 270 000 and 520 000 according to the UNAIDS Global Report (UNAIDS, 2004).

In response to this epidemic, the South African Government created the HIV/AIDS and STD Strategic Plan. This plan includes the provision of antiretroviral therapy in the public health sector in an attempt to reduce AIDS mortalities. Antiretroviral treatment (ART) for HIV infection consists of drugs that slow down the reproduction of the HIV virus in the body.

The Free State Department of Health (FSDOH) launched its provincial antiretroviral treatment program during May 2004. By the end of June 2006 a total of 31 public health facilities were empowered to provide antiretroviral drugs for 6200 patients in the Free State. The Actuarial Society of South Africa (ASSA) has developed an AIDS Demographic Model that can be used to project the impact of this disease on each province in South Africa. According to Chapman (2003) using the ASSA 2000 Model, it is estimated that in the Free State

- Approximately 480 000 people are HIV positive (based on 30.1% HIV positive mothers in the 2003 HIV Antenatal Survey);
- Seven percent (7%) of all HIV infected patients are in a World Health Organization (WHO) Stage 4 AIDS defining illness, which is approximately 31 111 patients;
- Annually, 28 290 patients will develop a WHO Stage 4 AIDS defining illness.

The WHO recommends that all people in a WHO stage 4 AIDS defining illness should commence with antiretroviral treatment immediately. This recommendation will pose serious challenges in managing the resources required for treating all these patients by the FSDOH. Mechanisms have to be developed to effectively monitor the antiretroviral treatment programme but at the same time provide the necessary **strategic information** in managing and evaluating the programme as well. It is clear that a number of factors are forcing the FSDOH in the direction of a data warehouse (DW).

This paper will indicate how a Health Department in South Africa, the FSDOH, tackled and successfully managed the challenges of creating a data warehouse. A background section will provide the history of the current operational system and the shortcomings of the system. That will be followed by a detailed discussion of the challenges involved in constructing the human resource data mart (HRDM) which is critical to the successful rollout of ART in South Africa. The Extraction, Transformation and Loading (ETL) process will be examined and slowly changing dimensions will be addressed. The paper then concludes with a discussion of a modified staging area that uses a materialized views approach to provide the platform for developing the human resource (HR) online analytical processing (OLAP) cube.

2. BACKGROUND

2.1 General

A data warehouse differs significantly from a conventional operational or transactional database in several aspects. First of all, a complex data structure must be maintained in order to offer flexible and dynamic retrieval of rich decision-support knowledge (Shin, 2003). For this, it maintains data that is more integrated, subject-oriented, non-volatile and time-variant in comparison with transactional or operational databases (Dodge & Gorman, 2000; Hristovski *et. al.,* 2000; Shin, 2003). Data structures of a data warehouse should also be more cross-functional (Shin, 2003) and support management decisions (Hristovski *et. al.,* 2000).

According to Saraceni *et. al.,* (2005), the linkage of several databases can assist with studying the distribution of diseases and for analysis of AIDS-related mortalities in Brazil. Although the linkage of databases is in essence not a data warehouse, it demonstrates the importance of analyzing information and using it to provide strategic information for the decision-making process.

Data warehouses have previously been used in the areas of health and public health (Davis *et. al.*, 2002; Lau & Catchpole, 2001; Prather *et. al.,* 1997). However, most data warehouses in the health areas are used for ***clinical treatment outcome*** or for ***biomedical studies*** and limited research has been done on the usage of data warehouses in public health for holistic decision-making.

2.2 Lack of Strategic Information

The Personnel and Salary (PERSAL) system is an online transaction processing (OLTP) based payroll system and is used by all the National and Provincial governments in South Africa. The system has been in a production environment since 1990 and was developed in Natural Adabas. At present, the system is being maintained by a private company.

Because the system is OLTP based, it proved inadequate in providing the necessary human resource statistics needed by antiretroviral programme managers.

Furthermore, every new change or new report must be submitted to a central *System Change Control* system. From there it will be prioritised and once accepted, handed over to the private company for development.

This process was cumbersome, inflexible and time consuming which led to overall frustration. In 2004, the FSDOH received approval from National Treasury to extract all relevant human resource data from PERSAL, thus allowing them the freedom of incorporating the data into a data warehouse.

3. CHALLENGES

The following sections will provide details on the challenges that were faced during the development of a data warehouse.

3.1 Limited Budget

According to Schubart & Einbinder (2000), research has showed that the key factors for successful data warehouse implementation are organizational in nature. Management support and adequate resources are most important because these address political resistance. Gatziu & Vavouras (1999) stated that data warehouse development is a demanding and costly activity of which the establishment thereof could be in excess of $1m. This can be a major obstacle in a developing country.

Taking these factors into consideration, top management was approached to direct the development of the data warehouse in early 2005. Because of a limited IT budget (0.68%), a decision was taken to break the project down into several data marts and to develop the data warehouse over a longer period of time. To cut back on costs, in-house existing staff was used to construct the data warehouse in lieu of making use of expensive outside consultancy firms.

Oracle is the current worldwide leader in the data warehouse tools marketplace (Vesset, 2006). Furthermore, Oracle 10.2g also offers all the functionalities required in both OLTP and DW based databases. Both these reasons guided the FSDOH decision to upgrade their existing Oracle9i infrastructure to Oracle 10.2g and make use of it for the data warehouse. The upgrade process was covered in an existing maintenance contract, resulting in no additional expenditure.

Human resources and pharmaceutical (ART drugs) costs were identified as the main cost drivers, and more strategic information was required in order to obtain sufficient funding for the ART programme.

Listed below are the identified data marts:

- human resources
- clinical patient ART treatment
- pharmaceuticals (ART drugs)
- patient mortalities
- tuberculosis

The Human Resource Data Mart (HRDM) was chosen as the first data mart to be constructed and will be the focus of the rest of this paper.

3.2 Extraction, Transformation and Loading Challenges

3.2.1 Data Extraction

The data in the OLTP system (PERSAL) is *transient data* of nature. According to Bruckner & Tjoa (2002), the key characteristic of *transient data* is that alterations and deletions of existing records physically destroy the previous data content. In order to keep the history of the data in tact, all modifications to the data had to be considered.

The ETL processes commenced with a data extraction process which are performed **twice** a month by Treasury. At the beginning of every month, the FSDOH will receive two sets of data. The reason for this approach is entrenched in the manner in which government officials receive their salaries in South Africa. The salary of permanent staff is paid on the 15th of each month. All the information related to this event constitutes data set one. However, additional or supplementary payments (i.e. S&T claims, overtime, fuel allowance) and workforce operations (promotions, staff re-allocations) can be made to government officials from the 16th until the end of the month. All these additional information constitutes data set two.

In essence, the first extraction consists of a full *data snapshot* taken on the 15th of the month from the *transient data set*. This includes **staff, posts** and the **hierarchical organization structure**. According to Bruckner & Tjoa (2002), a *data snapshot* is a stable view of data as it exists at some point in time. It is a special kind of periodic data. Snapshots usually represent the data at some time in the past, and a series of snapshots can provide a view of the history of an organization.

The second extraction consists of the supplementary changes to the *data snapshot* picture of the first extraction set in terms of **staff** and **posts** but **exclude** any changes to the hierarchical organization structure. This extraction process was preformed at the end of the month. It can be regarded as *semi-periodic data*. According to Bruckner & Tjoa (2002), almost all operational systems retain only a small history of data changes due to performance and/or storage constraints.

The challenge pertaining to more than one set of extraction data in the update window is the issue of *late-arriving data.* According to Bruckner & Tjoa (2002), *late-arriving data* is bothersome because it is difficult to integrate with existing fact and dimension tables, especially when surrogate keys are used in order to cope with slowly changing dimensions. Aggregates have to be updated, because the newly integrated data sets will change counts and totals of the prior history. Late-arriving data can therefore possibly change analysis results unexpectedly from the analyst's perspective.

In order to deal with the problem of late-arriving data, it was agreed that the data warehouse will be updated during the **first week** of the following month, reflecting the *transient data picture* and supplementary changes (*semi-periodic data)* that was made to it.

3.2.2 Time Stamping

The standard approach for storing periodic data (typically found in Data warehouses) is to use time stamped status fields for each record. For the HRDM the *load timestamp* method was used.

Slow changing dimensions (SCD) Type 2 will be used as far as possible. According to Berndt & Fisher (2001), this type of change adds rows to maintain an arbitrarily long history. The keys must be "generalized" in this approach by using a version number or some other mechanism, so that related rows can be retrieved as a coherent history.

Each table in the staging area had a column added called EXTRACT_DATE which translated to the record *load timestamp.*

3.2.3 Dealing with Slowly Changing Dimensions

One of the biggest challenges with the HRDM was the monthly changes to the organizational structure. Changes occur when new components (organizational units) are created, moved or become obsolete during the month. Components contain the posts for that particular unit and the links of the child components directly reporting to it.

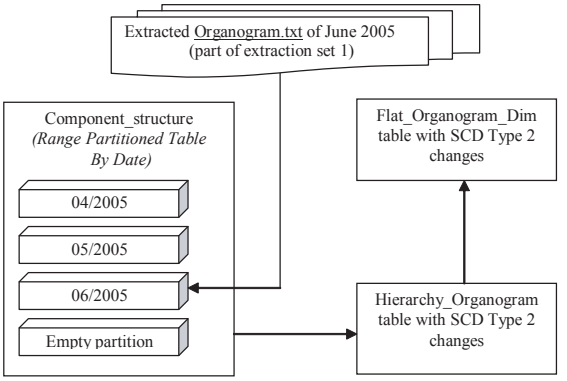
Changes in the organizational structure were not directly reflected in each month's download and had to be identified with specially developed algorithms in order to perform SCD Type 2. This was because the organizational structure was only included in extraction set 1 as a *data snapshot picture* called **Organogram.txt** and not a list of changes. See Figure 1 for the organizational structure data flow of June 2005 as an example.

The data for the organizational structure was imported into the COMPONENT_STRUCTURE partitioned table from the Organogram.txt file. This partitioned table then contained the organizational hierarchy for each month. The organizational hierarchy in turn, consisted of component details and linkages between child and parent components.

A table called HIERARCHY_ORGANOGRAM was constructed and populated with the hierarchy on the date the HRDM project commenced (April 2005). For each following month, COMPONENT_STRUCTURE was algorithmically compared to HIERARCHY_ORGANOGRAM using complex SQL statements and SET operators to help identify the following changes:

- New Component
- Component name change
- Parent component position change
- Parent component name change
- Deleted Component

Figure 1. Data flow for extracted organogram.txt (June 2005)



Each time a change was detected, a new record was inserted into HIERARCHY_ORGANOGRAM, with a new surrogate key. The superseding record was changed to the last date of the previous month. A surrogate key called ORGANOGRAM_KEY was created with the extract date (or *load timestamp*) concatenated with the component number to stay within the bounds of SCD Type 2.

Kimball & Margy (2002) pointed out that hierarchical structures of variable depth presents several problems in the relational environment. Some examples are the difficulty of navigation or rolling up of facts within these hierarchies using non-procedural SQL. This posed a problem for the FSDOH when using Oracle 'CONNECT BY' SQL extension in the same statement as a join. While 'CONNECT BY' is very useful when navigating recursive points in a dimension table, it can not be used by an ad hoc query tool. If the tool could generate this syntax to explore the recursive relationship, it cannot in the same statement be joined to a fact table. Even if Oracle was to remove this somewhat arbitrary limitation, the performance at query time would probably be not too good (Corr, 2001).

To overcome this problem, a bridge table or often called helper tables are inserted between the hierarchical dimension table and the fact table (Kimball & Margy, 2002). The problem the FSDOH experienced with this approach was entrenched in the manner the multidimensional online analytical processing (MOLAP) tool used the dimensional model for its analytical model. The MOLAP tool required a flat organizational view which in theory meant a totally denormalized view of the hierarchical organizational structure and relationships in HIERARCHY_ORGANOGRAM.

Kimball & Margy (2002) also pointed out that when navigating the bridge table via the standard SQL code, it is not for the faint of heart. In order to overcome the prerequisite of the MOLAP tool together with minimizing the SQL complexity for the FSDOH users, a ***modified version*** of a bridge table was introduced. The table FLAT_ORGANOGRAM_DIM was created and used as one of the dimensions in the dimensional model (See Figure 2).

This ***modified version*** of a bridge table might not be the perfect solution should the organizational structure consist of more than 10 levels. To overcome this, the table is re-created every month from all the SCD Type 2 changes captured within HIERARCHY_ORGANOGRAM. In this manner the algorithm will allow an extra level (meaning an extra table column) when it detects it, thus avoiding the possibility of missing data. However, the only manual action to be taken is to insert this additional level (table column) within the MOLAP tool.

3.2.4 Example of a SCD Type 2 on a Parent Component

The following example (See Figure 3) will illustrate a SCD Type 2 on a parent Organizational Unit (Component) between April 2005 and June 2005 and the domino effect it will have on its child components.

- Step 1: Algorithm detects a change in *parent name* in component 011200
- Step 2: Perform SCD Type 2 and load changes into HIERARCHY_ORGANOGRAM

HIERARCHY_ORGANOGRAM

Organogram Key	Extract date	Component Name	Parent Component	Date From	Date To
01-APR-2005-011200	01-APR-2005	Hospital A	011000	01/04/2005	30/06/2006
01-JUL-2006-011200	01-JUL-2006	Pelonomi Hospital	011000	01/06/2006	

- Step 3: Force the change in all child components of component 011200. Only ***Component 011333*** will be illustrated below.

HIERARCHY_ORGANOGRAM

Organogram Key	Extract date	Component Name	Parent Component	Date From	Date To
01-APR-2005-011333	01-APR-2005	AIDS (Unit)	011200	01/04/2005	30/06/2006
01-JUL-2006-011333	01-JUL-2006	AIDS (Unit)	011200	01/06/2006	

- Step 4: Convert the hierarchical organizational structure into a flat organizational structure

Figure 2. Dimensional model

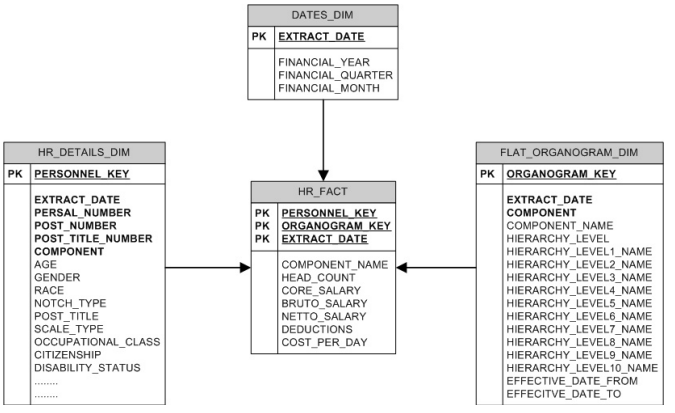
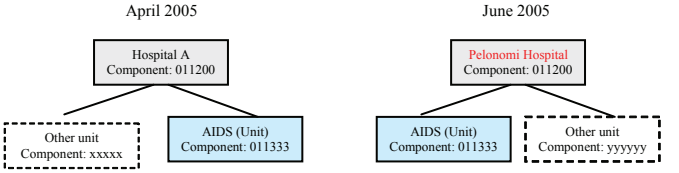


Figure 3. Parent component name change



FLAT_ORGANOGRAM_DIM							
Organo-gram Key	Extract date	Component Name	Effective Date From	Effective Date To	Level 1	…	Level x
01-APR-2005-011200	01-APR-2005	Hospital A	01/04/2005	30/06/2006	HEALTH		Region A
01-JUL-2006-011200	01-JUL-2006	Pelonomi Hospital	01/06/2006		HEALTH		Region A
01-APR-2005-011333	01-APR-2005	AIDS (Unit)	01/04/2005	30/06/2006	HEALTH	….	Hospital A
01-JUL-2006-011333	01-JUL-2006	AIDS (Unit)	01/06/2006		HEALTH	….	Pelonomi Hospital

3.2.5 Using Materialized Views and SCD Type 2

According to Becker (2004), one of the problems of the SCD Type 2 technique is the large number of additional rows required to support all the changes. Barbusinski *et. al.*, (2003) pointed out that joining the fact and associated dimensions would also require complex temporal joins at analysis time. Furthermore the SQL statement must include time reference for both the fact and associated dimensions. All these factors will lead to an undesired environment for non-sophisticated users such as in the case of the FSDOH.

One possible way of overcoming these obstacles, is by using a materialized view (mview) to hide the complexity. A materialized view also physically stores the data that corresponds to the view's defined query (Dodge & Gorman, 2000). According to Goldstein & Larson (2001) query processing time can be improved through the use of materialized views.

For these reasons it was decided to make use of Oracle's materialized views. HR_DETAILS_DIM (mview) was created by joining all the posts with the matching staff member details. A staff member could also belong to more than one post. In order to uniquely identify a staff member with a particular post, a surrogate key called PERSONNEL_KEY was constructed for this purpose.

The PERSONNEL_KEY was constructed using a concatenated combination of the following fields from the posts and staff tables:

- EXTRACT_DATE (staff details)
- PERSAL_NUMBER (staff details)
- POST_NUMBER (post details)
- POST_TITLE (post details)
- COMPONENT (post details)

Thereafter, HR_FACT (mview) was created by joining FLAT_ORGANOGRAM_DIM (table) and HR_DETAILS_DIM (mview) to ensure consistency with all the SCD Type 2 changes in FLAT_ORGANOGRAM_DIM.

3.2.6 Building OLAP Cubes

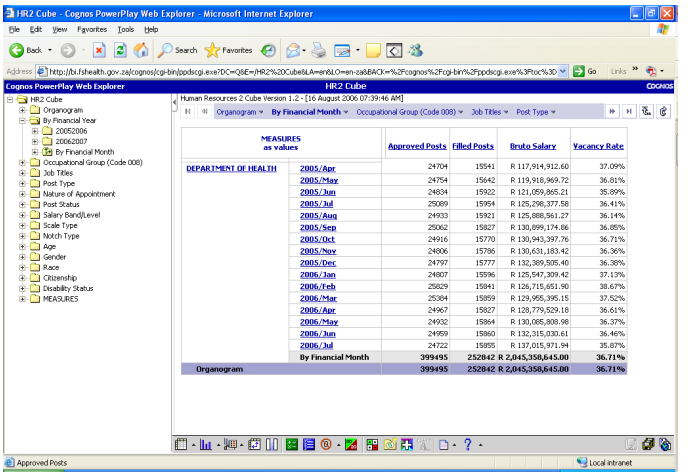
The HRDM OLAP cube was constructed from the dimensional model (See Figure 4). This was all done using Cognos Framework Manager and Cognos Transformer Series 7.

Research done by Gorla (2003) to evaluate OLAP tools in ease of use and usefulness, suggested that MOLAP be used for non-sophisticated computer users and relational online analytical processing (ROLAP) for sophisticated users.

Since most of the users at FSDOH can be categorized as non-sophisticated computer users, the **MOLAP** architecture was the choice of platform. The cube was deployed using Cognos Enterprise Server Series 7 which delivers **Web-based OLAP (WOLAP)** content, but using an underlying architecture that is still MOLAP. According to De Beer (2006), WOLAP is also seen as the next generation BI tool providing "thin-client" viewing tools for analyzing information.

The users were able to generate pivot tables (See Figure 4) from the WOLAP cube to assist them in obtaining strategic human resource information.

Figure 4. Pivot table from human resource data mart



4. CONCLUSION

Efficient resource management is critical for the success of the rollout of antiretroviral therapy in South Africa. Human resources management and ART drugs management was identified as the key factors but also the main cost drivers. A HRDM was built to provide strategic information for the ART programme. FSDOH management was now able to perform efficient staff allocations, monitor absenteeism and identify overworked personnel in time. Problematic ART clinics and hospitals in terms of staff turnaround could now also be easily identified by using trends, providing the FSDOH management team enough time to address the problem.

Future work and research could be done to link the HRDM to the ART clinical data set to identify health workers infected with HIV and AIDS. With this information, FSDOH management can obtain a better picture on the infection rate of HIV and AIDS on its health workers.

In conclusion, this paper demonstrated that it is possible to overcome the challenges of building a large-scale data warehouse, by starting small, using in-house knowledge and skills and to build data mart by data mart. The ETL process was modified to overcome the challenge of using SCD Type 2 within a hierarchical dimension. Materialized views were used to assist with the construction of the OLAP cube by camouflaging the complexities created by SCD Type 2. The end result was a MOLAP cube which provided an environment, conducive for analytical HR operations.

5. REFERENCES

1. Barbusinski L, Howard S, Jennings M, Kelley C, Oates J. (2003). The relationship between a fact and dimension table, DMReview.com http://www.dmreview.com/article_sub.cfm?articleId=6349
2. Becker B. (2004). Kimball Design Tip #53: Dimensions Embellishments. Retrieved September 3, 2006, from http://www.rkimball.com/html/designtipsPDF/KimballDT53Dimension.pdf
3. Berndt DJ, Fisher JW. (2001). Understanding Dimension Volatility in Data Warehouses (or Bin There Done That). *Sixth INFORMS Conference on Information Systems and Technology* (INFORMS/CIST-2001)
4. Bruckner RM, Tjoa AM. (2002). Capturing Delays and Valid Times in Data Warehouses – Towards Timely Consistent Analyses. *Journal of Intelligent Information* Systems, 19(2), p169-190. Kluwer Academic Publishers.
5. Chapman RD. (2003). Plan for Implementation of ARV's in the Free State Province. Unpublished.
6. Corr L (2001). Kimball Design Tip #17: Populating Hierarchy Helper Tables. Retrieved September 22, 2006, from http://www.kimballgroup.com/html/designtipsPDF/DesignTips2001/KimballDT17Populating.pdf
7. Davis X, Wan C, Ross L, Wen X & Thomas B. (2002). A data warehouse concept for HIV prevention program evaluation. *AIDS Education and Prevention: Official Publication Of The International Society For AIDS Education*, 14(3 Suppl A), p120-122
8. De Beer, E (2006). Mobilising BI with data quality. Computing SA, July 2006, p35

9. Dodge G, Gorman T. (2000). Essential Oracle8i Data Warehousing: Designing, Building and Managing Oracle Data Warehouses. Wiley. New York.
10. Department of Health (Free State) (2006). Corporate Strategic Plan 2006/2007 to 2014/2015
11. Gatziu S, Vavouras A. (1999). Data warehousing: Concepts and mechanisms. INFORMATIK Volume 1 of 1999
12. Goldstein J, Larson P. (2001). Optimizing Queries using Materialized Views: A Practical Scalable Solution, ACM SIGMOD, 2001
13. Gorla N. (2003). Features to consider in a data warehousing system. *Communications of the ACM,* 46(11), p111-115
14. Hristovski D, Rogac M, Markota M. (2000). Using Data Warehousing and OLAP in Public Health Care. *Journal – American Medical Informatics Association*, 7, p369-373.
15. Kimball R, Margy R. (2002). The Data Warehouse Toolkit. Wiley Computer Publishing. Second Edition.
16. Lau RKW, Catchpole M. (2001). Improving data collection and information retrieval for monitoring sexual health. *International Journal of STD and AIDS*, 12(1), p8-13
17. Prather JC, Lobach DF, Goodwin LK, Hales JW, Hage ML, Hammond WE. (1997). Medical data mining: Knowledge discovery in a clinical data warehouse. *Proceedings of the 1997 AMIA Annual Fall Symposium, Bethesda: American Medical Informatics Association,* p101-105
18. Saraceni V, Da Cruz MM, Lauria LM, Durovni B. (2005). Trends and Characteristics of AIDS Mortality in the Rio de Janeiro City after the Introduction of Highly Active Antiretroviral Therapy. The Brazilian Journal of Infectious Diseases 2005, p209-215
19. Schubart J, Einbinder J. (2000). Evaluation of a data warehouse in an academic health sciences center. *International Journal of Medical Informatics*, p319-333
20. Shin B. (2003). An Exploratory Investigation of System Success Factors in Data Warehousing. *Journal of the Association for Information Systems,* Volume 4, p141-170.
21. UNAIDS.ORG. (2004). Report on Global AIDS epidemic, July 2004. Retrieved February 2, 2006, from http://www.unaids.org/bangkok2004/report_pdf.html
22. Vesset, D (2006). Worldwide Data Warehousing Tools 2005 Vendor Shares, IDC #203229, Volume 1. Retrieved December 1, 2006, from http://www.oracle.com/corporate/analyst/reports/infrastructure/bi_dw/idc-dw-tools-2005-1.pdf

A Story on "Story Telling" in a Virtual Learn-Work Environment

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1. INTRODUCTION

The Open University of the Netherlands (OUNL) is an institution for higher distance education. At the School of Computer Science 70% of the students already have other degrees and are in paid employment. They want to acquire additional know-how or retrain for a different occupation. In order to meet today's learning needs of the bachelor students in Computer Science and the needs of ICT-industries for employees with up-to-date domain expertise together with academic team competencies, the OUNL has designed and implemented in the year 2001 the course 'Design Project' (400 hours of study). This course has an open learn-work environment 'OTO'[2], designed as a virtual company (VC). Students in this course (re)design a solution for a real-world company's problem in the domain of computer science. Since 2001 14 teams (about 95 students) have been active in OTO.

Knowledge construction in organizations is crucial for the continuous improvement of products and services. ICT-professionals (should) need to learn to focus on users and consumers, and to regard clients as co-developers of an ICT-product. This article (story) describes OTO, and how internal knowledge management is implemented to enable students to preserve their experiences in an informal and narrative way.

2. THE COURSE DESIGN PROJECT AND THE LEARN-WORK ENVIRONMENT OTO

What students know and understand is grounded in perceived experiences from their interaction in the worlds they live in (Jonassen, 1991 p. 10; Jonassen, 1994 p. 34-35). Their experiences are situated in the interaction world of their study and professional job. In all these worlds they have developed routines and habits.

A learn-work environment as OTO should give students the opportunity for doubting their obvious acting, questioning the behaviour of others and transforming their habits developed through participating in their interaction worlds. However changing 'routine acting' is always very difficult. Routine does not have much presence in a world of interaction and a lot of people, especially computer scientist whose focus is security and nonambiguity, see doubt as a feeling of insecurity. Creating doubt is considered as an unpleasant activity and not as a necessary prerequisite for change (Bitter & Crutzen, 2002; Crutzen, 2005). The culture of Computer Science differs from the culture of the worlds in which their products will be used. The invisibility of 'routine-acting' is precisely the problem of computer scientist designing ICT-representations for actors in other interaction worlds.

The course Design Project is built on notions of social constructivism and critical transformative interactions. It is an example of computer supported collaborative learning and is competence and experience based (Westera, Sloep & Gerrissen, 2000). These premises are expressed in the goals of OTO and in the responsibilities of the students. The business goal of the company OTO is to offer to other organisations a cooperative and participative redesign of the relation between the business processes and their information system. The internal business goal is competence development of each employee, of each team and of OTO itself by means of knowledge and human resource management and by evaluation of the internal business processes, strengthening the changing potential of OTO. Students succeed in this course if they show sufficient involvement, participation and responsibility in designing the learning and working process of themselves, of their team and of OTO. During the project students are temporary employees in OTO and work collaboratively in teams of 5 to 10 members. The workload for students is generally 15 hours a week during half a year. They are guided in respect to their organizational and social competencies. The OTO-staff members (a director, a human resource manager, a project manager and some coaches) are all members of the OUNL organization. They are responsible for making OTO ready, for the exploitation of OTO and the support of students. The director in cooperation with the project manager is responsible for the contacts with external clients and acquires project proposals from which the student teams can choose. External client organizations must make a commitment that they are willing to give participation time in the project. The team refines the chosen initial project proposal together with the representatives of the external organization to a project draft, a first product idea and later on to an external project planning script and a final contract. This contract symbolises the end of the A(cquisition)-phase (about 1,5 month) and the beginning of the P(roject)-phase (about 4,5 months) of the working process (Figure 1)

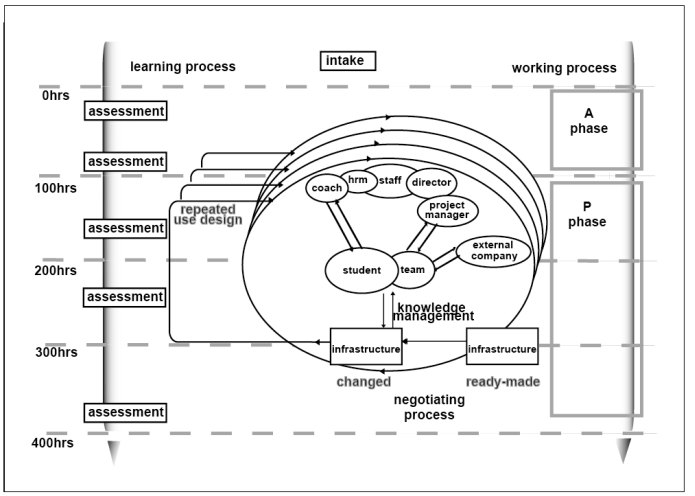
3. THE LEARNING AND WORKING-PROCESS IN THE VC OTO

The main processes in OTO, working and learning, cannot be completely planned in advance. Students are responsible for detailed design of the working process. OTO is not supposed to be a working environment in which learning results depend on learning occurring by chance. On the contrary OTO is purposefully designed to facilitate critical transformative learning. OTO offers the students a set of well-defined competencies they can develop. They are regarded as key objectives for learning on the job, and are essential for preparation for professional practice. The personal growth objectives for each OTO professional are laid down in a personal development contract initiated in the intake. The contract will be renewed constantly through peer-, coach- and self-assessments. Each assessment is followed by a coach-student consultation. The personal coach supports the learning process of each student employee.

Together with the external planning script each team composes at the end of the A-phase an internal planning script in which the tasks and the roles of each team member are mentioned. These tasks and roles are linked to the competencies they want to explore. It is the responsibility of the team to combine the working and learning process in the internal planning script. During the P-phase these planning scripts are continuously adjusted to the circumstances in the project interaction. A project manager from the OTO staff supports the working process in each team. A very useful instrument is the personal reflection document in the electronic student portfolio in which coach, project manager and student comment the ongoing activities in relation to the chosen tasks and competencies. This commenting enables the student to reflect on her/his performance and to relate activities in the working process to the chosen objectives of the learning process.

OTO provides in its infrastructure a variety of tools to support electronic communication, collaboration, planning, knowledge management, and tools for assessment, design and development. In the knowledge base are templates, skeleton contracts and a library with relevant articles on methods and theories. Regular face-to-face meetings on the initiative of the students appear to be indispensable for this kind of collaboration. In the electronic course material a global description of the working and learning processes and of the competencies is provided. The infrastructure is offered to students mainly as an open structure with only minimal prescriptive elements. The teams can decide autonomously which tools, methods and theories they want to use for making the product. Client's close involvement is the only constraint. Using this structure, students and teams can negotiate a tailored, personal growth. Due to its critical use by students, teams and staff, OTO is growing into a virtual environment of differences in acting.

Figure 1. The structure of the working and learning process in OTO



So the name 'Design Project' refers to several design-aspects associated with this course. Seen from the outside world, students are designing an ICT-product for an external client. Internally, OTO students are defied to design ('to construct') their own learning and working process on an individual level by critical reflection on their competencies, roles and tasks within this course and, as a spin-off, also in their daily work. Team members negotiate their individual goals and (re)design their learning processes at an early stage on a team level in order to come to the best expectancy on learning and working for the team as a whole. Only a high degree of participation of all team members can lead to mutual responsibility for the learning processes. The design process of the students stretches even further to an organizational level. Each team is responsible to attribute to the design of OTO in the form of a team-reflection on what is learned during the course. This leads to knowledge about used methods, practices and experiences and contributes to the learning organization OTO.

Apart from designing their learning process students design their working process according to the requirements and the hectic of the ICT-project at hand. This is a continuous team process, based on the individual competencies and participation. Here students design e.g. procedures for communication, for decision-making and for their division of labour. Designing participation of clients and future users is an important part of this working process.

4. THE IDEAL INTERNAL KNOWLEDGE MANAGEMENT (KM)

OTO develops solutions in dialogue with its customers and creates ict-products like analyses, design proposals, software, prototypes and working procedures. Quality of products and processes depends primary on making acquired insights and knowledge productive for the actual and future projects. OTO wants to perform as a learning organisation. The arrangements in and the structure of OTO should sustain knowledgebased working and learning as pleasant, successful and efficiently as possible. To turn this into reality, OTO needs a knowledge management process together with according roles. This was originally designed as follows. Each team has an internal knowledge manager. These managers are alert on relevant experiences, turn them into 'lessons learned' for future working and learning in OTO on all levels. They are responsible to store this knowledge within the electronic environment and make it accessible for the actual and future teams. It is their task to question periodically OTO-employees about their important experiences. They stimulate discussion and reflection concerning the good and bad practices, which pitfalls appeared and how these latter can be avoided.

Knowledge managers are also responsible for archiving the team documents and making an accessible team archive structure with relevant comments for future use. Although they are finally responsible for ensuring that relevant knowledge and experiences are in an accessible form for renewed consultation or reuse, they do not have to carry out all these activities themselves. All members of the team actively contribute to the permanent KM process.

To guarantee the KM process quality, it is a fixed item in the team leader's two-weekly report to the project manager. Also at the end of the project the internal knowledge manager must, together with the team, write an evaluation report whose emphasis must lie on the following three aspects: working in a virtual space, working with a virtual team, and working for a design task, containing also recommendations for the following teams; lessons learned how the working and learning culture should be changed. The evaluation text will be discussed in a closing meeting of staff and team. The knowledge manager is also responsible for clarifying the electronic working environment in a final state, reusable and accessible for future teams.

5. ENCOUNTERED PROBLEMS IN KM

However in spite of this ideal KM process an evaluation of OTO of the first five teams in OTO shows a serious problem to solve (Oord, 2004). Students experienced an overload of formal information produced by the staff and previous teams on relevant subjects for performing their tasks. This problem will become larger because the growing amount of information will go together with a decrease of accessibility Students need more condensed, accessible and reusable information about working in OTO as well as about specific subjects in their working process. The mere existence of electronic facilities and a well-defined structure for storing team documents was no guarantee that new knowledge is meaningful constructed, is accessible and reused by future teams. Formal KM is done by the students only within their own project horizon and is hardly accessible for future teams and focussed only on the production and not on the transfer and reuse of this knowledge. Successful KM in OTO should become a part of the students' habits. However it depends highly on the acceptance by all OTO members. Making KM ready therefore needs strong participation of all involved.

6. STORYTELLING AS A SOLUTION

The expectation of the OTO-staff was that a participatory design project with the students could guarantee meeting the goal of a KM that can create a "critical transformative room"(Crutzen, 2005). At the beginning of the study period 2004-2005 an iterative design and implementation process for renewing KM was started. The knowledge managers of a number of successive and parallel teams adopted the idea of the OTO-staff for storytelling as a form of KM for virtual work-environments with strongly changing teams.

6.1 Why Storytelling

According to Snowden the key of using storytelling as a disclosure technique is having groups of social cohesive communities who will have a sufficient body of common experience to enable a story base to emerge. The OTO teams are communities of practice and in a collective process of individual competence development. The teams share a common interest and task. They have together a time-bounded experience for good and ill. (Snowden, 2000) The aim of storytelling is telling current and future employees of OTO on experiences, tips, failures and successes in an informal, readable way that could be very close to their own experiences. This kind of information was not explicitly present in the course material but the informal character of stories could be a starting point and a pointer to parts of the formal information produced by OTO.

Storytelling can "engage, involve and inspire" staff and students, "using language that is more authentic and a narrative " and "provides the context in which knowledge arises as well as the knowledge itself, and hence can increase the likelihood of accurate and meaningful knowledge transfer." Stories can "communicate ideas holistically" in an "easy-to-understand form". The emotional component of stories can help students to articulate tacit knowledge and to tell implicit knowledge wrapped up in their own interpretation. Stories are open for reinterpretation and can be connected to the own interest. "Stories are memorable and (...) can provide a 'living, breathing' example of how to do something and why it works". The character of formal information has a more descriptive character. On the other hand stories are more concrete and can lead to direct action - they can help to close the 'knowing-doing gap'. Reading and producing stories is learning in an open transformative and amusing way. Slandering incorporates always the challenge to search for the truth, the lies and all interpretations in-between.[3]

6.2 The Process of Design and Implementation of Storytelling in OTO

At first the knowledge managers of the teams SideFlux and PreMath (2004-2005)[4], have designed a procedure for storytelling which was workable for their own OTO-teams on the basis of the existing situation at OTO. The target group for the design was the actual active employees and also the future employees. The fellow-team members of the knowledge managers have participated in the design process. The knowledge managers, responsible for the introduction of the process of storytelling in their own team, discussed the procedure and the way in which it should be carried out within that team. The result of these efforts was that each team member of SideFlux and PreMath wrote a number of stories, where upon the managers wrote the cover stories to indicate the interrelationships between the stories. These products are transferred to the managers of the teams KryptosLogos, Meta/Z and UseIt[5] (2005-2006). They have refined the procedure and made the functional specifications for an electronic environment that could support the story-telling procedure. On that basis they have searched for a suitable web-based open source application and choose Plone[6]. This choice was particularly based on the feature of redefining a workflow for the story-telling procedure. Also the possibility of commenting already placed stories was an important requirement. In their first prototype they have implemented the agreed workflow and they have shown that the system meets largely the requirements. At present at the start of two new teams the prototype is turned into a more final product, with available stories for these teams and the staff. They can read them, comment them and tell new stories. The commenting is important: future students can make their own interpretations visible and add useful pointers to the formal, general or specific team documents of OTO.

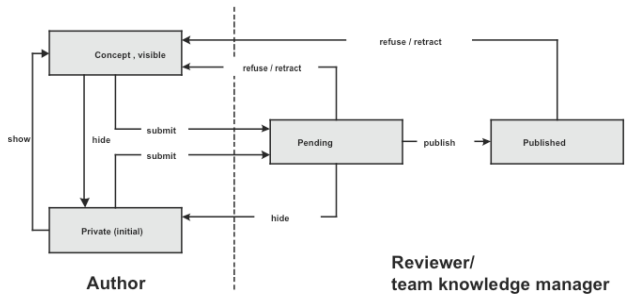
6.3 The Workflow of a Story

In this new system a story is initially created in a strictly personal folder with the state "Private (initial)" (Figure 2). Stories in this state are only accessible by the author: the author can change the content of the story and it's "properties" such as keywords, publication dates, and extended author-information. The author can also determine which other stories (content) are related.

The author can change the story to the state "Visible/concept". The story then is visible to all other users but might be filtered from search-folders, depending on the search-criteria. It stays visible after submitting the story to the reviewer, a role defined by the system but in OTO performed by the knowledge manager. Only if the author chooses for a submission out of the "Private (initial)" then the story is only visible for a reviewer. The contents of stories with status "Published" or "Pending" cannot be changed anymore by the author. In all states it is possible for the author to change the sharing property, important for co-authoring and reviewing. In all states the author can remove the story.

Upon entering the system, the reviewer's attention is drawn to the 'Revision list' where the entries to be reviewed are listed. 'Reviewing' here means changing the contents and the properties of the stories. These options are useful to make the stories 'fit' in the story-hierarchy, by classifying the story by adding or removing content, keywords or links to related content. The reviewer alone is responsible for these actions. Both the author and the reviewer can retract a story from the state "Published".

Figure 2. The state transition diagram of a story



6.4 The Structure of the "Unstructured" Story Base

The stories do not have a predefined structure, and are not restricted to certain subjects. A story is just a piece of free text, sometimes some illustrations are added, and contain meta-information about author, publication-date, state and keywords. Searching in these stories is supported by different techniques:

- Using keywords
  Using keywords is a means to classify stories along more dimensions, for example in time (periods), in working-categories, in activities and so on. This implies that every storyteller and reviewer must add the appropriate keywords to every story. In a two-dimensional classification in relative time and process at least two keywords must be added to every story (Table 1). There is an extended list of keywords, maintained by the reviewers to enable a precise tagging of the stories.
  Classification of stories by means of keywords is visible in the form of 'Related subjects'. While reading a story, a list is presented of other stories that use the same keywords. Jumping back and forth between related stories is easy as long as the used keywords are significant and the list of related stories is not too long.
- Full text searching
  Full text searching is based on all words in the stories. Extended search enables searching on text, title, keywords, publication date, author and status.
- Search folders
  A third technique is the use of search folders whose contents are dynamically determined by a set of criteria. These search folders can e.g. be used to filter stories from certain authors or teams, and/or on certain subjects. The content of these folders is refreshed every time it is accessed.

6.5 The Content of the Story Base

After the engagement of 5 teams the story base is filled with 92 stories. In Table 1 an overview of all the themes are given. In one story on "story telling" a student gave an overview on possible subjects:

- "Our project" (stories which concern your project)
- "Tutorials" (stories with tips and/or best practice concerning a certain subject)
- "Complain & critical department" (basic idea: I find it this way heavy/difficult/not nice/why I must this or that?)
- "Nonsense" (humour, ironic, stupid subjects)

He did also give the advice that stories should not be just the channel for one's frustrations but should be a positive support for future employees. A lot of stories have links to relevant formal knowledge. Mostly individual good and bad experiences in OTO are reported, accompanied with advices. Not all stories are just positive: a lot of critical remarks are made on the concept VC as a learn/work environment for distance education. The most popular themes are "competencies" and "assessment", because that is the part of the learning process that most students are not familiar with. For the working process a lot of stories are related to planning. Students are frustrated that many activities consume more time as planned, especially when the client interactions are not always going very smoothly.

One of the difficult issues for every team is building up a communication structure, students live in the Netherlands and in Belgium and their geographical distance could be up to 400 km. They have to create an effective combination of several means of meeting and contacting in a regular time schedule.

The story base reflects the communication problems. A lot of advices, technical and organisational are given. This kind of stories might prepare future students by helping them to build alternatives and flexibility in their internal and client contacts.

7. CONCLUSIONS

So far story telling was a successful internal project with engaged participation of students and staff. But it can only be called successful if a next generation of students use the story base and add their comments to the stories. The amount and content of the comments will indicate whether story telling is successful for transferring knowledge.

With the process of implementing storytelling and the storytelling process the prerequisites of a constructive learning environment are enhanced because knowledge and skills are best acquired in the context of a real life experience, preserving the

Table 1. The story themes and keywords

Process \ Relative Time	1st Period (0-100)	2nd Period (100-200)	3rd Period (200-300)	4th Period (300-400)
Working process	A-phase, general	P-phase, interim		P-phase end Project roundup
	Writing rough project outline			Product presentations
	Writing Internal project plan External project plan			Final product deliveries
		P-phase, general		
	Analyses, design, implementation, software developments, software development tools			
	Use of templates,			
	Planning, project management			
	The role team leader,			
Learning process	Determination of individual competencies	Development of individual competencies		Qualification
	Competence descriptions in general			
	Assessments, coaching, self-reflection			
Communication	Meetings, face-2-face, virtual, mobile groupware tools			
	Team communication			
Knowledge management	Knowledge management, general			
	The role knowledge manager			
	Management of the virtual workspace			
	Storytelling			
Life outside OTO	Relation between working in OTO and the regular job			
	The combination of working in OTO and family life			

complexities and uncertainties of real life. Storytelling enables team members to be connected over time and allow negotiating the constructed meaning on the VC OTO intensively and differentiated. The stories of the student represent the work they are doing. The students are the persons who are "making the show happen". Their stories and the formal information of the staff "fashions a web of stories" in which the tension of a constructive learning process can be perceived (Boje, 2001, p. 8, 61). The stories express the fragile balance between the prescriptive elements and the variety of free choices in the course "Design project".

10. ACKNOWLEDGMENT

We thank all the team's knowledge managers during the period 2004-2006 for their valuable contributions: Maiko van Dalen, Olaf Haarman, Erik Schouten, Erik-Jan Spaans, Han Opgenoort, Jorgen de Wit, Raymond Waaijer.

8. REFERENCES

Bitter-Rijpkema, M. E., Crutzen, C. K. M. (2002). The Conflict between Constructivist and Prescriptive Learning in a Virtual Learn-Work Environment. In Kallenberg, A.J., van de Ven, M.J.J.M. (Eds.), *The New Educational Benefits of ITC in Higher Education, Proceedings*, p. 78-87, http://cecile-crutzen.de/Downloads/2002-Conflict-Constructivist-and-Prescriptive-Learning.pdf.

Boje, D. M. (2001). Narrative Methods for Organizational & Communication Research. London, Sage Publications.

Crutzen, C. K. M. (2005). Questioning Gender in E-learning and its Relation to Computer Science - Spaces for Design, Working and Learning. In Braidotti, R., Baren, A. van *The Making of European Women's Studies*, Vol. VI, p. 40-59, http://cecile-crutzen.de/Downloads/2005-Questioning-Gender-in-E-learning-Full-paper.pdf.

Jonassen, D. H. (1991). Objectivism versus Constructivism: Do We Need a New Philosophical Paradigm? *Education Technology Research & Development, 39*(3), 5 – 14.

Jonassen, D. H. (1994, April). Toward a Constructivists design model. *Educational Technology, 34*(4), 34 – 37.

Oord, P. (2004). Participatory Design of Knowledge Management in a Virtual Learning Environment. In *PDC 2004 Proceedings of the Participatory Design Conference 2004*, Toronto, Vol. II p.42.

Snowden, D. (2000). Story circles and heuristic based interventions, Part Three of Basics of Organic Knowledge Management, In *Knowledge Management,* Vol. 3, Issue 10, p. 15-19, http://www.cognitive-edge.com/ceresources/articles/9_Organic_KM_3of3_interventions.pdf (retrieved august 2006).

Westera, W., Sloep, P. B. & Gerrissen, J. (2000). The design of the virtual company: Synergism of learning and working in a networked environment. *Innovations in Education and Training International, 37*, 24-33.

ENDNOTES

1 Faculty Computer Science, Open University of the Netherlands (http://www.ou.nl).

2 OTO is the acronym for "Ontwerp Transfer Open Universiteit Nederland" (Design Transfer Open University of the Netherlands) (http://www.open.ou.nl/otonet/).

3 See the chapter "Storytelling" of the publication "KM toolbox: inventory of tools and techniques of the National Electronic Library for Health", http://www.nelh.nhs.uk/knowledge_management/km2/storytelling_toolkit.asp, retrieved august 2006.

4 SideFlux has produced a social browser for an organisation involved in teacher education. PreMath has made a product for a digital university that can link assessments with electronic content for students with gaps in mathematics.

5 KryptosLogos has made an interactive educational tool for explaining coding and decoding methods. Meta/Z has built a search application that made the different applications of an organisation accessible. UseIt has made for a "testing institute" an application for interface evaluation.

6 http://plone.org.

Value Creation: The Next Generation of Knowledge Management

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ABSTRACT

This paper provides a review of value creation literature by adapting and extending KM generations models (Koenig, 2002; Vorakulpipat & Rezgui, 2006). An interpretive stance is adopted so as to provide a holistic understanding and interpretation of organizational KM research and related Knowledge Management Systems (KMS) and models. It is suggested that once organizations promote knowledge sharing (past generation KM) and knowledge creation (present generation KM), it is necessary to create sustained organizational and societal values. Value creation forms the next generation KM and represents key challenges faced by modern organizations. The research shows that value creation is grounded in the appropriate combination of human networks, social capital, intellectual capital, technology assets, and change processes.

INTRODUCTION

A knowledge-based perspective of the organization has emerged in the strategic management literature (Alavi & Leidner, 2001; Nonaka & Takeuchi, 1995). Organizational knowledge is recognized as a key resource and a variety of perspectives suggest that the ability to marshal and deploy knowledge dispersed across the organization is an important source of organizational advantage (Teece, 1998; Tsai & Ghoshal, 1998). Furthermore, it is widely acknowledged that one of the key sustainable advantages that a firm can have comes from what it collectively knows, how efficiently it uses what it knows, and how readily it acquires and uses new knowledge (Davenport & Prusak, 1998). Traditional organizations are beginning to comprehend that knowledge and its inter-organizational management, as well as individual and organizational capability building, are becoming crucial factors for gaining and sustaining competitive advantages (Preiss, Goldman, & Nagel, 1996). The gaining popularity of Knowledge Management (KM) has been reinforced by the quest for innovation and value creation. In this context, KM is perceived as a framework for designing an organization's goals, structures, and processes so that the organization can use what it knows to learn and create value for its customers and community (Choo, 1999).

Different views of knowledge lead to different perspectives of KM: (a) information technology (IT) perspective focusing on the use of various technologies to acquire or store knowledge resources (Borghoff & Pareschi, 1998); (b) socialization perspective focusing on understanding organizational nature (Becerra-Fernandez & Sabherwal, 2001; Gold, Malhotra, & Segars, 2001); and (c) information system (IS) perspective focusing on both IT and organizational capability perspectives and emphasizing the use of knowledge management systems (KMS) (Schultze & Leidner, 2002; Tiwana, 2000). The latter perspective forms the focus of the present paper.

The scope and definition of KM has evolved over the years. At present, it is argued that there are three generations of KM (Vorakulpipat & Rezgui, 2006). The first generation takes into account knowledge sharing or "supply-side KM" focusing on IT-driven KM (Koenig, 2002; McElroy, 1999). The second generation emphasizes knowledge creation or "demand-side KM" (McElroy, 1999). The third generation (or next generation) emphasizes value creation (Vorakulpipat & Rezgui, 2006).

The aim of the paper is to provide a review of value creation from a knowledge management perspective by adapting and extending McElroy's (1999) and Vorakulpipat and Rezgui's (2006) KM generation models. The paper, first, provides a general description of knowledge management systems (KMS). Then, presents an introduction of past and present generations of KM: knowledge sharing and knowledge creation, followed by a review of value creation presented as the next generation KM. The final section provides a conclusion with a summary of key findings from the review.

KNOWLEDGE MANAGEMENT SYSTEMS

Knowledge management systems (KMS) refer to a class of information systems applied to managing organizational knowledge (Alavi & Leidner, 2001). That is, they are IT-based systems developed to support and enhance the organizational processes of knowledge creation, storage/retrieval, transfer, and application. Many KM initiatives rely on IT as an important enabler, and tend for some of them to overlook the socio-cultural aspects that underpin knowledge management (Davenport & Prusak, 1998; Malhotra, 1999).

Reviewing the literature discussing applications of IT to organizational knowledge management initiatives reveals three common applications (Alavi & Leidner, 2001): (a) the coding and sharing of best practices, (b) the creation of corporate knowledge directories, and (c) the creation of knowledge networks. One of the most common applications is internal benchmarking with the aim of transferring internal best practices (O'Dell & Grayson, 1998).

While KMS tend to follow the normative trend (Schultze & Leidner, 2002), the interpretive approach is best reflected in environments supporting the development of communities of practice (CoP) (Wenger, McDermott, & Snyder, 2002). The success of these individually led initiatives has gradually attracted interest from both the research community and corporate senior management staff within and outside these organizations. They relate more generally to groups of individuals within or across organizational boundaries that share a common concern, a set of problems, or a passion about a topic, and who deepen their understanding and knowledge of this area by interacting using face-to-face or virtual means (synchronous and asynchronous) on a continuous basis (Wenger, McDermott, & Snyder, 2002). The gaining popularity of Communities of Practice has been reinforced by the quest for innovation and value creation as it is widely recognized that these only happen when empowered individuals are well connected using a variety of means and communication mediums both inside and outside the organization.

KNOWLEDGE SHARING AND KNOWLEDGE CREATION: THE PAST AND PRESENT GENERATIONS OF KNOWLEDGE MANAGEMENT

The scope and definition of KM has evolved over the years. The authors argue that the research community has moved from knowledge sharing to knowledge creation challenges. The latter is perceived as the present generation of KM (McElroy, 1999; Vorakulpipat & Rezgui, 2006).

Knowledge Sharing

Information technology (IT) has played an important role for over decades. Many organizations have focused on information dissemination for effective decision support enabled by IT. Hence, the first stage of KM has a strong IT focus (Koenig, 2002). There was a strong belief that the use of IT, in particular the Internet, intranet, and tools for knowledge sharing and transfer has the potential to create added value to the enterprise. Furthermore, this stage has seen the development of solutions to capture and share "best practices" and "lessons learned". In this context, McElroy (1999) identifies knowledge sharing as "supply-side KM" and "It's all about capturing, codifying, and sharing valuable knowledge, and getting the right information to the right people at the right time".

Knowledge Creation

Once knowledge is shared, it is essential that this promotes creation of new knowledge. However, knowledge creation is nurtured through a supportive social environment. Hence, knowledge creation focuses on socialization issues (rather than technology issues), including human and cultural factors. This points to (a) the importance of organization learning, (b) knowledge creation adapted from the SECI model (Nonaka & Takeuchi, 1995) with an emphasis on tacit/explicit knowledge conversion, and (c) Communities of Practice. McElroy (1999) identifies knowledge creation as "demand-side KM".

Several authors (Koenig, 2002; Snowden, 2002) have explored and proposed what would form the next KM generation. For example, Koenig (2002) argues that next generation KM will pay attention to taxonomy development and content management. However, Firestone and McElroy (2003) argue that these technologies already exist. The present paper adopts and extends McElroy's (1999) and Vorakulpipat and Rezgui's (2006) generations of KM to propose a new generation: Value Creation. The following sections provide a review of value creation.

VALUE CREATION: THE NEXT GENERATION OF KNOWLEDGE MANAGEMENT

The relationship between value creation and KM has been argued by several scholars (Chase, 1997; Despres & Chauvel, 1999; Gebert, Geib, Kolbe, & Brenner, 2003; Liebowitz & Suen, 2000). Moreover, Despres and Chauvel (1999) suggest that knowledge can be described as a source of value creation. Liebowitz and Suen (2000) include value creation into KM metrics for measuring intellectual capital. In terms of organization processes, Gebert et al. (2003) suggest that knowledge management processes have inherent value creation capabilities. From a more pragmatic perspective, Løwendahl et al. (2001) propose a framework for the analysis of value and knowledge creation in professional service firms (PSFs). Knowledge creation in PSFs is identified as a knowledge-intensive dynamic activity, delivered by highly educated employees who are closely linked with research and scientific development. The framework integrates the relationship between the domain choice and the knowledge base and argues that the bridge between the two is best explained as value creation processes (VCPs) with two interrelated dimensions: direct and indirect value creation for the clients. This confirms the increasing interests in value creation from a knowledge management perspective.

Value creation is gradually being established as the next generation of KM (Vorakulpipat & Rezgui, 2006). Therefore, once knowledge is created, it is necessary to study the impact on people in terms of value (Vorakulpipat & Rezgui, 2006). Five major factors toward value creation emerge from the literature: (a) human networks, (b) social capital, (c) intellectual capital (d) technology assets, and (e) change processes.

Human Networks

Allen (2003) suggests that organizational learning should be dynamic and that intangible assets and social prosperity are anticipated to create major impacts on KM. For example, the concept of Community of Practice (CoP) (Wenger, McDermott, & Snyder, 2002) is introduced as an effective social activity to share tacit knowledge in Xerox. This had the effect of promoting human networks and motivating people to share and create knowledge.

Intangible assets have the potential to create more value than tangible or physical assets. Three factors of intangibles, consisting of human capital, external capital, and structure capital, are expected to generate future benefits and create sustained organizational and societal values (Allen, 2003; Blair & Wallman, 2001). These also include business relationships, internal structure, human competence, social citizenship, environment health, and corporate identity (Allen, 1999). Once created, intangible and tangible value are included as a part of value networks for creating relationships between people, groups, or organizations.

Human capital can improve value creation in several ways. For example, formal and informal communication using face-to-face (including scheduled meetings) and virtual (synchronous/asynchronous) means (e.g. telephone and e-mail) are perceived as effective to promote knowledge sharing and creation. Whittaker, Frohlich et al. (1994) show a preference for informal communications (e.g. unscheduled meetings or any face-to-face interactions). Early face-to-face meetings in team work tend to improve the team's project definition (Ramesh & Dennis, 2002), and to enhance the effectiveness of subsequent electronic communications (Powell & Dent-Micallef, 1999). Therefore, lack of human networks or communication is identified as a problem that may lead to the ineffectiveness of teamwork (Pynadath & Tambe, 2002) and may hinder any knowledge sharing and creation activity.

Social Capital

The concept of social capital has recently been researched in the context of KM (E. Lesser & Prusak, 1999; E. L. Lesser, 2000; Nahapiet & Ghoshal, 1998). The idea of social capital – physical capital, financial capital, and human capital – can be applied to create value-added for firms. Because of its emphasis on collectivism and co-operation rather than individualism, distributed community members will be more inclined to connect and use electronic networks when they are motivated to share knowledge (Huysman & Wulf, 2006). In terms of socio-technical design, KM tools to support social capital are aimed to bridge various social communities. The tools may foster social capital by offering virtual spaces for interaction, providing the context and history of interaction, and offering a motivational element (e.g. score) to encourage people to share knowledge with each other (Huysman & Wulf, 2006). Tsai and Ghoshal's research reveals an association between social capital and firms' value creation (Tsai & Ghoshal, 1998). This relationship is supported by related research (Nahapiet & Ghoshal, 1998). Moreover, in terms of organizational structure, social capital helps people develop trust, respect, and understanding of others, especially in the context of a strong organizational bureaucratic culture. This contributes indirectly to value creation.

Intellectual Capital

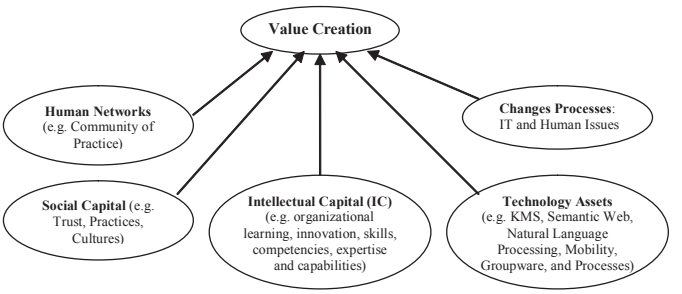
Intellectual capital (IC) has enjoyed a very rapid diffusion over recent years and is also a growing area of interest in KM. It encompasses organizational learning, innovation, skills, competencies, expertise and capabilities (Rastogi, 2000). Liebowitz and Suen (2000) exhibit that value creation is used as a KM metric for measuring intellectual capital. The value creation metric includes training, R&D investment, employee satisfaction, relationships development, etc. Nonaka et al. (2000) suggest that learning by doing can embody explicit knowledge into tacit knowledge through Internalization in the SECI process. Also, training programs can help trainees understand themselves, and reading documents or manuals can internalize the explicit knowledge written in such documents to enrich their tacit knowledge base. Adapted training can foster cohesiveness, trust, teamwork, individual satisfaction, and higher perceived decision quality, as highlighted in the literature (Tan, Wei, Huang, & Ng, 2000; Van Ryssen & Hayes Godar, 2000; Warkentin & Beranek, 1999). In addition, IPR and confidentiality issues should not be overlooked as Denning (1999) suggests that external knowledge sharing poses greater risks than internal sharing as they raise complex issues of confidentiality, copyright, and in the case of the private sector, the protection of proprietary assets. Overall, an interdependent convergence of intellectual assets and collaboration capabilities, underpinned by the use of collaboration technology, and KM activities is suggested to increase the potential of an organization to create value (Qureshi, Briggs, & Hlupic, 2006).

Technology Assets

Managing and enhancing the organizational processes of knowledge creation, storage/retrieval, transfer, and application have relied on the wide use of Knowledge Management Systems (KMS). This suggests that technology, including KMS, is an essential ingredient to sustain value creation. Applications of IT to organizational knowledge management initiatives has focused on three common applications (Alavi & Leidner, 2001): (a) the coding and sharing of best practices, (b) the creation of corporate knowledge directories, and (c) the creation of knowledge networks. While KMS initiatives rely on IT as an important enabler, they tend to overlook the socio-cultural aspects that underpin knowledge management (Davenport & Prusak, 1998; Huysman & Wulf, 2006; Malhotra, 1999; O'Dell & Grayson, 1998).

Moreover, the future KM can be envisioned as (a) the emphasis on the design of KM technology to fit organization culture; (b) the ability to embed KM technology in natural surroundings, and be able to retrieve knowledge whenever and wherever it is needed; and (c) the simple and effortless use of technology to create interaction (VISION, 2003). Semantic web, natural language processing, mobility, virtual collaborative workspaces are the important facets for future KM (VISION, 2003). Next generation KM will also be impacted and shaped by changes in IT

Figure 1. Value creation



and artificial intelligence development, and by the changes expected in people-centric practices to support innovative works (Wiig, 1999).

Change Processes

In this context, change management plays an increasingly important role in sustaining "leading edge" competitiveness for organizations in times of rapid change and increased competition (McAdam & Galloway, 2005). The future has only two predictable features – 'change and resistance to change' and the very survival of organizations will depend upon their ability not only to adapt to, but also to master these challenges.

Organizational change can be divided into two issues: IT and human issues. In terms of human issues, adapting organizational policies to motivate employees to share and create knowledge by providing monetary reward or recognition is suggested, as confirmed by Rus, Lindvall et al. (2002). On the other hand, technology adoption in organizations should not be overlooked. Technology Adoption Model (TAM) (Davis, 1989) proposes that perceived usefulness and perceived ease of use influence the use of information systems innovations and that this effect is mediated through behavioral intentions to use. Christiansson (2003) also agrees that study of the change process is necessary to create the requisite organizational and societal values. A KM maturity roadmap is an important milestone to enable organizations to assess the effectiveness of their KM implementations in the future.

A true value creation culture can be found through the appropriate combination of human networks, social capital, intellectual capital, technology assets, and change processes (Figure 1) where issues such as learning and trust must be blended successfully towards the vision of knowledge-enabled value creation.

CONCLUSION

The paper has presented a discussion of KM, generations of KM (knowledge sharing and knowledge creation, and value creation) based on a review and synthesis of a broad range of relevant literature. The definition of KM has evolved over the years. The paper defined knowledge sharing as the past generation KM, knowledge creation as the current generation KM, and value creation as the future generation KM. Value creation focuses on the organizational and societal impact of knowledge management. Human network, social capital, intellectual capital, technology assets, and change processes emerge as essential conditions to enable value creation. Focusing on social capital, the paper refers to collective capabilities derived from social networks. The higher the level of social capital, the more distributed communities are stimulated to connect and share knowledge (Huysman & Wulf, 2006). In terms of technology, members of communities will be more inclined to use adapted KMS when they are motivated to share knowledge with others. KMS that embed social awareness can play an important role in addressing these requirements, promote social capital in fragmented and distributed networks, and enable KM initiatives in an organization. However, the organization's ability to effectively use, acquire, share, apply and create knowledge is more important and should not be overlooked.

KM has major implications in the learning capability of an organization and its ability to adapt to an ever changing and competitive environment. Therefore, migration from knowledge sharing to knowledge creation and from knowledge creation to value creation is necessary although it may be difficult to negotiate and achieve. The authors are currently working on a KM capability and maturity framework that will facilitate these transitions, and an empirical research on value creation capabilities in a KM perspective.

Clearly, it is important for researchers conducting KM-related research to understand the various factors that affect value-added KM. The authors hope that the present review will contribute to the ongoing debate on KM and its future evolution.

REFERENCES

Alavi, M., & Leidner, D. (2001). Review: Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues. *MIS Quarterly 25*(1), 107-136.

Allen, V. (1999). The Art and Practice of Being a Revolutionary. *Journal of Knowledge Management, 3*(2).

Allen, V. (2003). *The Future of Knowledge Increasing Prosperity through Value Networks*. MA: Butterworth-Heinemann.

Becerra-Fernandez, I., & Sabherwal, R. (2001). Organizational Knowledge Management: A Contingency Perspective. *Journal of Management Information Systems 18*(1), 23-55.

Blair, M. M., & Wallman, S. M. H. (2001). *Unseen Wealth: Report of the Brookings Task Force on Intangibles*: Brookings Institution Press.

Borghoff, U. M., & Pareschi, R. (1998). *Information Technology for Knowledge Management*. New York: Springer.

Chase, R. L. (1997). Knowledge Management Benchmarks. *Journal of Knowledge Management, 1*(1).

Choo, C. W. (1999). The Art of Scanning the Environment. *ASIS Bulletin Pre-print http://www.choo.fis.utoronto.ca/FIS/ResPub/ASISbulletin/default.html.*

Christiansson, P. (2003, April 23-25). *Next Generation Knowledge Management Systems for the Construction Industry.* Paper presented at the CIB W78 Construction IT Bridging the Distance, Auckland.

Davenport, T., & Prusak, L. (1998). *Working Knowledge: How Organizations Manage What They Know*. Boston, MA: Harvard Business School Press.

Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly, 13*(3), 319-340.

Denning, S. (1999). Seven Basics of Knowledge Management. *Communication Technology Decisions, Autumn/Winter*(1).

Despres, C., & Chauvel, D. (1999). Knowledge management(s). *Journal of Knowledge Management, 3*(2), 110-123.

Firestone, J. M., & McElroy, M. W. (2003). *Key Issues in the New Knowledge Management*. MA: Butterworth-Heinemann.

Gebert, H., Geib, M., Kolbe, L., & Brenner, W. (2003). Knowledge-Enabled Customer Relationship Management: Integrating Customer Relationship Management and Knowledge Management Concepts. *Journal of Knowledge Management, 7*(5), 107-123.

Gold, A. H., Malhotra, A., & Segars, A. H. (2001). Knowledge Management: An Organizational Capabilities Perspective. *Journal ofManagement Information Systems, 18*(1), 185–214.

Huysman, M., & Wulf, V. (2006). IT to Support Knowledge Sharing in Communities, towards a Social Capital Analysis. *Journal of Information Technology, 21*, 40-51.

Koenig, M. E. D. (2002). The Third Stage of KM Emerges. *KMWorld, 11*(3), 20-21.

Lesser, E., & Prusak, L. (1999). Communities of Practice, Social Capital and Organizational Knowledge. *Information Systems Review, 1*(1), 3-10.

Lesser, E. L. (2000). *Knowledge and Social Capital: Foundations and Applications*. Boston: Butterworth Heinemann.

Liebowitz, J., & Suen, C. Y. (2000). Developing Knowledge Management Metrics for Measuring Intellectual Capital *Journal of Intellectual Capital, 1*(1).

Løwendahl, B. R., Revang, Ø., & Fosstenløkken, S. M. (2001). Knowledge and Value Creation in Professional Service Firms: A Framework for Analysis. *Human Relations, 54*(7), 911-931.

Malhotra, Y. (1999). *Beyond 'Hi-Tech Hidebound' Knowledge Management: Strategic Information Systems for the New World of Business*: Working Paper BRINT Research Institute.

McAdam, R., & Galloway, A. (2005). Enterprise Resource Planning and Organisational Innovation: A Management Perspective. *Industrial Management & Data Systems, 105*(3), 280-290.

McElroy, M. W. (1999). The Second Generation of Knowledge Management. *Knowledge Management* 86-88.

Nahapiet, J., & Ghoshal, S. (1998). Social Capital, Intellectual Capital, and the Organizational Advantage. *Academy of Management Review, 23*(2), 242–266.

Nonaka, I., & Takeuchi, H. (1995). *The Knowledge-Creating company: How Japanese Companies Create the Dynamics of Innovation*. NY: Oxford University Press.

Nonaka, I., Toyama, R., & Konno, N. (2000). SECI, Ba and Leadership: A Unified Model of Dynamic Knowledge Creation. *Long Range Planning 33*, 5-34.

O'Dell, C., & Grayson, C. J. (1998). If Only We Knew What We Know: Identification and Transfer of Internal Best Practices. *California Management Review, 40*(3), 154-174.

Powell, T. C., & Dent-Micallef, A. (1999). Information Technology as Competitive Advantage: The Role of Human, Business, and Technology Resources. *Strategic Management Journal, 18*(5), 375-405.

Preiss, K., Goldman, S. L., & Nagel, R. N. (1996). *Cooperate to Compete - Building Agile BusinessRelationships*: Van Nostrand Reinhold.

Pynadath, D. V., & Tambe, M. (2002). The Communicative Multiagent Team Decision Problem: Analyzing Teamwork Theories and Models. *Journal of Artificial Intelligence Research, 16*, 389–423.

Qureshi, S., Briggs, R. O., & Hlupic, V. (2006). Value Creation from Intellectual Capital: Convergence of Knowledge Management and Collaboration in the Intellectual Bandwidth Model. *Group Decision and Negotiation, 15*(3), 197-220.

Ramesh, V., & Dennis, A. R. (2002). *The Object-Oriented Team: Lessons for Virtual Teams from Global Software Development.* Paper presented at the HICSS35, Hawaii.

Rastogi, P. N. (2000). Knowledge Management and Intellectual Capital – The New Virtuous Reality of Competitiveness. *Human Systems Management, 19*(1), 39-48.

Rus, I., Lindvall, M., & Sinha, S. S. (2002). Knowledge Management in Software Engineering. *IEEE Software, 19*(3), 26-38.

Schultze, U., & Leidner, D. E. (2002). Studying Knowledge Management in Information Systems Research: Discourses and Theoretical Assumption. *MIS Quarterly, 26*(3), 213-242.

Snowden, D. (2002). Complex Acts of Knowing; Paradox and Descriptive Self-awareness. *Journal of Knowledge Management, 6*(2), 1-14.

Tan, B., Wei, K., Huang, W., & Ng, G. (2000). A Dialogue Technique to Enhance Electronic Communication in Virtual Teams. *IEEE Transactions on Professional Communications, 43*(2), 153-165.

Teece, D. (1998). Capturing Value from KnowledgeAssets: The New Economy, Markets for Know-How, and Intangible Assets. *California Management Review, 40*(3), 55-79.

Tiwana, A. (2000). *The Knowledge Management Toolkit: PracticalTechniques for Building a Knowledge Management System*. NJ: Prentice Hall.

Tsai, W., & Ghoshal, S. (1998). Social Capital and Value Creation: The Role of Intrafirm Networks. *Academy of Management Journal, 41*(4), 464-476.

Van Ryssen, S., & Hayes Godar, S. (2000). Going International Without Going International: Multinational Virtual Teams. *Journal of International Management, 6*, 49-60.

VISION. (2003). VISION Next Generation Knowledge Management. *http://km.aifb.uni-karlsruhe.de/fzi/vision/*.

Vorakulpipat, C., & Rezgui, Y. (2006). *From Knowledge Sharing to Value Creation: Three Generations of Knowledge Management.* Paper presented at the The IEEE International Engineering Management Conference, Salvador, Bahia, Brazil.

Warkentin, M., & Beranek, P. M. (1999). Training to Improve Virtual Team Communication. *Information Systems Journal, 9*, 271-289.

Wenger, E., McDermott, R., & Snyder, W. M. (2002). *Cultivating Communities of Practice: A Guide to Managing Knowledge*. Cambridge, MA: Harvard Business School Press.

Whittaker, S., Frohlich, D. M., & Daly-Jones, O. (1994). *Informal Workplace Communication: What is It Like and How might We Support It?* Paper presented at the CHI '94, Boston, MA.

Wiig, K. M. (1999). What Future Knowledge Management Users may Expect. *Journal of Knowledge Management, 3*(2), 155–165.

Corporate Social Responsibility in the Dynamic Information Age of Inter-Systems Connectivity

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ABSTRACT

The Information age has caused an explosion of information through rapidly changing technologies. This technological change is accompanied by an accelerating shift in work relations, of which this paper focuses on connectivity, interdependence and dynamism. Along with this change in relations, new ethical cultures are evolving at different levels: individual, corporate, governmental, NGO and global. This paper then focuses on the work done in the Corporate Social Responsibility field to see how it has evolved to adapt to the new mode of inter-dependent connectivity in a dynamic environment of changing relationships.

Keywords: Corporate Social Responsibility, Information Age, connectivity, inter-dependent systems, economic relations

CORPORATE SOCIAL RESPONSIBILITY IN THE DYNAMIC INFORMATION AGE OF INTER-SYSTEMS CONNECTIVITY

With the wide diffusion of information on the internet, consumerist and environmental movements have become more powerful, as they are able to play on the trust that the brand is supposed to provide (Clarke, 2003). Their role has been to focus on fairness in corporate practices: those who violated expected norms of fairness would get punished (Kahneman et al, 1986 a & b). This paper seeks to take into account additional features of the information age: connectivity, dynamism and inter-system dependence and see how these have influenced the concept of corporate social responsibility. Part I describes the Information Age and explains how different concepts of Social responsibility relate to the new economic relations created by this Age; where possible the examples are limited to Information Technology (IT), even though in the information age all industries are affected by IT. Part II zooms in on the evolution of some of the different concepts and theories in the Corporate Social Responsibility (CSR) area before and after the era of connectivity and tries to show how theory has evolved and the debate has shifted to take into consideration the connectivity and inter-dependence questions.

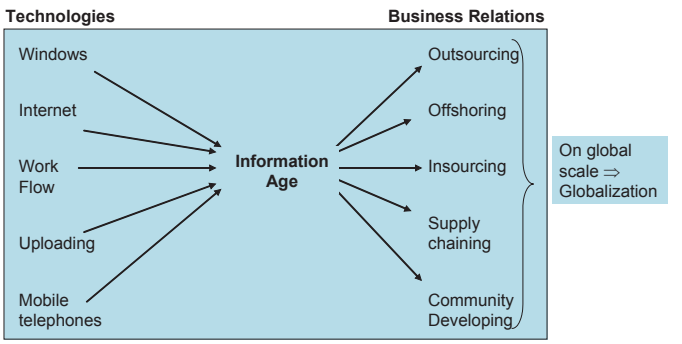
I. INFORMATION AGE OF INTER-DEPENDENT CONNECTIVITY AND SOCIAL RESPONSIBILITY

A. Interdependent Conncetiviy and Information Needs

The information age is characterised by new technologies, which have led to globalization (Friedman, 2006). Some salient new technologies include windows, internet, workflow software, uploading and mobile telephones. The combination of these technologies has resulted in an accelerated shift to new work relations such as outsourcing, offshoring, insourcing, supply chaining and community developing (see Figure 1).

The key words in these new work relations are connectivity and collaborating. These collaborative forms replace hierarchical modes and the balance of countervailing power is continuously changing. It may be IBM today, Intel tomorrow, and Microsoft the next day, and so on... Thus, it is not only connectivity and collaborating but dynamic connectivity and collaborating. This is not to say that there are no issues of countervailing power on any given day. Within the information field, somebody will decide which information technology to use, who has authorization to upload or download, etc. However, neither the relationships nor the technologies are frozen.

Figure 1. Information age: Technological causes and business outcomes



In the prior vertical hierarchical mode, a person owed responsibilities to his superior in terms of accountability and to his subordinates in terms of caring and protection. Now, in this new horizontal collaborationist mode, the stakeholder becomes all-important. This is a two-way stakeholder relationship among equals (or more equal than before). The supplier needs the customer and the customer needs the supplier but they are both looking for better and more profitable relationships (leapfrogging) as well as trying to embed the existing relationship. A key element in these relationships therefore is the tension created by this conflict between trust and abandonment. Trust is required to ensure that gains would be equitably distributed across the supply chain and that everyone involved survives, at least while the relationship is ongoing. This trust requires new institutional arrangements. If the connections and collaborations are global, the institutional arrangements also need to be global.

One of the key elements required to ensure continuity of trust is the ability to control the stakeholder, and to obtain pertinent information. In the old hierarchical framework, the trust was obtained by the provision of information. The shareholders were provided annual accounting reports, the employees were asked to provide weekly or daily performance reports.

In the new horizontal mode (see figure 2), the information cannot come from authority: it has to come from sharing. Since the stakeholders are interdependent, they may need to pool their information to be able to control each other. However, all information flow is asymmetric leading to joint problems of adverse selection (who is going to be my partner among the whole lot of Indians in the field) and moral hazard (what if he takes the advance and does not deliver). What complicates things further is that in this information age, every person connected to the internet is a stakeholder in the connectivity itself. He can thus create or destroy relationships and even the internet (virus attacks, see Holzinger, 2000 for examples). He can also use the rapid speed of communications to launch speculative attacks on currencies. Terrorists can also use a global supply chain to manufacture bombs. Thus, each person or stakeholder in this network has information about his intentions, which no one else may have. This asymmetric information problem could be solved if there are guaranteeing institutions (governments, rating agencies). These institutions again require information dissemination to be able to exercise

Figure 2. Information needs in an information age of connectivity

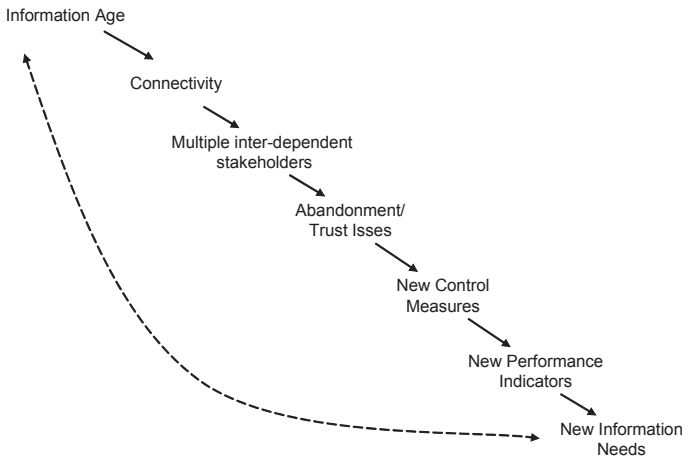
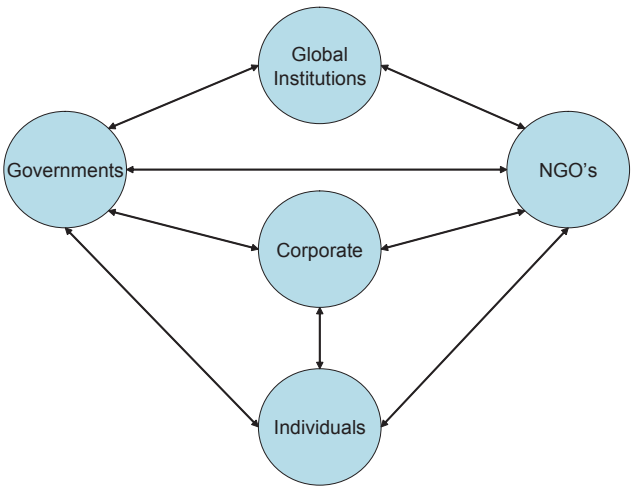


Figure 3. The corporate centric vision relationships of social responsibility between actors



their function. What kind of information is pertinent to control in this new information age of dynamic connectivity would be a central question for research. However, the information needs would themselves modify the information age as new technologies are developed to provide this information.

Information needs depend on performance indicators required. These performance indicators need to respond to the critical success factors that need to be controlled. In an old-world economy, profits may have been enough (Friedman, 1970). However, in the information age, where many pressure groups can widely disseminate information, a corporation now has to meet many other ethical, social and environmental criteria. The information needs therefore also depend upon the (social) responsibilities of different actors.

B. Social Responsibilities in the Age of Inter-Dependent Connectivity

There are a multitude of actors involved: individuals, corporations, governments, non-governmental organisations (NGOs), and global institutions such as the World Trade Organization, World Bank, etc, and the information age has modified all their responsibilities. Figure 3 indicates the relationships between these actors: the two-way arrows suggest that each influences the others. Firms and their corporate responsibilities play a central role because they have the economic power to back whatever role they wish to play. The other actors, notably the governments and NGO's but also individuals as employees or customers try to influence this role. The payments of firms to these actors (taxes, donations, bonus, discounts) allow them to nuance the policies of the other actors. Global institutions usually act through governments or NGO's since they would not be able to afford constant interaction with millions of firms or billions of individuals.

For individuals, the survival of the system requires efficiency, equity as well as environmental protection. Efficiency requires a responsibility to continuing education and keeping oneself informed of all relevant changes in technology. Equity requires a responsibility to respect intellectual property of others' websites and to create inter-dependencies by educating others so that they can use the individual's abilities. These inter-dependencies are acutely highlighted in value-based networks (Wheeler, Volbert & Freeman, 2003) such as e-Bay, IBM, HP and Cisco. Environmental protection requires, for example, not overloading the system by spamming and limiting the use of printers.

At the corporate level, the Social Responsibilities of the information age could require helping staff evolve so that they can keep their jobs in a dynamic environment, outsourcing and downsizing if this will help survival and create growth elsewhere, and adding diversity to add value. Hoekstra (2003) indicates that the IT outsourcing to India has reduced the brain drain from that country since IT skilled people can earn as much sitting in their own cultural milieu. CSR also requires providing transparent reliable information to the network partners, based on reality and not hope (Hoekstra, 2003). If one plans a 30% growth, all other partners prepare for it. If this growth is far off the mark, it creates problems for all. Failure of one major actor could drown thousands of collaborators, as evidenced by Enron. This includes failure of an actor owing to war in one country. The global consequences of war in any member country of a global supply chain have resulted in corporations reminding the concerned governments of the global economic costs of war (Fort & Schipani, 2002; Friedman, 2006). Both mention that the Indian IT industry exerted diplomatic pressure on the US and Indian governments to avoid an India-Pakistan war in 2002, mentioning clearly that India's presence in the global supply chain could create economic disruptions and costs well beyond India's borders. The Indian IT industry did this fearing that their customers would go elsewhere if there were a political risk in doing business within India. Thus the CSR in the age of connectivity goes much further than the internal security risk of virus attacks and robbing banks expressed by Holzinger, 2000.

Fort and Schipani (2002) find that the global corporation has power over the developing States because they pay local taxes and provide jobs, education, skills and transfer of technology. Therefore, they argue that a firm's Social Responsibility includes leveraging these to support the establishment of democratic regimes wherever they do business and, to set a model, establishing democratic regimes in its own internal governance structure. In this line, Hoekstra (2003) indicates that IT industries have invariably transported stakeholder-sharing concepts, such as stock options and performance incentives to reward employees and partners, to developing countries in advance of other industries. Fort and Schipani (2002) also add that the corporation should structure itself in a way that develops small communities working together with face-to-face interaction and consensual decision-making, with should lead to sustainable peace.

Government Social Responsibilities may mean providing continuing education, disseminating information on new technologies, making infrastructure such as bandwidth accessible to all, and promoting environmental safeguards from virus attacks as well as military attacks (Friedman, 2006). Government responsibility would also include creating new legal institutions to adapt to the new economic relations, such as intellectual property right protection for software and intangible music and books, which help add to the trust necessary to collaborate, as well as transparency and disclosure requirements from corporations. The latter is especially important in an information age to limit losses from asymmetric information, and thus permit collaboration between distant stakeholders (Fort and Schipani, 2002).

NGOs play a role as pressure groups to impose ethical guidelines, stimulate voluntary codes of conduct and warn away terrorists: for example, the existence of associations like ATTAC (advocating a Tobin Tax) may deter financial speculators. These NGOs use information technology to disseminate information and they would not be such powerful stakeholders without this tool (Waddock, 2005). NGOs also serve as venues for discussions of issues of citizenship between the spreading forces of corporate globalization and the pressing desires for individuality (Fort & Schipani, 2002).

Figure 4. Should business be invested with social responsibility?

Arguments for Corporate Social Responsibility	Arguments Against Corporate Social Responsibility
Long-run self interest	Profit Maximization
Public Image	Costs of Social Involvement
Viability of Business	Lack of Social Skills
Avoidance of government regulation	Dilution of Business's Primary Purpose
Sociocultural Norms	Weakened International Balance of Payments
Stockholder interest	Business has enough power
Let Business Try	Lack of Accountability
Business has the resources	Lack of Broad Support
Problems can become profits	CSR idea is grounded on economics, and ignores history, religion, culture, etc.
Prevention in better than curing	CSR idea is based on fixing capitalism's woes: this is too conservative
	CSR idea separate's business ethics from society's ethics
	CSR idea is based on limited rights and responsiblities

Extracted from Davis (1973) and Freeman & Liedtka (1991)

The Global institutions have the primary responsibility to ensure harmonization of essential business laws so that the necessary infrastructure for trading across nations is created. They also have the responsibility of deciding what the global CSRs are. For the moment, a voluntary set of principles, such as UN Global Compact and Global Reporting Initiatives, have been initiated. However, voluntary efforts lack the stamp of legitimacy. At the same time, there are now a number of agencies which rate CSR of the world's leading firms. These include, for example, Accountability, FTSE-4good, Business in The Community, Dow Jones Sustainability Index, Business Ethics 100 (Hopkins, 2005) and Vigeo. However, none of these considers whether the firm takes into account the dynamic nature of supply chain relationships in the IT world and the responsibilities of firms to each other.

Having discussed the evolution of the new information age and seen how it has affected the social responsibility of different actors, the next section sees how the theoretical discussion of the concept of CSR has evolved to take into account the new needs of dynamic interconnectivity.

II THE EVOLUTION OF CORPORATE SOCIAL RESPONSIBILITY IN A CONNECTIVITY MODE

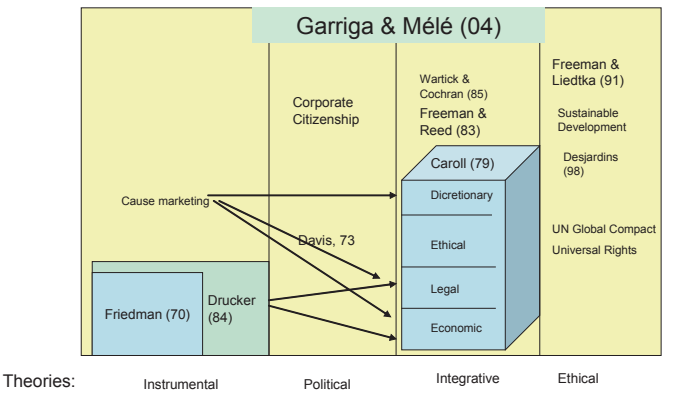
A. Evolution of the CSR Concept

There is a debate on what CSR is. There are so many theories that there are now papers classifying the theories (Carroll, 1979; Garriga & Mélé, 2004) and we will just look at a few of these. The basic minimum in terms of CSR was set by Nobel laureate Milton Friedman (1970) for whom the only responsibility of business is to use its resources to increase profits while conforming to laws. All other responsibilities are for the government to deal with. Otherwise, there is an agency problem between a manager's desire to instil his views of what is good for society by using corporate funds. This is tantamount to imposing an illegitimate tax on the corporation. At the other extreme are people who lobby for increased corporate philanthropy (Brammer and Millington, 2003 study the evolution of charitable contributions in the UK). Between corporate philanthropy and Milton Friedman's "only profit" goals, there is Drucker's (1984) definition of CSR: « to turn a social problem into economic opportunity and economic benefit, into productive capacity, into human competence, into well paid jobs, and into wealth». While Friedman (1970) left these problems to governments, Drucker (1984) explained that government is not in a position to solve the problems because in any action it takes, it creates vested interests that keep it from realizing the option value of abandoning a course of action. Therefore, governments cannot experiment. Thus, he felt that NGOs would need to step in as they at least have competition between themselves. In most cases, the responsibility of corporations is to ensure that there is enough capital formation for their own survival. Additionally, companies may have certain capabilities and strengths which may make them more suitable to serve the community (Hoekstra; 2003). This is fortunate in a world where the increase in information has led to harmful tax competition, reducing the government's ability to provide services, thus renewing the call for Corporate Citizenship to mend society's broken contracts (Waddock, 2005).

Davis (1973) resumes the reasons for and against social responsibilities of business, as summarised in figure 4, and suggests that a trade-off needs to be established. Many authors (Purcell et al, 1974; Carroll, 1979) feel that CSR means going beyond the legal minimum advocated by Friedman (1970), with a point to combining profitable activity with meeting the common good. Carroll (1979) summarises the different positions of different authors and concludes that there is a hierarchy (not mutually exclusive) between meeting economic responsibilities, meeting legal responsibilities, meeting ethical responsibilities and finally discretionary responsibilities (which would include philanthropy). This hierarchy can be for different social issues such as consumerism, environment, occupational safety etc. He adds a third dimension by suggesting that enterprises have different response mechanisms such as reaction, defence, accommodation and proaction. Wartick and Cochran (1985) indicate how the Carroll (1979) model incorporates the challenges to CSR such as economic responsibility, public responsibility and social responsiveness. More recently, we have seen how CSR has been developed in cause marketing to marry promotional appeals with philanthropic giving (Smith & Alcorn, 1991) in order to attract customers for the firm (Irwin et al, 2003), thus creating connectivity between corporations and NGOs. This is a manifestation of the enlightened self-interest argument (Purcell et all, 1977; Besser, 1999): business benefits indirectly from socially responsible behaviour, for example from higher employee motivation and better reputation. Brammer and Millington (2003) indicate that charitable contributions may also result from a need to influence stakeholders. Negative reasons within this framework would include firms resorting to social responsibility for fear of punishment by consumers if they did not follow fairness standards (Kahneman et al 1986a and1986b; Campbell, 1999). Desjardins (1998) argues that economic growth meets the economic and legal minima concepts but it also causes environmental degradation that would ultimately cause the business to be non-sustainable. Thus, there is a need for a business to look at its responsibility not only to the whole social body of stakeholders but also to the physical environment in which it is operating. While environmental waste has been discussed at lengths, the information waste discussion should go on similar lines. So far, we are not aware of the health hazards to the environment by storing so much information on line. However, the duplication and waste does cause psychological fatigue for researchers who come up with many pages providing the same information, and are led to the paradox of choice: when more is less (Schwartz, 2004). More recently, Garriga and Mélé (2004) have classified CSR theories into instrumental, political, integrative and ethical theories. For example, Friedman's "economic and legal minimum" view is an instrumental theory, Davis (1973) is representative of a political theory, Carroll's (1979) Corporate Social Performance model is an integrative theory and Freeman's Stakeholder approach is an ethical theory. Figure 5 attempts to put some of these theories in Carroll's perspective which itself is within the perspective of Garriga & Mélé (2004).

Thus, the debate on the role of CSR and related concepts has moved in recent years to try to capture the changing economic and social relations caused by in-

Figure 5. Mapping the theories



ter-dependent connectivity, as can be seen by the addition of stakeholder theory to the CSR phenomena.

B. How Inter-Dependent Connectivity has impacted the CSR Concept

Within the CSR discussion, different authors have included connectivity from different perspectives in their models. Some of these are presented here to the extent they are required to bring out this paper's perspective, and are illustrated in Figure 6.

The starting point to such an interconnected view comes from the Stakeholder approach (Freeman & Reed, 1983) which views the interests of all stakeholders (employees, customers, suppliers, governments; consumer groups, NGOs) as important and not just the shareholders. Thus, the enterprise owed a responsibility to all the people with which it was connected, internally and externally. The focus is on the enterprise.

Within this framework, a narrow view is that of Holzinger (2000) who looks at information security leaks and fixes a minimal social responsibility of business to its partners (customers, suppliers) to have good internal governance procedures to protect against hackers. This social responsibility could be reinforced by pressure groups such as insurance companies and governments. We note that in this view, we see shades of Friedman (1970) and this could be considered as a corresponding minimalist CSR view in the age of inter-dependent connectivity.

Inspite of the continuing linking of the Stakeholder concept to CSR, Freeman & Liedtka (1991) insist that the "CSR" concept is not a good one. Their reasons overlap some of the reasons given by Davis (1973) and the others are incorporated in Figure 4. They suggest that Corporations be viewed as connected networks of stakeholder interests. In this network, human beings and communities aim for mutual support and unparalleled achievement. They would like to see corporations as the means by which human beings create their visions for self and community. From this work, the paper takes the focus on the individual human being. Therefore, in figure 6, we've added shapes for the stakeholders and shown interconnected people within the company.

More specifically to the Interconnectivity question, Wheeler, Colbert and Freeman (2003) look at CSR in a network world. After explaining Value-Based Networks and the importance of CSR (specifically ensuring that all stakeholders benefit and corporate philanthropy) in information technology companies using networks, they use a three level pyramid to classify corporate cultures from doing minimum harm to doing maximum good: Compliance Culture, Relationship Management Culture and Sustainable Organization Culture. These require, respectively, a close watch over societal needs and societal frameworks, ensuring all stakeholders are obtaining value in the short term, and that this is sustainable over time. Thus, figure 6 adds that the stakeholders also get some focus (and are shaded).

An associated stream dealing with Value Added Communities was "MetaCapitalism" started by Means and Schneider (2000). These authors predicted a radical transformation of the corporate world into scarcely capitalised, brand focussed, highly flexible, customer oriented firms engaged in on-line exchanges or networks, driven by the new information technology. This paper therefore assumes an expectation for business corporations to atomize with time. (In figure 6, this is manifested by the smaller corporation size).

The last viewpoint presented here to develop this paper's perspective is the Inter-Systems Model of business proposed by Stormer (2003), in which the business cannot be taken as an independent system, but as a network of communities operating within the firm and the firm as an interdependent actor in a larger system. Thus, there is a need to analyse how changes in one part of the larger system can affect the corporation and vice versa. This viewpoint allows transcending the stakeholder theory (Freeman & Reed, 1983) where the central focus remains on the corporation in which all the stakeholders are interested. In the Inter-Systems model, each stakeholder becomes a separate system, and thus equally important. Stormer (2003) concludes that strategy becomes more complex because of the interdependence of the systems with which the firm is attached. (In figure 6, all the stakeholders are linked to each other with double-sided arrows).

Putting together what we have extracted from the above literature we can say that pushed to its limit, each inter-dependent stakeholder becomes an individual. Thus, the connectivity between individuals and their connected clusters (termed firms or governments, or NGO's) and the connectivity between clusters becomes focused on the needs of the individuals, all of whom are equally important. In all these recent evolutions, therefore, one thing seems to be clear: the importance of the individual seems to be expanding and that of the corporation seems to be reducing. Thus, the focus is on what the individual is able to do. Hence, the rights and responsibilities are those centred on individuals as indicated in Figure 7 and not those centred on organizational types (corporate, government, NGO or global), as depicted earlier in Figure 3.

However, Mickhail and Ostrovsky (2005) looked at the MetaCapitalism prophesy outlined above. They find little connection between the predicted outsourcing and the predicted boom in share prices. They offer various reasons for this including inability in a changing world to distinguish between core and non-core; inability to extract maximum from employees and stakeholders if relationships are perceived as short-term; the need for companies to retain facilities to retain flexibility; the inherent conflict of interest for sharing the cake that sets a limit to the model; dominant firms continue to control smaller firms and thus extract economic rent from their size and also determine the conditions necessary for entry into the VAC. Thus, reality requires viewing the IT as a continuum of unequal partners, competing and collaborating with each other at the same time.

Another view is a naturological view of the corporate community relationships and the extended skew selection theory proposed by Hill and Cassill (2004). In this view, the corporation is inter-dependent with its community, taking resources and energy from it and giving back goods, services and philanthropy. The sustainability

Figure 6. New approaches to take into account interconnectivity

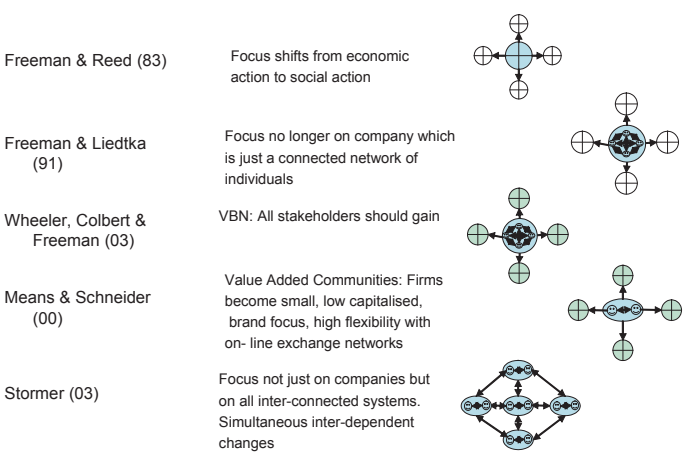
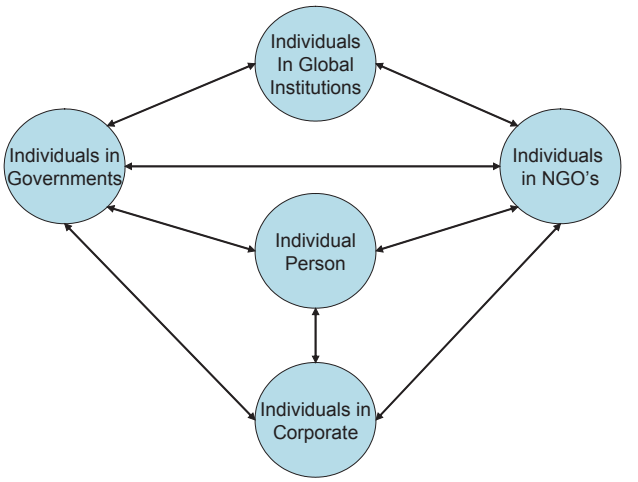


Figure 7. The person-centric vision relationships of social responsibility between actors



of an actor (the corporation) depends on its ability to produce income and capital in oscillating good times and bad, and in its ability to share it with its community to ensure the survival of the community. Without the community, the corporation cannot survive. Thus, the corporation would like to be larger and more powerful, but it also recognizes the biological viewpoint of safety in numbers. Thus, it needs to share part of its wealth with its community. Thus sharing offsets greed to some extent. Hill and Cassill (2004) state "Sharing a finite proportion of resources with others can help quell the impulse of advocacy firms, government agencies, and the judicial system to take a corporation's resources by force".

Thus, this set of authors would nuance our propos: we can see that neither the corporate centric view of figure 3 nor person centric view of figure 7 reflects the reality of today's position. There is however a possibility that there will be an evolution from the former to the latter.

CONCLUSION

The Information age has caused an explosion of information through rapidly changing technologies. This technological change has been accompanied by an accelerating shift in economic and social relations, of which this paper focused on connectivity, interdependence and dynamism. A key observation found common in much of the literature is the increasing focus on the individual's capacity to connect. This has created new information needs required for monitoring and controlling connectivity and the associated issues of trust and abandonment.

Along with this change in relations, new ethical cultures are evolving at different levels: individual, corporate, governmental, NGO and global to incorporate the needs of the information age.

This paper also looked at the work done in the CSR field to see how it has evolved to adapt to the new mode of inter-dependent connectivity in a dynamic environment of changing relationships. The role of the corporation is being questioned: is it the means (agency) to individual (principal) satisfaction or is it the principal, determining human (agency) roles?

While many of the theoretical concepts can be adapted, there is much more work required in the measures of the degree of connectivity and to associate appropriate responsibility. The determination of information needs required for strategic control in this age of dynamic inter-dependent connectivity is a possible area for future research. At the very least information required would need to come from a multitude of stakeholders or systems.

The Hill and Cassill (2004) study also opens up questions for future research, including the resource allocation decision between the organization and the community, member's propensity for greed and sharing, and the impact of sharing on the quantity and quality of social capital available to the focal corporation with different levels of resource abundance.

Another area of future research is to establish what kind of responsibilities a firm has to its partners to reduce the tension between trust and leapfrogging. Although work in this area is being done by behavioural economists, an area to extend that work would be what responsibility one has to usher in trust and to make soften abandonment. Perhaps as a start, every actor needs to understand his own personal responsibility to evolve with the system and not to hold on to the old power syndrome inherent in hierarchical organizations.

There is also scope for studying the origins of the field of management thought: whether the recent application of systems approach are embedded in European or American roots.

The entire systems approach to social responsibility might also include research into the constituents of the social utility function to decide the gamut of areas which could be included. If a detailed Leontief type input-analysis is required, perhaps there are linkages to be looked at with this area of economics.

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REFERENCES

Besser, T. L. (1999). Community Involvement and the Perception of Success among Small Business Operators in Small Towns. Journal of Small Business Management, Oct99, 37(4), 16-29.

Brammer, S. & Millington, A. (2003). The evolution of corporate charitable contributions in the UK between 1989 and 1999: industry structure and stakeholder influences. Business Ethics: A European Review, 12(3), 216-228.

Campbell, M.C. (1999) Perceptions of Price Unfairness: Antecedents and Consequences. Journal of Marketing Research, 36(2), 187-199.

Carroll, A.B. (1979). A Three-Dimensional Conceptual Model of Corporate Performance. Academy of Management Review, 4(4) 497-505.

Clarke, B. (2003). Brands are now judged on what they do, not say. Marketing, 12/11/2003, 18-18.

Davis, K. (1971). The Case for and Against Business Assumption of Social Responsibilities. Academy of Management Journal, 16(2), 312-322

DesJardins, J. (1998). Corporate Environmental Responsibility. Journal of Business Ethics, 17(8), 825-838.

Drucker, P. F. (1984). The New Meaning of Corporate Social Responsibility. California Management Review, 26(2). 53-63.

Fort T.L & Schipani, C.A..(2002). Adapting Corporate Governance for Sustainable Peace. Vanderbilt Journal of Transnational Law, 36, 377-426

Freeman, R. E. & Reed, D. L. (1983). Stockholders and Stakeholders: A New Perspective on Corporate Governance. California Management Review, Vol. 25(3), p88

Freeman, R. E. & Liedtka, J. (1991). Corporate social responsibility: A critical approach. Business Horizons, Vol. 34 (4), p92

Friedman, M. (1970). The Social Responsibility of Business is to Increase its Profits. The New York Times Magazine, Sept 13. 1970.

Friedman, T. (2006). "The World is Flat: The globalized world in the twenty-first century". U.K. Penguin.

Garriga, E. & Melé, D. (2004). Corporate Social Responsibility Theories: Mapping the Territory. Journal of Business Ethics, 53(1/2), 51-71.

Hill, R.P. & Cassill, D.L. (2004).The Naturological View of the Corporation and Its Social Responsibility: An Extension of the Frederick Model of Corporation–Community Relationships. Business & Society Review, 109(3), 281-296.

Hoekstra, B. (2003). CSR and the IT Industry in Bangalore: Observations of a Practitioner. IIMB Management Review, 15(4), 78-81.

Holzinger, Al (2000). Information Security Management and Assurance: A Call to Action for Corporate Governance. Information Systems Security, Vol. 9 (2), p32-39

Hopkins, M. (2005). Measurement of corporate social responsibility. International Journal of Management & Decision Making, 2005, Vol. 6 (3/4), 213-231.

Irwin, R.L.; Lachowetz, T.; Cornwell, T.B.; Clark, J.S. (2003). Cause-Related Sport Sponsorship: An Assessment of Spectator Beliefs, Attitudes, and Behavioral Intentions. Sport Marketing Quarterly, 12(3), 131-139.

Kahneman, D.; Knetsch, J. L.; Thaler, R. (1986a). Fairness as a Constraint on Profit Seeking: Entitlements in the Market. American Economic Review, 76(4), 728-41.

Kahneman, D.; Knetsch, J. L.; Thaler, R. (1986b) Fairness and the Assumptions of Economics. Journal of Business, 59(4) S285-S300.

Means, G. & Schneider, D. (2000). Metacapitalism: The E-business Revolution and the Design of 21st Century Companies and Markets, John Wiley & Sons, Inc.

Mickhail, G. & Ostrovsky, A. (2005). The Metacapitalism Quest. Journal of American Academy of Business, Cambridge 6(1), 290-298.

Purcell, T.V.; Albright, L.E.; Grant, D.L.; Lockwood, H. C.; Schein, V. E.; Friedlander, F. (1974). What are the Social Responsibilities for Psychologists in Industry? A Symposium. Personnel Psychology, 27(3), 435-453.

Schwartz, B. (2004). The Paradox of Choice: Why more is less. HarperCollins.

Smith, S. M. & Alcorn, D. S. (1991). Cause Marketing: A New Direction In The Marketing Of Corporate Responsibility. Journal of Consumer Marketing, 8(3), 19-35.

Stormer, F. (2003). Making the Shift: Moving from "Ethics Pays" to an Inter-Systems Model of Business. Journal of Business Ethics, 44(4)4, 279-289.

Waddock, S. (2005). Corporate Citizens: Stepping into the Breach of Society's Broken Contracts. Journal of Corporate Citizenship, 19, 20-24.

Wartick, S.L. & Cochran, P. L. (1985). The Evolution of the Corporate Social Performance Model. Academy of Management Review, 10(4). 758-769.

Wheeler, D.; Colbert, B. & Freeman, R.E. (2003). Focusing on Value: Reconciling Corporate Social Responsibility, Sustainability and a Stakeholder Approach in a Network World. Journal of General Management, 28(3), 1-28.

Financial Performance of Internet and Brick-and-Mortar Companies: A Comparative Analysis

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ABSTRACT

This paper aims to explore potential differences in financial performance of Internet companies and the traditional brick-and-mortar companies. A compressive financial ratio analysis is used to investigate these differences for the period from 1998 to 2003. Contrary to our expectations, the average performance of the Internet companies was significantly worse than that of traditional brick-and-mortar companies.

INTRODUCTION

Since the late 1990s, buying and selling goods over the Internet has become a common business practice. Forrester research reported that E-commerce sales in 2005 increased 22% to $172 billion from $141 billion in 2004. This trend is expected to continue and according to Forrester, e-commerce sales will reach $228 billion in 2007 (Khan 2006). Even U.S. e-commerce sales in 2004 alone were estimated at $69.2 billion, which represent 23.5 percent increase from 2003 (U.S. Census Bureau 2005).

In spite of its importance and contribution to the whole economy, e-commerce is associated with the stock market bubble and the following crash. During this so-called dotcom crash, in 2000 and 2001, many, often very promising Internet companies, went out of business (Javalgi et al. 2004).

Practitioners and academic researchers provided a number of explanations for the dotcom crash (Shama 2001; Thornton and Marche 2003). The possible explanations included inexperienced management, absence of sound business model, and lack of attention to financial reality.

Prior to the dotcom crash, many business managers and investors followed the assumption that the traditional financial analysis tools are restricted to old economy. For example, a systematic ratio analysis has been rarely conducted for Internet companies. This is very surprising due to the fact that ratio analysis is one of the most common tools used for measuring financial performance (Bharadwaj 2000; Hunton et al. 2003; Kudyba and Vitaliano 2003; Santhanam and Hartono 2003; Motiwalla et al. 2005; Bose and Pal 2006).

According to a rich body of research, ratio analysis is a powerful tool in assessing the financial health of companies and predicting business failures (Beaver 1966; Altman 1968). However, regarding the Internet companies, it is not clear whether this method needs to be adjusted and what the reasonable ratios are.

This scarcity of financial ratio research in Internet companies provides motivation for our study. Although Motiwalla et al. (2005) examined the impact of e-business on financial performance, the study focused on an intra- and inter-industry level of three industries. Besides, the examined firms were not pure "click" companies but "brick and click" companies, which decided to embrace the Internet in order to support their traditional operations and to improve the bottom-line performance. In contrast, our study focuses on the financial performance of pure "click" companies and compares it with that of the traditional brick-and-mortar companies.

The structure of our paper is as follows: the next section, based on literature review, introduces a set of hypotheses; research methodology section describes the methodology, the results section presents the empirical results, and the discussion section includes a brief discussion of the results. The final section provides conclusions of the paper and offers some ideas for future research.

BACKGROUND AND RESEARCH HYPOTHESES

The Internet has changed the way the organizations conduct their business today. The number of firms that take advantage of Internet technology has grown rapidly in the late 1990s. Firms that heavily use the Internet for their business activities are commonly defined as the dotcoms, Internet firms or pure "click" companies. Consequently, many of these companies conduct their business almost exclusively over the Internet. Dotcoms can be classified into two categories: the digital and physical dotcoms depends on the products and services that they sell (Barua et al. 2004a). Yahoo and eBay are examples of digital dotcoms that deliver services directly over the Internet. Amazon.com is an example of physical dotcoms, which are often referred to as e-retailers that sells physical products on the Internet.

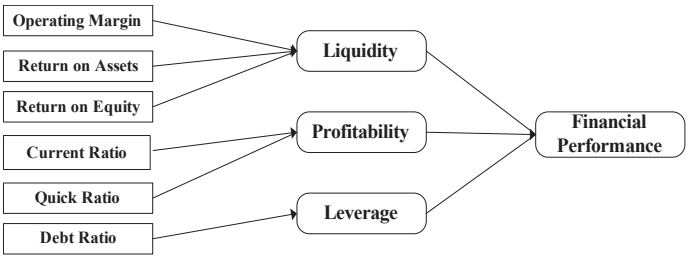
As described previously, Internet companies are often associated with dotcom crash. During this period, many firms run out of cash, closed their doors for business or become easy acquisition targets. Liquidity, or ability to meet financial obligations in short term, is important factor in avoiding financial difficulties. Thus, Internet companies may be expected to have liquidity problems. However, we argue that most of the Internet companies which managed to survive the dotcom crash and are in operations for several years must have a better position in liquidity. In other words, their liquidity is not worse than the established brick-and-mortar companies. The most well known measure of liquidity of the firms are current and quick ratios (Yang et al. 2001; Pasiouras et al. 2006). Therefore, the following hypothesis is proposed.

H1: Internet companies' liquidity, measured in terms of *current ratio* and *quick ratio,* is comparable to the traditional companies' liquidity.

Internet related technologies enable firms to reduce inventory, decrease stock-out situations, and improve response time (Barua et al. 2004b), and organization's operational efficiency and effectiveness (Chang et al. 2003). For example, these dotcoms can enjoy the benefits of reduced transactions cost, smaller or no inventory, 24/7 access with minimal cost (Motiwalla et al. 2005). Thus, we assume that Internet companies have greater operational efficiency as compared with traditional brick-and-mortar companies. There are several common measures of profitability. *Operating margin* (OM) is considered as one of important profitability measures since it measure a firm's core operations by excluding interest expenses, other financing costs, and other non-operating income (Kudyba and Vitaliano 2003). *Return on assets* (ROA) has been the most commonly used measure of firm performance (Hitt and Brynjolfsson 1996; Bharadwaj 2000) and a useful performance measure since it incorporates organizational profitability and efficiency (Hunton et al. 2003). *Return on equity* (ROE) is also another performance indicator that was often used in previous research (Hitt and Brynjolfsson 1996; Wheale and Amin 2003; Shin 2006). Regarding the Internet companies, the obvious ability of reaching a large customer base combined with the indisputable advantages of reduced costs should translate into higher profitability. Thus, the following hypothesis is proposed.

H2: Internet companies' profitability, measured in terms of *operating margin* (OM), *return on assets* (ROA), and *return on equity* (ROE), is greater than traditional companies' profitability.

Figure 1. Financial performance measure



Most of Internet companies finance their operations mainly with help of the venture capital and the stock market (Wheale and Amin 2003). More traditional sources of financing, such as bank loans, prevalent in the brick-and-mortar firms, are rather uncommon for Internet companies. Leverage, defined as ability to meet financial obligations in long-term, is also another important factor identifying financial difficulty. *Debt ratio* is a commonly used measure of leverage (Yang et al. 2001). Therefore, the following hypothesis is proposed.

H3: Internet companies' financial leverage, measured in terms of *debt ratio*, is lower than traditional companies' financial leverage.

The hypotheses can be summarized into the research model shown in Figure 1.

RESEARCH METHODOLOGY

The "matched sample comparison group" methodology is used to explore the potential differences in financial performance between Internet based and traditional brick-and-mortar companies. This method has also been used in previous studies (Bharadwaj 2000; Hunton et al. 2003). Our sample includes two groups; the treatment and control groups. The treatment group represents a sample of Internet companies and the control group represents companies that were selected to match the treatment group by size and industry.

Sample Selection

To select Internet firms, we started out with the list from USA Today Internet 100 Index (as of August, 9, 1999). This index consisted of 100 most relevant Internet companies at this time. To be included, the companies needed to have market capitalization of $200 millions and their share price needed to be at least $12 (Smith 1999). The selection from USA Today Internet 100 Index, assured that our treatment group included only firms which can be considered as Internet companies with relatively established business. Furthermore, this selection procedure increased comparability of the firms and minimized selection bias. From this initial list of 100 Internet companies, firms that are not included in Compustat were removed. Furthermore, firms that have merged with another firm or had missing data during the period from 1998 to 2003 were removed. As a result, the treatment group includes 16 firms.

To control for confounding changes in industry and the firm size, we followed some steps to select a matching control firm that is comparable to the treatment firm. Initially, firms from the same primary four-digit code as the treatment firm were selected from Compustat as potential control firms. Then, we used total assets and annual sales as the size measure, which are commonly used as proxies for the firm size and chose the firm that has the closest to the corresponding treatment firm's values in 1998. When no comparable control firms were available, we allowed the size measures to be between 70% and 130% of the treatment firm's values. Next, we allowed using three-digit SIC codes, and then if no potential firms are found, two-digit SIC codes are finally used to select the control firm. This method was also used in previous studies for selecting matching control group from the same industry and similar in size as the treatment group (Barber and Lyon 1996; Hunton et al. 2003). Once the potential control firm is selected, the firm is evaluated carefully to make sure that it is a traditional brick-and-mortar company. Companies with substantial portion of sales on Internet were not considered for the control group since they are considered "brick and click" companies. See the Appendix for the list of treatment and control groups.

For all treatment and control firms, we selected six years' (1998 – 2003) financial data. As a result, 192 data points were included in our analysis.

Table 1. List of financial ratios studied

Ratio	Category	Description
Current Ratio	Liquidity	Current assets / Current liabilities
Quick Ratio	Liquidity	(Current assets – inventories)/ Current liabilities
OM (Operating Margin)	Profitability	Operating income / Net sales
ROA (Return on Assets)	Profitability	Net income / Total assets
ROE (Return on Equity)	Profitability	Net income / Stockholders' equity
Debt Ratio	Leverage	Total debt / Total assets

Measuring Performance

To evaluate financial performance, we used ratio analysis, which is the most commonly used approach to measure a firm's performance (Beaver 1966; Altman 1968; Barney 1997; Bharadwaj 2000; Hunton et al. 2003). We used two liquidity based ratios (*current* and *quick* ratios), three profit based ratios (OM, ROA, and ROE) and one leverage ratio (*debt ratio*) for investigating the performance of 16 Internet companies and 16 traditional brick-and-mortar companies. Financial data from Compustat are pulled for these companies for the years from 1998 to 2003.

Liquidity ratios are used to examine the firm's ability to meet its current debts. Profitability ratios are used to determine firm's profitability or efficiency. Leverage ratios are used to predict the long-term solvency of the firm. The list of the financial ratios included in this study is shown in Table 1.

RESULTS

Descriptive Statistics

To assure the comparability between the treatment and control groups, a t-test and non-parametric (Mann-Whitney) tests were carried out. As depicted in Table 2, on average, treatment group's total assets were slightly larger and control group's sales were slightly larger. However, these differences were statistically insignificant. Therefore, it could be assumed that the characteristic of companies included in the control group is comparable to these selected for the treatment group.

Results of the Differences Between Two Groups

Table 3 summarizes the results of the differences of financial performance, as captured by studied ratios, between the treatment and control groups. The t-statistics from the t-test and the Z-statistics from the Mann-Whitney (non-parametric) test

Table 2. Descriptive statistics for Internet (Treatment) and traditional (Control) firms

Variables	Treatment group		Control group		T-test (p value)	Mann-Whitney Test (p value)
	Mean	Std. dev.	Mean	Std. dev.		
Total assets (in million)	266.3	338.6	225.1	226.5	-0.405 (0.323)	0.226 (0.821)
Sales (in million)	109.0	154.9	147.2	148.9	0.712 (0.765)	-1.131 (0.258)

Table 3. Performance differences between treatment and control firms

Performance measures	1998		1999		2000	
	T	Z	T	Z	T	Z
Current Ratio	1.513	1.697 [c]	2.375 [b]	2.392 [b]	-0.249	-0.900
Quick Ratio	2.376 [b]	2.232 [b]	2.997 [a]	2.717 [a]	0.107	1.068
OM	-3.237 [a]	-2.374 [b]	-3.006 [a]	-2.299 [b]	-2.587 [b]	-2.337 [b]
ROA	-2.605 [b]	-3.110 [a]	-1.950 [c]	-3.034 [a]	-2.709 [b]	-3.467 [a]
ROE	-0.671	-2.412 [b]	-2.142 [b]	-2.808 [a]	-0.485	-2.714 [a]
Debt Ratio	-2.396 [b]	-2.105 [b]	-1.464	-1.818 [c]	-1.162	-1.780 [c]
Performance measures	**2001**		**2002**		**2003**	
	T	Z	T	Z	T	Z
Current Ratio	-0.621	-0.669	-0.552	-0.051	0.870	0.956
Quick Ratio	-0.531	-0.679	-0.012	-0.707	1.474	1.508
OM	-2.842[a]	-2.940[a]	-1.669	-1.508	-0.774	-0.720
ROA	-3.768[a]	-3.241[a]	-2.660[b]	-2.770[a]	-1.634	-1.222
ROE	-2.435[b]	-2.789[a]	-2.200[b]	-2.789[a]	-1.772 [c]	-1.397
Debt Ratio	-0.956	-1.677[c]	-1.335	-1.780[c]	-1.390	-1.538

[a] *1 % level*
[b] *5 % level*
[c] *10 % level*

are reported. A negative sign before the test statistic indicates that the performance of the treatment group (Internet firms) is lower than the control group (brick-and-mortar companies) and a positive sign indicates otherwise.

Results from the analysis were as follows: First, the Internet firms' *current* and *quick* ratios were higher than the traditional firms in 1998, 1999, and 2003 although they were not significant in 2003. The positive signs of these ratios indicate the Internet firms' ability to meet short-term obligations is high. However, these ratios have changed to negative and low during 2000 to 2002 although they were not significant. The unusually high ratios in 1998 and 1999 could be easily explained with high cash reserves initially raised from investors. In contrast, beginning in 2000 the *current* and *quick* ratios of the Internet and traditional companies are not significantly different. Based on these results our hypothesis 1 seems to be supported.

All differences in profit ratios in each of the six years were negative. Thus, the average performance of the treatment group was significantly lower than that of the control group.

For example, OM was significant and negative for all years except for 2003. This shows that, on average, Internet companies were not able deliver their products or services at high price while keeping their costs low. ROA was significant and negative for all years except for 2003. Also, ROE was significant and negative in 2001 to 2003. These profitability ratios indicate that Internet firms were not as profitable as the traditional firms. Therefore, our hypothesis 2 is not supported.

The negative *debt ratio* in each of the six years indicates that the treatment group's leverage ratios were lower than that of the control firms. Thus, it indicates that Internet firms are considered to be less leveraged than traditional firms. Companies that are highly leveraged are believed to be at greater risk of bankruptcy if they cannot make payments on their debt. In other words, when financing their business operations, Internet companies seem to rely more on equity investors than on banks and other creditors. Our hypothesis 3 seems to be supported.

DISCUSSION OF RESULTS

The results of our analysis show substantial similarities and differences in accounting measures of Internet as compared to the traditional brick-and-mortar companies. In the line with our expectations, the liquidity (as measured by *current* and *quick* ratios) of Internet companies is comparable to the liquidity of brick-and-mortar companies. In addition, as we expected, the Internet companies still rely on investors and equity as main source of financing their business and their average *debt ratio* is low.

Contrary to our expectations, the average performance of the Internet companies was significantly worse than that of traditional brick-and-mortar companies. Our results are also contrary to the common theory that companies constantly learn to be more efficient as they stay in business (Jovanovic 1982). Accordingly to this theory, companies which are not able to learn and improve their efficiency to match their competitors are not likely to survive over long term.

Surprisingly, the differences in performance did not prevent the studied Internet companies to successfully survive the dotcom crash. Moreover, these differences did not diminish over the time and even the most current financial records of Internet companies are still dissimilar from the brick-and-mortar companies. One possible explanation could be that the negative differences in the business performance (as measured by OM, ROA, and ROE) reflect the relatively early stage in the development of these companies and very vibrant but growing market. Contrary to the brick-and-mortar companies, Internet companies must invest heavily to protect and build their market shares. They are less likely to have the luxury to rely on established brands, protected or highly regulated markets, or loyal customer base. This claim could be supported by the observation that in Internet companies financial accounting losses are accepted by the investors as necessary strategic investments and often rewarded with increasing stock prices (Wheale and Amin 2003).

Results of our study are summarized in Table 4.

Table 4. Summary of results

Hypothesis	Supported?	Results
H1	Yes	Liquidity of Internet companies is comparable with traditional brick-and-mortar companies
H2	No	Profitability of Internet is lower than the profitability of traditional brick-and-mortar companies
H3	Yes	Financial leverage of Internet companies is lower as compared with traditional brick-and-mortar companies

CONCLUSIONS AND FUTURE RESEARCH PLANS

Contrary to our expectations, the average financial performance of the Internet companies was significantly worse than that of traditional brick-and-mortar companies. Although we expected that the Internet companies should be more efficient since these companies made great deal of investment in technology to support e-commerce business operations, our results indicated otherwise.

There are several limitations of our study. First, Internet companies in our sample are those who survived after the dotcom crash and did not go bankrupt or merged. All Internet companies studied were still in operations as of year 2003. Second limitation of our study is that accounting measures might not be the best measures although they are the most commonly used financial performance measure in the previous studies. Third our results are limited to only six ratios. A greater number of ratios may yield different results. In addition, our results are based on relatively short series of data. As mentioned earlier in our analysis, we only used available financial information from the years 1998-2003. It is possible that a longer time period might produce different results. Finally, another limitation is our relatively small sample size of companies studied, which might limit the generalizability of the findings although it does not affect our ability to draw the conclusion.

In spite of these limitations, we believe our study made an important contribution to the research by exploring financial performance of Internet companies using ratio analysis. Research comparing the Internet companies with traditional companies can provide valuable information to IT managers searching for higher productivity or profitability. For companies engaged in e-commerce, this kind of research could help to determine their optimal level of IT investments. Furthermore, it points out the potential gaps in performance which can then be addressed by business managers.

There are plenty of research opportunities related to our study. One future research could simply validate our results with the expanded sample size of companies and an expanded set of financial ratios. Further research opportunity is also to find out the portion of technology investment of Internet companies and determine the productivity or profitability impact from IT. Although Internet companies were not as profitable or efficient as the traditional companies in our study, the years that we have studies might have caused the different outcome since many of Internet companies went out of business during this period. It might be worth investigating using financial data beyond year 2003 to determine if these companies' performance is improving.

REFERENCES

Altman, E.I. "Financial Ratios, Discriminant Analysis and the Prediction of Corporate Bankruptcy," *The Journal of Finance* (23:4) 1968, pp 589-609.

Barber, B.M., and Lyon, J.D. "Detecting Abnormal Operating Performance: The Empirical Power and Specification of Test Statistics," *Journal of Financial Economics* (41:3) 1996, pp 359-399.

Barney, J.B. "What is performance?," in: *Gaining and Sustaining Competitive Advantage*, Addison-Wesley, Boston, MA, 1997, pp. 30-64.

Barua, A., Brockett, P.L., Cooper, W.W., Deng, H., Parker, B.R., Ruefli, T.W., and Whinston, A. "DEA evaluations of long- and short-run efficiencies of digital vs. physical product "dot com" companies," *Socio-Economic Planning Sciences* (38:4) 2004a, pp 233-253.

Barua, A., Konana, P., and Whinston, A. "An Empirical Investigation of Net-Enabled Business Value," *MIS Quarterly* (28:4) 2004b, pp 585-620.

Beaver, W.H. "Financial Ratios as Predictors of Failure," *Journal of Accounting Research* (4:Empirical Research in Accounting: Selected Studies 1966) 1966, pp 71-111.

Bharadwaj, A.S. "A resource-based perspective on information technology capability and firm performance: An empirical investigation," *MIS Quarterly* (24:1) 2000, pp 169-196.

Bose, I., and Pal, R. "Predicting the survival or failure of click-and-mortar corporations: A knowledge discovery approach," *European Journal of Operational Research* (174:2) 2006, pp 959-982.

Chang, K.-C., Jackson, J., and Grover, V. "E-commerce and corporate strategy: an executive perspective," *Information & Management* (40:7) 2003, pp 663-675.

Hitt, L., and Brynjolfsson, E. "Productivity, Business Profitability, and Consumer Surplus: Three Different Measures of Information Technology Value," *MIS Quarterly* (20:2) 1996, pp 121-142.

Hunton, J., Lippincott, B., and Reck, J.L. "Enterprise resource planning systems: comparing firm performance of adopters and nonadopters," *International Journal of Accounting Information Systems* (4:3) 2003, pp 165-184.

Javalgi, R., Cultler, B., and Tood, P. "An Application of an Ecological Model to Explain the Growth of Strategies of Internet Firms: The Case of eBay and Amazon," *European Management Journal* (22:4) 2004, pp 464-470.

Jovanovic, B. "Selection and the Evolution of Industry," *Econometrica* (50:3) 1982, pp 649-670.

Khan, M.R. "Forrester: E-Commerce Sales in Multi-channel World Surged 22% to $172B in 2005," in: *DM News*, January 17, 2006.

Kudyba, S., and Vitaliano, D. "Information Technology and Corporate Profitability: A Focus on Operating Efficiency," *Information Resources Management Journal* (16:1) 2003, pp 1-13.

Motiwalla, L., Khan, M.R., and Xu, S. "An intra- and inter-industry analysis of e-business effectiveness," *Information & Management* (42:5) 2005, pp 651-667.

Pasiouras, F., Gaganis, C., and Zopounidis, C. "Multicriteria decision support methodologies for auditing decisions: The case of qualified audit reports in the UK," *European Journal of Operational Research* (upcoming) 2006.

Santhanam, R., and Hartono, E. "Issues in Linking Information Technology Capability to Firm Performance," *MIS Quarterly* (27:1) 2003, pp 125-153.

Shama, A. "Dot-coms' coma," *The Journal of Systems and Software* (56:1) 2001, pp 101-104.

Shin, N. "The impact of information technology on the financial performance of diversified firms," *Decision Support Systems* (41:4) 2006, pp 698-707.

Smith, E.B. "New index measures wide range of Net stocks," in: *USA Today*, August 9, 1999.

Thornton, J., and Marche, S. "Sorting though the dot bomb rubble: how did the high-profile e-tailers fail?," *International Journal of Information Management* (23:2) 2003, pp 121-138.

U.S. Census Bureau "Quarterly Retail E-Commerce Sales 4th Quarter 2004," in: *United States Department of Commerce News*, February 24, 2005.

Wheale, P.R., and Amin, L.H. "Bursting the dot-com 'Bubble': A Case Study in Investor Behaviour," *Technology Analysis & Strategic Management* (15:1) 2003, pp 117-136.

Yang, B., Li, L.X., Ji, H., and Xu, J. "An early warning system for loan risk assessment using artificial neural networks," *Knowledge-Based Systems* (14:5-6) 2001, pp 303-306.

APPENDIX 1: TREATMENT AND CONTROL COMPANIES

Treatment Group	Control Group
Amazon.com	Bay St Bancorp Inc
Ameritrade	Blair Corp
Autobytel	Calif First National Bancorp
Barnesandnoble.com	Elbit Vision Systems Ltd
Broadcom	Electro Scientific Inds Inc
Checkfree Holdings	Electro Rent Corp
DoubleClick	First Albany Companies Inc
eBay	Hummingbird Ltd
iVillage	Integral Systems Inc
MarketWatch	Mercury Interactive Corp
Multex.com	Medquist Inc
Net.Bank	Obie Media Corp
Priceline.com	Pervasive Software Inc
Sportsline USA	Pinnacle Data Systems Inc
TheStreet.com	Softech Inc
Yahoo	Star Gas Partners –LP

Data Mining of Crime Research Information Statistics Portal: The Experience and Lessons Learned

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ABSTRACT

In an effort to find interesting information in a volume of crime data provided by the Secure Police Department (a fictitious name), we applied data mining techniques and algorithms to this data. We discovered that data mining is an effort that takes a lot of planning and preparation, requires domain expertise, and is extremely resource intensive. The results we got are lackluster, for instance, correlations and patterns from the results are readily apparent, they are very rarely of the "interesting" variety. However, we think the experience and lessons learned have helped us and will help others be prepared for any future similar endeavors. The lessons can be summarized as: 1) Planning and preparation is a key to successful data mining, 2) Domain expertise is a necessity to perform successful data mining, 3) Data mining applications are extremely processor and main memory resource intensive and the appropriate hardware and software are necessary for successful data mining.

INTRODUCTION AND BACKGROUND

In the United States today crime is a major concern. The CIA, FBI, and other federal agencies are concerned with national security; city and county law enforcement agencies keep a constant vigil on criminal activities in their own jurisdictions; and individuals are worried about their safety within the community. In the meantime, the budget for local law enforcement and intelligence agencies takes a hit due to mediocre economic growth, which leads to downsizing of both personnel and programs. To better make decisions and optimally allocate limited resources, local law enforcement and intelligence agencies need better quality information in a timely manner.

It has been observed that "A major challenge facing all law-enforcement and intelligence-gathering organizations is accurately and efficiently analyzing the growing volume of crime data" (Chen et al., 2004). As the volume of this crime data becomes enormously large, new techniques have to be used to turn this data into usable information and knowledge; and thus, appropriate actions can be taken accordingly. Data mining holds the promise of making it easy, convenient, and practical to explore very large databases for law enforcement and intelligence agencies. Data mining is a powerful tool that uses complex algorithms to look for patterns in very large sets of data. Criminal investigators who may lack extensive training as data analysis can easily explore large databases quickly and efficiently through the implementation of data mining techniques in the form of commercial and other applications (Chen et al., 2004; Fayyad and Uthurusamy, 2002).

The Shared Urban Data System (SUDS) is a web based secure portal that has been created as part of the Community Information Project by the Center for Community Criminology and Research at the *Academic University* (a fictitious name) located in the Mid-south area. SUDS provides a host of information-based services for the local community including neighborhood planning and development, public safety, and public health, etc. While SUDS is a portal to all information and services housed in a large number of databases, the CRISP (Crime Research Information Statistics Portal) system is a more specific subset of information services tied to a single database. The CRISP database is of crime incident information provided by the *Secure Police Department* as part of the Community Information Project. The database is used for queries and reports centered on offense types, geographic locations (through a GIS mapping interface), dates and time ranges, and suspect and victim information.

This paper describes a project that applied a variety of data mining techniques to the CRISP database using a commercial data-mining tool. The tool selection was based on the tool availability, usage characteristics, and architecture. The tools evaluated were IBM Intelligent Miner, SPSS Clementine, and Megaputer PolyAnalyst. Our eventual decision to use Megaputer PolyAnalyst 5.0 was due to the availability to the student for a research product, the ability to use the tool directly, via ODBC, in connection with an SQL Server 2000 server without an intermediate tier, and the incorporation of a large number of data mining algorithms available within the base program.

LITERATURE REVIEW

Our summary of existing research literature on data mining of crime data is organized as follows. We first talk about the imperatives of applying data mining techniques to crime data and we then go into details on different data mining techniques that have been successfully applied to crime data.

To us, the marriage between data mining techniques and crime data happened naturally. A retrospective review tells that there are roughly three major reasons why this happened. First, the volume of crime data has become unwieldy. When investigating a crime, law enforcement agencies usually record as much information as possible about the crime. After the attack on WTC in New York City on September 11, 2001, concern about national and local security has increased dramatically. At a national level, the FBI, CIA and Homeland Security are all acting to collect and analyze information to prevent further terror attacks. These efforts have had an affect on local authorities, motivating them to monitor criminal activities in their own jurisdictions using similar intelligence techniques (Chen et al., 2004). All above activities result an exponential increase in the volume of crime data. Manual processing of this data is not feasible anymore; new techniques to accurately and efficiently process crime data had to be found.

Second, the budget for local law enforcement and intelligence agencies continues to see reductions due to mediocre economic growth (as of this writing in 2006). These economic factors lead to downsizing of both law enforcement personnel and programs. To better make decisions and optimally allocate limited resources, leadership in law enforcement needs quality information in a timely manner.

Third, its ability to reveal patterns in extremely large data sets makes data mining a tool that fits this job perfectly (Brown, 1998). Compared to manual processing, which is time and labor intensive, data mining holds the promise of making it easy, convenient, and practical to explore very large stores of crime data for law enforcement organizations and users.

There are many data mining techniques can be applied to crime data. Some examples of the specific applications and techniques of this work are given below as derived from current scholarly literature on the data mining of crime data.

Lin and Brown (2006) present an outlier-based data association method for linking criminal incidents. In this technique, according to them, "an outlier score function is defined to measure the extremeness of an observation, and a data association method is developed based upon the outlier score function." They applied this

method to the robbery data in Richmond, Virginia, and compared the result with a similarity-based association method. Their results show that the outlier-based data association method is promising.

Estivill-Castro and Lee (2001) incorporate two knowledge discovery techniques, clustering and association-rule mining, into a fruitful exploratory tool for the discovery of spatial-temporal patterns. They present two methods for this exploratory analysis and the detail algorithms to effectively explore geo-referenced data. They illustrate the algorithms with real crime data. They demonstrate their approach to a new type of analysis of the spatial-temporal dimensions of records of criminal events.

Brown (1998) describes a software framework for building and applying data mining algorithms to crime analysis problems. This framework provides specific focus on spatial data mining. The author provides several reasons to justify this focus: 1) spatial queries are more time consuming, 2) spatial analysis is harder to do than analyses based on attribute matching, 3) spatial data mining has the potential to yield important immediate benefits for crime analysis as crimes have an inherently spatial component (Brantingham and Brantingham, 1984), and 4) spatial analysis is a key to law enforcement resource allocation.

Chen et al. (2004) present a general framework that shows the relationship between data mining techniques applied in criminal and intelligence analysis and the crime types. They identify and arrange eight crime types (traffic violations, sex crime, theft, fraud, arson, gang/drug offences, violent crime, and cyber crime) in increasing order of public harm on the horizontal axis. On the vertical axis, they arrange the techniques in increasing order of analysis capability. They identified four major categories of crime data mining techniques: entity extraction, association, prediction, and pattern visualization. Each category represents a set of techniques for use in certain types of crime analysis. They then identified the intersection of the techniques with the crime types denoting where each technique could be effectively used for each crime type, completing the framework.

THE ARCHITECTURE USED IN THIS STUDY

PolyAnalyst is a product of Megaputer, and Version 5.0 is the latest version of PolyAnalyst. It is a data-mining tool that incorporates a large number of data mining algorithms in a single package. It can be configured to work as a traditional client server application or can be set up in a multi-tier architecture with a dedicated PolyAnalyst server. The client server implementation can be configured to read the data from the database importing all of the data into the project file created by PolyAnalyst or, alternatively, a subset of the algorithms can be used, via OLEDB to mine the data in place. We took the conventional means of using a traditional client server approach and allowed the application to import the data. Our connection to the database was done over a wide area link via a secure VPN connection to the network of *Academic University* to the SQL Server 2000 server where the CRISP data was located.

Some challenges encountered were the ability of the program to deal with the large amount of data and the physical limitations of the client server infrastructure. With the size of our datasets being much larger than 500,000 records, the PolyAnalyst program seemed to have some difficulty reading and dealing with a dataset this size given the simple client server configuration. In talking with the representatives of Megaputer, many of these shortcomings would be addressed by moving to a multi-ties architecture, using more advanced, server-based, architecture. Running the client under Windows XP Professional or Windows 2000 workstation would often reach the 4 GB limit on the operating systems address space.

To get around some of the limitations, we used a strategy that allowed us to work with smaller subsets of the data. Since we had to select our data via a join across six tables to get the information that we need, we included conditions that would select one year at a time in our data selection statements. Once we had the data imported into PolyAnalyst in a project file, we further subdivided the data into more manageable sections for testing different algorithms prior to starting large mining runs.

DATA PREPARATION AND ANALYSIS

Discussions with criminologists to narrow area of interest and type of discovery led us to believe that weapons crimes, specifically gun related crimes, were of particular interest to the SUDS team. There is a special program within the *Secure Police Department* at this time to crack down on gun crime. Anything that could be found to assist in the pursuit of this endeavor would be seen as a positive production of information from a data mining perspective.

Prediction and prevention are other major goals of the *Secure Police Department* and something that they would like to be able to do better. If a model can successfully predict some criminal activities, prevention mechanism can be deployed to effectively prevent some crimes from being committed. This would aid in crime deterrence and more effective utilization of police resources. Any information that data mining could provide to assist in the mission of prediction and prevention would be seen as positive generation of information.

Geospatial Modeling using Geographic Information Systems (GIS) is a very powerful tool that can be used to visually present crime data based on geospatial features. These kinds of presentation can be used to spot crime patterns. This type of information and modeling is being done on a small scale through the SUDS project at this time. A larger and more automated effort than the current one is desirable. There is the potential to create such special game maps from the data used from the CRISP database.

Data preparation for our task was significant and mostly a trial-and-error experience. The data had been pre-cleaned for the SUDS project so most problems had been dealt with. Other than having to tune our selection SQL to return meaningful, yet manageable dataset, we had to convert string values to categorical and Boolean fields that PolyAnalyst could interpret and also to handle some missing values that were in the data. In the creation of a commercially viable data-mining tool, Megaputer had to create generic algorithms that could be used under a wide variety of circumstances. In doing so they had to place some restrictions and criteria on the input of data to the algorithms. Such restriction took the form of selective data types, for example. When using a directed algorithm, such as a Decision Tree, a target attribute could only be of certain data types (say, categorical). A previous understanding of the direction of the inquiries and the organization of the data will help greatly in setting up the data sets for analysis.

Part of the data preparation was to study the metadata that we had been provided by the criminologists and system administrators of the SUDS database for context and use of the attributes. While a lot of the variables appeared straightforward, some variables needed explanation as to their particular use or importance, relevant to our tasks of data exploration. Redundancies and other dimensionality reductions were done at this point. There was often overlap from one table to another that was not apparent due to lack of naming conventions and other factors.

The analysis that we performed on the dataset was largely explorative in nature. We looked at many algorithms to see if we could apply some of them to our project. Below are a list of the techniques we considered and a brief description of the algorithms used taken from the PolyAnalyst User Manual.

- Nearest Neighbor - The Nearest Neighbor exploration engine uses a memory-based classification system: assigning values to data points based on their "proximity" to other data points.
- Market Basket - The explored dataset consists of some number of records which are referenced below as "transactions" and a number of attributes or "products." The Basket Analysis engine finds sets of products that are present together in a significant part of all transactions. Such typical sets are called baskets of products. Certain additional limitations can be imposed when searching for these baskets, such as specifying the minimum portion, in percent, of all transactions containing a discovered basket.
- Cluster - Clustering is one of typical problems solved by data mining methods. This is a process of grouping cases or database records into subsets, such that the degree of similarity between cases in one group is significantly higher than between members of different groups. An exact definition of the similarity between cases as well as other details varies for different clustering methods.
- Decision Tree – This is the name given to large family of machine learning algorithms for the automated construction of tree-like classification rules for categorizing structured data. The process of creating a Decision Tree can be represented as splitting the analyzed dataset into diminishing parts consisting of increasingly homogeneous records: in terms of the percentage of different values of the target field.
- Text Analysis - The Text Analysis exploration engine performs morphological and semantic analysis of unstructured textual notes in a database format. Text Analysis extracts and counts the most important words and word combinations from textual notes, and stores terms-rules for tokenizing database records with patterns encountered terms.

Once we had created subsets of our main dataset it was easy to test many algorithms for their appropriateness. The subsets of the datasets were done with tools in PolyAnalyst that would let you take random, top or bottom samples to create data subsets. They could be done on a percentage of total records or a total count basis. You could also decide which of the attributes to include in the subsets of data. Once the subsets were created it was a simple matter to choose that subset and apply a technique to it. Similarly, you could use a subset to train a directed algorithm and then apply the rule set generated by the training to the remaining data, or the World data as it was referred to in PolyAnalyst.

The analyses that we completed included a Link Analysis, a Decision Tree, and a Text Analysis. We directed our decision tree and link analysis algorithms to target the attribute that contained values for "Weapon Type" and our text search was directed to search for weapons in the text phrases of the narratives given with each of the cases. PolyAnalyst contained built-in semantic libraries through a connection to external rule base for guiding the text search as well as common files of stop words. The results of the classification and association routines provided a large number of links, most of which were meaningless. Some of the more meaningful links, that had stronger correlation and coverage were also, unfortunately, quite intuitive. The text analysis looked primarily at occurrences and the results there seemed good, but not perfect. For example the semantic database picked up on 35 occurrences of the term "cutlass" in the narratives and determined that it was a weapon. Although this is possible, we found it more probable that these occurrences were in reference to an Oldsmobile and not to a sword fight.

RESULTS AND DISCUSSION

A result that became readily apparent in all of our analyses was that correlations are easily found and meaningless correlations are even easier to find. For example, the use of a weapon in crimes of type "Assault" had a large correlation and coverage from several of the algorithms giving the rule:

Assaults ⇔ Weapon Use

Similarly the absence of the use of a weapon in crimes of type "Home Burglary" had a large correlation and coverage from several of the algorithms giving the rule:

Home Burglary ⇔ No Weapon

Even more simplistically the correlations where 2 geographic location identifications were used in the same algorithm they were both correlated as can be seen by the following rule:

Zip code ⇔ Precinct and Ward

It was the "interesting" correlations that proved to be elusive to our exploration.

CONCLUSIONS, LESSONS LEARNED, AND FUTURE DIRECTION

Although the things that were learned here are not ground breaking or revolutionary, they were situations that we encountered in the actual attempt to perform a data mining exercise from scratch. While there are many studies and publications that talk about data mining and crime data analysis, these lessons "from the field" are presented here as practical information for both researchers and practitioners.

A major revelation in our data mining trials was that the preparation and planning is central to data mining; whereas the execution of algorithm and analysis can be an easy part. We spent much more time up front researching the importation, mapping, cleaning, and retyping of data than we did on the exploration phase of the project. Similarly we found that setting up a tool to mine existing data can be a challenging and time consuming process. The data preparation could have been done better to accommodate the tool and made the data mining process a lot easier. The data, which was primarily in string fields for use in a web portal environment, was not conducive to data mining. For example, it would have been much easier to manipulate those fields with a value of "True" or "False" if the field values were 1 or 0, respectively, in a data-mining context.

Another finding from this study was that this type of analysis is highly domain exclusive and a domain expert is an important resource. Without the assistance of criminology resources and even resources that had domain knowledge specific to our dataset, the task of exploration would have been much more difficult.

We also developed a new appreciation for how resource intensive data mining is. The ability to saturate a 4 GB address space in a matter of minutes of processing was impressive and let us know just how important it is to use well tuned and efficient algorithms and code in the data mining task. It was also apparent that these analyses were very processor intensive as well as main memory intensive. Some of the algorithms took several hours to run on datasets that were 80-90 thousand records in size.

In the future, we plan to develop a better understanding of tool and data handling inside the tool. This would make it much easier and less time consuming for us to choose the algorithm and prepare the data for that algorithm. This would also let us have more precision in selecting and assigning values to parameters of the algorithms. We would also like to be able to determine more interesting questions for exploration and analysis. This would involve a great deal more time with the criminologist and possibly with the police departments to find out what is of interest and helpful to them as we choose datasets, attributes and algorithms. Another improvement that could be done to advance this line of study would be to improve the infrastructure to handle larger datasets. The addition of another tier with a dedicated PolyAnalyst server would facilitate the use of larger datasets and give quicker processing times.

Applying data mining techniques on crime data is not an option, but a necessity. Data mining, given quality data and the appropriate techniques, can bring forth accurate information in a timely fashion and this information can enhance decision-making and analysis for all law enforcement agencies. Past successes in crime data mining suggest the future of it is very promising. We think our experience and lessons learned during this exploratory study have helped us and will help others be prepared in any future similar endeavors.

REFERENCES

Brantingham, P. and Brantingham, P. (1984). *Patterns in Crime.* Macmillan Publishing Company, New York.

Brown, D.E. (1998). The Regional Crime Analysis Program (ReCAP): A Framework for Mining Data to Catch Criminals. *Proceedings of 1998 IEEE International Conference on Systems, Man, and Cybernetics,* 3: 2848-2853.

Chen, H., Chung, W., Xu, J.J., Wang, G., Qin, Y., and Chau, M. (2004). Crime Data Mining: A General Framework and Some Examples. *Computer,* 37(4), 50-56.

Estivill-Castro, V. and Lee, I. (2001). Data Mining Techniques for Autonomous Exploration of Large Volume of Geo-Referenced Crime Data. *Proceedings of the 6th International Conference on Geocomputation.*

Fayyad, U.M. and Uthurusamy, R. (2002). Evolving Data Mining into Solutions for Insights. *Communications of ACM,* 45(8), 28-31.

Lin, S. and Brown, D.E. (2006). An Outlier-based Data Association Method for Linking Criminal Incidents. *Decision Support Systems,* 41(3), 604-615.

Ensuring Data Quality for Asset Management in Engineering Organisations*

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ABSTRACT

Data Quality (DQ) has been an acknowledged issue for a long time. Researches have indicated that maintaining the quality of data is often acknowledged as problematic, but is also seen as critical to effective decision-making. This paper investigates the issues emerging from unique nature of engineering asset data. It discusses the various asset management (AM) DQ issues and presents exploratory research on how engineering asset organizations in Australia are addressing DQ issues based on a large scale national-wide DQ survey that was conducted. It provides a better understanding of AM DQ issues and assists in identifying elements which will contribute towards the development of an AM specific DQ framework. The research findings suggest that while the organizations are concerning the quality of data, there is a disconnection between data custodians and data producers and high level data owners. The majority of AM organizations still adopt a reactive approach on DQ management.

1. INTRODUCTION

Almost every process and activity in the organisations involves data. Levitan and Redman (1998) suggest that data provides the foundation for operational, tactical, and strategic decisions. As data becomes increasingly important in supporting organizational decisions, modern organizations, both public and private, are now continually generating more data than at any other time before. More data, however, does not necessarily mean better information, or more informed business decisions. In fact, many are finding it difficult to use the data. It is estimated that more than 70% of generated data is never used (Koronios, 2006). Gartner Research (Desisto, 2004) found that bad data is worse than no data at all. There is strong evidence that most organisations have far more data than they possibly use; yet, at the same time, they do not have the data they really need (Levitan and Redman, 1998). Despite this apparent explosion in the generation of data it appears that, at the management level, executives are not confident that they have enough correct, reliable, consistent and timely data upon which to make decisions. Many say they are drowning in data and are starved of information.

Consequently, the quality of the data that managers use becomes critical. Poor-quality data, if not identified and corrected, often leads to decisions being made more on the basis of judgment rather than being data driven (Koronios et al., 2005). Without quality data, organisations are running blind and make any decision a gamble (ARC, 2004). This can lead to disastrous economic impacts on the health of the company. In some cases, it could also lead to catastrophic social consequences such massive power failures, industrial or aviation disasters.

Industry has recently put a strong emphasis on to the area of asset management (AM). In order for engineering organizations to generate revenue they need to utilize assets in an effective and efficient way. Often the success of an enterprise depends largely on its ability to utilize assets efficiently. In other words, asset management has been regarded as an essential business process in many organizations, and is moving to the forefront of contributing to an organization's financial objectives.

Previous studies in asset management suggest that a common, critical concern with engineering asset management is the lack of quality data (Eerens, 2003; IPWEA, 2002). Recent researches by U.S. GAO (2004) clearly demonstrates that achieving data quality is the key challenge engineering organisations face today in successfully implementing effective engineering asset management. Saunders (2004) indicated that although very large amounts of data is being generated from asset condition monitoring systems, little thought has been given to the quality of such generated data. Thus the quality of data from such systems may suffer from severe quality limitations.

As an important initiative proposed by the Australian federal government and the industry sector, studies were commenced in 2003 into the impact of the quality of data on AM organisations including the Royal Australian Navy, utilities, transportation and mining companies, and local governments. In 2006, a large scale national-wide survey was conducted into data quality issues in engineering asset management, with a sample size of 2000 and a response rate of over 23.9%. This is one of the largest nation-wide surveys of its kind, aimed as directly addressing data quality issues in engineering asset management organisations in Australia. This paper discusses the development of the data quality framework through this survey and presents some of its findings. Data and information are often used synonymously. In practice, managers differentiate information from data intuitively, and describe information as data that has been processed. Unless specified otherwise, this paper will use data interchangeably with information.

2. DATA QUALITY

Numerous researchers have attempted to define data quality (DQ) and to identify its dimensions (Wang et al., 1993; Fox et al., 1994; Wand et al., 1996; Wang et al., 1996; Shanks et al., 1998; Kahn et al., 2002). Traditionally, data quality has been described from the perspective of accuracy. However, many researches have indicated that DQ should be defined as beyond accuracy and is identified as encompassing multiple dimensions. Through literature, many authors have tried to explain the meaning of all relevant dimensions from several points of view (Strong, 1997; English, 1999; Ballou et al., 1998; Orr, 1998). Even, any of them have tried to identify a standard set of DQ dimensions valid for any data product; but as Huang et al. (1999) state, it is nearly impossible due to different nature of different data environment.

Four most frequently mentioned data quality dimensions in the literature are accuracy, completeness, timeliness and consistency (Liu, 2002; Naumann, 2002; Bouzeghoub et al., 2004; Batini et al., 2004; Strong, 1997). Unfortunately, a set of data may be completely satisfactory on most dimensions but inadequate on a critical few. Furthermore, improving on one DQ dimension can impair another dimension. For example, it may be possible to improve the timeliness of data at the expense of accuracy (Ballou et al., 1995). It may be complete at the cost of concise representation (Neely 2002). Moreover, different stakeholders in an organisation may have different DQ requirements and concerns (Giannoccaro et al., 1999). Data whose quality is appropriate for one may not be sufficient for another (Neely, 2002). The DQ dimensions considered appropriate for one decision may not be sufficient for other types of decisions. As a result, Wang and Strong (1996)'s widely-accepted definition of data quality "*quality data are data that are fit for use by the data consumer*" is adopted in this research.

Maintaining the quality of data is often acknowledged as problematic, but is also seen as critical to effective decision-making. Examples of the many factors that can impede data quality are identified within various elements of the data quality literature. These include: inadequate management structures for ensuring complete, timely and accurate reporting of data; inadequate rules, training, and procedural guidelines for those involved in data collection; fragmentation and inconsistencies among the services associated with data collection; and the requirement for new management methods which utilize accurate and relevant data to support the dynamic management environment.

Clearly, personnel management and organizational factors, as well as effective technological mechanisms, affect the ability to maintain data quality. Wang (1998) clarifies this relationship by drawing an analogy between manufacturing and the production of data. In this way they derive a hierarchy of DQ responsibilities, ranging from management processes down to individual procedures and mechanisms (Wang et al., 1995). Their framework specifies a top management role for DQ policy, i.e. overall intention and direction related to DQ, and a DQ management function to determine how that policy is to be implemented. This, in turn, should result in a DQ system for implementing DQ management, within which DQ control is enforced through operational techniques and activities. DQ assurance then comprises all of the planned and systematic actions required to provide confidence that data meet the quality requirements. With the aim of improving DQ, Wang (1998) also suggests a Total Data Quality Management (TDQM) framework (define, measure, analyze and improve) for continuously managing data quality problems.

3. ENGINEERING ASSET MANAGEMENT

According to British Standards Institute (2004), asset management encompasses activities that are aimed at establishing the optimum way of managing assets to achieve a desired and sustained outcome. The objective of asset management is to optimize the lifecycle value of the physical assets by minimizing the long term cost of owning, operating, maintaining, and replacing the asset, while ensuring the required level of reliable and uninterrupted delivery of quality service (Eerens, 2003; Spires, 1996; IPWEA, 2002). At its core, asset management seeks to manage the facility's asset from before it is operationally activated until long after it has been deactivated. This is because, in addition to managing the present and active asset, asset management also addresses planning and historical requirements.

Asset management is process-oriented. The AM process itself is quite sophisticated and involves the whole asset lifecycle that can span a long period of time (Steed, 1988). The lifecycle for a typical asset involves several interdependent stages including design, plan, acquisition, installation, operation, maintenance, rehabilitation and disposal. At every stage of the process, AM also needs to collaborate and synchronize with other business processes, which is vital to the effective management of engineering assets. The cost and complexity of engineering assets demands considerable planning to identify appropriate solutions and evaluate investment opportunities. These same characteristics are reflected in the need for an extended acquisition process, a comprehensive request for proposal, and an equally comprehensive purchase agreement that addresses guarantees and warranties. Installation and placing in service of engineering assets is also complex and requires a proper set of processes to manage contractors. Once the asset is acquired, it must be tracked throughout its useful life. Finally, records must be made of its eventual disposition.

The sophistication of the engineering asset management process requires substantial information to be collected throughout all stages of a typical asset's lifecycle. This information needs to be maintained for a very long time, often dozens of years in order to identify long-term trends. This kind of process also uses this information to plan and schedule asset maintenance, rehabilitation, and replacement activities. In order to manage and support the complicated AM process and its data requirements, a variety of specialized technical, operational and administrative systems exist in asset management. These not only manage, control and track the asset through its entire lifecycle, but also provide maintenance support throughout the lifecycle of the asset. Considering the complexity and importance of asset management, these systems are normally bought from multiple vendors and each is specialized to accomplish its task. Unfortunately, this leads to an extremely difficult integration job for the end-user.

Engineering processes rely heavily on input of data and also produce a large amount data. Engineering data itself is quite different to typical business-oriented data as illustrated in Table 1. It has unique data characteristics and complex data capture processes from a large variety of data sources. This large amount of data therefore can suffer from data quality problems. The nature of such data quality problems has not previously been investigated in Australian engineering-oriented organizations.

4. RESEARCH DESIGN

In DQ studies, four types of stakeholders have been identified: data collector, data custodian, data consumer, and data owner (Strong, 1997; Wang, 1998). In this study, DQ stakeholders in asset management are defined as follow:

- Data collectors are those who create or collect asset data e.g. technician, data entry staff;
- Data custodians are those who design, develop, manage, and operate the asset management information systems e.g. IT manager, data manager;
- Data consumers are those who use the asset information in their work activities e.g. maintenance engineer, senior manager;
- Data owners are those who own and responsible for managing the entire data in asset management systems e.g. asset manager.

The DQ survey was designed to address the questions developed in the literature review, in order to understand the general perceptions towards data management issues and further establish the extent of data quality maturity. A multi-section questionnaire were mailed to a 2000 large random sample of asset manager, data collector, data custodian and data consumer, in 1100 geographically dispersed engineering asset management organizations in Australia (including 572 organizations in the public sector). The questionnaire provided a guideline in the beginning to ensure that respondents had a common understanding of the various sections and definitions. The questionnaire was pre-tested by initially mailing it to 15 companies. Changes were incorporated and the questionnaires were then mailed to the remaining companies. The survey population for the questionnaire was chosen from engineering asset management organizations based in Australia. These organizations represent a variety of industries:

- utility (water, electricity, gas, oil);
- mining & resources;
- transport (rail, airline, ship, automobile);
- defence; and
- local government.

This list was matched with databases like the Business Who's Who of Australia and the specific industry-related associations to develop a list of Australian AM organizations. We believed that being the key participants or leaders in the major areas of engineering asset management, these organizations would be potential candidates for having AM information systems. Once the data was collected, statistical tools & methods were used to analyze the data and report the results. The results of this survey study were used to develop an AM DQ framework. The AM DQ framework will form the foundation for further research in order to perform data audit to identify nature and volume of DQ problems, and to develop a specification of the functional requirements for asset management data cleansing & enrichment software packages

5. THE AM DQ FRAMEWORK

Based on the analysis of DQ and AM literature together with the empirical findings from the DQ survey, *an* AM specific DQ framework was developed as shown in Figure 1. This framework is useful to guide the research into AM DQ issues, because it highlights the root perspectives on DQ problems, illustrates how they emerge during the process of AM; and outlines the basic DQ management criteria.

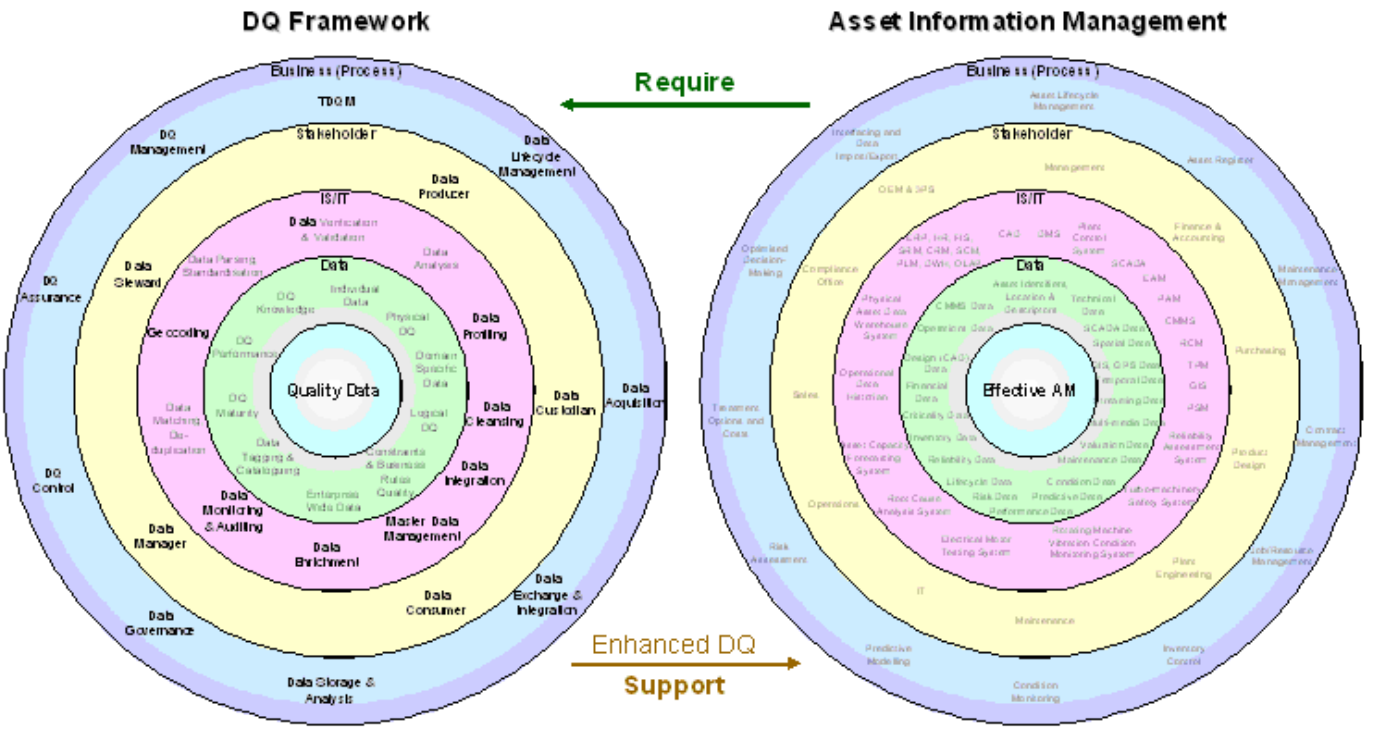
Asset data is the key enabler in gaining control of assets. These asset data is created, processed, stored, and used throughout an asset's lifecycle by a variety of stakeholders together with an assortment of technical and business systems during the whole AM process. The quality asset data in turn provides foundation for effective asset management. As asset information management underlies all the asset-based management processes, the ensured DQ for asset information management assists the optimization of AM decision-making.

Because these asset data are quite different to typical business data, in order to ensure the quality of these asset data, AM DQ also has its own process, which also involve multiple DQ stakeholders such as data collector, data custodian, and

Table 1. Differences between engineering asset data and typical business data (Source: Developed by the authors)

Element	Typical Business Environment	Engineering Asset Management
Data Environment	Transaction-driven, product-centric business data environments	Continuous data, process-centric open control system and manufacturing data environments
Data Characteristics	• Self-descriptive • Static • Intrinsic quality • Discrete value with fewer or no constraints • Current • Transactional data • Often structured • Easy to audit • Can be cleansed using existing tools • Similar data types	• Non self-descriptive • Dynamic • Intrinsic / extrinsic quality • Continuous value with constraints (e.g. within a range), precision value • Temporal • Time-series streaming data • Often unstructured • Difficult to be audited • Difficult to be cleansed using existing tools • Diversity of data types
Data Category	Inventory data, customer data, financial data, supplier data, transaction data etc	Inventory data, condition data, performance data, criticality data, lifecycle data, valuation data, financial data, risk data, reliability data, technical data, physical data, GPS data etc
Data Sources	Mainly transaction-based textual records from business activities	Disparate data sources • Spatial data – plans/maps, drawings, photo • Textual records – inspection sheets, payment schedules • Attribute records – separate databases, maintenance/renewal records, fault/failure records, field books • Real-time CMS/SCADA • Other sources – existing/previous staff and contractors, photos
Data Capture	• Often manually by data providers in fixed format • Data often entered by reasonably trained, dedicated personnel with proper relevant knowledge • Data collection environment is stable, well pre-organized • Data entry point is within the business	• Electronically, involving sensors, technical systems such as SCADA systems, condition monitoring systems • Manually, involving field devices, field force, contractors, business rules • Data collected in a variety of formats • Requires to collect substantial data from many different parts of the organization • Data often entered by less/un trained, less dedicated personnel without proper relevant knowledge • Data entry environment can be unstable, harsh, less pre-organized • Data entry point can be far from the organization site
Data Storage	• Data to be kept in accordance with appropriate compliance requirements • Data stored on functional information systems	• Very large amount of data to be maintained for extended time for AM engineering and planning process • Data stored on various operational and administrative systems
Data Processing	• Comprehensive • Process independent • Easy for data integration	• Not comprehensive • Process dependent • Complex to integrate data, need both vertical and horizontal data integration
Data Usage & Analysis	o Data to be shared only among relevant business systems o Data to be communicated to internal stakeholders o Use general, common knowledge to interpret data o Easy for management use	o Data to be shared among various technical (e.g. design, operations, maintenance) and business systems o Data to be communicated to an array of stakeholders, business partners and contractors, subcontractors o Need experts with professional knowledge to interpret data o Difficult to translate asset data into meaningful management information

Figure 1. The AM DQ framework (Source: Developed by the authors)



require specialised supports of DQ technology and systems. The AM data will need to go through the DQ process, by a variety of DQ stakeholders and various DQ technology & systems, in order to ensure its quality. The asset data of enhanced DQ can then provide the foundation for effective asset management.

6. RESEARCH FINDINGS

This survey is the first national data quality survey performed in Australia, focusing specifically on the data quality issues of engineering asset management organisations. The following findings show the different attitudes and perceptions towards data quality. More importantly, it shows that the current strategy, policy and tools that the organisations employ for their data management solution.

6.1 Current Attitude & Awareness Towards Data Quality

The above result shows that the majority of survey participants recognise the important role that data quality is playing in achieving the success of an asset-intensive organisation.

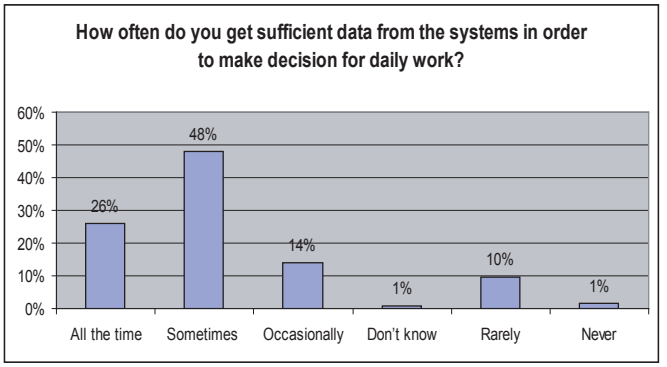
TOP Approach	Element	Chi-square Test	Kruskal-Wallis Test
Organisation	Industry	0.012	0.000
	Organisation size	0.772	0.459
	Organisation site(s)	0.215	0.007
People	Job position level	0.037	0.020
	Job function	0.704	0.138
	Data role	0.164	0.016

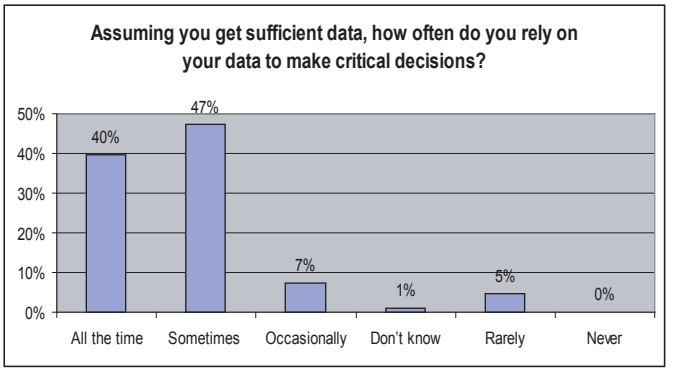
However, there is a statistically significant difference in the levels of DQ awareness across the different industry groups, and various job position levels as shown in Chi-square test and Kruskal-Wallist test. An inspection on the mean rank for the industry groups suggests that defence had the highest awareness scores, with local government reporting the lowest. In terms of job position levels, senior manager in strategic level had the highest awareness of DQ importance, with operational staff in lower level being the lowest. There is no significant relationship found between DQ awareness level and organisation size or job function.

6.2 Current Perception of DQ Confidence

Despite the overwhelming DQ awareness, a DQ confidence gap exists among the different data roles.

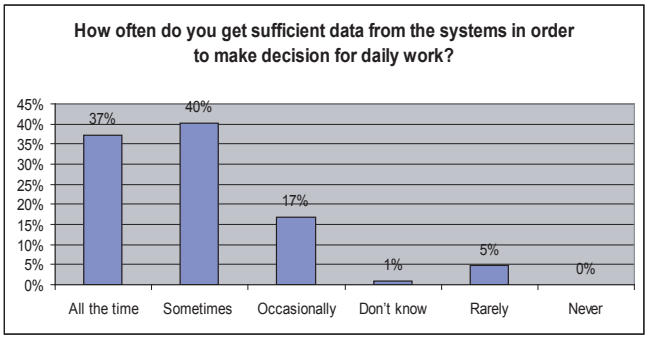
6.2.1 From Data Owners' Point of View

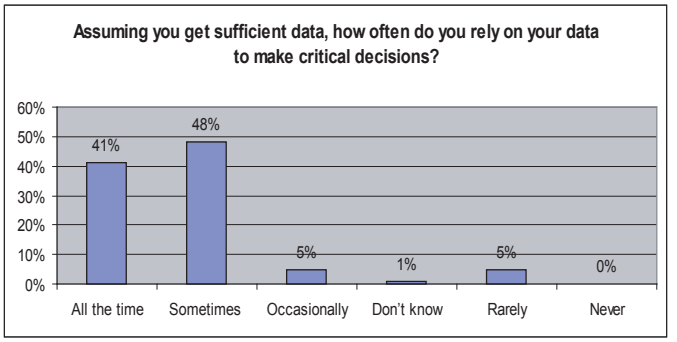




The above left figure shows that the majority of data owners (Asset managers) are happy with the amount of the data that they can access. However, there is a relatively small group (about 7%), who is not satisfied with the quality of data for decision making as shown in the figure on the right.

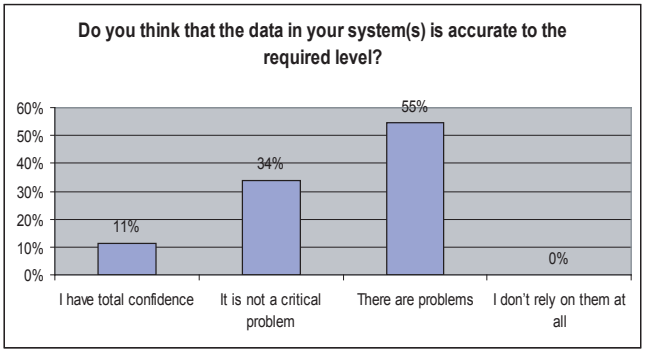
6.2.2 From Data Consumers' Point of View

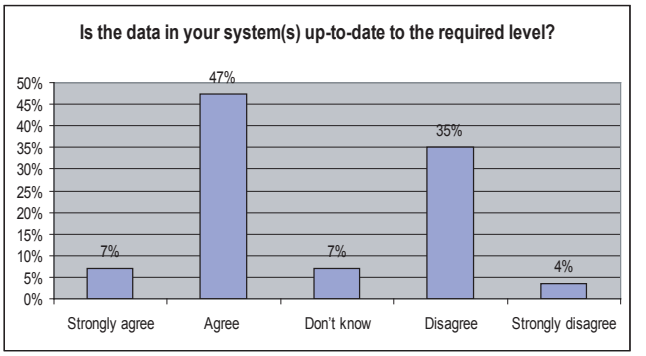




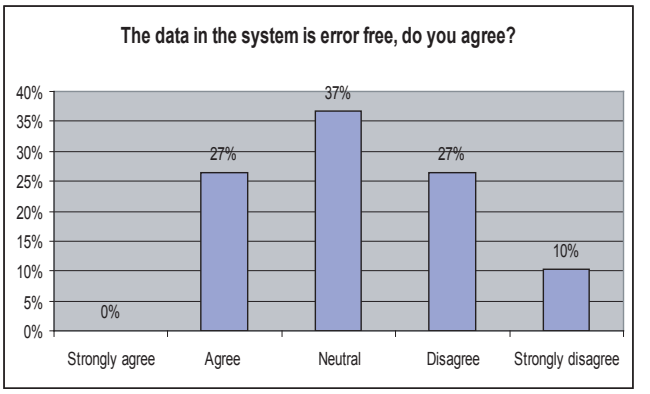
A consistent opinion is suggested by the data consumers' group. However, it does necessarily show that the data quality problem is not a major concern within the participating organisations.

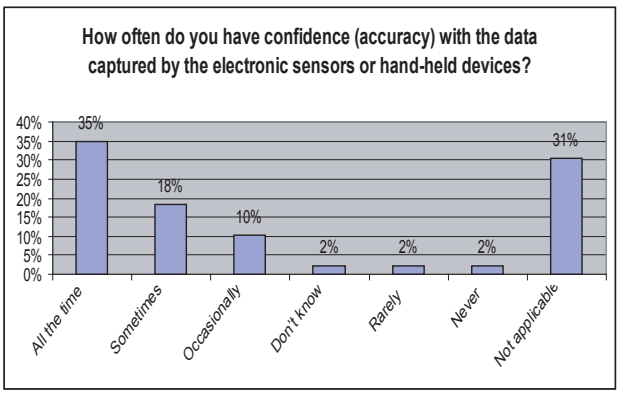
6.2.3 From Data Custodians' Point of View





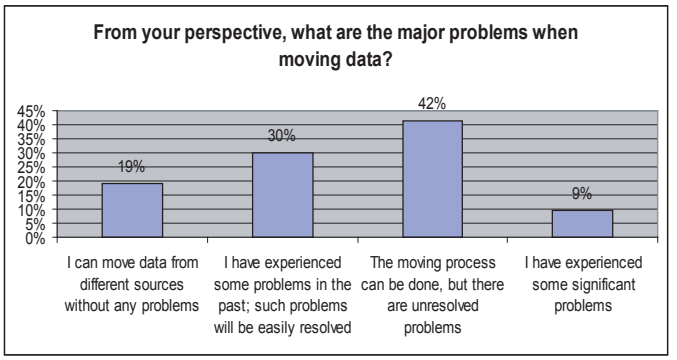
6.2.4 From Data Producers' Point of View





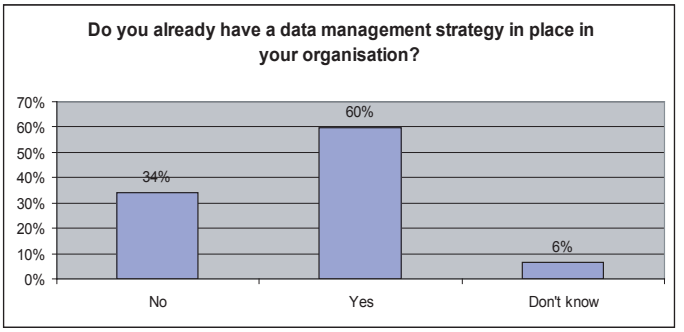
The above figures shows that the data producers and data custodians acknowledged that there were data quality problems. Especially, data producers do not have much confidence on their data quality. Perhaps, the data owners and data consumers may have higher levels tolerance of poor quality data. Nevertheless data quality problem is still facing critical challenges in most organisations. Also, the different attitudes found between groups may ring the alert bell that there may be a disconnection between the operational level personnel and the strategic level managers.

Some problems are suggested by the data custodians. For example, it suggests that moving/migrating data may generate many quality related problems, as shown below.

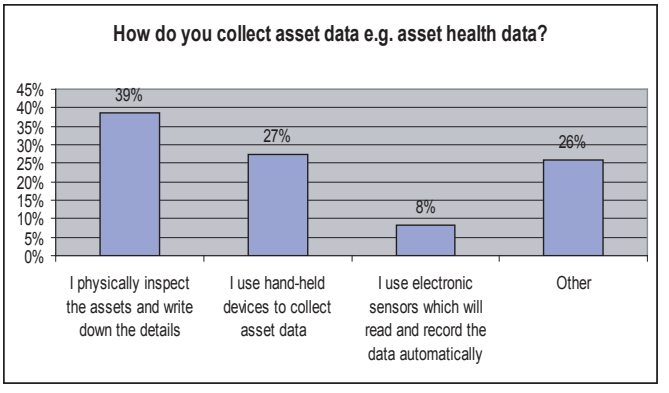


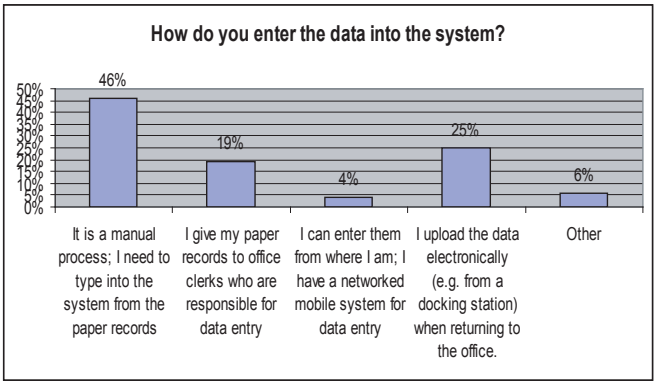
6.3 Current Strategies, Policies & Tools Employed for Achieving High Quality of Data

According to the 60% of data owners, there is data management strategy for data quality in place in their organisations, as shown in below.

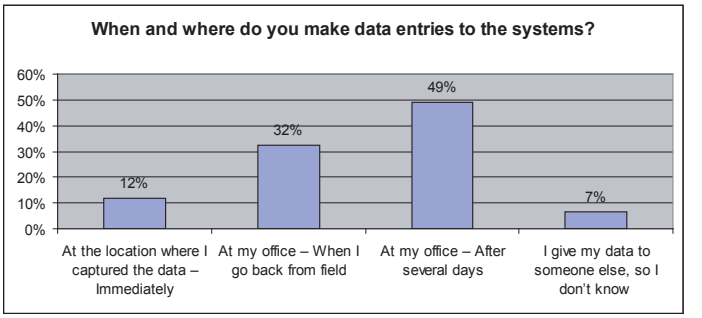


Down to the data capture level, data producers listed different ways of data collection and entry.



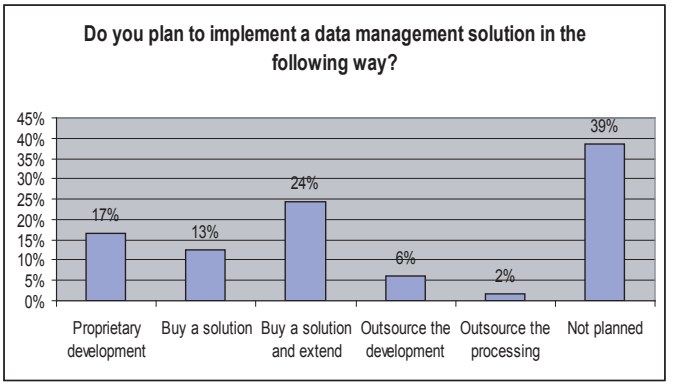


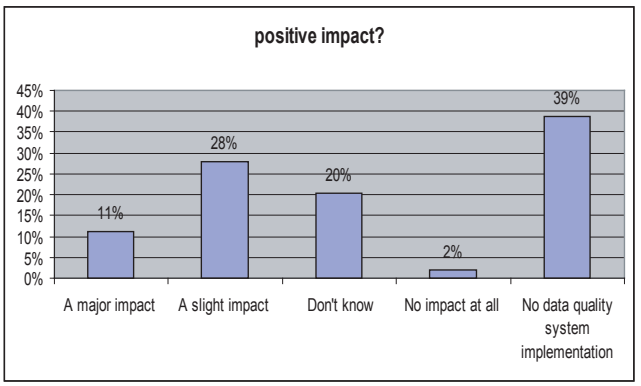
The majority of data producers still adopt a manual data entry process, which primarily rely on paper records. Especially, the figure below suggests that these data may not be entered immediately on site. Approximately 49% of these data were entered at the office after several days. Thus, the accuracy and completeness of these data may not be satisfactorily achieved.



6.4 Towards Future

It is "interesting" to find that 39% of asset owners have no plans to implement any data management solutions in near future. While the answer from Data custodians to the question *"Has implementing a data quality system had a positive impact on the success of any major IT implementations which your organization has put in place (e.g. Enterprise Resource Planning)?"* shows that no data quality systems (e.g. data profiling and cleansing systems) were implemented or planned to be implemented.





7. CONCLUSION

This paper included a proportion of survey findings. Nevertheless, these results suggest that while the organizations are concerned about the quality of data, there is lack of scrutinized discussion on the various issues associated with data quality problems. More importantly, there is a disconnection between data custodians and data producers and high level data owners. The majority of engineering asset organisations in Australia has no plans to neither implement any data quality management solutions nor develop any strategic plans. This finding is very different from AIM and PricewaterhouseCoopers findings. Perhaps, the engineering asset management organisations in Australia still adopt a reactive approach and only focus on the daily operations. A more comprehensive analysis will show the different attitudes and management strategies in relation to sizes of the organisations and the industries that they operate within. Further, these findings will be compared with the general data quality surveys.

This paper provided a better understanding of data quality issues for asset management and is assisting in identifying elements which will contribute towards the development of a data quality framework specific to engineering asset management. This in turn will assist in providing useful advice for improving data quality in this area. As an increasing number of organisations are putting in resources in data management solutions, there is growing need for suitable guidelines to help them develop appropriate strategies and employ right tools. Perhaps this is why data quality research becomes more critical.

8. ACKNOWLEDGMENTS

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ENDNOTE

* This research is conducted through the Centre for Integrated Engineering Assets Management (CIEAM).

9. REFERENCES

[1] ARC Advisory Group. (2004) 'Asset Information Management – A CALM Prerequisite', *White Paper*, ARC Advisory Group.

[2] Ballou, D. P., Wang, R. Y., Pazer, H. L. & Tayi, K..G. (1998) 'Modeling Information Manufacturing Systems to Determine Information Product Quality', *Management Science*. Vol. 44, No. 4, pp. 463-485.

[3] Ballou, D.P., & Pazer, H.L. (1995) 'Designing Information Systems to Optimize the Accuracy-timeliness Tradeoff', *Information Systems Research*. Vol. 6, No. 1, pp. 51-72.

[4] Batini, C., Catarci, T., & Scannapiceco, M. (2004) 'A survey of Data Quality Issues in Cooperative Information Systems', *Tutorial presented at the 23rd International Conference on Conceptual Modeling (ER2004)*, Shanghai, China.

[5] Bouzeghoub, M., & Peralta, V. (2004) 'A Framework for Analysis of Data Freshness', *Proceedings of the First ACM International Workshop on Information Quality in Information Systems (IQIS 2004)*, Paris, France.

[6] British Standards Institution. (2004) PAS 55: Asset Management. Part 1: Specification for the optimised management of physical infrastructure asset.

[7] Desisto, D. (2004) 'Bad Sales Data Is Worse Than No Data at All', *Research Paper*, Gartner Research.

[8] Eerens, E. (2003) *Business Driven Asset Management for Industrial & Infrastructure Assets*. Australia: Le Clochard.

[9] English, L.P. (1999) *Improving Data Warehouse and Business Information Quality: Methods for reducing costs and increasing Profits*. Willey & Sons.

[10] Fox, C., Levitin, A.V. and Redman, T.C. (1994) 'The notion of data and its quality dimensions', *Information Processing & Management*. Vol. 30, No. 1, pp. 9-19.

[11] Giannoccaro, A., Shanks, G., & Darke, P. (1999) 'Stakeholder perceptions of data quality in a data warehouse environment', *Australian Computer Journal*, Vol. 31, No. 4, pp. 110-117.

[12] Huang, K., Lee, Y. W., & Wang, R. Y. (1999) *Quality Information and Knowledge*, Upper Saddle River, N.J.: Prentice Hall.

[13] IPWEA. (2002) *International Infrastructure Management Manual*, Australia/New Zealand Edition. The Institute of Public Works Engineering Australia.

[14] Kahn, B.K., Strong, D.M. & Wang, R.Y. (2002) 'Information Quality Benchmarks: Product and Services Performance', *Communications of the ACM*, Vol. 45, No. 4, pp. 184-192.

[15] Koronios, A. (2006) Foreword of *Challenges of Managing Information Quality in Service Organisations*, Idea Group Inc., USA.

[16] Koronios, A., Lin, S., & Gao, J. (2005) 'A Data Quality Model for Asset Management in Engineering Organisations', *Proceedings of the 10th International Conference on Information Quality (ICIQ 2005)*, 4-6 November 2005, Cambridge, MA. USA, pp. 27-51.

[17] Levitin, A.V., & Redman, T.C. (1998) 'Data as a resource: properties, implications and prescriptions', *Sloan Management Review*. Vol. 40, No. 1, pp. 89-101.

[18] Liu, L., & Chi, L. (2002) 'Evolutionary Data Quality- A Theory-Specific View', *Proceedings of the 7th Intl. Conf. on Information Quality*, Massachusetts Institute of Technology, Cambridge, MA, pp. 292-304.

[19] Naumann, F. (2002) *Quality-Driven Query Answering for Integrated Information Systems*, LNCS 2261, Springer-Verlag.

[20] Neely, P., & Pardo, T. (2002) 'Teaching Data Quality Concepts Through Case Studies', *Center for Technology in Government*, Albany.

[21] Orr, K. (1998) 'Data Quality and System Theory', *Communications of the ACM*. Vol. 41, No. 2, pp. 66-71.

[22] Saunders, D. (2004) 'Innovation in Asset Management - Achieving a Nexus of Cost and Capability', *UDT Pacific 2004*. Hawaii, USA.

[23] Shanks, G., & Darke, P. (1998) 'Understanding data quality in a data warehouse', *Australian Computer Journal*, Vol. 30, No. 4, pp. 122-128.

[24] Spires, C. (1996) 'Asset and maintenance management – becoming a boardroom issue', *Managing Service Quality*. Vol. 6, No. 3, pp. 13-15.

[25] Steed, J.C. (1988) 'Aspects of how asset management can be influenced by modern condition monitoring and information management systems', *IEE Research Article*, The Institution of Electrical Engineers, UK.

[26] Strong, D.M. (1997) 'IT Process designs for Improving Information Quality and reducing Exception Handling: A Simulation Experiment', *Information and Management*. Vol. 31, pp. 251-263.

[27] United States General Accounting Office. (2004) 'Water Infrastructure: Water Utility Asset Management', GAO-04-461, Washington, D.C.

[28] Wand, Y., & Wang, R.Y. (1996) ,Anchoring Data Quality Dimensions in Ontological Foundations', *Communications of the ACM*, Vol. 39, No. 11, pp. 86-95.

[29] Wang, R.Y. (1998) 'A product perspective on total data quality management', *Communications of the ACM*, Vol. 41, No. 2, pp. 58-65.

[30] Wang, R.Y., & Kon, H.B. (1993) 'Toward Total Data Quality Management (TDQM)', in *Information Technology in Action: Trends and Perspectives*. Wang, R.Y. (Eds). NJ: Prentice Hall.

[31] Wang, R.Y., & Strong, D.M. (1996) 'Beyond Accuracy: What Data Quality Means to Data Consumers', *Journal of Management Information Systems*, Vol. 12, No. 4, pp. 5-33.

[32] Wang, R.Y., Storey, V.C., & Firth, C.P. (1995) 'A Framework for Analysis of Quality Research', *IEEE Transactions On Knowledge and Data Engineering*, Vol. 7, No. 4, pp. 623-640.

Anticipated and Unanticipated Consequences of the Development of Accounting Information Systems

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ABSTRACT

This paper aims at objectively viewing the consequences of the development of a typical accounting information system. Accounting is a tool for organization, documentation, and rationalization of economic decisions. Some of the significant consequences, such as rationalization and legitimization of economic action, were unanticipated at the early stages of evolution of financial accounting. In making the distinction between intended and unintended consequences, the goal is to understand how the primary components of the system evolved.

INTRODUCTION

The purpose of this paper is to demonstrate different consequences of the development of accounting information systems and to weigh the opposing arguments of whether the consequences of accounting were actually anticipated by those who developed early accounting techniques. Behavior is a complex interaction of several human processes aimed at achieving a goal. It involves conscious or unconscious selection of particular choices of actions. The selection refers to the fact that there are other courses of action that are foregone by the individual. Based on the selection, the desired consequences are elicited. Nevertheless, the mind cannot grasp the entire consequences of a chosen course of action (Simon, 1945). Implicit in this argument is that anticipated consequences might bring around, inadvertently, other unanticipated consequences. Accounting is more important now more than it ever was, and studying its history is significant to understand its roots, impact, and the early influences that shaped those techniques.

LITERATURE REVIEW

Accounting is "the process of identifying, measuring, and communicating economic information to permit informed judgments and decisions by users of the information" (American Accounting Association, 1966). The definition is broad because it describes accounting as a measurement and reporting instrument for any activity with financial ramifications.

History of Accounting

Accounting, as a tool for control and accountability, existed in a primitive form thousands of years ago in early civilizations. The Chaldean-Babylonian, Assyrian and Sumerian civilizations all had highly organized systems of government and also had the oldest surviving business records, dating as far back as 3500 BC. The records kept relate to counting crops and grain (Mann, 1994). Evidence also exists that a powerful bureaucracy, supported by accounting techniques, coordinated the political and economic domains in ancient Egypt in the New Kingdom (1552-1069 BC). Kemp (1989) argues that the bureaucratic system was rooted in devising routines for measuring, inspecting, checking, and controlling other people's activities. Detailed accounting records were kept for taxation, documentation of income and barter transactions and listing of inventory and workers' wages.

Luca Pacioli is well known today for suggesting the double-entry bookkeeping system (or the "Method of Venice"), even though the system was widely used in Italy and very refined at that time. He discussed the Journal, the Ledger, barter, company or joint venture, agency and bank accounts, income and expenditure accounts, the balance sheet, and the general rules of bookkeeping. Italian merchants helped introduce the system in the 1600s to merchants in other countries that had less organized means of record keeping.

Double-entry system was a means of reducing the uncertainty faced by the merchants and the incidence of bankruptcy, which was often due to poor bookkeeping (Mann, 1994). Mills (1994) adds that two events, the commercial revolution and printing, came together in Northern Italy to create the conditions whereby the region could invent double-entry. He attributes the commercial revolution in Italy to the expansion of population and the Crusades. Both events increased the trade passing through the Italian cities of Genoa and Venice.

Rationality and Social Action

A distinction is made between anticipated and unanticipated consequences of purposive social action. While anticipated consequences are desired objectives of the action, unanticipated consequences are unintended products of the action that were not expected in advance (Merton, 1936). Some of the institutions, tools and techniques taken for granted in the modern days are, in fact, unintended consequences of some action. In his thesis regarding the emergence of modern capitalist thinking, Weber (1958) argues that Capitalism, as an economic ideological model, has not developed to its modern form until the West applied its "rational" thinking to commercial activity in the eighteenth century.

Though debatable, Weber's theory argues that the eighteenth century merchant did not *intend* to build the modern, well-integrated web of institutions, ethics, and technologies. All he wanted was to seek the divine salvation that only came to those who perform economically well in their daily calling. Those rational institutions that exist today are unanticipated consequences to the merchant's behavior in his quest for salvation. These consequences may be more frequent the farther one moves from the action.

THEORETICAL FRAMEWORK

Researchers have enthusiastically attributed several aspects of our modern life to the development of accounting information systems. Highly regarded academics, such as Schumpeter, Sombart and Weber, in different disciplines have provided a great deal of arguments that accounting, either directly or indirectly, is responsible for the society's economic development, the creation of several institutional arrangements, and the emergence of large businesses. While these arguments might be true, the original intent of the developers of financial accounting during the fourteenth and fifteenth century did not receive the due attention. This section aims at presenting views regarding the anticipated versus the unanticipated consequences of accounting systems development.

Anticipated Consequences

There is not much debate that accounting in general is a useful business tool. From Italian merchants in medieval ages to multinationals in the twenty-first century, accounting has evolved in application. Since the medieval ages, basic accounting techniques provided enterprises with an organized tabulation of accounts and the relationships among them, an efficient method of tracking funds owed to and by others, and a clear representation of how a specific business operation affects a firm. Several researchers contend that the intended consequences were (depicted in figure 1): to allow the business owner to keep track of his dealings through recording details of transactions, to hold agents accountable, and to objectively determine fair share of revenue in transactions that included partners (Carruthers and Espeland, 1997).

Even though early accounts were narrational, with all kinds of information presented, they served mainly to assist the memory of the businessman. The double-entry method could save time and prevent disputes by reducing suspicion, ignorance, and memory lapses. The audience for the account was the proprietor or record keeper alone, to whom the account answered the following two questions: "What do I own? What have I done?"

Further challenges for financial accounting came about due to business activities growing complex, in terms of value and parties involved. Accounting techniques were gradually refined to provide an objective assessment for the effect of ventures on a merchant's capital and profit motive. Even though profits were a minor concern at these early times, the maintenance of capital and improvement of a country's wealth were major ones. According to Carruthers and Espeland (1997), the audience for the accounts was separate from the record keeper and the question that these accounts answered was: "Am I being cheated?"

Through the use of primitive accounting techniques, single merchants were able to unite their resources in partnerships and trade collectively overseas for better bargains in the name of the partnership. They pooled their resources without fear of losing track of their invested capital or confusing percentages of ownership. An account in each partner's name recorded the partner's investments, withdrawals and share of profits or losses, thus providing a readily available balance. When a partner wanted to terminate his association with the partnership, he would withdraw his known amount of capital, which was recorded in his account and maintained separately from partnership operations (Schumpeter, 1939). The continuity of the business was therefore not upset, lending more credibility to the merchants and their venture and gaining more confidence from banks and customers.

Accounting also provided merchants with the ability to invest in several ventures and trade with several merchants without fear of losing money due to confusion. Merchants adapted accounting techniques to include partners' personal accounts. Their question was: "What is my fair share of the Revenues?" Additionally, the proliferation of joint stock companies in the nineteenth century still created wider audiences for accounts, ones who are even less familiar with the operations of a company. Further, investors diversified into several ventures, making knowledge of these ventures less likely. They now relied on accounts to provide needed information (Yamey, 1962).

During the nineteenth century, two important changes took place that influenced both accounting theory and practice. First, the industrial revolution brought the need for permanent, large-scale, fixed capital investment, which complicated the accounting practice because consistent allocation of expenses and revenues to artificial accounting periods became necessary. Second, depreciation was incorporated into the valuation of assets leading to a more arbitrary determination of income (Chatfield, 1977).

Moreover, the proliferation of joint stock companies in the nineteenth century made it necessary to keep track of capital and distinguish it from income, in order to avoid the reduction of invested capital. Governments in the UK and the US intervened to ensure the maintenance of capital, the preparation of fair financial statements and the regular audits of the accounts by independent auditors. Accounts now were *legally* required to answer the questions: Are investors being cheated? Is capital being maintained? (Carruthers and Espeland, 1991). Later, accounting also started serving regulatory compliance purposes, including tax reports.

The above arguments suggest that accounting has developed gradually to its sophisticated form known today. Although it started as primitive documentation

Figure 1. The need for accounting techniques in modern societies

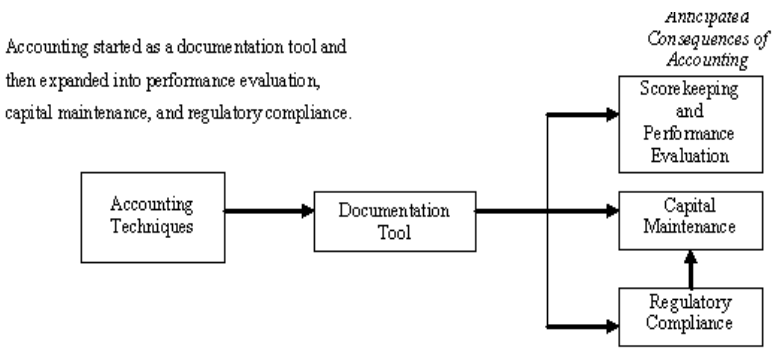
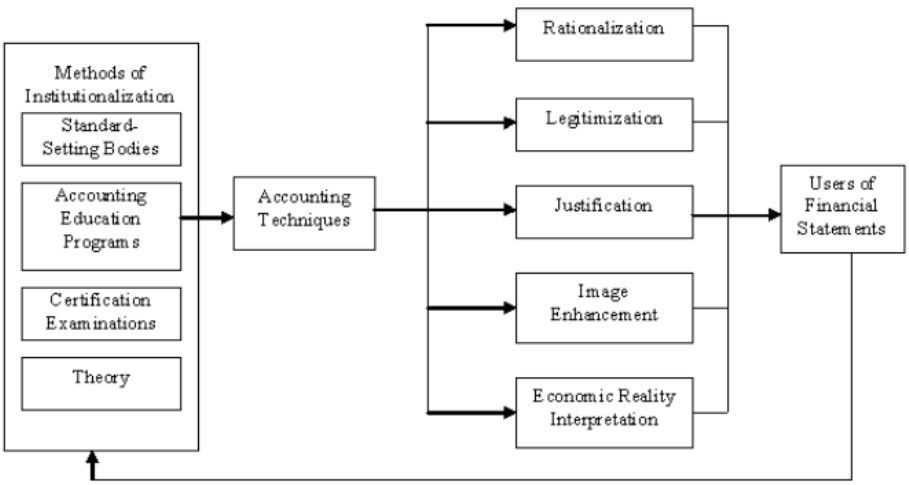


Figure 2. Accounting techniques, reinforced by institutional factors, achieve several functions that help form the reality seen by users of financial statements who attempt to shape accounting techniques through the institutions



tool, it developed incrementally as businesses started growing more complex, to serve as a tool for capital maintenance, performance evaluation, and regulatory compliance. The following propositions are made:

Proposition 1: Accounting systems were mainly used in the fifteenth and sixteenth century as a documentation tool.

Proposition 2: Accounting systems evolved during the period between the seventeenth and twentieth centuries from a documentation tool to performance evaluation, capital maintenance, and regulatory compliance tools.

Unanticipated Consequences

Weber (1958) argues the eighteenth century merchant did not *intend* to build the modern, well-integrated web of institutions, ethics, and technologies. The theme of Weber's (1958) thesis can be equally applied to the development of accounting as an information system. Accounting has been in existence for some time and was claimed to have set in motion the wheels of development for several institutions. Two of the unintended consequences of accounting systems development are as follows. First, accounting helped enhance rationality, maximize investment outcomes, and extend the development of capitalist production methods. Second, the institutionalization of accounting took place through the development of a whole infrastructure of educational and professional bodies (see figure 2 below).

1. Accounting as a Key to Enhance Rationality and Maximize Wealth

a. The Technical Role

Prominent social theorists claim that accounting played a key *technical* role in enhancing rationality and furthering the development of capitalist methods of production. "The most general presupposition for the existence of this present-day capitalism is that of rational capital accounting as the norm for all large industrial undertakings which are concerned with provision for everyday wants" (Weber, 1927). Accounting allows capitalists to evaluate rationally the consequences of their past decisions and to calculate current and future resources. Weber argues that rational capital accounting, along with calculable law, rational technology (mechanization), free labor, and the commercialization of economic life is an element in a general process of rationalization that is both the antecedent to and the consequence of modern capitalism.

Weber's argument is consistent with his thesis in "*The Protestant Ethic and the Spirit of Capitalism"* (1958), which concedes that rational economic behavior was essential for Protestants who sought salvation. This rational behavior could be attained only if the individual accumulates wealth through careful, rational investment. Accounting steps in by providing a means of measuring alternative investment opportunities and efficiently managing daily business activities.

Schumpeter (1950) argues that economic activity in general brings about a rational attitude, stating that "The capitalist practice turns the unit of money into a tool of rational cost-profit calculations, of which the towering monument is double-entry bookkeeping". Also, Sombart (1953) argues that capital, that amount of wealth which is used in making profits and which enters into the accounts, did not exist before double-entry bookkeeping. Through double-entry bookkeeping possibilities were created and the ideas of acquisition and economic rationalism were developed.

Weber believes that for-profit enterprises would not survive if they were not sufficiently profitable (Weber, 1978). Those enterprises that adopted the double-entry method were at a technical advantage over those that did not and, in the long run, the latter would be driven out of the market. In addition, accounts provide the necessary information to measure and compare the alternatives of a certain choice, allowing individuals to estimate the probabilities of success and the possible payoffs associated with various alternatives (Carruthers and Espeland, 1991).

Several other researchers have advocated the role of accounting in investment evaluation. Accounts provide technical information on the outcome of previous business actions (Littleton and Zimmerman, 1962), and hence an accurate assessment of the relative success of particular investments. Accounts provide a businessman with a record of current assets, which indicates the economic means at his disposal and they help make decision making more rational and so contribute to the maximization of profits (Chambers, 1966). One can safely assume that the original developers of financial accounting did not have investment decision-support as one of their main goals for accounting development.

b. The Rhetorical Role

Accounting was also used as a tool for projecting signals about an individual or an organization. The efficacy of pious invocations in establishing legitimacy and enhancing credibility was recognized. The account books of Italian merchants invoked the name of God for centuries. At times where papal prohibition on usury was a concern for merchants, double-entry bookkeeping was used to explicitly document the balanced nature of firm transactions (Carruthers and Espeland, 1991). Thus proving the legitimacy and justness of the business and the moral legitimacy of profits.

In addition, double-entry bookkeeping was recognized as a vehicle for self-transformation, because it required curiosity and intelligence. Failure to adhere to this method, in fact, aroused suspicion regarding one's character and resulted in degeneration. Businessmen who had to rely on others to help them manage their affairs required them to know the principles of the double-entry system and employ it in a systematic, standardized, and tabulated manner. Self-transformation was conductive to capitalist activity. Weber (1956) argues that caution, informed decision-making and the avoidance of speculation, values promoted by double-entry bookkeeping, became celebrated values and a crucial feature of advanced capitalist societies.

Accounts have been manipulated to convey a desired impression, legitimate someone's performance, or strengthen a particular position. The dependence of businessmen on credit means they are especially vulnerable to expectations and standards of other businessmen because one's credit depends on one's reputation. The extent of careful record keeping was a decisive factor in building one's good personal reputation. At early times, double-entry accounts documented a man's frugality and diligence (Earle, 1989). So individuals held accurate records to obtain credit at favorable rates. Managers always try to negotiate numbers that will make them look good. Accounts are also used to justify decisions and to excuse mistakes (Watts and Zimmerman, 1979). Income numbers are sometimes artificially smoothed to enhance retrospective appearance of predictability and certainty or to signal expectations (Barnea, Ronen, and Sadan, 1976).

Thompson's (1967) argues that organizations act to reduce the uncertainties surrounding them in the complex real world through such actions as sealing off their technical core and reducing dependencies on others. Organizations use their technical knowledge of accounting for "window-dressing". Accounting was also used to predict future environmental factors that impact an organization (e.g. future sales, expenses and demand).

Double-entry bookkeeping reduces the complexity of the economic reality and presents decision makers with a simple "bottom-line" that does not reflect all possible interpretations and judgments. As March and Simon (1958) put it, accounting is a cognitive device that influences the "premises of decision making", by determining the kind of information that was available to various audiences.

c. Accounting and Impact on Rationality

Skeptics of the importance of accounting argue that little theoretical change took place in the 300 years after Pacioli and that the techniques of double-entry took a long time to diffuse throughout Europe and become rigorously adhered to by most practicing businesses (Winjum, 1972). Ideally, double-entry facilitates the "economic rationality" described by Weber, Schumpeter, Sombart and modern accountants. In practice, however, the full potential of double entry was rarely exploited (Connell-Smith, 1951). Accounts were infrequently balanced (Coleman, 1963).

Yamey (1956, 1962, 1964) cautions against reading modern economic conceptions of profit and capital into pre-nineteenth century uses of double entry. Not only were such modern concepts of the organizational economy still emergent, but also the institutions of the marketplace themselves provided information adequate for the needs of the time. Virtually all economic activity in that earlier era was controlled either by market transactions or by administrative fiat, which meant that prices and rules provided the information needed for rational decision making. Account books were not an important source of information for economic decision making. They were kept primarily to provoke the memory, support claims in court, and sometimes as a way to handle negative numbers in the arithmetically unsophisticated era (Winjum, 1972). Yamey believes that the arguments of Sombart and Weber, giving strong credit to accounting for stimulating the "rationalistic pursuit of unlimited profits as an essential element in the capitalistic spirit", are overestimated.

These criticisms are consistent with Chandler (1977) who believes that until late in the nineteenth century, the invisible hand of market processes did most of the coordination and product pricing. Accounting was not seriously called for until modern firms, resulting from vertical and horizontal integration, appeared and the visible hand of managerial administration took over the coordination. Only then, accounting emerged as a powerful tool for resource allocation and control. The following propositions are needed to test the above arguments:

Proposition 3: In its technical sense, accounting was used as a tool for economic rationalization, investment outcome maximization, and production method development.

Proposition 4: In its rhetorical sense, accounting was used as a tool for self-transformation, legitimization, justification, image improvement, and selective information presentation tool.

2. The Institutionalization of Accounting

On the other hand, accounting is now an established discipline. The organizations, certification and qualification processes, education programs, and theory that underlie the practice of accounting today are consequences that were not envisioned by the early developers. The early institutionalization of accounting was produced by two things: education and mercantile networks (Carruthers and Espeland, 1991). The specialized education of merchants, either in schools or in apprenticeships, familiarized them with the double-entry method. Commercialization helped diffuse the double-entry method from Italy over the rest of Western Europe. The network of businessmen helped foster the formal adherence to this method, because reputation and creditworthiness within the business community were necessary for solvency and were maintained with the help of one's accounts. In the twentieth century, the dependence on accounting became very strong. Organizations can neither manage their daily operations nor design strategic plans unless a reliable accounting system provides accurate and useful information.

Standard-setting organizations, certification, and education programs were not intended as institutionalization mechanisms by the early developers of accounting. These institutions did not emerge until late nineteenth century, and since then they are in constant evolution. Early developers of financial accounting were more interested in keeping primitive records (e.g. the Journal) where transactions were recorded in a narrational form. They were not interested in preparing financial statements in their current format and thus did not conceive of standards that would govern the format and content of these statements. The following proposition is suggested:

Proposition 5: Early practitioners of accounting were not concerned with creating universal standards as much they were concerned with crude recording of daily events in journals.

CONCLUSION

This paper aims at objectively viewing the consequences of the development of accounting as a system. Testing the propositions empirically may substantiate the different arguments regarding intended versus unintended consequences of the development of accounting. Based on the findings, researchers might be interested in (1) identifying a pattern of accounting development and relating it to a particular practice or institution, such as stock markets, multinationals, among others. This might prove very important to a field such as international accounting, where researchers are struggling to attribute differences in accounting practices around the world to certain events or environmental factors. It may also be important to study (2) why the unintended consequences were described as closely associated with accounting, explaining more the position of accounting in a macroeconomic setting.

Further, the degree of development of accounting at different times can be an important factor in analyzing the decisions of investors or organizations. Accounting, in its rhetoric role, may have had a stronger impact than its technical role, although the latter was studied much more extensively. Also, the resolution of the conflict of opinions between Yamey and Weber and Sombart will provide a more clear indication of the relative strength of accounting as one of the building blocks of capitalism.

REFERENCES

American Accounting Association (1966). A statement of basic accounting theory. Evanston, Illinois: AAA.

Barnea, A., Ronen, J. & Sadan, S. (1976). Classificatory smoothing of income with extraordinary items. Accounting Review, 51, 110-122.

Chandler, A. D, Jr. (1977). The visible hand: The managerial revolution in American business. Cambridge: Belknap Press of Harvard University Press.

Carruthers, B. G. & Espeland, W. (1991). Accounting for rationality: Double-entry bookkeeping and the rhetoric of economic rationality. American Journal of Sociology, 97, 31-69.

Chambers, R.J. (1966). Accounting, evaluation and economic behavior. Englewood Cliffs, New Jersey: Prentice-Hall.

Chatfield, M. (1977). A history of accounting thought. Huntington. New York: Krieger.

Coleman, D.C. (1963). Sir John Banks: Baronet and businessman. Oxford: Clarendon.

Connell-Smith, G. (1951). The ledger of Thomas Howell. Economic History Review, 3, 363-370.

Earle, P. (1989). The making of the English middle class. Berkeley and Los Angeles: University of California Press.

Kemp, B.J. (1989). Ancient Egypt: Anatomy of a civilization. London: Routledge.

Littleton, A.C. & Zimmerman, V.K. (1962). Accounting today: Continuity and change. Englewood Cliffs, New Jersey: Prentice-Hall.

Mann, G. (1994). The origins of double-entry. Australian Accountant, July, 17-21.

March, J.G. & Simon, H.A. (1958). Organizations. New York: Wiley.

Merton, R.K. (1936). The unanticipated consequences of purposive social action. American Sociological Review, 1, 894-904.

Mills, G.T. (1994). Early Accounting in Northern Italy: The role of commercial development and the printing press in the expansion of double-entry from Genoa, Florence and Venice. Accounting Historians Journal, 21, 81-95.

Schumpeter, J. (1939). Business cycles. New York: McGraw-Hill.

Schumpeter, J. (1950). Capitalism, socialism, and democracy. New York: Harper Torchbooks.

Simon, H.A. (1945). Administrative behavior. New York: Free Press.

Sombart, W. (1953). Medieval and modern commercial enterprise. In F.C. Lane and J. Riemersma (Eds.), Enterprise and secular change, 25-40. Homewood, Illinois: Irwin.

Thompson, J.D. (1967). Organizations in action. New York: McGraw-Hill Book Company.

Watts, R.L. & Zimmerman, J.L. (1979). The demand for and supply of accounting theories: The market for excuses. Accounting Review, 54, 273-305.

Weber, M. (1927) 1981. General economic history. Translated by F. Knight. New Brunswick, New Jersey: Transaction.

Weber, M. (1958). The protestant ethic and the spirit of capitalism. New York: Scribner's.

Weber, M. (1956) 1978. Economy and society. Edited by G. Roth and C. Wittich. Berkeley: University of California Press.

Winjum, J.O. (1972). The role of accounting in the economic development of England, 1500-1750. Urbana, Illinois: Center for International Education and Research in Accounting.

Yamey, B. (1956). Introduction. In A.C. Littleton and B.S. Yamey (Eds.), Studies in the history of accounting. Homewood, Ill.: Irwin.

Yamey, B.S. (1962). Some topics in the history of financial accounting in England, 1500-1900. In W.T. Baxter & and S. Davidson (Eds.), Studies in accounting theory, 98-117. Homewood, Illinois: Irwin.

Yamey, B.S. (1964). Accounting and the rise of capitalism: Further notes on a theme by Sombart. Journal of Accounting Research, 2, 117-119.

Conceptual Design for Personalized Situation-Aware Information Seeking and Retrieval Services in Data Intensive Domains

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ABSTRACT

Personalized information seeking and retrieval is regarded as the solution to the problem of information overload. Personalization algorithms and techniques are maturing, but their centralized implementation solutions are becoming less efficient for dealing with ever changing user information needs in data intensive, dynamic and distributed environments. In this paper, we present a conceptual design for personalized, situation-aware information seeking and retrieval services, which offers a new way of thinking about the retrieval of personalized information for time critical applications.

Keywords: *personalization, information seeking and retrieval, situation awareness, service-oriented architecture*

1. INTRODUCTION

Today information is distributed globally. Organizations and information seekers can now access information anywhere anytime via wired or wireless networks. The coordination of organizational processes distributed over various independent locations has improved significantly. However, this increase in information availability cannot guarantee that users are able to retrieve and access all the information that specifically meets their needs. Organizations have to operate in increasingly complex environments, where, dynamically changing information structures, and distributed heterogeneous data resources make it increasing difficult to find the 'right information' at the 'right level of details' in the 'right format' , and at the 'right time'. The problem is amplified in domains such as crisis response networks, medical and healthcare networks, where the accuracy of the retrieved information and obtaining it in a time critical manner are extremely important.

Personalized information seeking and retrieval is regarded as the remedy when it comes to relieving the problem of information overload. Research in the field mainly focuses on developing models, methods and tools that can be used to adapt information content and its presentation to the individual user's information search goals and preferences. Today, personalized techniques are able to provide feasible solutions to the problem of inappropriate information overload at technological level ranging from simple user-controlled information personalization to autonomous system-controlled adaptation [Mizzaro & Tasso, 2002]. Many academic and commercial off-the-shelf information search services and tools are available to filter out irrelevant information effectively, and to rank and present information in a user preferred way.

Although these personalization techniques and algorithms are maturing, their centralized implementation solutions are becoming less efficient for supporting the rapidly changing information needs in dynamic and distributed environments. Changes in organizational or personal information needs may lead to a need to redesign a complete application. Therefore, it is necessary to design personalized information seeking and retrieval application in an agile and flexible way, to provide personalized information in a time critical manner, which can be adapted easily to meet changing information needs. Our increasing understanding of component-based design principles, service-oriented architectures and other aspects of complex information retrieval achievements provide the possibility to achieve this objective. The modularization of complex systems into components, or services that interoperate primarily via exchanging standardized messages at interfaces has become IT technology evolution. All these advances in IT have stimulated a new requirement concerning on modeling and designing personalized information search services in a dynamic and distributed environment to satisfy high-level functional requirements for personalization flexibly in one hand, and to use the specific personalization techniques, algorithms and available technology infrastructure to realize these requirements on the other. Building on the advantages of a service-oriented approach, we propose a new conceptual design for personalized, situation-aware information seeking and retrieval services. We believe this approach provides a new way of thinking about the retrieval of time critical, personalized, situation-aware information in data intensive domains.

Our conceptual design is presented in section 2. We tested and evaluated our conceptual design by applying it in a real-life case. The results are presented in section 3. Our conclusions and an outline for future work are presented in section 4

2. CONCEPTUAL DESIGN

2.1 The Concept of Information Seeking and Retrieval

Information seeking and retrieval is a human-IT system interaction activity in the sense of an IT supported environment. According to research into user information behavior, users' information needs are stimulated when they lack the information required to solve a problem [Wilson, 1998]. Problem solving occupies an important place in the research on information seeking and retrieval [Gaslikova, 1998]. [Gaslikova, 1998] summarizes problem solving in the context of information seeking and retrieval in three stages: problem identification, query formulation, and validation of received information. She claims that any information seeking and retrieval system has to provide suitable software tools for realizing each stage of a problem-solving process. Taking this into account, we regard information seeking and retrieval as a user-system interaction process. It comprises three sub-processes shown below.

- *The information seeking process*: This is the process used, generally or precisely, to identify the problem that initializes a user's information acquisition activity. This covers the question: what is the problem?
- *The information searching process:* This is the process used to identify and structure the specific information required to solve the problem, and to find the locations of required information. It concerns on the questions what information is required? Where to find the required information? And how to access to it?
- *The information obtaining process:* This is the process used to obtain the required information from the various resources and to return the information back to the user.

Users validate the received information during the interaction process with the system.

2.2 Personalized Information Needs

Personalized information needs play an essential role in determining the relevance of any delivered information. The literature shows a deepening understanding of the concept information needs and its role in the information seeking and retrieval. [Taylor, 1968] and [Belkin, 1982] argue that users' characteristics, e.g. users' personality, knowledge, personal interest and preferences etc., determine their information needs. [Wilson, 1994] and [Niedźwiedzka, 2003] shows that social placement or a professional role, e.g. users' professional roles connected with their occupied positions, are the most important determinants of users' information needs. [Wilson, 1999]'s problem solving model abstracts the process of problem solving from context.

Since our research is confined to domains such as crisis response and management networks, healthcare and medical networks, etc., we argue that individuals' personal interests and preferences may not strongly influence their information needs. Although different users in these contexts may have different knowledge levels about their professional role, we consider that their knowledge will be inherent to the professional role they play within their work situations. Therefore, we regard the professional roles users adopt in the society to be one of the most important factors influencing their specific information needs although their personalities and/or knowledge may influence their search strategies.

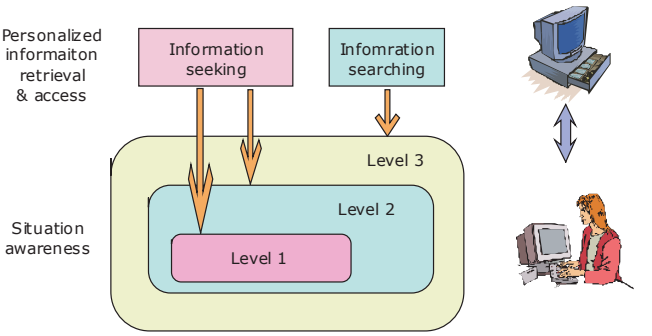
However, users' roles are not sufficient to reflect their actual needs. Information needs change as the users' situation changes, and this directly influences users' judgment regarding information relevance. Role-based information needs are relatively stable and predictable, while an ongoing situation may change these information needs. When users are able to be aware of their situation, in which they are involved, the users are able to identify their problem, and to formulate their information needs. Based on our previous arguments, we believe that personalized information seeking and retrieval is triggered by users' role-based perceptions of a problem they need to solve. We therefore define personalized information seeking and retrieval as an information acquisition process, aimed at providing users, with their role relevant personalized information based on dynamically and automatically perceiving and responding to the users' situations.

2.3 Situation Awareness

2.3.1 Situation Awareness in the Context of Information Seeking and Retrieval

The concept situation awareness (SA) is usually applied to operational situations, especially in the fields of artificial intelligence, agent-based systems, crisis response and management, military planning, etc. [Endsley, Bolte & Jones 2003]. Research in the field of SA focuses mainly on helping persons to be aware of their situations so that they can make informed decision about future actions [Endsley, Bolte & Jones 2003]. [Endsley & Rodgers, 1998] formally defines SA as "the perception of elements in the environment along with a comprehension of their meaning and along with a projection of their status in the near future" [Endsley & Rodgers, 1998]. This definition breaks down into three separate levels [Endsley, Bolte & Jones 2003].

Figure 1. Information seeking and retrieval to support SA process



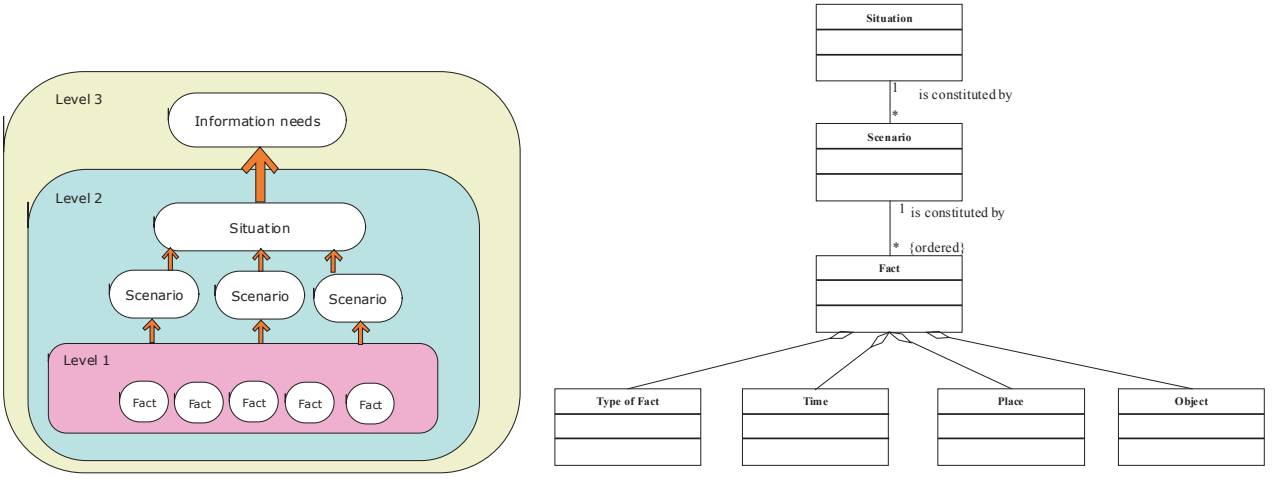
- Level 1—perception of the elements in the environment
- Level 2—comprehension of the current situation, and
- Level 3—projection of future status.

These three levels reflect the process of how people are aware of their situations mentally. Although today's advanced IT technology can replace a huge amount of information processing work, until now, it cannot replace a human's mental information processing process. We regard the information seeking and retrieval provided in our approach as a means to provide support for the users' SA process. We claim that our definition of information seeking and retrieval can be used to provide suitable support for all three steps of SA defined by [Endsley, Bolte & Jones 2003] shown in Figure 1. Levels 1 and 2 of [Endsley, Bolte & Jones 2003] are supported by the information seeking process, aimed at identifying the problem. Level 3 is supported by the information searching process, aiming at defining what information is needed.

2.3.2 Situation Model

Users perceive the problem they need to solve when their situation is described clearly. We choose to use the term situation since it can imply dynamic changes in users' surroundings, the influence of changes on the users, and the users' stable or permanent surroundings. Situation is defined in the [Merriam-Webster] as "the relative position or combination of circumstances at a certain moment". In the [Dictionary], situation is defined as "the combination of circumstances at a given

Figure 2. SA process



(a) (b)

moment; a state of affairs". From these definitions, we can see that, a situation consists of a concrete story describing where what happened, when, who are involved, and their relationships.

It is not feasible to specify all possible situations in the context of information seeking and retrieval for any domain. Historical usage data is required to detect situations. This argument is also used in [Endsley, Bolte & Jones 2003]'s three levels of SA model, where an unknown situation is derived from known information. The question, what historical data or information is required to be collected at different level of the SA processes for the users to realize their situation, becomes important; and can be reformulated as what information can be used to describe and model the situation. Based on the [Endsley, Bolte & Jones 2003] 's three levels of SA model, we need to perceive the elements in the environment (Level 1 in the SA) as the information that can be used to comprehend current situation (Level 2 in the SA), in order to project future status (Level 3 in the SA).

The first step in the SA process is to perceive the elements in an environment. The information elements that can be directly perceived describe the things that are known to have happened or to exist, i.e. the concept fact. Therefore, the information describing those things that have happened or existing things can be abstracted and conceptualized as a combination of 'type of fact', 'time', 'place' and 'involved objects'. The description of a fact can be made by combining 'type of fact' and any or all other three concepts.

Perceived facts are only direct observations made in the environment. They cannot provide narrative descriptions of users' situation. Therefore, facts do not supply sufficient information to understand a situation fully. To support the second level of the users' SA, we use the concept scenario in our research. We define *scenario* as a *short story reflecting a situation*. In this scenario, known outcomes are described, in conjunction with the casual relationships of a group of detected facts. Unknown scenarios can be derived by combining known facts, or from known scenarios. The SA process in our research is presented in Figure 2 (a), and the situation model is presented in Figure 2 (b).

2.4 Service-Oriented Approach for Personalized Information Seeking and Retrieval

A service-oriented approach provides a design principle for the handling of complex, dynamic and distributed information systems. Personalization can be provided by composing existing services, which are implemented on the basis of well-defined service behaviors and interfaces. This design principle is suitable for a distributed, dynamic and heterogeneous environment. According to the service-oriented system design principle, we assume that a solution for the detected information needs in users' specific situations can be quickly reconfigured by using a composition of encapsulated, replaceable and reusable services [Stojanovic, Dahanayake & Sol, 2004]. Based on sub-sections 2.2 and 2.3, we can now formulate the complete framework for personalized, situation-aware information seeking and retrieval, as shown below in Figure 3.

2.4.1 The Concept Service

According to the literature [Papazoglou, 2003, Stojanovic, Dahanayake & Sol, 2004, Douglas, 2003. etc], in the initial phase of our research, we informally defined the term *service* as "*A service is planned and designed in such a way that it has a specific functionality and it is very simple, but together they perform relatively complex tasks*". This informal definition gives the basic requirements for defining a service in the service-oriented approach. A service must have a specific functionality. As mentioned before, the solution for a detected problem is constituted of a service or a combination of services. Therefore, the specific functionality a service must have in our design is that it provides information. As a result, we simply define the services that consume information and provide information as information services. We assume that the solution to satisfy user's information needs is constituted by an information service or a group of information services. The information provided by a group of services is the collective outcome of all involved information services instead of a simple combination of outcomes of each service. Information services can be assembled and composed by smaller information services. At the level of a simple information service, its required operation and output is realized by grouping a specific collection of information search software components. We present the concept of service in Figure 4.

Figure 3: A framework of personalized situation-aware information seeking and retrieval

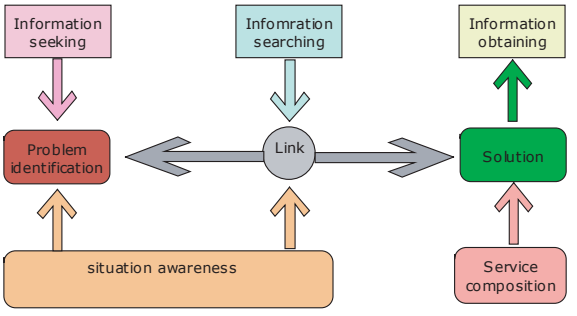
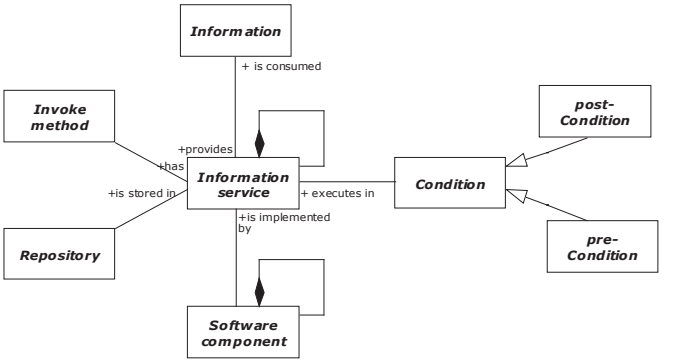


Figure 4. The concept of information service



2.4.2 Task Model

After the appearance of task-oriented information seek and retrieval in the 1990s [Vakkari, 2003], the concept task has been diligently used in the context of information search as [Byström & Hansen, 2005]. The concept task has gained increasing attention as it provides an important cue to help us to understand why people seek information, what type of information they need, and how they are going to use the information [Byström & Hansen, 2005; Taylor, 1991]. Our definition of a task is mainly based on the research of [Vakkari, 2003; Byström & Hansen, 2005; Vakkari, 2003]. We regard *a task to be a specific piece of work, in which a person or a group of persons undertakes a series of actions in a situation*. Defining a task as a piece of work indicates that it has a performer, a meaningful purpose, and an undertaken context [Hackman, 1969; Byström & Hansen, 2005]. This is a definition, which emphasizes the conceptualizing of tasks more from the point of view of the actors and the social context of the task performance [Checkland & Holwell, 1998, Suchman, 1995].

We define *the organizations or organizational units as actors*. Each actor has a list of professional roles. A role is defined in [Merriam-Webster] as "a function or part performed especially in a particular operation or process". Obviously, role is a function relevant concept. *The professional roles of an actor are defined in terms of functions an actor must provide.* Therefore, actors are exclusive, and based on the functions they provide, i.e. their professional roles. A task is performed when an actor adopts one of its professional roles. A task can be composed of smaller tasks. At the level of a simple task, it is constituted of a series of interconnected actions. A task is undertaken in a context, i.e. the situation, where an actor is required to adopt one of its professional roles. According to the definition of task in our research, tasks are required to be identified from an actor's professional roles, i.e. from the functions an actor can provide. However situation is a dynamic concept, as perceived by the SA process defined in section 2.3.2. It s not feasible to define all tasks corresponding to a specific situation. Instead, the tasks can be defined in facts, which are more concrete and tangible. Since a task can be composed of smaller tasks, required tasks in a detected situation can be composed of sub-tasks identified using the relevant facts. Tasks are undertaken in a process to formulate the solution for an existing fact.

Based on the concepts defined in the previous subsections, we formulate a meta-model of personalized information seeking and retrieval on the basis of service-oriented system design principle. The meta-model is shown in Appendix 1.

3. CASE STUDY

We tested the conceptual design by applying it in a real life case. The case study presented in this section was taken from an ongoing EU research project. The harbor described in this case study is one of the largest and most important harbor infrastructures in the world. Global collaborations for natural disasters recovery and anti-terrorism cooperation have encouraged management at this harbor to take put in global information networking, designed to share information with other crisis experts and professionals. The harbor management intends to build a more flexible and extendable information platform to provide all authorized and involved actors with access to their role-based personalized, situation-aware information to facilitate the performance of their tasks during a crisis response.

Since the development of a complete system is not yet feasible, due to the difficulty of building trust between the various crisis relief/response organizations, and getting them to share their information, we built an early prototype demonstration to show that it would be possible to build such a service-oriented platform to provide personalized, situation-aware information seeking and retrieval services for crisis response situation.

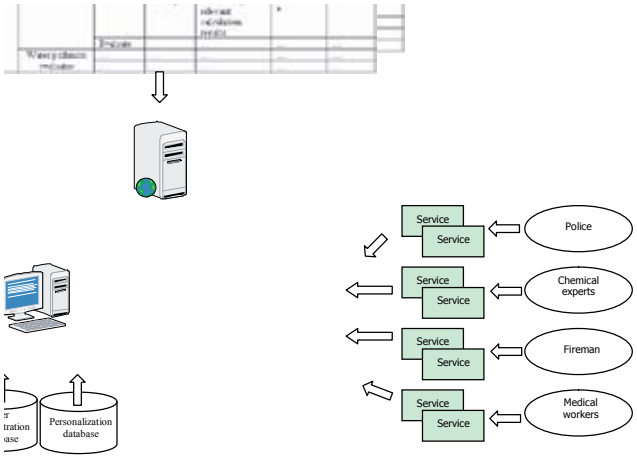
We utilized three computers in our prototype implementation shown in Figure 5, representing the service consumer, service provider, and service broker in a SOA respectively. The information provided by the actors involved was encapsulated as information services. We believe there are four main actors in crisis response: police, medical experts, fireman, and chemical experts. We implemented several information services for these 4 actors as jini services in our prototype. These jini services were required to be registered on a jini lookup server. The requested registration information is shown in the table in Figure 5. We used a simple example from a chemical expert to show what, and how, the required information on information services is registered in the jini lookup server. In the client PC, we use Liferay 4.0[1] as the portal software, and embedded Tomcat 5.0[2] as the web server to build the 'crisis response and management portal'. We built two databases, a user administration database and a personalization database, which were used to support personalized information seeking and retrieval applications running on this portal. User's role-based profiles, stored in the user administration database, were used to control their information access. The personalization database was built based on the meta-model presented in Appendix 1. Previous existing crisis situations, their constituting scenarios, scenarios' constituting facts, facts' solutions, etc, were stored in the tables of situations, scenarios, facts, solutions and tasks as the historical information in the personalization database. The personalization database was implemented in MySQL[3].

Tasks are keys that are used to search for the required information services provided by the different organizations. When a task is selected, it generates a service search template, which is constituted of three attributes, actor, role and task. A selected task generates this service search template by filling in the actor name, role name and task name. The service search template will then be sent to the jini lookup server to look for the relevant information services. All the information services of a selected task are returned to the user. Information service name, information service description, service status and location are also returned to the user. It is the users' work to figure out their required information services based on the returned service information.

4. CONCLUSION & FUTURE WORK

In this paper, we presented a new way of thinking of retrieving personalized information based on service-oriented design principle. Our situation model is capable of reflecting and inferring the unpredictable and dynamic situation users are facing. Our task model is capable of personalizing users' information needs in a dynamic situation according to their professional role(s). The combination of the situation model and task model allows users' role-based personalized, situation-aware information needs to be sufficiently inferred, and well structured in a meaningful way. Simultaneously, applying service-oriented design principle in our conceptual design allows us to realize independent service implementation and service modeling, and quickly to configure information acquisition applications

Figure 5. Prototype architecture



to satisfy users' dynamic information needs by choosing the required services. We believe that our conceptual design provides a possible solution to building a bridge between high-level functional requirements and low-level technology availability.

The next step of our research is to focus on how to reduce the time to action in a time critical situation using an effective information coordination service for situation aware process orchestration [González-Rivera, 2006].

REFERENCES

[Byström & Hansen, 2005] *Conceptual Framework for Tasks in Information Studies*, Katriina Byström, Swedish School of Library and Information Science, Göteborg University and Högskolan I Borås, Preben Hansen, Swedish Institute of Computer Science (SICS), JOURNAL OF THE AMERICAN SOCIETY FOR INFORMATION SCIENCE AND TECHNOLOGY, 56(10):1050–1061, 2005, http://www3.interscience.wiley.com/cgibin/fulltext/110497382/PDFSTART

[Checkland & Holwell, 1998] *Information, Systems and information systems: Making sense of the field. Checkland, P. & Holwell S., Publisher: John Wiley & Sons; 1 edition (November 27, 1997), ISBN: 0471958204*

[Dictionary] http://dictionary.reference.com/search?q=environment&x=42&y=13

[Douglas, 2003] *Web Services and Service-Oriented Architectures: The Savvy Manager's Guide (The Savvy Manager's Guides)***,** Douglas K. Barry, Publisher: Morgan Kaufmann (April 1, 2003) ISBN: 1558609067

[Endsley, Bolte & Jones 2003] *Designing for situation awareness: an approach to user-centered design***,** Endsley, Mica, R., Bolte, B., and Jones, Debra G., British Library Cataloging in Publication Data, ISBN: 0-7484-0966-1 (hbk) ISBN:07484-0967-X(pbk)

[Gaslikova, 1998] Gaslikova, Irina *"Information Seeking in Context*" and the development of information systems." Information Research, 5(1) Available at: http://informationr.net/ir/5-1/paper67.html

[González-Rivera, 2006] Information Coordination Service for Situation Aware Process Orchestration: improving time to action in emergency response, Rafael González-Rivera, draft proposal, Delft University of Technology, the Netherlands, Feb, 2006

[Hackman, 1969] Hackman, J.R. (1969). T*owards understanding the role of tasks in behavioral research*. Acta Psychologica, 31, 97–128.

[Merriam-Webster] http://www.m-w.com/dictionary/environment

[Mizzaro & Tasso, 2002] Stefano Mizzaro and Carlo Tasso, Personalization Techniques in Electronic Publishing on the Web: Trends and Perspectives, Universidad de Málaga, Departamento de Lenguajes y Ciencias de la Computación, Proceedings of the AH'2002 Workshop on Personalization Techniques in Electronic Publishing Málaga, Spain, May 2002 Selected papers, http://www.dimi.uniud.it/mizzaro/AH2002/proceedings/PerElPub.pdf#search=%22user-controlled%20information%20personalization%20to%20autonomous%20system-controlled%20adaptation%22

[Niedźwiedzka, 2003] "*A proposed general model of information behavior*" Niedźwiedzka, B. (2003) *Information Research*, **9**(1) paper 164 http://InformationR.net/ir/9-1/paper164.html

[Stojanovic, Dahanayake & Sol, 2004] *An Approach to Component Based and Service-Oriented System Architecture Design*", Stojanovic, Z., and Dahanayake, A. and , Sol, H.G., (2004):Faculty of Technology, Policy and Management, Delft University of Technology Jaffalaan 5, 2628. BX Delft, The Netherlands, {Z.Stojanovic, A.Dahanayake, H.G.Sol}@tbm.tudelft.nl

[Vakkari, 2003] *Task-Based Information Searching*., Vakkari, Pertti, Annual Review of Information Science and Technology (ARIST), v37 p413-64 2003,

[Wilson, 1994] Prof. T.D. Wilson, INFORMATION NEEDS AND USES: FIFTY YEARS OF PROGRESS? Department of Information Studies University of Sheffield, In Vickery, B.C. (Ed.), *Fifty years of information progress: a* Journal of Documentation *Review*, (pp. 15- 51) London: Aslib, 1994.

[Wilson, 1999] *"Exploring models of information behaviour: the 'uncertainty' project,* Wilson, T.D, Information Processing and Management, Volume 35, Number 6, November 1999, pp. 839-849(11)

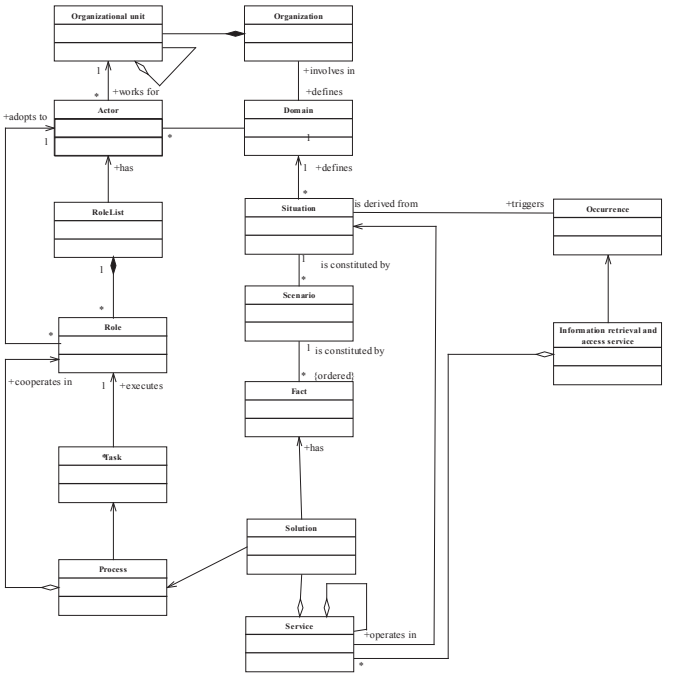
ENDNOTE

1 Information about liferay can be found from http://www.liferay.com/web/guest/home

2 Information about Tomcat can be found from http://tomcat.apache.org/

3 Information about MySQL can be found from www.mysql.com

APPENDIX 1



Achieving Business Benefits from a Global ERP Implementation

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ABSTRACT

This paper provides an understanding of the implementation, use and business benefits achieved from a global ERP system by an Australian manufacturing organisation. Using an interpretive case study approach ERP implementation and use were examined retrospectively as processes within context over time. The business benefits achieved were assessed using Shang & Seddon's (2000) ERP business benefits framework. The business benefits achieved are explained in terms of the ERP implementation success factor literature, and themes relating to the use of the ERP system that were identified from the empirical findings.

INTRODUCTION

For more than ten years there has been an increasing industry trend to buy off-the-shelf software rather than custom build software to provide an integrated solution for the business transaction processing requirements of organizations. These Enterprise Resource Planning (ERP) systems are large, complex software packages that provide an integrated real-time environment based on an enterprise wide data model with a set of software applications which allow processing of all the data of the organization (Bancroft, Seip and Sprengel, 1998). Collective investment by organizations worldwide in ERP systems since the early 1990s has been in the order of many billions of dollars. However there have been widely varying outcomes from ERP system implementations with a high degree of risk associated with implementation and use.

To date most ERP research has concentrated on the implementation project itself. However the primary focus of this research was on the post-implementation period i.e. the use of the ERP system. The implementation and use of an ERP system was viewed in this research from the perspective of organizational change (Davenport, 2000). The specific research question addressed was:

How and why do business benefits evolve during ERP system use?

The rest of paper begins by placing the study within the existing ERP literature. A brief outline of the research design follows, including details of the characteristics of the case study organization. The results are presented and discussed, followed by concluding remarks.

BACKGROUND

Four strands of the existing ERP literature provide the background to this research. The first is the literature that has proposed ERP life cycles (e.g. Markus and Tanis 2000, Parr and Shanks 2000, Ross and Vitale 2000). Markus and Tanis (2000) propose four phases in the ERP life cycle: "Chartering", "Project", "Shakedown" and "Onward and Upward". The Chartering phase is an initial planning phase however there is some evidence to suggest that in practice some organizations omit the activities in this phase (Markus, Axline, Petrie and Tanis 2000). The Project phase involves getting the system up and running in one or more business units in the organization. The extent of planning undertaken for the ERP system by the organization, and any effects of the Project phase, for example, time relative to schedule, cost relative to budget and functionality relative to original proposed scope (Markus et al. 2000) influences the business benefits gained. The Shakedown phase starts when the system goes "live" and finishes when normal operations are achieved. The final phase, Onward and Upward, starts when normal operations are achieved and lasts until the system is replaced. The research described in this paper, although focussed on the Shakedown and Onward and Upward phases which together make up the post implementation period, examines the influence of the previous phases on the business benefits achieved by the organisation.

The second group of ERP literature has concentrated primarily on the Project phase of ERP systems and proposed critical success factors (e.g. Holland and Light 1999, Parr, Shanks and Darke 1999) or "recipes" for success with ERP implementation (e.g. Markus and Tanis 2000). Some of these studies have included issues or problems and/or business benefits achieved in the Shakedown and Onward and Upward phases (e.g. Markus et al. 2000, Chang and Gable 2002). And a third strand of the literature has developed models for assessing the business benefits achieved with ERP systems. There are two viable measurement models for assessing the business benefits of ERP systems in use. Compared with the Gable, Sedera and Chan (2003) model, the Shang and Seddon (2000) business benefits framework was developed using data from a much larger number of organizations (233) from different industry sectors. Shang and Seddon's (2000) framework for assessing the business benefits of ERP systems includes five dimensions of benefits: operational, managerial, strategic, IT infrastructure, and organizational, with multiple possible benefits within each dimension. It also has the advantage of assessing business benefits from a single perspective i.e. that of the business managers. This benefits framework was used to assess the business benefits achieved during the post-implementation period in the manufacturing company studied in this research.

Finally, some studies have looked at the ERP system in use in order to explain the business benefits achieved from ERP systems. Markus and Tanis (2000) and Markus et al. (2000) related the business consequences to events in the earlier ERP life cycle phases and to external influences due to changing business conditions. However, there is little information provided on the internal organizational influences on the business benefits, such as changes to organizational structure and culture. Neither is there any attempt to assess the "success" of the individual organizations studied.

In a study of manufacturing organizations Ross and Vitale (2000) identified four obstacles to achieving business benefits from ERP systems. They were failure to plan and implement performance metrics for the new system, inadequately resourcing the Shakedown and Onward and Upward phases, no improved management decision making and inadequately addressing resistance to change. Two studies have looked at the business benefits from ERP systems and the factors that contribute to them. The first study (Davenport, Harris and Cantrell 2004) developed a statistical model that identified three main factors (integrate, optimize and informate) that predict perceived business value to the organization as a whole. In contrast Gattiker and Goodhue (2005) focused on benefits from ERP systems at an individual manufacturing plant rather than the organization as a whole. The Gattiker and Goodhue (2005) model identified four factors contributing to plant level benefits in manufacturing organizations: interdependence (between plants), differentiation (i.e. between plant differences), time elapsed since implementation and customization. Both the Davenport et al. (2004) and Gattiker and Goodhue (2005) models are predictive rather than explanatory. This study differs by aiming to understand and explain how and why the case study organization achieved business benefits from its ERP system.

RESEARCH DESIGN

An interpretive case study method was used to answer the research question. The case study organization (ManB) had begun implementation more than four years prior to data collection. Since business benefits take time to accrue it was expected that with this time frame business benefits from the ERP system would be clearly evident.

Table 1. Background data for the ManB ERP implementation

Motivation for Implementing SAP	Strategic business reasons
Cost of Implementation	~AUD$25 million
Sites	Multiple (65 sites in 5 countries)
Modules	FI, CO, MM, PP, SD, AM
Version of SAP implemented	3.0F , then upgrade to 4.6B
Implementation Strategy	Small Bang (all modules at one site, or small group of sites, at a time)
Implementation Approach	System replacement
Implementation Partner	Yes
Business process reengineering	No
Customisation?	Yes, but minimal
Business Restructuring	Accounts payable and accounts receivable shared services after go-live
Was project completed on time, within budget and within original scope?	Yes
Number of users	~1000
When were the business benefits assessed?	Four years after the first site went live. One and a half years after last site went live i.e. full implementation.

An overview of the ManB ERP implementation is shown in Table 1.

The theoretical framework that underpinned data collection was adapted from Orlikowski (1993). The Shang and Seddon (2000) ERP benefits framework was used to assess the business benefits achieved. The adapted Orlikowski framework and the Shang and Seddon (2000) framework provided the main basis for the semi-structured interview protocol.

The primary source of data was from in-depth interviews with key informants chosen because of their position within the organization. The interviewees included a senior manager (General Manager IT and Business Solutions), the Group Business Solutions Manager (Finance), the Group Business Solutions Manager (Manufacturing), the Group Project Manager and the SAP Applications Manager. Interviews were tape recorded to ensure accuracy and were returned to interviewees for verification. To provide triangulation other sources of data collected were company documentary evidence and archival data such as post implementation reviews etc.

The case study research design conformed to the principles for conducting interpretive field studies in IS developed by Klein and Myers (1999). Full details of the research design can be found in Staehr, Shanks and Seddon (2002).

RESULTS AND DISCUSSION

ManB achieved extensive business benefits from its ERP implementation. The business benefits achieved at ManB are shown in Figure 1 using the Shang and Seddon (2000) benefits framework. Some additional business benefits not in the original Shang and Seddon benefits framework were achieved at ManB and these are shown in bold italic in Figure 1. The business benefits at ManB were not uniform across all sites. This variation in business benefits also occurred within a particular functional area. The fact that different business benefits were realized not only in different functional areas but also at different sites within the same organization highlights the difficulty in assessing the business benefits overall that an organization achieves with its ERP system.

Table 2 below shows the major situations and/or actions that influenced the eventual achievement of extensive business benefits at ManB. The first column in Table 2 lists the contextual influences, both internal and external to the company, followed by the phases of the ERP lifecycle. Column 2 specifies the situation/action at ManB that influenced the achievement of business benefits, while column 3 explains the influence and indicates in parentheses the subsequent phases of the ERP lifecycle affected. Column 4 shows whether the situation/action resulted in a positive or negative influence.

The results in Table 2 provide a process oriented view of the ERP implementation at ManB. The two contexts, external and internal to the organization, had the potential to influence the achievement of business benefits right across the ERP lifecycle. Each phase of the ERP lifecycle had the potential to influence the current and subsequent phases of the ERP lifecycle. Examination of the influences of situations/actions contributes to understanding how and why ManB achieved extensive business benefits from its ERP implementation. The external and internal contexts provided mainly positive contextual influences across the entire ERP lifecycle.

During the Chartering and Project phases of the ERP lifecycle critical success factors (CSF) reported in prior ERP research were identified at ManB. Examples of each of these CSFs at ManB appear matched by number in Table 2 below:

1. Top management support (e.g. Holland and Light, 1999; Parr et al., 1999; Brown and Vessey, 2003)
2. Project champion (e.g. Parr et al., 1999; Sumner, 2000; Somers and Nelson, 2001)
3. Project management (e.g. Holland and Light, 1999; Parr et al., 1999; Duplaga and Astani, 2003)
4. Change management (e.g. Markus and Tanis, 2000; Aladwani, 2001; Brown and Vessey, 2003; Markus, 2004)
5. Minimal customization (e.g. Holland and Light, 1999; Parr et al., 1999; Brehm, Heinzl and Markus, 2001; Somers and Nelson, 2001; Soh and Sia, 2005)
6. Project team characteristics (e.g. Parr et al., 1999; Ross and Vitale, 2000; Robey, Ross and Boudreau, 2002)
7. Implementation strategy (e.g. Holland and Light, 1999; Duplaga and Astani, 2003)
8. Education and training (e.g. Somers and Nelson, 2001; Robey et al., 2002; Sumner, 2000)

However, despite the presence of these CSFs at ManB, and no major issues due to the contexts and earlier phases that needed resolving during the Shakedown

Figure 1. Business benefits achieved at ManB (adapted from Shang and Seddon (2000))

BENEFIT DIMENSION	BENEFIT CATEGORIES
1. OPERATIONAL	1.1 Cost reduction 1.2 Cycle time reduction 1.3 Productivity improvement 1.4 Data quality improvement 1.5 Customer services improvement *1.6 User accountability*
2. MANAGERIAL	2.1 Better resource management 2.2 Better decision making 2.3 Better performance control
3. STRATEGIC	3.1 Supports current and future business growth plan 3.2 Supports business alliances 3.3 Supports business innovation 3.4 Supports cost leadership 3.5 Supports product *and service* differentiation 3.6 Supports external linkages 3.7 Enables world wide expansion 3.8 Enables ebusiness
4. IT INFRASTRUCTURE	4.1 Increased business flexibility 1.2 IT cost reduction 4.3 Increased IT infrastructure capability
5. ORGANIZATIONAL	5.1 Supports business organizational changes 5.2 Facilitate business learning and broaden employee skills 5.3 Empowerment 5.4 Changed culture with a common vision 5.5 Changed employee behaviour with a shifted focus 5.6 Better employee morale and satisfaction *5.7 Standardization*

KEY: Benefit category = business benefit achieved
Benefit category = new business benefit

Table 2. Overview of ManB ERP implementation and use **(KEY:** *"+ve" and "–ve" indicates positive or negative influence, C = Chartering, P = Project, S = Shakedown, OU = Onward and Upward)*

	Situation/Action	Influence (Phase affected)	
External context	Demand for SAP experts in the Australian IT industry	ManB did not lose IT staff. The policy of training existing IT staff to support SAP after implementation, the excellent communication between the existing ManB staff and the implementation partner consultants during the project, and the payment of bonuses to the ManB staff at the completion of the project all contributed. (**C**, **P, S** and **OU**)	+ve
		Changes/enhancements to the software to fit existing business processes not easy to obtain. (**C** and **P**)	
	Dependence on software vendor		–ve
Internal context	ManB's motivation for the SAP implementation involved strategic business reasons including risk reduction.	The SAP implementation proceeded despite a forecast negative return on investment. (**C, P**, **S** and **OU**)	+ve
	Although SAP software used by another part of the parent organization there was no compulsion to choose SAP.	Software chosen was capable of meeting the requirements of the business. (**S** and **OU)**	+ve
	Restructure to shared services after go-live.	Managers/users already had some working knowledge of the software when shared services were implemented. (**OU**)	+ve
Chartering and Project phases (C and P)	[1]Management understood the scale of the project and the need for comprehensive planning process.	(**C**, **P**, **S** and **OU)**	+ve
	[2]Experienced project manager and champion.		
	[3]Project completed on time, within budget and with original scope.	(**P**, **S** and **OU**)	+ve
		(**S** and **OU**)	+ve
	[4]Comprehensive and well thought out change management plan.	(**P**, **S** and **OU**)	+ve
	[5]Minimal customization of the SAP software.		
	[5]Used several different templates across the sites i.e. did not use a "one template fits all" approach	(**P**, **S** and **OU**)	+ve
		(**S** and **OU**)	+ve
	[6]Excellent working relationship with implementation partner.		
	Best business people on the implementation team.		
	[7]Small bang implementation strategy.	Facilitated a quality configuration (**P, S** and **OU**)	+ve
	[8]Used learning from early implementations to improve subsequent implementations.	Low risk implementation strategy (**S** and **OU**)	
	[8]Existing IT staff trained to support SAP post go-live.	Some training deferred until after go-live when users could learn using	+ve
	Few issues remaining from these phases to be solved in subsequent phases.	"real" data. (**P**and **S**)	+ve
		(**S** and **OU**)	
			+ve
		(**S** and **OU**)	
			+ve
Shakedown (S)	Some issues with user education and training.	Users not aware of their scope of influence with integrated software (**S** and **OU**)	–ve
		Users did not understand the increased need for data quality (**S** and **OU**)	–ve
		Results didn't look as good after go-live as they did before (**S**)	
	Issues with poor management control practices	Users "didn't know what they didn't know" (**S** and **OU**)	–ve
		A disincentive to having properly trained staff (**S** and **OU**)	
	Phone support inadequate	Limited availability of IT staff for training and support (**P**, **S** and **OU**)	–ve
	Businesses had to pay for extra training		–ve
	IT staff involved in other site implementations/new project work		–ve
Onward and Upward (OU)	Use of key users and professionals (e.g. accountants, engineers) for support services		+ve
	Sweeps of sites for training		+ve
	Issues with shared services		–ve
	Some productivity issues with poorly trained staff		–ve
	Business suggesting improvements to existing processes		
	Business suggesting new projects to leverage off the SAP system		+ve
	Business has a common language for strategic planning		+ve
			+ve

phase, other issues surfaced during the Shakedown phase that provided negative influences affecting the achievement of business benefits (see Table 2). This should not be considered unusual, since, consistent with the effect of organizational change (Eason, 1988), in this phase the process of adapting to the new system typically results in a performance dip (Markus and Tanis 2000; Ross and Vitale 2000) which may last up to 12 months or more. However, at ManB most sites were back to normal operations within 6 months.

A number of themes emerged in the Shakedown phase that highlighted areas for improvement. There were ongoing issues with education, training and support and change management. The deficiencies in education and training in the Project phase meant that users were not sufficiently aware of the integrated nature of the software and the increased need for data quality. The telephone support provided once the implementation team left the site was a problem for users who "didn't know what they didn't know". Additional training and support was required at some sites but the resources were often not available since the same team was used for ongoing implementations and for training. Also the business unit requesting additional training had to pay for it, surely a disincentive.

Change management was required to deal with issues of poor management practice:

"Basically, it hit the fan, where there were poor management practices. They were flushed out in the early days. SAP was accused of actually having wrong numbers. We went through, did a whole lot of work as to whether the configuration was right, whether the reporting was right, all those sorts of things. Time and time again it was proven that the system was doing what the system should do and that the poor practices were very much made visible and led to improved practices over time." (General Manager Information Technology & Business Solutions)

In the Onward and Upward phase there were sweeps of all sites to ascertain training needs. Key users and professionals who moved from site to site were used to provide more support opportunities:

"I spend a lot of my day just connecting people between plants and saying, well this plant does it this way, why don't you talk to this person. They might be completely different business units, but they can share information and they can talk the same language." (Group Business Solutions Manager - Manufacturing)

This reduced the load on the centralized support facility.

During the Onward and Upward phase process improvements and new projects to leverage off the ERP system were suggested by the business rather than being initiated from the IT staff. This occurred as business users came to better understand the capabilities of the ERP system.

Although not entirely free of problems the ERP implementation at ManB did achieve extensive business benefits. Two major contributing influences emerged from analysis of the empirical data and the ERP research literature. The first was that the approach ManB adopted towards its ERP implementation indicated a strategic business motivation which has been linked by Markus (2000) to achieving more business benefits from ERP systems. The second influence involved the individual manufacturing plant level. ManB showed a variation in business benefits from site to site. In their study of local plant level benefits from ERP systems Gattiker and Goodhue (2005) found that interdependence between plants increases the business benefits achieved through the integration provided by the ERP system. There was substantial interplant trading at ManB. However, Gattiker and Goodhue (2005) also found that differences between plants decreased benefits. They suggested that customization is one way to alleviate this although they could not provide supporting evidence. ManB was able to accommodate the differences between plants by using several different templates, and in the case of one plant, letting it keep its legacy system (see number 5 in Table 2). Therefore the interdependence between plants and the accommodation of variation between plants contributed to the extensive business benefits achieved.

CONCLUSION

ManB achieved extensive business benefits from its ERP implementation (see Figure 1). At ManB the possible negative consequences due to external and internal contextual influences on the organization did not eventuate due to management's strategic business motivation, planning and foresight during the Chartering and Project phases. The successful Chartering and Project phases set the scene for the achievement of business benefits during ERP system use. During the Project phase the accommodation of differences between manufacturing plants contributed to the business benefits achieved. Although there were some issues that arose during Shakedown these were overcome in readiness for the Onward and Upward phase. During the Shakedown and Onward and Upward phases some themes that influenced the achievement of business benefits at ManB emerged. They were *education, training and support*, *change management*, and the need for adequate *people resources*. Once the business users fully understood the capabilities of the ERP system business benefits were achieved through *business process improvement* and *new projects that leveraged off the ERP system*. These results are of interest not only to IS researchers and IS practitioners but to senior management in organizations. They contribute to our understanding of how and why some organizations gain more business benefits from their ERP systems than others.

REFERENCES

Aladwani, A. (2001). Change management strategies for successful ERP implementation, *Business Process Management Journal* 7(3): 266-275.

Bancroft, N., Seip, H. and Sprengel, A. (1998) *Implementing SAP R/3*, 2nd edn, Manning, Greenwich.

Boudreau, M. (2003). Learning to use ERP technology: A causal model, in R. Sprague (ed.), *Proceedings of the 36th Hawaii International Conference on System Sciences*, IEEE Computer Society, Los Alamitos, CA.

Brehm, L., Heinzl, A. and Markus, M. L. (2001). Tailoring ERP systems: A spectrum of choices and their implications, in R. Sprague (ed.), *Proceedings of the 34th Annual Hawaii International Conference on Information Systems*, Vol. 9, IEEE Computer Society, Maui, HI. (9 pages).

Brown, C. V. and Vessey, I. (2003). Managing the next wave of enterprise systems: Leveraging lessons from ERP, *MIS Quarterly Executive* 2(1): 65-77.

Chang, S. and Gable, G. G. (2002). A comparative analysis of major ERP life cycle implementation, management and support issues in Queensland government, *Journal of Global Information Management* 10(3): 36-54.

Davenport, T. (2000) *Mission Critical*, Harvard Business School Press, Boston.

Davenport, T. H., Harris, J. and Cantrell, S. (2004). Enterprise systems and ongoing process change, *Business Process Management Journal* 10(1): 16-26.

Duplaga, E. and Astani, M. (2003). Implementing ERP in manufacturing, *Information Systems Management* 20(6): 68-75.

Eason, K. (1988). *Information Technology and Organizational Change*, Taylor Francis, London.

Gable, G. G., Sedera, D. and Chan, T. (2003). Enterprise system success: A measurement model, in S. March, A. Massey and J. DeGross (eds), *Proceedings of the Twenty-Fourth International Conference on Information Systems, Association for Information Systems*, pp. 576-591.

Gattiker, T. F. and Goodhue, D. L. (2005). What happens after ERP implementation: Understanding the impact of interdependence and differentiation on plant-level outcomes, *MIS Quarterly* 29(3): 559-585.

Holland, C. P. and Light, B. (1999). A critical success factors model for ERP implementation, *IEEE Software* 16(3): 30-36.

Klein, H. and Myers, M. D. (1999). A set of principles for conducting and evaluating interpretive field studies in information systems, *MIS Quarterly* 23(1): 67-93.

Markus, M. L. (2000). Conceptual challenges in contemporary IS research, *Journal of Global Information Management* 8(3): 42-48.

Markus, M. L. (2004). Technochange management: Using IT to drive organizational change, *Journal of Information Technology* 19(1): 3{19.

Markus, M. L. and Tanis, C. (2000). The enterprise systems experience – from adoption to success, in R. Zmud (ed.), *Framing the Domains of IT Research: Projecting the future through the past*, Pinnaflex Educational Resources, Cincinnati, Ohio, chapter 10, pp. 173-207.

Markus, M. L., Axline, S., Petrie, D. and Tanis, C. (2000). Learning from adopters' experiences with ERP: Problems encountered and success achieved, *Journal of Information Technology* 15(4): 245-265.

Orlikowski, W. (1993). CASE Tools as Organizational Change: Investigating Incremental and Radical Changes in Systems Development, *MIS Quarterly*, 17(3): 309-340.

Parr, A. and Shanks, G. (2000). A model of ERP project implementation, *Journal of Information Technology* 15(4): 289-303.

Parr, A., Shanks, G. and Darke, P. (1999). Identification of necessary factors for successful implementation of ERP systems, in O. Ngwenyama, L. Introna, M. Myers and J. DeGross (eds), *New Information Technologies in Organisational Processes*, Kluwer Academic Publishers, Boston, pp. 99-119.

Robey, D., Ross, J. W. and Boudreau, M. (2002). Learning to implement enterprise systems: An exploratory study of the dialectics of learning, *Journal of Management Information Systems* 19(1): 17-46.

Ross, J. W. and Vitale, M. R. (2000). The ERP revolution: Surviving versus thriving, *Information Systems Frontiers* 2(2): 233-241.

Shang, S. and Seddon, P. B. (2000). A comprehensive framework for classifying the benefits of ERP systems, *in* H. Chung (ed.), *Proceedings of the Sixth Americas Conference on Information Systems*, Association for Information Systems, pp. 1005-1014.

Shanks, G. (1997) The challenges of strategic data planning in practice: an interpretive case study, *The Journal of Strategic Information Systems*, 6(1): 69-90.

Soh, C. and Sia, S. (2005). The challenges of implementing "vanilla" versions of enterprise systems, *MIS Quarterly Executive* 4(3): 373-384.

Somers, T. and Nelson, K. (2001). The impact of critical success factors across the stages of enterprise resource planning implementations, in R. Sprague (ed.), *Proceedings of the 34th Annual Hawaii International Conference on Information Systems*, Institute of Electrical and Electronic Engineers, Inc., New Jersey, USA.

Staehr, L., Shanks, G. and Seddon, P. (2002). Understanding the business benefits of ERP systems, *in* J. DeGross (ed.), *Proceedings of the 8th Americas Conference on Information Systems*, Association for Information Systems, Dallas, Texas, pp. 899-906.

Sumner, M. (2000). Risk factors in enterprise-wide/ERP projects, *Journal of Information Technology* 15(4): 317-327.

The Importance of "Emotional" Features in Web-Based CRM System

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ABSTRACT

The notion of managing customer relationships would lead to better profitability has gained more attention from companies today. Companies' CRM efforts are not only limited to the physical contact points with customers: CRM program extends even to the online channel. However, recently researchers tend to focus on the importance of managing customer experience within the CRM initiatives. Past studies claim that CRM is not just a system solution to improve marketing and selling product/services. CRM system should also enable the features that would increase customers' emotional value and better experience. However, what are the "emotional features" that can be delivered in an online environment and what are the effects of those features on customer retention? Based on the literature, this study investigates the relationships between emotional features and customer retention. As such, questionnaire surveys were used to gather consumers' perceptions toward the internet as a shopping medium. In this study, we use structural equation model to test the fitness of data to the research model and reported the path loadings of studied variables. The findings determine that "emotional" constructs: personalization, place/track orders and online community influence customer retention. We discuss the results and suggest some directions for future research.

1.0 INTRODUCTION

The battle for customers has never been more intense. Heighten customer expectation and globalizations of trades are the uprising pressures which lead to a rise in competition. These factors force companies to switch from a product-centric approach to a customer-centric approach (Xu, Yen, Lin & Chou, 2002). At this junction, retailers who are at the front end of the supply chain and interact directly with customers are in a critical position to fully comprehend what induces repeat purchases (retention) (Feinberg & Kadam, 2002). Many researchers argue that in order to keep customers companies need to emphasize on customers emotional values, that is, the service attributes that make customers feel they are treated well enough to attract them to keep coming back (Anonymous, 2006). These "emotional" features can provide better customer experience leading to higher retention rates (Markwick, 2006).

Past studies have examined the roles of customer experience and emotional values in the traditional marketing environment (Schmitt, 1999; Wolf, 1999). However, limited research focuses on the influences of "emotional" features in an online environment. Since the Internet has become a significant (if not the only) channel of marketing for many firms, the study to understand the effect of emotional features on online retention merits further investigations.

1.1 Why Electronic Customer Relationship Management (E-CRM)?

E-CRM refers to the marketing activities, tools and techniques, delivered via the Internet which includes email, world wide web, chat room, e-forums etc. bearing on locating, building and improving long-term customer relationships (*Lee-Kelley,Gilbert & Mannicom, 2003). Driven by economics of customer management – well defined segmentation will lead to cost effective marketing efforts and increased profits, enabling technology such as the Internet is vital for firms to identify the differences in customers' behavior- preferences and attitude toward company's products. Coupled with other technology at the back-end such as customers' database, warehousing and data mining, value adding and personalized products or services could be offered, which in turn create an edge over competing companies.*

Driven by intense competition and cost-efficiency inspiration, firms are closely looking at marketing strategies that could win consumer loyalty. Businesses on the Internet are confronted with greater challenges as consumers' searching costs for price, quality information and comparisons across stores are much lower (Bakos 1997; Lynch & Ariely 2000), hence switching barriers almost do not exist (Yang & Peterson 2004). Research in understanding consumer retention has been the subject of investigation in the marketing area for a few decades. The motivation is driven by consumer economics in which keeping consumers may lead to securing sales (Jackson 1985) and serving repeat consumers costs less than acquiring new ones (Reichheld 1996). Consumer retention has been a primary goal of almost all companies, including Web-based companies (Peppers & Rogers 1995; Reichheld and Schefter 2000).

1.2 The Internet as a Tool of Retaining Customers

Front-end internet applications such as email, World Wide Web and chat room need to be supported with a well-built back-end system that utilizes the power of, among others, intelligent agents and database engines. Without a powerful back-end system, these Internet applications will not be able to function effectively. The E-CRM process begins at the first customer contact point such as a browser. That is, when customers visit a company's website the activities will be captured by a cookie file and logged in a server for initial profiling purposes. In turn, this profile allows firm to understand customer's surfing pattern which may be useful for future marketing plans. Added with users' information obtained from a web form, individual customer's profile is built up and stored in a database at the back-end. At this point, customers can interact with the database to check product availability, retrieve order details, track an order as well as personalize certain services.

Subsequently, a data warehouse application can be applied to sort periodical reports of customers' activities, which in turn, serve as input to an entailing data mining process. Next, the extraction of valuable information from a mining process may be used to produce buying trends vital to determine particular patterns in customers' behaviour leading to more effective customer segmentation. Indeed a consumer will revisit a Web site until there is another Web site that offers better quality service. In other words, it is the quality of products/services that makes the difference (Feinberg & Kadam 2002). Thus the imperative of understanding the level of quality of service rendering better customer experience, which may lead to retention should be investigated and is discussed next.

2.0 THEORETICAL FRAMEWORK

2.1 Customer Experience

In recent years, there seemed to be an increase in interests toward understanding the roles of customer experience in managing relationships. In particular researchers shifted their focus from merely investigating the impact of CRM systems to Customer Experience Management, also known as CEM, on improving relationships. In fact, many researchers claim that the economy, in particular the service sector, has been transformed into an attention economy (Davenport & Beck, 2002), entertainment economy (Wolf, 1999), emotion economy (Gobe & Zyman, 2001) or an experience economy (Pine & Gilmore, 1998; Schmitt, 1999). As many of service offerings have been commoditized, firms are advised to seek new ways to achieve competitive advantage by focusing on management of customers' experiences (Pullman & Gross, 2004).

Customer experience has been defined as the quality of event that accounts for anticipation, ***emotional involvement***, a uniqueness that makes the aforementioned stand out from the ordinary, and reaches some form of completion (Dewey, 1963). In addition, Price et al. (1995) suggests that extraordinary experiences are those activities characterized by high levels of emotional intensity which is usually triggered by an unusual event. The goal of providing such experience is to orchestrate experiences that are functional, purposeful, engaging compelling and memorable (McLellan, 2000). Hence, properly executed experience management will induce sense of loyalty not only through a functional design but also by creating ***emotional connection*** through engaging, compelling and consistent context (Pullman & Gross, 2004). However, the literature lacks studies that investigate the importance of "emotional features" leading to customer retention in an online environment.

2.2 Putting Customer Experience into the Online CRM System

Since the goal of CRM systems is to increase customer retention, and managing customer experiences are vital to encourage retention, this study examines the effect of several "emotional features" available on companies' Web sites on customer retention. The emotional features included in this study are:

Personalization Component

Consumers' involvement in designing products/services offered by Web sites is imperative since consumers have the very best understanding of their needs and relay the information to the providers (Von Hippel 1998). This knowledge of consumers' preferences is vital to avoid the sacrifice of consumer goodwill and maintain superior satisfaction (Du et al. 2003). Indeed, personalization attracts consumers to come back repeatedly since it turns consumers into product 'makers' rather than simply product 'takers' (Winer 2001), Thus, consumers are empowered in ways that they can choose their own preferred design, colour, product updates and other attributes that go well with their tastes. Slywotsky (2000) refers to this process as a "choiceboard" where consumers take a list of product attributes and determine what they want. The consumers are actually facilitating the activities of the company especially in product design, data collection and consumer service, which in turn extract value from participating in the marketing process (Moon 1999). Hence, the first hypothesis is:

H1: Personalization component offered by companies' Web sites influence customer retention.

Placing Orders and Order Tracking Components

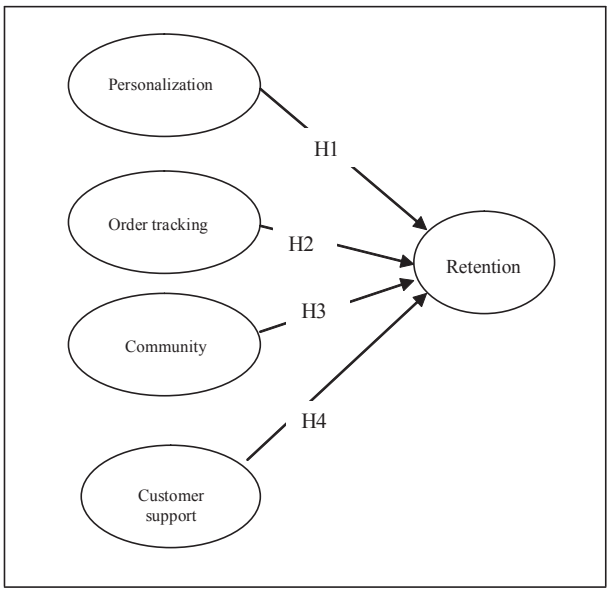
Certainly, consumers will feel empowered and in control when they are able to easily find a product/service, learn more about it and quickly make a purchase decision. For example, a site may provide features such as shopping carts, one-click ordering and order tracking to provide superior convenience and higher levels of consumer control (Batty & Lee 1995). Indeed, users who experienced superior values rendered by a site may never bother to switch and face uncertainties of service quality offered by other sites. A second hypothesis follows:

H2: Placing orders and order tracking components offered by companies' Web sites influence customer retention.

Online Community Component

To make a Web site more enticing Winer (2001) suggests building an *online community* of site users. This would make it more difficult for the consumer to leave the acquaintances who also patronize the company. Consumers can exchange information with each other and obtain online help from their online members when a product related problem arises (Moon 1999). These experiences create stickiness - the extent to which a company is able to attract consumers to use a site relatively longer and return (Strauss & Frost 1999), and consumers are more likely to revisit the site (Singh 2002). Therefore, online community can serve as an exit barrier since the relationship that develops among the members of the group may make it difficult for consumers to switch. Therefore, this study proposes the third hypothesis:

Figure 1. Hypothesized relationships



H3: Online community component offered by companies' Web sites influence customer retention.

Customer Support Component

It is a necessity that an online company maximizes its efforts in communicating the firm's image and purpose to its consumers (Bitner 1992). Consumers constantly demand for careful, continuous, and useful communication with company representatives (Lohse & Spiller 1998). Since these attributes are frequently identified as salient dimensions in store selection behaviour (Jarvenpaa & Todd 1997; Kolesar & Galbraith 2000), company representatives should have the knowledge and basic technology skills to answer online questions. They should understand consumer-specific needs, have the capacity to handle problems that arise and address consumer complaints in a friendly manner (Yang & Peterson 2004). Hence, the fourth hypothesis is:

H4: Customer support component offered by companies' Web sites influence customer retention.

Figure 1 depicts the relationships between the constructs being studied.

3.0 METHODOLOGY

3.1 Questionnaire Design

The questionnaire used in this study was designed based on the research objectives discussed. The questionnaire consisted of three parts. The first part, Section A, consisted of demographic information such as a respondent's age group and income level. Section B consisted of general information about a respondent's internet activities. These questions included respondents access location, number of years using the Internet, types of Internet activities and time spent in a week on the Internet. The third part, Section C, was designed to assess the attributes affecting respondents' satisfaction, retention and loyalty on the Internet respectively. The respondents were asked to indicate their opinions pertaining to various dimensions of the three variables being studied. A 5-point labelled Likert type scale was used with anchor from 1="Strongly Agree" to 5= "Strongly Disagree".

3.2 Operationalization of Variables

The items for the studied variables: *personalization, place/track orders, online community, customer support and retention* were constructed from the literature

Table 1. Measurement items

Variable	Items	Cronbach's Alpha
Emotional features: *Personalization*	Create my own account Knows my preferences Greet me by my name Offers what I want	0.86
Place/Track orders	Allows to check order status anytime Place orders anytime Keep me well informed	0.82
Online community	I feel sense of belonging Enjoy sharing ideas and information Enjoy exchanging information	0.75
Customer support	Quick response to enquiries Professional handling of complaints Always updated with customers' activities	0.74
Retention	I will re-visit the Web site I will recommend to my friends This is the site of my choice I will definitely return	0.89

pertaining to the respective subject matter. Table 1 summarizes the list of items used to measure each research variable.

3.3 Sampling

Primary data for this research were collected using a personally-administered questionnaire as this method will ensure a higher response rate. Research assistants helped in contacting respondents via email, and distributing and collecting the questionnaire in person. Secondary data for this study came mainly from newspapers, the Internet, journals, publications, magazines, books, and databases accessed via the Internet.

The main source of users list came from various education, government and corporate institutions in Klang Valley, Penang, Johor Bahru and Kuching. The nature of work that people do in these institutions requires the use of Internet hence they are appropriate source of primary data for this study. For example, it is common for university staff and students to use the internet for communication or to conduct research. Likewise, most companies in the selected cities have internet connections on their premises and the method of communication within these companies is mainly email. Malaysian government is one of the leading examples in implementing e-government in Asia. Most of the government offices are internet-enabled and in fact, the use of intranet within these departments is common. Thus, the choices of these institutions are deemed appropriate for this study. 1000 respondents were chosen using systematic random sampling. A total of 671 (67.1%) responded to the survey while the remaining respondents either could not be contacted or declined to participate. Descriptive analysis was used to report the profile of research respondents while measurement model was conducted to examine the items of research constructs: personalization, place/track orders, online community, customer support and retention. In addition, Structural Equation Model (SEM) was conducted to test the cause-effect relationships of these variables.

4.0 DATA ANALYSIS AND RESULTS

4.1 Respondent Profile

The respondents were almost evenly split by race (37 per cent Malay, 34 per cent Chinese, 24 per cent Indian and 5 per cent others) and gender (50 per cent were male and 50 per cent female). Most of the respondents were 21 to 30 years of age (51 per cent), followed by the age groups of 31 to 40 and below 20 years at 29 per cent and 10 per cent, respectively. These three groups contributed approximately 90 per cent of the overall total in term of age. 49 per cent of the respondents had spent at least 15 years in education. Most of the respondents were executives (48 per cent) and more than half of them earn between RM12, 000 to RM36, 000 per annum (51 per cent).

4.2 Structural Equation Model (SEM)

To test the fitness of research model to the data, SEM was conducted. Drawn from the literature, this study posits that customer retention on the Internet may be influenced by several emotional features: personalization, place/track orders, online community and customer support.

The results indicate that indicate a good fit to data: χ^2 /df= 2.88, RMSEA= 0.058, CFI=0.98, TLI= 0.96 and AGFI= 0.92 (see Table 2). Hence, the causal diagram fits the study data well. In terms of hypothesized relationships between the exogenous constructs, it can be seen personalization (β= 0.24), place/track orders (β= 0.46) and online community (β= 0.37) and favourably influence customer retention. However, this study indicates that customer support has no significant influence on customer experience (β= 0.11): the path coefficient was not significantly different from zero. The path loadings are illustrated in Figure 2 below.

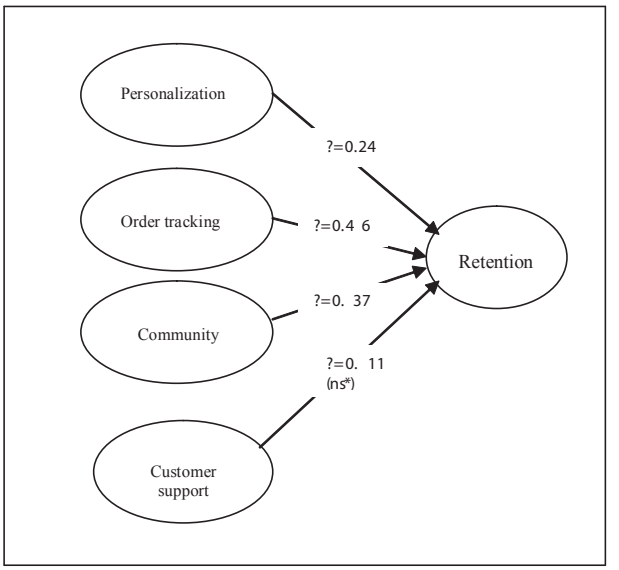
5.0 DISCUSSION AND CONCLUSION

Certainly, the internet is a "new" medium of commerce which attracts different types of consumers than that of traditional shopping channel. The internet channel is perceived as fast, real time access to information and process, and allowing some level of control, thus expectations of online service provider performance

Table 2. Goodness-of-fit statistics for the research model

Goodness-of-fit measures	4-dimension	Recommended value
Chi-square	176.30	
χ^2/df	2.88	≤3.0[a]
Root mean square of error of estimation (RMSEA)	0.060[1]	≤ 0.06[b]
Adjusted Goodness-of-fit index (AGFI)	0.92	close to 0.90[c]
Tucker-Lewis Index (TLI)	0.96	>0.95[d]
Comparative Fit Index (CFI)	0.98	>0.95

Figure 2. Path loadings from cause-effect tests



*Note: * non-significant path loadings*

are higher compared to the traditional channel. Undoubtedly, online consumers seek for better characteristics than those that merely satisfy them in order to entice consumers to come back; such as ability to personalize services, ability to decide on purchase immediately and track the status of their orders and offline-online synchronized orders. Facilities such as tracking order status, history of purchases or activities and allowing certain degree of customization enhances consumers' experience, in turn, these pleasant encounters form emotional values which attract customers to return. Evidently, companies like Amazon have gained competitive advantage from all these emotional features: one-click ordering, personal name greeting, product recommendation and reviews from previous users. Providing these features on one's site may improve their relationship with consumers and gain a competitive edge.

Interestingly, this study reports that customer support does not influence customer retention. A possible explanation for this is Internet customers have higher expectations of service if compared to the traditional channel. The Internet enhances customers' empowerment through its self-service oriented transactions. Hence, customers' expectations of service leading towards retention would be the features that encourage empowerment, sense of control and appreciation (such as personalization, tracking and online community). These emotional values may not be realized and achieved through mere email communication with customer support personnel, helpdesk or frequently-asked-questions (FAQ).

Our study emphasizes that firms striving for building long-term relationships with online consumers should be well aware of the emotional features that help them encourage customer retention. This study contributes in identifying the online features forming emotional values leading to increased retention. Indeed, on the Internet, consumers who are dissatisfied with the experience on a particular Web site may easily switch to another provider. Therefore, superior service quality placing reasonable attention on and delivering features that induce customer pleasant experience and increasing emotional value should be considered.

This study is subject to several limitations. Firstly, the respondents from this research were mainly working adults in urban localities, well educated and have at least three years of experience using the Internet. Further research is needed to generalize the results across different groups of Internet users in Malaysia. The results of this study may be applied to other countries with similar culture and business environment. Therefore, before conclusions and implications can be made to other countries with different culture and business environment (such as the Western region), further research should be conducted.

REFERENCES

Anonymous (2006). Building loyalty by creating positive customer experiences, Teller Vision, August, 2-3.

Bakos, JY (1997), 'Reducing buyer search costs: implications for electronic marketplaces', *Management Science*, vol. 43, no. 12, pp. 1676-1692.

Batty, JB & Lee, RM (1995), 'Intershop: enhancing the vendor / customer dialectic in electronic shopping', *Journal of Management Information System*, vol. 11, no. 4, pp. 9-31.

Bitner, MJ, Booms, BH & Mohr, LA (1994), 'Critical service encounters: The employees viewpoint', *Journal of Marketing*, vol. 58, no. 4, pp. 95-106.

Davenport, T & Beck, J. (2002). The attention economy: Understanding the new currency of business. Harvard Business School Press.

Dewey, J. (1963). Experience and education. Collier Books, New York.

Du, X, Jiao, J & Tseng, MM (2003), 'Identifying customer need patterns for customization and personalization', *Integrated Manufacturing Systems*, vol. 14, pp. 387-396.

Gobe, M., & Zyman, S. (2001). Emotional branding: The new paradigm for connecting brands to people. Allworth Press, New York.

Feinberg, R., & Kadam, R. (2002). E-CRM web service attributes as determinants of customer satisfaction with retail web sites. International Journal of Service Industry Management, 13, 432-51.

Jackson, BB (1985), 'Building customer relationships that last', *Harvard Business Review*, vol. 63, pp. 120-128.

Jarvenpaa, SL & Todd, PA (1997), 'Consumer reactions to electronic shopping on the World Wide Web', *International Journal of Electronic Commerce*, vol. 1, no. 2, pp. 59-88.

Kolesar, MB. & Galbraith, RW (2000), "A service-marketing perspective on e-retailing: implications for e-retailers and directions for further research", *Internet Research: Electronic Networking Applications and Policy*, vol. 10, no. 5, pp. 424-438.

Lee-Kelley. L., Gilbert, D., & Manniconm, R. (2003). How e-CRM can enhance customer loyalty. *Marketing Intelligence Planning*. 21, 239-48.

Lohse, GL & Spiller, P (1998), 'Electronic shopping', *Communication of ACM*, vol. 41, no. 7, pp. 81-89.

Lynch, JG & Ariely, D (2000), 'Wine online: Search costs affect competition on price, quality and distribution', *Marketing Science*, vol. 19, no. 1, pp. 83-103.

Markwick, N. (2006). Creating a sense of belonging works for customers online, Revolution, September, 82.

McLellan, H (2000). Experience design. Cyberpsychology & Behavior, 3, 59-69.

Moon, Y (1999), 'Interactive technologies and relationship marketing strategies', *Harvard Business Review*, 9-599-011, pp. 1-12.

Peppers, D & Rogers, M (1995), 'A new marketing paradigm: share of customer, not market share', *Planning Review*, March/April, pp. 14-18.

Pine, B. & Gilmore, J. (1998). Welcome to the experience economy. Harvard Business School Press.

Price, L., Arnold, L., & Tierney, P. (1995). Going to extremes: Managing service encounters and assessing provider performance, Journal of Marketing, 59, 83-97.

Pullman, ME. & Gross, MA (2004). Ability of experience design elements to elicit emotions and loyalty behaviours, Decision Sciences, Summer, 35, 551-578.

Reichheld, F.F., & Teal, T. (1996). *The loyalty effect: The hidden force behind growth, profits and lasting value.* Harvard Business School Press, Massachusetts.

Reichheld, F.F., and Schefter, P. 4 (2000). E-loyalty: Your secret weapon on the web. *Harvard Business Review,* 78*,* 105–13.

Schmitt, B (1999). Experiential marketing, The Free Press, New York.

Singh, M (2002), 'E-services and their role in B2C e-commerce', *Journal of Managing Service Quality*, vol. 12, no. 6, pp. 434-446.

Slywotsky, A.J (2000), 'The age of the choice board'*, Harvard Business Review*, pp. 40-41.

Strauss, J & Frost, R (1999), *Marketing on the Internet*, Prentice-Hall Inc., Upper Saddle River, NJ.

Von Hippel, E (1998), '*Economics of product development by users: The impact of `sticky' local information', Management Science*, vol. 44, pp. 629-644.

Winer, R. (2001). A framework for customer relationship management. *California Management Review*, 43, 89-105.

Wolf, MJ (1999). The entertainment economy-How mega-media forces are transforming our lives, Times Books, New York.

Xu, Y., Yen, D. C., Lin, B., & Chou, D. C. (2002). Adopting customer relationship management technology. *Industrial Management & Data Systems.*102, 442-52.

Yang, Z., & Peterson, R.T. (2004). Customer perceived value, satisfaction, and loyalty: The role of switching costs, *Psychology & Marketing*, 21, 799–822.

Developing Buddy: Towards Greater Dependability and Maintainability in Meta-Search

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ABSTRACT

Most meta-search engines use web scraping as an ad-hoc method to extract results from the output display of various search engine sources. However, a search engine may cease operation, merge with other engines or its display format may change. A dependable meta-search engine must, thus, adapt to display changes in search engine sources and be maintainable even by people with low programming skills. This paper describes the design and development of Buddy, a meta-search engine that is able to help web users search more effectively into multiple search engine sources. It allows integration of a new search source with minimum complexity and programming knowledge, leading to greater dependability and maintainability. Search results are aggregated from multiple sources to remove duplicate and sponsored links and to give the most relevant results each time. Buddy also allows query refinement and saving of search results locally in user computers or remotely in emails.

Keywords: Meta-search engine, Information Retrieval, Web scraping in Java

1. INTRODUCTION

The World Wide Web may be considered the largest database in the world, with its huge collection of data covering every part of our lives. Each day, each second, a humongous number of people search the Web for information and data of their interest, such as news, word documents, research papers, pictures, music and video. The sole aim of these searchers is to find answers to their queries.

However, they may not be able to find all the best answers in a single search engine. E.g. searching Google (www.google.com) alone is still considered insufficient even though it seems to have the largest repository of web pages [1]. This is because there is very little overlap in the databases of different search engines [2]. Since the top results ranked by different search engines are very different from each other, Web searchers potentially miss relevant results by using only one search engine. Here comes the need and relevance of meta-search engines that have the underlying philosophy that "having many heads is better than one" i.e. instead of searching into only one search engine, it may be worthwhile to get another opinion from other search engines. As searching manually into individual search engines is time-consuming and inefficient, meta-search engines (see [3] for a list of meta-search engines) allow searching into various search engines simultaneously.

1.1 Issues with Meta-Search Engines and Their Development

Unfortunately, meta-search engines today are too ad-laden [4]. They are becoming "meta-yellow pages" where searchers query paid listings and get advertisements in their search results. Searchers are forced to sieve through irrelevant sponsored sites ranked among the search results.

There are two ways in which meta-search engines are able to search into other search engines: 1) Using the APIs provided by search engines e.g. Google's Java-APIs. However, this method is not feasible when searching into many search engines. To connect to ten search engines that use different APIs, such a method will require learning how to apply ten different APIs. This will makes the connection to a search engine's database a tedious task and it would be difficult to maintain the system. Moreover, unlike Google, not many search engines are willing to share their APIs with the public. 2) To overcome this limitation, a web scraping technique [5] can be used to extract the results from the output display of various search engines. This allows connecting and extracting data from many search engine sources without having to learn new APIs.

This leads us to the most important issue, which is the focus of this paper – dependability and maintainability. The output display of search engines may change and cause extraction of results using web scraping method to fail. New search engines can emerge anytime in the World Wide Web. Existing search engines may cease to exist or merge with another engine. A dependable meta-search engine must, thus, adapt to display changes in search engine sources and be maintainable even by people with low programming skills.

In this paper, we describe the design and development of Buddy, a meta-search engine developed at the School of Computing, National University of Singapore and accessible at http://buddy.redirectme.net

The remainder of the paper is organized as follows. In Section 2, we briefly describe the features of Buddy that lead to greater maintainability and dependability. Target users and guiding objectives are also discussed. Section 3 discusses the system design considerations. In Section 4, we see the system architecture of Buddy. Section 5 highlights the experimental results on evaluating the system. Section 6 concludes the paper by sharing the lessons learnt and possible future enhancements.

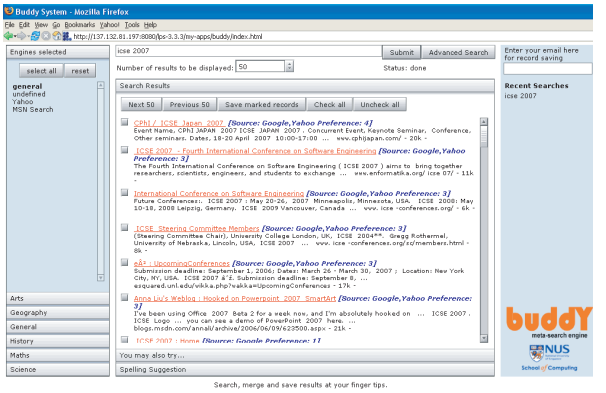
Let us now look at the Buddy Meta-search Engine.

2. THE BUDDY META-SEARCH ENGINE

Figure 1 shows a snapshot of the Buddy Meta-search Engine. Buddy extracts results directly from search engines chosen by the user. No paid links are added into the final merged results. Sponsored links from the source search engines are actually omitted. The system thus minimizes the occurrence of sponsored links in search results, while maximizing relevant links.

Buddy has been designed for dependability and maintainability – it can easily connect or disconnect to/from search engines. At the same time, it can adapt to display output changes in the search engine sources. In Buddy, adding a new source search engine does not require learning its APIs. Any changes to the output display of the source search engines will require minimal modification. The web scraping technique in Buddy makes use of existing Java's Regular Expression and Pattern matching capability [6]. If the output display of source search engines changes, the system administrator just needs to modify the Regular Expression that governs the web scraping structure. This means that there is no need to change the underlying data structures of the system. Maintaining the system will also require little programming knowledge. There is no need to recode the system or web scraping methods if changes occur to the source search engines. Modifications are done in a declarative approach (see Section 3.1).

Figure 1. Snap-shot of Buddy (accessible at http://buddy.redirectme.net)



Understanding searcher needs is important if we are to attract users to use Buddy. Besides being able to extract results from search engines, Buddy can also extract results from sites such as Dictionary.com (www.dictionary.com) to provide spelling suggestions for queries with spelling errors[1].

Buddy can extract query refinement suggestions from sites like Ask.com (www.ask.com) and Yahoo (www.yahoo.com) that provide query refinements together with the searched results. This shows the flexible web scraping method used in our proposed system.

Buddy also enables searchers to save their results locally in their computers or to send their results to their email so that they can access the results in future.

2.1. Target Users

Buddy, though a general-purpose meta-search engine, has been developed keeping in mind, the educational needs of students and teachers in Singapore. The education system in Singapore encourages schools to use materials outside their textbooks, including project-based learning. Earlier, students used encyclopedias to gather this extra information. With the technology available today, students have switched to gathering information from the World Wide Web. Search engines have thus become useful tools for students to do their learning or to gather data for their projects. Teachers can also turn to search engines to gather useful teaching materials. Buddy primarily aims to help such students and teachers in their needs by providing customizable mechanisms to search from specific sources.

Agarwal and Poo [7] discuss classifying a typical Internet searcher into one of 4 searcher modes (or categories) – 1) novice[2], 2) data gatherer, 3) location searcher and 4) focused searcher. In the novice mode, the searcher knows nothing about of the domain under search. As data gatherer, he/she is familiar with the domain or subjects under search. A data gatherer just needs information on the topic he/she is knowledgeable about. A location searcher just needs to locate information previously encountered. The searcher in focused searching mode needs a specific answer to a specific question.

As a novice, it is sometimes hard to decide which results are relevant and which are not. A novice is also unsure of what he/she is searching for. The web-based interface of Buddy has to provide an intuitive way of selecting the search engines. Buddy has separated search engine choices into categories, namely – Science, Math, Geography, History, Arts and General Search. This will helps students to better focus their search into specific domains. Buddy also provides query refinements and spelling suggestions for searchers. This is especially useful when the searcher is in a novice mode. Unlike existing meta-search engines, Buddy does not include sponsored links in its results.

As a data gather, a searcher's aim is to gather information. Searching one search engine is not enough. Searching many search engines manually is inefficient. Buddy is able to search multiple search engines concurrently and return merged results without duplicates or sponsored links. Hence a data gather can select the specific domains he/she wants to search into.

As a location searcher, a searcher wishes to find the results that he/she came across previously. Since Buddy provides utilities to let searchers save or email their results, these can be accessed again locally in user computers or remotely in their email account.

A focused searcher wishes to be able to query about a specific question. Buddy supports Boolean searching. This helps a focused searcher to obtain better results.

As students are still in a stage of learning, we expect more students to fall under the modes of *novice* and *data gatherer*, especially when searching for education-related materials. We would expect teachers to be in the *data gatherer, location searcher*, or *focused searcher* modes most of the times. Once the searchers get their answers, they might want to share the results with other students or teachers. This is where the save-results utility provided by Buddy comes in handy.

2.2. Objectives Guiding Buddy

To summarize, the objectives guiding the development of Buddy are twofold:

1. **Dependability and Maintainability.** This is the most important objective. Connecting to source search engines should be easy. Buddy should be adaptable to changes in search engine sources. Additional search engines could easily be added into Buddy without recoding the data structures and methods. Any changes to the source search engines should require minimal modifications to the system, keeping the underlying data structures untouched. Modification should be done in a declarative approach. People maintaining the system need not be proficient in their programming skills.
2. **To be an appropriate Learning tool** (the name 'Buddy' reflects this objective). Buddy must cater to the needs of a searcher in any of the 4 searcher modes described in Section 2.1. Besides being able to search into multiple search engine databases, Buddy must be able to provide tools for disambiguation, such as query refinement and spelling suggestions so as to guide searchers in the novice mode. Buddy must also allow searchers (data gatherers and focused searchers) to search into specific directories and subjects. Buddy must enable use of Boolean expressions to make queries specific for searchers (focused searchers). Buddy must enable searchers (location searchers) to keep track of the searches they had done and to retrieve their previous search results. Finally, the system must minimize the number of sponsored links in the results.

3. SYSTEM DESIGN CONSIDERATIONS

Buddy was implemented using Java Development Kit (JDK) version 1.4.2 and Sun System Application Server 8. Java codes were written with EditPlus2 text editor. The web-based user interface (GUI) was implemented in JSP and OpenLaszlo (www.openlaszlo.org), the open-source platform for rich Internet applications. JSP files were written with Macromedia Dreamweaver 4. Some of the decisions and considerations in designing Buddy are:

- **Declarative Approach.** Properties of the data structures of source search engines are described in script files, contributing to maintainability. The integration of new search engine is simple.
- **Web scraping method.** There are a few open-source parsing tools [5][8] However, these are usually complex and incur a steep learning curve. Hence, we defined a simple web scraping method that uses Java Regular Expression and Pattern Matching API [6] and requires knowing only Regular expressions to modify the web scraping structure. E.g. 3 parts of the search result (shown in 3 different lines)

  "
  Yahoo!
  Welcome to Yahoo!, the world's most visited …"

  can be extracted using

(?:)	match URL
(.*?)(?:?)	match Title
(.*?)(?: <small><i>?)	match Description

  Expressions in bold define the groups of string that we scrape from the HTML page.
- **Multithreading.** Multithreading enables parallel request and retrieval of results from the parent search engines. Experiments have shown that parallel searches perform better than sequential searches [9].

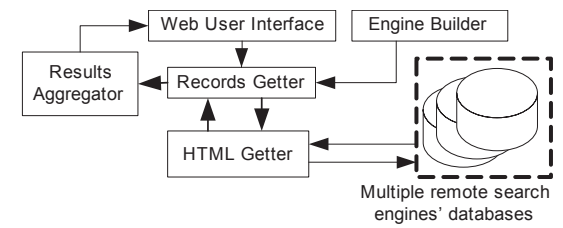
- **Query refinement method.** Most search engines use tools like WordNet [10] to help them perform query refinements. With the flexible web scraping method, Buddy scrapes query refinements and spelling suggestions from other search engines, as defined in configuration files. Hence, it is lightweight and useable on low-cost platforms.
- **Merging of results.** The simplest way of aggregation is to return all the results in one page without any post processing and re-ranking. This can lead to biased or overlapping results. In contrast, positional methods are computationally more efficient [11] and more precise. We use a positional method of ranking the merged results.
- **Web-based interface.** As the system was implemented using Java, Java Server Pages (JSP) was used to interact with the user and server. The GUI of the system aims to be intuitive and user-friendly. As the target users of the system are students and teachers, it is appropriate that the system is able to connect to subject-specific directories. Search engines are classified according to categories, namely Science, Math, Geography, History, Arts and General Search. E.g. Science category will include science-related search engines and directories – Scirus, Google's Science Directory and Yahoo's Science Directory. This will help searchers focus their search in a specific subject.

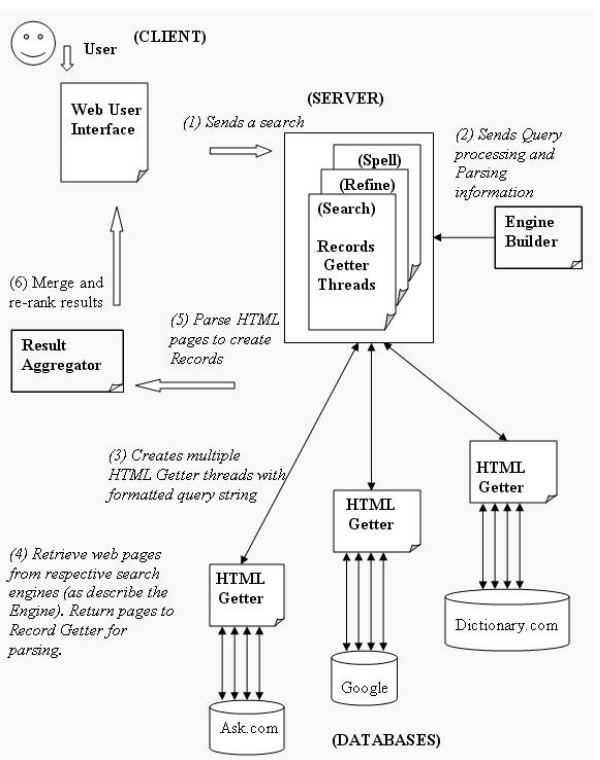
4. SYSTEM ARCHITECTURE

Buddy is made up of 5 components (see Figure 2):

1. **Web User Interface** – interacts with searchers
2. **Records Getter** – processes queries and parses/scrapes HTML pages; returns a vector of Records (results)
3. **HTML Getter** – retrieves HTML pages with the format query URL string; multithreading is used to speed up page retrieval.
4. **Engine Builder** – informs Records Getter to perform query processing and HTML parsing of different query/results format of different source search engines.
5. **Results aggregator** – merges, removes duplicates and re-ranks search records. Borda Positioning Rule was used to merge and re-rank the results, as it is relatively inexpensive, computationally efficient and has desirable properties such as anonymity, neutrality and consistency [11][12].

Figure 2. (Top) System architecture; (Bottom) Interaction among components





5. EXPERIMENTAL RESULTS

To test the performance of Buddy, 37 queries[3] were selected to obtain statistical results. These 37 search terms have been used previously in other studies [11] [12].

Experiments were done on a system with AMD Athlon XP 1600+ 1.4Ghz, 768 MB of RAM and a 2000 kbps Internet connection.

Two tests were conducted:

1. The first test connected the system to 6 search engines (Google, Yahoo, MSN Search, AllTheWeb, AltaVista, and Ask.com) individually to obtain 200 normal search results per query.
2. The second test meta-searched into 3 search engines (Google, Yahoo, and MSN Search) concurrently to return aggregated search results (only top 200 from each search engines is used; we would expect about 600 results per query). At the same time, we also searched for query refinements from Ask.com and Yahoo, and spelling suggestions from Dictionary.com.

The reader should note that we did not want to compare the performance of the various rank aggregation methods, nor compare performance with other meta-search engines. Instead, we wanted to evaluate the time taken to parse the HTML pages and aggregate the results against the total time taken to complete the task. This is to evaluate the amount of overhead (in terms of processing time) used for parsing and aggregating results. The tests were also to show that the system was running properly.

5.1. Test-1 Analysis

In this test, Buddy was used to search into 6 search engines individually to obtain 200 results per search engine per query.

Parsing Overhead

We are able to evaluate the parsing overhead incurred in this test. Parsing overhead is the amount of processing time required to parse HTML pages to create Vectors of Records.

From Figure 3, Buddy clocked an average of 2.5 seconds while searching into Google for 200 results per query. Ask.com took the longest time, with the bulk

Figure 3. Time taken for Buddy to search sequentially into each search engine

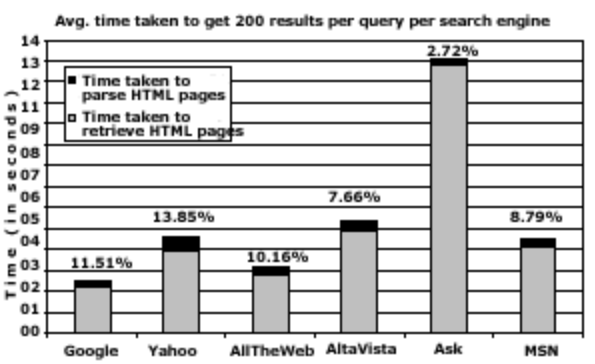


Table 1. Breakdown of records obtained by Buddy from each search engine (total 37 queries)

Search engine	Total no. of unique records	Total no. of duplicates	Total records
Google	7389	11	7400
Yahoo	7398	2	7400
AllTheWeb	7393	7	7400
Alta Vista	7395	1	7396
Ask	7357	11	7368
MSN Search	7312	48	7360
Total statistics	44244	80	44324

of the time spent on retrieving the HTML Page. We observed that on the average, only 7.24% of the processing time is involved in parsing. Bulk of the time is being used to retrieve the HTML pages instead.

Limitation Factor

We conclude that the performance of Buddy is limited by the connection speed to the search engines. We will expect the speed of combined search to be limited by the speed of slowest search engine selected. For instance, Searcher A selects Google and Ask.com. Searcher B selects Google and MSN Search. The system will take a longer time to obtain results for Searcher A because page retrieval from Ask.com is relatively the slowest (Figure 3).

Overlapping Records

It is interesting to note that there are actually a few (less than 1%) duplicates already present within the results of a search engine (Table 1). E.g. out of the 7400 records from Google, the system has removed 11 duplicates.

5.2. Test-2 Analysis

In Test Two, for every query, Buddy is used to perform the task of searching 3 search engines to obtain 600 results, to obtain query refinements and spelling suggestions. The final results are obtained by merging 200 results from each of the 3 search engines. We will expect some duplicated results to be removed. Here, we evaluated the overhead incurred for result aggregation. The top 3 fastest search engines from Test One (Google, Yahoo and MSN Search) were selected to participate in this test.

Results Aggregation Overhead and Performance

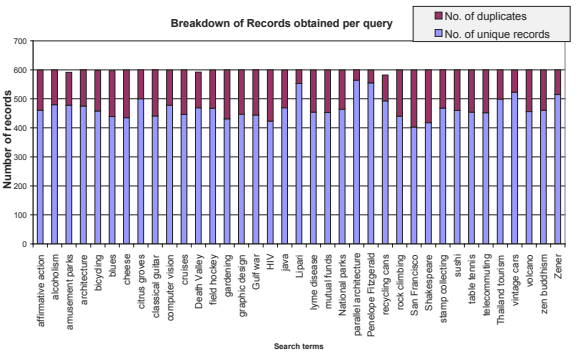
From Figure 4 (top), we can see that the average overhead cause by result aggregation is only 0.32%. The system has, on average, removed 21.78% of the total results that are overlapping. Also from Figure 4 (bottom), we can see that about one-fifth of the results are duplicates. For each query, the system takes about an average of 7.86 seconds to gather about 600 results from the 3 search engines, aggregates them and provides, on average, 90 query refinements. The performance is better than Helios [9], which took 12.4 seconds to retrieve 600 results.

In summary, the average time for Buddy to retrieve, parse and merge 600 results from Google, Yahoo and MSN Search is 7.8 seconds per query. This timing includes the retrieving and parsing of query refinement and spelling suggestions from Ask.com and Dictionary.com.

The performance of the system is greatly affected by the available bandwidth. Parsing and result aggregation overhead is not significant compared to that of HTML retrieving.

Figure 4. (Top) Statistics for Buddy to metasearch Google, Yahoo and MSN Search (200 results per search engine); (Bottom)Breakdown of records obtained per query

Search records from Google,Yahoo,MSN Search (200 results per search engine)							
	Query	No. of unique records	No. of duplicates	No. of Query refinements	No. of Spelling suggestions	Time Taken for Result Aggregations	Total Time taken (millisecs)
1	affirmative action	461	138	88	0	31	7438
2	alcoholism	480	120	115	0	15	12531
3	amusement parks	478	113	97	1	16	7531
4	architecture	475	125	140	0	31	6922
5	bicycling	458	140	65	0	32	7235
6	blues	439	158	138	0	16	7500
7	cheese	435	164	145	0	31	7171
8	citrus groves	500	100	5	7	32	7360
9	classical guitar	441	159	84	3	16	7656
10	computer vision	478	121	21	0	16	7657
11	cruises	446	154	133	0	46	7166
12	Death Valley	469	123	96	0	31	8438
13	field hockey	467	132	80	0	31	7687
14	gardening	431	169	149	0	31	7234
15	graphic design	447	153	132	0	15	6922
16	Gulf war	444	156	65	0	31	7109
17	HIV	423	177	103	0	32	11812
18	java	469	130	137	0	15	7469
19	Lipari	553	47	6	20	31	7781
20	lyme disease	454	145	78	0	15	7344
21	mutual funds	453	147	144	5	31	7843
22	National parks	464	135	144	2	32	8219
23	parallel architecture	564	36	11	0	15	7469
24	Penelope Fitzgerald	555	44	3	0	32	8172
25	recycling cans	493	89	48	1	15	7125
26	rock climbing	440	160	136	0	31	6750
27	San Francisco	403	196	135	0	16	7672
28	Shakespeare	418	182	138	0	16	7578
29	stamp collecting	468	132	60	0	31	11860
30	sushi	460	140	142	0	15	7203
31	table tennis	454	146	130	0	47	8500
32	telecommuting	452	148	58	0	16	7266
33	Thailand tourism	499	101	50	0	16	7813
34	vintage cars	523	76	58	6	32	7454
35	volcano	456	144	144	0	31	8094
36	zen buddhism	461	138	53	0	16	6797
37	Zener	515	85	26	49	16	7204
	Total Stats:	17326	4823	3357	94	922	290972
	% time spent on results aggregation=	Total Time Taken for Result Aggregations/Total Time taken =				922/290972 =	0.32%
	Avg. search time per query (millisecs) =	Total time taken/ 37 querys =				290972/37	7864.11
	% of records are duplicates=	Total number of duplicates/Total number of records=				4823/(17326+4823)	21.78%



6. CONCLUSIONS AND FUTURE WORK

Currently, Buddy can already connect and extract data from

1. 9 search engines (Google, Yahoo, MSN Search, AllTheWeb, AltaVista, Ask.com, Scirus, AOL and Lycos).
2. 15 Directories (Science, Math, Arts, History and Geography Directories) from Google, Yahoo and Open Directory Project.
3. Non-search engine sites such as Dictionary.com.

Web scraping has been an important method in the data extraction module of this system. It is an ad-hoc method that does not require us to learn extra APIs of the databases we want to connect to. It has enabled the system to extract data from virtually any free search engines that return results in HTML format.

It is interesting to note that the project has not involved external open source tools like XQuery or WordNet. The whole project has been done using standard Java

APIs. This shows the text processing power of Java language. Web scraping can be conveniently done using Java's Regular Expression and Patten Matching.

Declarative approach enables us to easily change the web scraping structure just by changing the regular expressions. We can also change the properties of the source search engines by editing the parameters in their descriptor script files. This does not require much programming knowledge to maintain the system.

This proposed meta-search system will be useful to searchers, especially to the target users in the education domain. The system is suitable for searchers who 1) want to have a wider range of answers to their queries from multiple sources 2) dread to see sponsored links 3) need help in query refinements and spelling suggestions 4) want to share their results with others or save their results for future reference. Thus, the system is certainly a suitable learning tool for students and teachers, and should find applicability in schools.

The system retrieves results straight from sources, without adding sponsored links to distract users. The system lets searchers have wider range of answers to their queries from multiple sources. The system is useful to novice searchers who need help in query refinements and spelling suggestions. The system also allows searchers to share their results with others or save their results for future reference. This system is certainly a suitable tool for learning for the students and teachers. Above all, it serves the primary objective of being a meta-search engine with increased dependability and maintainability.

Several problems were encountered and lessons learnt in the development of Buddy. The performance of the initial prototype was not desirable. This was because of the lack of parallelism being employed in the implementation. Retrieving HTML pages is usually the bottleneck of the whole search process because it takes a relatively long time to retrieve the pages. Subsequently, multithreading was used to retrieve the pages from the search engines, and the performance of the system is acceptable now. From the tests conducted (see Section 5), we can see that performance is greatly influenced by the amount of bandwidth available. The processing cost of parsing and result aggregations is not that high compared to that of retrieving HTML pages. Performance will be affected if the available connection speed is low. If we can speed up the HTML retrieval process by using faster Internet connection, the system's performance will improve.

Future work can include multi-language support, support for Really Simple Syndication (RSS) format [13] and classification of search results into appropriate categories.

REFERENCES

[1] J. Barker, "The Best Search Engines – UC Berkeley - Teaching Library Internet Workshops", *Finding Information on the Internet: A Tutorial*, UC Berkeley, 2006, Accessed 5 Sep 2006 from http://www.lib.berkeley.edu/TeachingLib/Guides/Internet/SearchEngines.html

[2] G.R. Notess, "Little overlap despite database growth!", *Search Engine Statistics: Database Overlap*, Search Engine Showdown, Accessed 5 Sep 2006 from http://www.searchengineshowdown.com/statistics/overlap.shtml

[3] C. Sherman, "Metacrawlers and Metasearch Engines", *SearchEngineWatch*, 23 Mar 2005, Accessed 4 Sep 2006 from http://searchenginewatch.com/showPage.html?page=2156241

[4] PCWorld, "The Straight Story on Search Engines", *PCWorld Computing Center*, About.com, 2006, Accessed 5 Sep 2006 from http://pcworld.about.com/magazine/2007p115id97431.htm

[5] ceperez, "HTML Screen Scraping Tools Written in Java", *Manageability – Java Open Source*, Accessed 5 Sep 2006 from http://www.manageability.org/blog/stuff/screen-scraping-tools-written-in-java/view

[6] Sun Microsystems, "Pattern", *Sun Java2SEv1.4.2*, 2003, Accessed 5 Sep 2006 from http://java.sun.com/j2se/1.4.2/docs/api/java/util/regex/Pattern.html

[7] N.K. Agarwal and D.C.C. Poo, "Meeting knowledge management challenges through effective search", *Int. J. Business Information Systems*, 1(3), 2006, pp.292-309.

[8] B. Goetz, "Java theory and practice: Screen-scraping with Xquery", *Java technology / XML, IBM DeveloperWorks*, Accessed 4 Sep 2006 from http://www-128.ibm.com/developerworks/xml/library/j-jtp03225.html

[9] A. Gulli and A. Signorini, "Building an open source meta-search engine", Special interest tracks and posters of 14th WWW Conf., May 10-14, 2005, Chiba, Japan.

[10] Princeton University, *WordNet: a lexical database for the English language*, Cognitive Science Laboratory, Accessed 3 Sep 2006 from http://wordnet.princeton.edu/

[11] M.S. Mahabhashyam and P. Singitham, "Tadpole: A Meta search engine Evaluation of Meta Search ranking strategies", *CS276A Project, Stanford University*, Fall 2002, Accessed 7 Sep 2006 from http://www.stanford.edu/class/cs276a/projects/reports/mmahathi-pavan.doc

[12] C. Dwork, R. Kumar, M. Noar and D. Sivakumar, "Rank aggregation methods for the web" In *Proceedings of the 10th International Conf. on the World Wide Web (WWW10)*, May 1-5, 2001, Hong Kong, ACM Press and Addison Wesley, pp.613-622.

[13] D. Winer, *RSS 2.0 Specification*, Berkman Center for Internet & Society, Harvard Law School, Accessed 4 Sep 2006 from http://blogs.law.harvard.edu/tech/rss

ENDNOTES

1 There are many misspelt words that Google cannot detect e.g. arrowplane, arrowdynamic, brase, buule, colar, canntin, diform, doubl, etc.

2 'Novice' was termed 'learner' and 'location searcher' was termed 'location seeker' in [7]. The terms have subsequently been revised to remove ambiguity.

3 affirmative action, alcoholism, amusement parks, architecture, bicycling, blues, cheese, citrus groves, classical guitar, computer vision, cruises, Death Valley, field hockey, gardening, graphic design, Gulf war, HIV, java, Lipari, lyme disease, mutual funds, National parks, parallel architecture, Penelope Fitzgerald, recycling cans, rock climbing, San Francisco, Shakespeare, stamp collecting, sushi, table tennis, telecommuting, Thailand tourism, vintage cars, volcano, zen buddhism, and Zener.

Comparing Student Teachers' Preferences and Perceptions on E-Learning

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ABSTRACT

Electronic learning is a new trend in higher education institutes around the globe but there is a paucity of solid research concerning student teachers' readiness for this direction. A questionnaire was developed by adapting Hiltz's framework to determine student teachers' perceptions on areas that contribute to the success of electronic learning. A total of 70 student teachers participated in the survey. 44 of them took at least one information technology module and the remainder took no information technology modules. The two groups of students gave high ratings on most items asked. However, their perceptions on group dynamics and mode of teaching were significantly different. The research findings and the implications for use in teaching education are discussed.

1. INTRODUCTION

Information technology plays an important role in the modern world by providing easy access, flexibility, support for multimedia presentations, enabling communication virtually with anyone in the world. The development of information technology also has a significant impact on education by supporting a paradigm shift, i.e., shifting from a teacher-centred to a student-centred mode of teaching and learning. "We are finding that, for a small but growing percentage of people, new forms of communications, publications, and collaboration and the way data are accessed, represented and manipulated are changing the way knowledge is conceived, challenged, justified, and disseminated in their disciplines" [1]. Indeed, some universities offer online courses to cater for those who prefer to study using online platforms to complement face-to-face teaching. Myers, Bennett, Brown & Henderson [2] found that "Educational technologies may open new avenues for more students to access opportunities and information, increase forms of interactions among teachers and students and encourage collaboration across institutions" (p. 84). It was also suggested that academics who use E-learning may become better teachers as they may reflect on their teaching and also initiate more dialogue with other teachers on the potential benefits of various teaching methods [2].

The Hong Kong Institute of Education (HKIEd) is a tertiary teacher education institute in Hong Kong. It was realized that information technology has been used to support many projects related to assisting teaching and web-based learning in the past few years. HKIEd has adopted a popular learning platform, namely Blackboard, to facilitate this new mode of learning. Although there are many articles on methods for measuring the success of e-learning at different higher educational institutes [3, 4] there are very few articles that focus on factors affecting E-learning for teacher education. It is understood that it might not be feasible or desirable to completely replace face-to-face lectures with an e-learning mode as presentation and communication skills are considered essential attributes for effective teaching. However, given the positive feedback on the use of discussion forums to complement face-to-face learning at the HKIEd [5], and the easy access and high availability of computers at schools in Hong Kong [6], it is now an appropriate time to explore factors affecting the success of E-learning implementation, and also to determine whether student teachers are ready to learn some modules completely online.

2. A FRAMEWORK FOR E-LEARNING

The success of E-Learning can be measured from both students' and faculty members' perspectives by using educational outcomes as an indicator. To align with the educational reforms, learners should be prepared to develop "learning how to learn" skill and other generic skills in addition to basic content acquisition [7]. Drawing from diverse literature, Hiltz [8] came up with a research framework with the independent variables of technology, and course and student characteristics; intervening factors of amount and type of use of virtual classroom; and a dependent variable - better learning experiences.

Technological determinism - The efficiency and effectiveness of system design and implementation will directly influence user behaviour [9]. Specific resources such as hardware, software, and communication technologies could be important factors affecting user accessibility and reactions to particular aspects of E-Learning.

Social-psychological approach - The attitudes and capabilities of educators and learners when using information technology can be grouped as: 1) the perceived value of computer-based information, and 2) computer literacy. Both are accepted as important factors influencing the success of E-Learning [8, 10-12] .

Human relations school - The relationships and interactions among educators and students could be a significant facilitator or inhibitor to teaching and learning in the E-Learning mode. Implementing E-Learning successfully requires task interdependence in which agreement and collaboration of members are necessary and essential. It is imperative that members are comfortable with open discussion of and decision making in relation to E-Learning [8, 13].

Interactionist perspective - The success of E-learning depends on the interactivity among elements mentioned above, and these are influenced by information culture and national culture. Information culture refers to the characteristics of administrators, learners and educators in the use of collaborative information technology for knowledge sharing [12, 14]. National culture refers to "the collective programming of the mind that distinguishes the members of one group or category of people from another" [15]. In the learning environment, interactivity involves the way people think, act and communicate.

A questionnaire was developed based on Hiltz's [8] research framework. However, various independent variables are reworded so that they are more appropriate to the learning environment under study, they are: system resources, computer literacy, and perceived value of computer-based information, group dynamics and learning culture. Since it would be very difficult to measure human learning process and outcomes, the effectiveness of outcomes could be measured through the perception of students and their preferences [8, 16, 17]. Thus, the dependant variables for the success of E-Learning could be interpreted in terms of perception and preferences. Two sets of hypotheses are formulated as follows:

1(a): *System resources* are positively related to student teachers' *perceptions* of E-Learning for teacher education.
1(b): *Computer literacy* is positively related to student teachers' *perceptions* of E-Learning for teacher education.
1(c): *Perceived value of computer-based information* is positively related to student teachers' *perceptions* of E-Learning for teacher education.
1(d): *Group dynamics* are positively related to student teachers' *perceptions* of E-Learning for teacher education.
1(e): *Learning culture* is positively related to student teachers' *perceptions* of E-Learning for teacher education.

2(a): *System resources* are positively related to student teachers' *preferences* of E-Learning for teacher education.
2(b): *Computer literacy* is positively related to student teachers' *preferences* of E-Learning for teacher education.
2(c): *Perceived value of computer-based information* is positively related to student teachers' *preferences* of E-Learning for teacher education.

2(d): *Group dynamics* are positively related to student teachers' *preferences* of E-Learning for teacher education.

2(e): *Learning culture* is positively related to student teachers' *preferences* of E-Learning for teacher education.

3. THE STUDY

There were seventy participants who were pre-service student teachers studying for the Bachelor of Education (Primary) at the HKIEd. Forty four of them took an information technology (IT) module either as an elective or as one of their IT minor studies module. They were mainly year 1 or year 2 students and they were classified as IT students in this paper. The other twenty six participants took general studies as their major and did not take IT as their minor, and they did not take electives and they were year 4 students (non-IT students). IT student teachers were asked to fill in an online questionnaire during their break time towards the end of the semester whilst the non-IT student teachers filled in the same questionnaire using hard copies as there were only a few computers accessible in their classroom. They were not obliged to fill in the questionnaire as no identity was required.

4. FINDINGS AND DISCUSSION

The questionnaire was in a 5-likert scale with strongly disagree, disagree, agree, strongly agree and not applicable. It was found that participants were mostly positive on the items asked as most items had more than half as "agree" or "strongly agree" answers. The answers to "not applicable" are not shown as they were rather insignificant. When these two categories of answers are combined, it was found that they gave the highest rating to the *question 3.3 - usefulness of computer-based information* (95.77%), followed by *2.2 - My level of computer competency is good enough to access different materials* (90.14%) *1.1 - Easy to get access to computer facilities outside campus (88.73%)*. In fact, *question 1.1- easy to get access to computer facilities outside campus* had the highest strongly agree answer. This implies student teachers have good connected computer facilities at home.

It is interesting to observe that some items show dichotomous results. Two out of three items of learning culture had polarized results. About half of them enjoyed reading on-line materials and take part in on-line discussions whilst the other half preferred the opposite (question 5.1 and 5.2). There were slightly more students preferred more face-to-face learning (question 7.1).

Despite adequate student teachers' computer competence and having appropriate infrastructure in place, they were unwilling to take online modules. They gave the lowest rating to *question 7.2 - I prefer to take some modules completely delivered online (35.21%), 4.4 - if my views are different from others in a group, I am reluctant to express it out* (36.62%), and *6.4 - I learn more using traditional board and chalk method (40.85%).* The findings suggest that students were still more comfortable with the traditional mode of learning where the educator is the expert and they are not completely confidence on their own learning as they "*still need some instructions from instructors rather than control my own learning process"* (question 4.3, 88.13%). They were more likely to accept lectures' instruction rather than questioning them (question 4.2, 85.92%).

This finding is somewhat disturbing as they did not seem to have adapted to the new mode of learning and it seems that they may have been adopting a surface learning approach. "Students who believe that knowledge is handed down by authorities or experts would not bother too much in questioning or understanding the learning materials, which would be committed to memory by the surface strategy" [18]. Perhaps it is the Chinese culture to accept and respect their seniors that make them unwilling to take some modules online. The findings further suggest that the learning culture and perhaps the national culture have a strong impact on student teacher's preferences even though they had good perceptions on E-learning.

Multivariate Correlation was used to test the strength between two variables for the hypotheses under investigation. It was found that most variables were significant at the 0.05 level (see Table 4). Hypothesis *2(b): Computer Literacy is positively related to student teachers' preferences of E-Learning for teacher education* was not significant at 0.05 level, that means computer literacy does not affect respondents' preferences on e-learning. All other hypotheses were significant means that all other independent variables affect respondents' preferences and perceptions on e-learning.

The two groups of student teachers were analysed using One-way analysis. It was found that all 5 items of group dynamics (*question 4.1 - To express my views or ideas that contradict what instructors say is not comfortable, 4.2 - I am more likely*

Table 1. Top ranking

Rank	Items	S. Disagree	Disagree	Agree	S. Agree
1	3.3 Perceived value of computer-based information as Useful	2.82	1.41	73.24	22.54
2	2.2 My level of computer competency is good enough to access different materials	1.41	8.45	73.24	16.90
3	1.1 Easy to get access to computer facilities outside campus	4.23	7.04	56.34	32.39

Table 2. Ambivalent finding

Items	S. Disagree	Disagree	Agree	S. Agree
5.2 I like to take part in discussion about my learning with instructors or other students by using e-mail or discussion board rather than doing the work alone.	4.23	45.07	45.07	4.23
5.1 I enjoy reading academic material on-line rather than listening to instructors in classrooms.	2.82	42.25	45.07	5.63
7.1 I prefer to have more E-Learning "lecture" to replace face-to-face learning	5.63	47.89	39.44	4.23

Table 3. Bottom ranking

Rank	Items	S. Disagree	Disagree	Agree	S. Agree
Last	6.4 I learn more using traditional board and chalk method	47.89	33.8	7.04	9.86
2nd Last	4.4 If my views are different from others in a group, I am reluctant to express it out.	7.04	54.93	30.99	5.63
3rd Last	7.2 I prefer to take some modules completely delivered online	11.27	50.7	29.58	5.63

Table 4: The relationships between the dependent variables (Perceptions, Preferences) and the independent variables (Resources, Computer Literacy, Perceived value of computer-based information, Group Dynamic and Information Culture). (N=70)

Correlation	Resources	Computer Literacy	Perceived value	Group Dynamic	Information Culture
Resources	----				
Computer Literacy	0.2014	----			
Perceived value	0.5391*	0.4030*	----		
Group Dynamic	0.1082	0.4681*	0.3307*	----	
Information Culture	0.4535*	0.3854*	0.4401*	0.4539*	----
Perceptions	0.5086*	0.4012*	0.5692*	0.4770*	0.5918*
Preferences	0.5695*	0.2161	0.5085*	0.2868*	0.6160*

** Correlation is significant at the 0.05 level*

to accept lectures' instruction rather than questioning them, 4.3 - I still need some instructions from instructors rather than control my own learning process, 4.4 - If my views are different from others in a group, I am reluctant to express it out and *4.5 - I am more likely to discuss assignments with my friends rather than tackling them alone.*) and item *6.4 - I learn more using traditional board and chalk method* are significant at $p < 0.01$ level but all other comparisons between the two group of student are not statistically significant. This finding suggests both groups of student teachers are positive regarding their ability to adapt to e-learning, and yet their preferences of learning mode and learning style were very different.

5. LIMITATIONS

Although all the respondents were studying the same programme, the IT and non-IT respondents were studying at a different level. Furthermore, the sample sizes of the two groups of students were also rather different. Therefore, one would be cautions at generalizing the findings in this paper to the student teacher population at HKIEd.

6. CONCLUSION AND IMPLICATIONS

This research has provided a first step in exploring the different factors affecting the successful implementation of E-learning for teacher education and to determine the differences between IT module students and non-IT module students. It was encouraging that student teachers were positive regarding most of the items asked which showed that they were ready to take part of the modules using the E-learning mode but they were unwilling to take modules completely online. The group dynamic is the only critical factor that affects IT and non-IT groups in their own preferences and preferences on e-learning. This suggests it is the knowledge and exposure rather than the skills that affect the perceptions and preferences of e-learning.

The findings were very informative and have four major implications; the first implication is that the HKIEd have provided a conducive environment for learners to engage in E-learning. The second implication is that student teachers were well prepared to study online as they did not encounter any problems regarding systems resources, individual differences and learning culture. The third implication is that it would be best to teach using blended learning as there is no unanimous preference regarding face-to-face versus e-learning. The fourth and possibly the most important implication is that; knowledge and experience with using IT to learn rather than the skills makes a big difference to preferences and perceptions towards e-learning.

We are mindful that this is only a preliminary finding and there is a great need to determine whether the IT student teachers were influenced by the concepts they learnt from the IT module or whether they were a group of students who were more proactive and therefore more positive on initiatives and innovative practices. The findings can be constructively complemented by focus group meetings to search for patterns of inter-relationships between different variables. It is appropriate to adopt a holistic view for any forward planning. The results would become more comprehensive and convincing with a larger sample for investigation.

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8. REFERENCES

1. Batson, T. and R. Bass, *Teaching and learning in the computer age.* Change, 1996. **28**(2): p. 42-47.
2. Myers, C.B., et al., *Emerging online learning environments and student learning: An analysis of faculty perceptions.* Educational Technology & Society, 2004. **7**(1): p. 78-86.
3. Hayashi, A., et al., *The role of social presence and moderating role of computer self efficacy in predicting the continuance usage of E-learning systems.* Journal of Information Systems Education, Summer 2004. **15**(2): p. 139-154.

4. Tham, C.M. and J.M. Werner, *Designing and Evaluating E-learning in Higher Education: A Review and Recommendations.* Journal of Leadership and Organizational Studies, 2005. **11**(2): p. 15-25.
5. Ng, E.M.W., *Enhancing Flexible and Collaborative Learning for Preservice Teachers through a Web-based Learning System.* Journal of Quality School Education, 2002. **2**: p. 53-63.
6. Leung, C.K., T.Y.V. Ng, and S.F.A. Tam, *Overall Study on Reviewing the Progress and Evaluating the Information Technology in Education (ITEd) Projects 1998/2003 - Final Report*. 2005, Education and Manpower Bureau: Hong Kong.
7. Seng, L.C. and S. Al-Hawamdeh, *New mode of course delivery for Virtual Classroom.* Aslib Proceedings, 2001. **53**(6): p. 238-242.
8. Hiltz, S.R., *The virtual classroom: Learning without Limits via Computer Networks.* 1994, Norwood, NJ.: Ablex.
9. Mowshowitz, A., *Virtual organisation.* Communication of the ACM, 1997. **40**(9): p. 30-37.
10. Larson, M.R. and R. Bruning, *Participant perceptions of a collaborative satellite-based mathematics course.* American Journal of Distance Education, 1996. **10**(1): p. 6-22.
11. McCollum, K., *A professor divides his class in two to test value of online instruction.* Chronicle of Higher Education., 1997. **43**(24): p. 23.
12. Jarvenpaa, S.L. and D.S. Staples, *The use of collaborative electronic media for information sharing: an exploratory study of determinants.* Journal of Strategic Information System, 2000. **9**: p. 129-154.
13. Claver, E., et al., *The performance of information systems through organizational culture.* Information Technology and People, 2001. **14**(3): p. 247-260.
14. Davenport, T.H., *Information Ecology*. 1997, Oxford: Oxford university press.
15. Hofstede, G., *Cultures Consequences : Comparing Values, Behaviors, Institutions, and Organisations Across Nations.* 2001, Thouson Oaks, London, New Delhi: Sage Publications.
16. Hiltz, S.R., *The virtual classroom:Learning without Limits via Computer Networks*. 1994, Norwood, NJ.: Ablex.
17. Alexander, S. and J. Mckenzie, *An Evaluation of Information Technology Projects in University Learning.*, in *Department of Employment, Education and Training and Youth Affairs,*. 1998: Australian Government Publishing Services, Canberra.
18. Chan, K.W., *Hong Kong teacher education students' epistemological beliefs and approaches to learning.* Research in Education, 2003(69): p. p.36-50.

Exploiting Process Thinking in Healthcare: Evidence of Positive Impact on Operating Theatre Efficiency

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ABSTRACT

In Finland, a project designed to modernize processes and reduce the waiting list for joint replacement surgery has recently been completed. The new surgery arrangements for artificial joint patients were monitored for a period of one year. The new arrangements involved relocating the anaesthesia phase outside the operating theatre. The reorganization of the patient care process for joint replacement surgery succeeded in achieving a 50 per cent increase in operations. While conventional operations can often be pushed up a notch with state-of-the-art technology, for example, this article supports the argument that process thinking can be exploited effectively to support new ways of work and improve productivity in healthcare.

INTRODUCTION

The Care Guarantee Act, which came into force in Finland in March 2005, has made many healthcare units look at the arrangement of the services they produce in a new light. Particular attention is fixed on the legal obligation concerning the waiting times between treatment decisions and treatment measures, which is to be no more than six months. The need to increase the number of operations has become a matter of current debate particularly in orthopaedics, where the length of queues has become unlawfully long at several hospitals. Improvements in controlling the queues have previously been achieved by the more efficient handling of referrals (Harno et al., 2000), but with surgery this was felt to be ineffective (Harno et al., 2001). In special operative areas, making use of all the development potential available within the traditional treatment chains should be explored as a permanent remedy, after first-aid obtained in the form of outsourced services. In this article we illustrate a case where process thinking and process development tools where exploited to support new ways of work and improve productivity in healthcare.

PROCESS THINKING

The term 'process thinking' refers to a number of management theories that have been used by industry in its quest for better operating processes over the last few decades. Large-scale application of them in the healthcare sector should be seriously considered because it is time to take a critical look at the publicly funded system. The system is struggling with the combination of rising demand and escalating costs in specialist medical care, while at the same time, there is strong support for reduced public-sector healthcare spending but firm rejection of any cuts in service levels. If the two targets are to become reality simultaneously, the methods enabling them to be achieved should be chosen on the basis of how deep the cuts should be. Cosmetic improvements would be fairly painless: for example, Total Quality Management would result in long-term improvements in operating processes as a more efficient use of resources would bring gradual savings. Some scholars have, however, likened some quality management theories to a rain dance (Schaffer & Thomson, 1992). In their view they look good, sound good and allow those involved to feel good, while at the same time they may have no influence on the rain itself.

There are also other management theories in the field of process thinking. According to the time-based management approach, all development should focus on process lead-time (Stalk & Hout, 1990). In such an approach all other positive aspects, improved quality, cost savings and customer satisfaction will follow automatically. However, development measures do not need to mean squeezing more out of the stages intended to boost the value of the treatment process. In fact, industrial companies have been able to find larger savings in the way they use the time that brings no added value, which, after all, accounts for more than 95% of the total. Cutting consultation times in health care would be sheer folly as the measure would probably only result in additional repeat visits. At the same time, all solutions speeding up the flow of information and improving the service capability of the support processes would be a real 'shot in the arm' to the system: replacing piles of paper with a byte-based system would, for example, give surgeons real-time access to x-ray images, which would allow quicker decision-making and, consequently, help to shorten treatment times.

In contrast to Total Quality Management, which emphasizes continuous development, Business Process Reengineering proposes a radical revision of the business process. The aim is to start from scratch without the burden of old operating approaches (Oliver, 1993; Hammer & Champy, 1993). The reengineering starts with a definition of the desired end result. This will form the basis for the planning of the new process functions and sequences. The aim is to maximize value-adding functions and to get rid of all operations not adding to the value. Extensive use of the information technology is often used as the means for achieving the desired results.

Effecting the operational changes required by Business Process Reengineering has been somewhat problematic. Resistance to change, which is inherent in human nature, and the fact that reengineering is often a zero-sum game, make the implementation of the change process more difficult (Buchanan, 1997). Besides, reengineering thinking emerged just as the recession of the early 90s began to bite, and was often used as a justification for drastic job cuts. In fact, for a while BPR was almost likened to the Black Death in the industrial sector. Since then it has lost some of its reputation and has evolved from a much-feared consulting tool into a set of practical measures. The theory, though somewhat worn-out, is still useful, as it underlines the importance of the information technology in performance improvement. Great potential for applying the theory and information technology can be found in sectors that for ages have relied on well-entrenched operating models, such as health care (Evans, Hwang & Nagarajan, 1997).

This article presents a case from hospital environment where process thinking was utilized. Seinäjoki Central Hospital implemented a project to revise processes in order to reduce queues in surgery, particularly artificial-joint surgery. The project was part of the ProViisikko project of the Hospital District of South Ostrobothnia and Tekes. This article describes the results of the experiment for the benefit of, for example, other operation units that are taking a close look at their operations and of developers and management in health care as support for decision-making. Parts of the study have been published in Finnish language (Jokipii et al., 2006).

STARTING POINTS FOR CHANGE AND EXPERIMENT

Seinäjoki Central Hospital wanted to reorganize the operations for artificial-joint patients so that three operations could be performed in the same operating room in the course of a normal day's work instead of two. The experimental period lasted from November 1, 2004 to November 30, 2005.

The revision of the treatment process utilized process thinking and process development tools. Of these, the theory of constraints was thought the best applicable for examining the process for treating artificial-joint patients. The point in this approach is to identify those stages in the process that dictate the maximum current throughput (Goldratt, 1990). By allocating additional resources and development action to these bottlenecks, the throughput can be improved without needing to interfere in the other stages of the process. The main change for increasing the usage of the operating room capacity was transferring the anaesthetic stage from the operating room to separate induction facilities. Experiments on this had been reported earlier in medical journals (Hanss et al., 2005; Sandberg et al., 2005, Torkki et al., 2005).

In the new arrangement, the anaesthetic stage was transferred outside the operating room. At the same time, one anaesthesia nurse was added to the operating team, working both in the operating room and in anaesthetic. Another anaesthetic nurse took the next patient in good time to the recovery room or to the operating room's induction facilities to be anaesthetized. As soon as the operating room was cleaned after the previous operation, the next patient could be prepared for surgery. The next patient was brought to the operating room already anaesthetized and in the correct position for the operation.

The duties of the orthopaedist that were not part of the operations or preparation for them were scheduled outside the operation days. Thus, the surgeon whose turn it was to operate was able to focus exclusively on the work in the operating room. At the beginning of the experimental period, the same orthopaedist operated for one week at a time, but this practice had to be changed so that the operation days were rotated among different practitioners. At the beginning of 2005, there were five orthopaedists working at Seinäjoki Central Hospital.

MATERIAL, METHODS AND RESULTS

In Finland in 2003, about 6,800 artificial joint operations were carried out on the hip and some 7,200 on the knee, and there were more than 1,700 instances of further surgery. These operations are performed in almost 70 hospitals, but the minimum number of 200 operations recommended by the Ministry of Social Affairs and Health is only exceeded in 25 units. Every year the Hospital District of South Ostrobothnia performs between 550 and 600 artificial-joint operations.

In the study, quantitative material was collected from the operating days in the experimental period on which three artificial-joint operations were carried out (n=49); because of the small number of orthopaedists, there were 2-3 of these days in a week. Comparative material consisted of the days on which two artificial-joint operations were carried out between January 1 and June 30, 2004 (n=27).

The time when patients were in the operating room and changeover times were recorded in the operation database. The time-monitoring material consisted of the times when the operating room was in use. The median time that patients were in the operating room and the median changeover time, when there is no patient in the operating room, were used for comparison purposes.

Qualitative material was collected through interviews during the experimental period and by means of a work-satisfaction questionnaire carried out among doctors and nurses a year after the experiment started.

The new operating model made it possible to carry out three operations during a normal working day. The orthopaedists examined the patients during a pre-operative visit or on the day preceding the operation. The first patient of the morning was in the operating room in time, and the operation started on time at 8.30 a.m. The anaesthetization stages for the second and third patients, which were carried out staggered with the operation, took slightly longer than if carried out in the operating room.

As it was possible to separate some of the steps previously carried out in the operating room and have them done outside, the hospital succeeded in increasing the throughput of the process by 50%, even though the usage capacity of the operating room remained almost the same.

Adding four nurses to the operating team (2 for anaesthetization and 2 for the operation) made it possible to shorten the changeover times considerably: the average time was reduced from 54 minutes to 13 minutes. This was because the team was able to take coffee and meal breaks in turn. One of the operation nurses was able to help the orthopaedist as necessary.

In the three-operation model, anaesthetizing the second or third patient of the day in separate facilities reduced the time the patient was in the operating room by 20 minutes (149 minutes vs. 129 minutes).

According to the questionnaire, fifty per cent or more of the doctors who took part in the experiment felt that the meaningfulness of their work and work motivation had increased and thought that the three-operation experiment should become a permanent fixture. The nursing staff felt that minimizing the idle waiting improves the atmosphere and increases work motivation to some extent. The doctors felt the new operating model improves the meaningfulness of the work and work motivation more than the nursing staff did.

DISCUSSION

The usage capacity of the operating room is generally considered to be the bottleneck in the operation process. This generalization leads easily to a practice where outsourced services or increasing the number of a hospital's own operating rooms are seen as the only options for increasing output. From our experiences the throughput of the process for artificial-joint operations can be increased while the usage capacity of the operating room remains the same or even decreases. Focusing the operations on one operating room proved to be effective.

An increase in the throughput of the operation process was sought without increasing the workload of the staff. The hospital succeeded in doing this by firstly dealing with idle waiting. Targeting greater efficiency here and a simultaneous improvement in the throughput required development in several areas, e.g. adding one nurse to the operating team, a bigger work contribution from the hospital attendant in preparing patients, preparing the anaesthetic in a new way and changing the orthopaedist's work schedule. The justification for adding one nurse was that in the revised staggered operation stage, there was also one patient more.

It was not possible to anticipate all the effects of the change. In order to ensure that things went smoothly, specialist experienced doctors acted as anaesthetists and orthopaedists during the experimental period, but at the same time the arrangement narrowed the opportunities for training specializing doctors. Furthermore, not enough preparation was made for the increase in the number of operations at all stages of the treatment process. At times, the growth in the throughput caused congestion on the ward and especially in further treatment at health centres.

In financial terms, the transfer to the practice of three operations was worthwhile. The resources for arranging three operations were obtained principally by utilizing the fixed costs of the hospital more efficiently. In alternative cost accounting comparing the additional cost caused by a hospital's own activities with the cost of an artificial-joint operation acquired from the private sector or another provider (minus the costs of the prosthesis, materials and cost of the treatment days) shows a difference of some USD 4,000 between the hospital's own work and outsourcing with regard to the added third primary operation per day. Because of the limited number of orthopaedists, however, it was not possible in the experimental period to run 'flat out' five days a week.

15 complete operations a week would be enough to meet the need for artificial-joint surgery in the entire hospital district, and the revised treatment process would generate annual savings of between USD 700,000 and USD 800,000 for the Hospital District of South Ostrobothnia, even taking into account the additional recruitment required.

CONCLUSIONS

The project by Seinäjoki Central Hospital offers an encouraging example of a way to exploit process thinking and process development tools in health care. Seinäjoki Central Hospital succeeded in obtaining a 50% increase in flow-through in the process for treating artificial-joint patients with the transfer of the anaesthesia stage outside the operating room in the reorganization. For every two joint replacement operations previously conducted, there were now three operations performed in the same theatre and in a normal working day. In the longer term, the arrangement would mean that in Finland the entire country's need for artificial-joint surgery, about 15,600 operations per annum, could be dealt with in 30 operating rooms.

The introduction of the new patient care process demonstrated that the operating theatre capacity was not causing a bottleneck, but that it was the orthopaedic

surgeons brought in at the various intervals who formed the key resource. The reorganized care process for patients requiring joint replacement surgery should produce annual cost savings of USD 700,000 to USD 800,000 for the Hospital District of South Ostrobothnia. Following the experience gained in the project, the Seinäjoki Central Hospital has decided to adopt the project model on a permanent basis. A similar reorganization is also possible in other hospital districts.

REFERENCES

Buchanan D. (1997) The Limitations and Opportunities of Business Process Re-engineering in a Politicized Organizational Climate. *Human Relations*, 50, 51–72.

Evans J., Hwang Y. and Nagarajan N. (1997) Cost reduction and process reengineering in hospitals. *Journal of Cost Management*, 11(3), 20-27.

Goldratt, E.M. (1990) Theory of constrains. Croton-on-Hudson, NY: North River Press.

Hammer M. and Champy J. (1993) Reengineering the Corporation - A manifesto for business revolution. Harper Business: New York, 1993.

Hanss R., Buttgereit B., Tonner P.H., Bein B., Schleppers A., Steinfath M., Scholz J. and Bauer M. (2005) Overlapping induction of anesthesia: An analysis of benefits and costs. *Anesthesiology*, 103 (2), 391–400.

Harno K., Arajärvi E., Paavola T., Carlson C. and Arnala I. (2001) Clinical effectiveness and cost analysis of patient referral by videoconferencing in orthopaedics. *Journal of Telemedicine and Telecare*, 7(4), 219–25.

Harno K., Paavola T., Carlson C. and Viikinkoski P. (2000) Patient referral by telemedicine: effectiveness and cost analysis of an intranet system. *Journal of Telemedicine and Telecare*, 6(6), 320–29.

Jokipii P., Kalliovalkama K. and Paavola T. (2006) Tekonivelpotilaan hoitoprosessin uudistaminen. *Suomen Lääkärilehti* (Finnish Medical Journal), 61(14), 1626–27.

Lee B. and Menon N. (2000) Information technology value through different normative lenses. *Journal of Management Information Systems*, 16(4), 99–119.

Oliver J. (1993) Shocking to the core. *Management Today*, 1993, Aug, 18–22.

Sandberg W.S., Daily B., Egan M., Stahl J.E., Goldman J.M., Wiklund R.A. and Rattner D. (2005) Deliberate perioperative systems design improves operating room throughput. *Anesthesiology*, (103)2, 406–418.

Schaffer R. and Thomson H. (1992) Successful Change Programs Begin with Results. *Harward Business Review*, 22(1), 80–89.

Stalk G. and Hout T. (1990) Competing Against Time - How Time-Based Competition is Reshaping Global Markets. New York: The Free Press.

Torkki P.M., Marjamaa R.A., Torkki M.I., Kallio P.E. and Kirvela O.A. (2005) Use of anesthesia induction rooms can increase the number of urgent orthopedic cases completed within 7 hours. *Anesthesiology*, 103(2), 401–405.

The Use of Online Discussions to Enhance Face-to-Face Block Mode Teaching

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ABSTRACT

This paper is a case study of the use of web-based communication technologies in conjunction with block mode teaching. It describes how an online discussion forum increased the participation of students, and provided feedback to the instructor on student interaction, learning and understanding. The contribution of the paper is its description of the specific advantages, both to the instructor and the student, of supplementing block mode teaching with online discussions. Guidelines for setting up an online discussion forum in block mode teaching contexts are provided, highlighting those of particular relevance to the block mode context.

Keywords: Block mode, online discussions, web-based technologies.

INTRODUCTION

Universities are increasingly choosing to present some course subjects via on-campus block mode or intensive programs presented over a one to four week period. One advantage of such programs is that they allow students to complete course requirements in a shorter time frame, whilst giving face-to-face access to instructors that may not be available on campus for longer periods. Another advantage is the opportunity to immerse students in a subject, with daily interactions giving both instructor and student the chance for more concentrated interaction. Use of visiting academics from other countries or specialized industrial or corporate instructors can enhance student opportunities for learning. Disadvantages of block mode teaching are that students do not have the time for wider reading and the deeper reflection and learning that may come when there is ample time for the linking of new knowledge to other subjects being studied at the same time (Burton & Nesbit, 2002; Davies, 2006).

These limitations can be partially overcome by providing students with greater opportunities for interaction with their fellow students and instructors both during and in between block mode sessions. One way of providing such increased opportunities is by supplementing formal lectures and tutorials with provision of an online discussion forum accessed using web-based communication technologies. Such web-based platforms for discussion can act as amplifiers, broadening the sharing of information beyond what is possible in an intense face-to-face environment (Tiene, 2000). Although the use of web-based communication technologies in conjunction with face-to-face instruction has been previously researched in detail (Dabbagh, 2002), their use in conjunction with block mode face-to-face teaching has been limited (Yorke et al., 2005; Fuller et al., 2003).

The focus of this paper is a case study that exemplifies the use of web-based communication technologies in conjunction with face-to-face block mode teaching. It describes how an online discussion forum increased the participation of students, and provided feedback to the instructor on student interaction, learning and understanding.

The contribution of the paper is its description of the specific advantages of supplementing block mode teaching with online discussions, both to the instructor and the student. It details how this can improve student participation and learning opportunities by expanding on already occurring classroom dynamics, and give the instructor greater awareness of student learning than would normally be available from face-to-face teaching alone. A set of guidelines is also provided for setting up an online discussion forum to be used in conjunction with block mode teaching.

USE OF ONLINE DISCUSSIONS IN EDUCATION

Online discussions are increasingly used in educational contexts as a component of both distance education and on-campus learning. Such discussions can produce more active engagement from students compared to the face-to-face environment (Muirhead, 2000; Thomerson & Smith, 1996) and have the potential to enhance student learning (Althaus, 1997; Dysthe, 2002; Vonderwell, 2002; Wu & Hiltz, 2004).

Students may find that the addition of online discussions to course teaching gives them more opportunity to reflect and respond to class material (Meyer, 2003; Wozniak & Silveira, 2004) as well as providing a space that suits some learning styles that are not well served in the face-to-face classroom (Poole, 2000; Scheiter, 1996). Minority or disenfranchised groups of students that avoid participation in face-to-face discussions will often express themselves more confidently in online discussions, although this may be dependent on use of a pseudonym (Anderson & Haddad, 2005; Chester & Gwynne, 1998).

Setting up an online discussion area does not guarantee its use. In all online environments, the role of the instructor in structuring and facilitating online discussions is critical to their success as a learning medium (Edelstein & Edwards, 2002; Gilbert & Dabbagh, 2005; Hiltz, 1993; Salmon, 2000). Online discussions can be effective however, in providing opportunities for collaborative peer learning, conversations with instructors, and enhanced understanding through reflection and communication of developing ideas (Cowan, 2006; Laurillard, 2002).

USING ONLINE DISCUSSIONS WITH BLOCK MODE TEACHING

The case being discussed here involved the teaching of an on-campus block-mode subject with 72 enrolled second-year undergraduate students at a university in the Asia-Pacific region. Students were majoring in either business, information technology or a combination of the two. The instructor was flown in from outside the country for two 2-week periods of instruction, separated by 5 weeks in between. The students all had a good level of adeptness with the use of technology and reasonable proficiency in written English. The instructor had previously taught both online and on campus, but had not taught in block mode. The block mode teaching consisted of 6 days a week of teaching in a combination of lectures and tutorials. Students had 2 one-hour lectures and a two-hour tutorial each day, all given by one instructor. As the subject matter involved the use of technology, tutorials were conducted in a computer lab, with each student on a dedicated computer with access to the Internet.

Students were first introduced to the online discussion forum to be used in a tutorial. A few students had previous experience of similar technologies, but for most it was a new experience. Each student was asked to logon to the online forum and post an introduction message. The instructor had already setup discussion topics, and posted an introduction prior to the class, modeling the kind of responses that were required. Students were asked specifically to *"...let us know who you are, where you are from, why you are doing this course, and what your hobbies and interests are. You can also include a photo or a link to your webpage if you have one"*.

The student who had been the first to ask a question in lectures was also the one who was first to post their introduction in the online forum. The level of personal disclosure varied, with some posting their name and course only, and others detailing their hopes, dreams and life philosophies. There was also some comment on first

impressions of learning in block mode. None posted photos, but a small number linked to their personal web pages, inviting response and comment.

One advantage of this process was that all students got to know a bit about the others. As there were four streams of tutorials, this could not have been achieved by asking students to stand and introduce themselves in the classroom. Online introductions also enabled students and the instructor to refer to a person's introduction later on in order to recall who they were. This was particularly useful in face-to-face block mode teaching, where there was less time to become familiar with faces and names through contact over a semester. A second advantage of the process was that it gave a voice to the quieter members of the class, and also enabled participation by those that were late or absent from the class. This was consistent with the greater confidence for some students that has been observed with anonymous interactions (Chester & Gwynne, 1998), although in this case, most students used their real names rather than a pseudonym.

As students became more familiar with using the online discussion forum, they began to adapt their use of it in different ways. For example, one student apologized to her fellow group assignment members,

" I wanna say sorry to my group mates ... for not being able to attend the discussions. When I feel better, then I'll be back!!! Any updates, pls let me know! " The disadvantage of having this visible communication available to students is that some learned they could sleep in and yet still log on to find out what was happening in the tutorial.

Using the first tutorial to get the students to post their introductions meant that the instructor was able to make sure that everyone was accounted for, match names to introductions, and assist anyone who was having difficulty with either registering or using the web-based software. It also allowed the instructor to ascertain whether people were having difficulties at an early stage of the classes.

Although the online forum was initially setup to teach students about internet technologies by first-hand experience, its advantages as a support to block mode teaching soon became apparent. Not only did it allow students and instructor to get to know more about each other, it provided feedback on course process and content, allowing changes to be made, or explanations to be provided in a more timely way than is possible when students are reluctant to ask questions face to face. It gave the instructor insight into attitudes about the course, as well as giving an indication of how engaged students were in their learning.

Initial use of the online forum as an addition to face-to-face classes received positive responses, as well as providing feedback on student apprehension about studying by block mode.

One student commented:

"I am actually finding this subject ...well actually this concept of just messaging and interacting while doing my ... course work quite interesting..... well the block mode system did not turn out that bad after all.... hope you ppl are enjoying this as much as I am".

Other positive comments were:

"I'm really looking forward to doing this subject now (yea...even though its a "block mode" subject)!" and "I'm very sleepy...it's 9.58 am on a rainy Saturday morning, usually I would still be sleeping, but this weekend I'm at uni!!! Although I must say, it isn't as bad as I thought it would be, this block mode isn't the nightmare I thought it would be."

There were, of course, also some negative responses:

"Aren't we getting a bit too excited over this message-posting business?" and "yes, finally!!!!!I just managed to get in....after struggling for say, almost half an hour!! Sigh.....how forgetful of me, really! Forgotten my username at first, then my password, then registered again and then waited for the acknowledgement, and then sigh...delaying here and there!!!!!"

Some of these responses were due to frustrations with the web-based technology itself, or with the process of its use interfering with what some considered "real learning".

A few students commented that they thought that interacting online was distracting from doing assignments and more serious study, and could not see any benefit from it. Once it was pointed out that some marks were to be allocated for online participation, everyone complied with at least the minimum interaction requirement.

As one student said:

"Well, I just can't find a time to log in here!! But let me introduce myself to you in this message board, as this will add some points into my record :)"

Although this means of getting student involvement detracted from the broader goal of peer learning, it did at least provide the opportunity for greater familiarity with the technology tools used, reflection on course content in responses to the required discussion topics, and a chance of increasing the interaction between the students themselves.

The responses also allowed the instructor to better ascertain the level of comfort each student had with English language, and pick up references to local language that was unfamiliar. This was important in giving assistance with assignment work, and referring students to appropriate support if it was necessary. Another benefit for the instructor was the information a few students provided about why they were not turning up to class. As one student said:

"Maybe I will be a while late for my tutorial .. since the sky is raining now .. I hope it won't traffic jam."

Not only was the instructor made aware of why, the student working from home could be brought up to date with the class material that they had missed.

During the break between the two 2-week teaching blocks, the instructor kept in touch with students via the online forum. Although a number of other communication channels were made available for contact with students during this time, such as email, phone and instant messaging, the predominant mode of contact the students chose was the online discussion forum.

This meant that students heard from the instructor even if they had not asked a question themselves, and everyone heard the answers to questions asked, so that no single student received unfair advantage from receiving information that others did not. It was also easier for the instructor to respond once in the online forum, rather than in a number of separate emails to students.

Although there was no new coursework during the break, students had been left with individual and group assignments to work on during this time. They were encouraged to report back regularly on their progress and any issues that arose, as well as give feedback on the conduct of the course, and ask questions on course content. This worked well, with students keeping their instructor in touch with progress on assignment work, and asking questions as they needed clarification on what was required of them.

One unexpected use of the Help Desk discussion area, set up by the instructor to answer student queries, was that it gained more use by the students helping each other.

Table 1 shows a list of the discussion topics, and the breakdown of student and instructor posts as a percentage of the total number of posts in each, giving an indication of where student participation was highest.

This shows that the Instructor made 25% of the postings, and the students the other 75%. This is a high workload for the instructor. It also shows the most active discussion to be the one on assessment tasks, which seems to fit with the common observation of student learning being dominated by a focus on what is required of them to pass the course, rather than the acquisition of knowledge for its own sake (Biggs, 1999). The low level of online discussion about course content was not surprising given that there was ample opportunity provided for such discussion in face-to-face lectures and tutorials.

The participation of students in interactions of this type demonstrated engagement both with the technology, and the course content. This was continued in the

Table 1. Instructor vs. student discussion posts

Discussion Topic	Number Total Posts	% Total Posts	Number Student Posts	% Student Posts	Number Instructor Posts	% Instructor Posts
Assessment Tasks	210	40	138	35	72	55
Introductions	144	27	133	34	11	8
Feedback	68	13	59	15	9	7
Informal Discussion	64	12	46	12	18	14
Notices	26	5	11	3	15	11
Course Content	9	2	5	1	4	3
Help Desk	8	2	5	1	3	2
	529	**100**	**397**	**75**	**132**	**25**

informal discussion area, which was used for discussing everything from politics and films, to asking questions about the exam.

The Assessment Tasks topic asked every student to choose a topic for their first assignment, and the topic and members for their group assignment. This was again easier than doing it in a classroom or tutorial format, as everyone could see what the others were suggesting, and there was no dispute over who got in first in choosing a particular topic. It also saved the instructor from having to write it all down, and kept track automatically of who had posted and who had not. This was a useful information management tool, and also helped in the process of familiarizing names and groups. It also allowed the instructor to follow up on anyone who appeared to be left without a group or not participating.

In terms of information management, use of the online forum provided a number of advantages to both the students and the instructor. For the students, it gave them a greater voice in talking to each other about the experience of block mode, and about the subject itself, as well as an outlet for those that might be isolated through not knowing other students enrolled in the course. For the instructor, it served as a vehicle to get to know the class, and documented examples of the issues of teaching in block mode. Overall, the online interaction was an aid to greater student engagement in the course and kept students involved in their learning activities between face-to-face teaching blocks.

SUGGESTED GUIDELINES FOR IMPROVING PARTICIPATION

Based on the online discussion forum interactions both in this case, and in comparison with similar online discussion forums discussed in the literature, a number of guidelines are recommended for improving student participation specifically in face-to-face block mode courses. Those of particular relevance to block mode teaching contexts are highlighted in bold type:

1. Introduce an online discussion forum as a supplement to face-to-face teaching.
2. As part of this initiative, setup an initial discussion framework prior to the commencement of block-mode teaching, with introductory posts by the instructor modeling the posts that students are to respond with.
3. It is generally best that the instructor sets up all discussion topics, otherwise students tend to start new topics without paying attention to topics that are already in existence. You can always add new topics later on if students request them.
4. Where possible, arrange for a tutorial session in a computer lab with all students, where they are introduced to the online discussion forum and asked to post their introduction to the rest of the class there and then. This overcomes the initial barrier of unfamiliarity with the technology, and allows the instructor to give immediate assistance.
5. Where introductions are being posted by a number of students at the same time in a computer lab environment, acknowledge all students individually, even if it is done within the one response. Students will notice if they are forgotten!
6. Unlike distance education courses which will have a lot of interaction in course content topics, block mode courses will tend to have more interaction in the social discussion topics unless they are specifically structured otherwise. Both block mode and distance education courses using web-based technologies will see a significant amount of interaction in topics related to assessment tasks. Take this into account by ensuring that both kinds of discussion topics are made available. If you want more online interaction around discussion of course content, then set this as a task for assessment.
7. Respond to all postings by students within 24 hours. This is important so that students remember what they posted, get immediate feedback, and do not feel disregarded. This does of course, mean that the instructor needs to schedule time each day to log in to the online discussion and respond to queries, and this should be taken into account in assessment of the instructor's overall academic load.
8. Have both formal and informal areas for conversation, and an area set aside for feedback.
9. Where feedback is posted by students, respond to each point raised, letting the student know that their feedback is appreciated, and what will be done about it.
10. Make participation in the online discussion forum a component of student assessment, so that students have a motivation to participate beyond it being a source of information.

CONCLUSION

In summary, use of web-based communication technologies can enhance the teaching of face-to-face block mode courses by allowing for interaction over an extended period of time, and increasing the depth of interaction. The most important issues to encourage student participation in such discussion forums are instructor interaction, timely response to student posts, provision of relevant information that meets the needs of students, and incorporation of an assessment component for the interactions.

The guidelines suggested are based on one example of teaching a face-to-face block mode course and need to be tested in a variety of block mode teaching contexts. They are suggested for use in conjunction with online discussion forums, but could be applied when using more recent and emerging communication tools such as wikis, blogs, write boards, and shared tagging (Alexander, 2006).

REFERENCES

Alexander, B. (2006). Web 2.0: A New Wave of Innovation for Teaching and Learning? *EDUCAUSE Review*, 41(2), 32–44. [Accessed 25 September 2006] http://www.educause.edu/apps/er/erm06/erm0621.asp

Althaus, S. (1997). Computer-Mediated Communication in the University Classroom: An Experiment with On-Line Discussions, *Communication Education* (46,3), 158–174.

Anderson, D. & Haddad, C. (2005). Gender, voice, and learning in online course environments, *Journal of Asynchronous Learning Networks*, 9(1).

Biggs, J. (1999). Teaching for Quality Learning at University, Oxford University Press, Buckingham, UK.

Burton, S. & Nesbit, P. (2002). An analysis of student and faculty attitudes to intensive teaching. Celebrating Teaching at Macquarie, Macquarie University. [Accessed 25 September 2006] http://www.cfl.mq.edu.au/celebrate/pdf/papers/burton1.pdf

Chester, A., Gwynne, G. (1998). Online Teaching: Encouraging Collaboration Through Anonymity, *Journal of Computer Mediated Communication*, 4(2), 1-20. [Accessed 25 September 2006] http://jcmc.indiana.edu/vol4/issue2/chester.html

Cowan, J. (2006), *On Becoming an Innovative University Teacher: Reflection in Action*, 2nd edition, Society for Research into Higher Education, OUP, England.

Dabbagh, N. (2002). Using a Web-Based Course Management Tool to Support Face-to-Face Instruction, *The Technology Source*, March/April 2002, 1-20. [Accessed 25 September 2006] http://ts.mivu.org/default.asp?show=article&id=1034

Davies, M. (2006). Intensive teaching formats: A review, *Issues In Educational Research*, 16(1), 1-20. [Accessed 25 September 2006] http://www.iier.org.au/iier16/davies.html

Dysthe, O. (2002). The learning potential of a web-mediated discussion in a university course. *Studies in Higher Education,* 27(3), 339-52.

Edelstein, S., & Edwards, J., (2002). If You Build It, They Will Come: Building Learning Communities Through Threaded Discussions, *Online Journal of Distance Learning Administration*, 5 (1), 3.

Fuller, A., McFarlane, P., Lam K. (2003). The Positive Model for Offshore Team Teaching, *Proceedings of the The 3rd IEEE International Conference on Advanced Learning Technologies (ICALT'03)*.

Gilbert, P.K., Dabbagh, N., (2005), How to structure online discussions for meaningful discourse: a case study, *British Journal of Educational Technology*, 36(1), 5-18.

Hiltz, S.R. (1993), *The Virtual Classroom: Learning Without Limits via Computer Networks*. Norwood, NJ: Ablex Publishing Corporation.

Laurillard, D.M. (2002), *Rethinking University Teaching*. Second Edition, London: RoutledgeFalmer.

Meyer, K. A. (2003). Face-to-Face Versus Threaded Discussions: The Role of Time and Higher-Order Thinking. *Journal of Asynchronous Learning Networks*, 7(3), 1-11.

Muirhead, B. (2000). Interactivity in a Graduate Distance Education School, *Educational Technology & Society*, 3(1), 93-96.

Poole, D. M. (2000). Student participation in a discussion-oriented online course: a case study. *Journal of Research on Computing in Education*, 33 (2), 162–177.

Salmon, G. (2000). *E-moderating: The key to teaching and learning online.* Kogan Page, London.

Schleiter, M. K. (1996). Using computer conferencing to break down racial and gender barriers in the college classroom. *Feminist Collections: A Quarterly of Women's Studies Resources* 17 (2), 16-17.

Thomerson, D., & Smith, C. (1996). Student perceptions of affective experiences encountered in distance learning courses. *American Journal of Distance Education*, 10(3), 37-48.

Tiene, D (2000), Online Discussions: A Survey of Advantages and Disadvantages Compared to Face-to-Face Discussions, *Journal of Educational Multimedia and Hypermedia*, 9(4), 369-382.

Vonderwell, S. (2002). An examination of asynchronous communication experiences and perspectives of students in an online course: A case study. *The Internet and Higher Education,* 6, 77-90.

Wozniak, H. & Silveira, S. (2004). Online discussions: Promoting effective student to student interaction. In R. Atkinson, C. McBeath, D. Jonas-Dwyer & R. Phillips (Eds), *Beyond the comfort zone: Proceedings of the 21st ASCILITE Conference*, Perth, 5-8 December, 956-960.

Wu, D., Hiltz, S. R. (2004). Predicting Learning from Asynchronous Online Discussions, *Journal of Asynchronous Learning Networks*, 8(2), 139-152.

Yorke, J., Hametz, I., Pannell, M., Rees, T., Hiltz, S.R. (2005). Investigating the Power of Presence: Using Online Communities to Support New Academic Faculty, In V.Uskov (Ed), *Proceedings -Web-based Education 2005*, Grindelwald, Switzerland, 21-23 February 2005.

Software Piracy Determinants Among University Students: An Empirical Analysis

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ABSTRACT

Software piracy is widespread in many parts of the world. Websites such as Kazaa and more recently BitTorrent based websites have made it easier to access pirated software, which has resulted in increased emphasis on the issue of software piracy in both the software industry and research community. Earlier empirical studies have looked at software piracy as an intentional behaviour. This study explores the demographic, ethical and socio-economical factors that can represent software piracy as an unintentional behaviour among a developing country's university students. The authors have conducted a comparative analysis of university students from Pakistan and Canada, two countries that differ economically and culturally. The results of the study indicate that software piracy behaviour is different in both groups of students, but that there are also some similarities.

1. INTRODUCTION

According to Husted (2000), knowledge and information are now more important factors in a national economy than the traditional physical assets that previously indicated economic well-being. Therefore, the protection of intellectual property (IP) has received increased attention recently. Software is also an intellectual property and any unauthorized duplication of computer software is a crime. However, the practice of making illegal copies of software amounts to high rates in various parts of the world. Software piracy directly affects the earnings and profitability of the software industry. Software piracy causes loss of earnings to the firm and loss of tax revenue to the economy of the country (Simmons, 2004; Givon, Mahajan & Muller, 1995). A recent study claims that "For every two dollars' worth of software purchased legitimately [globally], one dollar's worth was obtained illegally" (BSA, 2005, p. 3). The same study claims that eight in every ten software programs installed on PCs in Pakistan are pirated, while the rate in Canada is 35%.

Studies have shown that low national income and low personal incomes are not the only reasons for which software is pirated; Swinyard, Rinne, & Kau (1990) observed that attitudes towards software piracy are affected by cultural standards and customs. Therefore, "the neglect of culture as an explanation of software piracy seems odd given the fact that cultural values have such a significant impact on a wide array of business practices in different countries" (Husted, 2000, p. 200). This study is therefore an attempt to understand those cultural, social and ethical factors that can determine attitudes of software piracy behavior among university students.

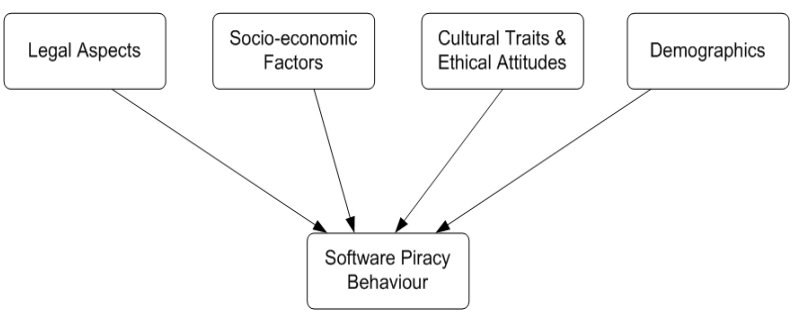
The next section presents a brief overview of the current literature along with a description of the research model developed of this study. Section three lists hypotheses of this study. Section four details the adopted research methodology followed by an analysis of the collected data. The results and their implication are discussed in section five, followed by the conclusion.

2. LITERATURE REVIEW & RESEARCH MODEL

Empirical studies have been done on the subject of software piracy in different developing countries such as Saudi Arabia (Al-Jabri & Abdul-Gader, 1997), Thailand (Kini, Ramakrishna & VijayaRama, 2003), People's Republic of China (Wang, Zhang, Zang & Ouyang, 2005) Malaysia (Rahim, Rahman & Seyal, 2000), India (Gopal & Sanders, 1998) and Jordan (El-Sheikh, Rashed & Peace, 2005). Although Husted (2000) and Proserpio et al. (2004) included Pakistan as one of the countries in their respective analytical studies of software piracy, empirical studies on the software piracy issues of Pakistan do not exist in the literature. This seems odd considering the fact that the software piracy rate in Pakistan is one of the highest in the world. A comparative study can therefore provide a means of highlighting differences and possible similarities of software piracy determinants between a developed and developing country. Therefore Canada was chosen for this purpose as it is culturally and economically different from Pakistan and can provide a contrasting view. Moreover, there hasn't been any recent Canadian scholarly literature[1] in this context. This research can therefore help fill a part of that void and the results can provide a better understanding of a developing country's software piracy issues that can help the policy makers to address the problem more effectively.

Theory of reasoned action (TRA) suggested by Fishbein & Ajzen (1975) and theory of planned behavior later developed by Ajzen (1991) have been used

Figure 1. Software piracy behavior model



Source: Butt (2006)

extensively in the literature to explain software piracy behavior and intentions. Both of these theories look at behavior as an intentional act. While it is true that the literature on software piracy (a significant portion of which is based on TRA and TPB) has helped in understanding various aspects of the matter, there have been no empirical studies to prove that software piracy can be conceptualized as an unintentional behavior or as a behavior that is the product of the social and cultural environment within which the behavior is carried out.

The model developed for this research[2] (shown in fig. 1) includes social norms as one of the variables. The basic structure of this model has been adopted and modified from a model that was used by Proserpio et al. (2004). Their model was based on a multi-causality approach to determine software piracy factors in 76 countries (including Pakistan and Canada) and is therefore appropriate for this research[3].

The research question for this project is to determine whether software piracy behavior among university students of a developing country can be conceptualized in terms of social and cultural norms and customs, rather than in terms of intentions as has been described (for piracy amongst university students) in most of the literature. We therefore contradict the notion of intentional software piracy behavior and suggest that software piracy can be represented as a consequential behavior that results from social norms of a developing country's society.

3. HYPOTHESES IN THIS STUDY

Earlier studies (Marron & Steel, 2000; Rapp & Richard, 1990) have found a strong inverse correlation between piracy rates and the income level of the country. Therefore, it is hypothesized that:

H1: Income will have a direct influence on piracy behavior of subjects.

H2: High price of original software will have a direct influence on the piracy behavior of subjects.

Many studies (Marron & Steel, 2000; Shin et al., 2004; Husted, 2000; Al-Jabri et al., 1997; Gopal & Sanders, 2000) have concluded that the collectivistic culture or the collectivistic nature of the society is to blame for the high software piracy rates. Moreover, "among high IDV [individualistic] countries, success is measured by personal achievement. Canadians tend to be self-confident and open to discussions on general topics; however they hold their personal privacy off limits to all but the closest friends" (Geert-Hofstede.com, 2006, para. 3). This implies that unlike Pakistan, Canada is based on an individualistic culture and therefore people would refrain from collectivistic activities. Therefore, social norms and culture will be taken into consideration as well and the following is hypothesized.

H3: Social/Cultural norms will have a direct influence on the piracy behavior of subjects.

Several studies (Moores & Dhillon, 2000; Moores & Dhaliwal, 2004; Simpson et al. 1994) concluded that high availability of illegal software and lack of legal implications thereof have an effect on piracy intentions and behavior. The following is therefore hypothesized:

H4: There will be a direct relationship between the availability of pirated software and the intent of subjects.

H5: Legal enforcement will have a direct influence on the intent of the subjects.

H6: Legal enforcement will have a direct influence on the social norms.

Several authors (Kini et al., 2003; Higgins & Makin, 2004; Sims et al., 1996) have found that males were more inclined towards pirating software. Therefore, the following is considered as the null hypothesis for gender.

H7: There will be no difference between males and females regarding their software piracy behavior.

"People's perceptions of a particular behavior are shaped by the existing value system of the society" (Lau, 2003, p. 234). Several studies (Jones, 1991; Swaidan, Rawwas, & Al-Khatib (2004); Siegfried, (2004); and Limayem et al. (1999)) have determined that ethical beliefs of individuals are crucial in their decision-making process. It is therefore hypothesized that:

H8: There will be a direct relationship between attitudes towards piracy and the piracy behavior of subjects.

The discussion that has been presented so far in this research extensively elaborates on the fact that current literature regards piracy behavior as intentional. To conform to the current literature, the following final hypothesis is made.

H9: There will be a direct relationship between intent and actual piracy behavior of subjects.

4. RESEARCH METHODOLOGY

4.1 Site Selection

As is the case with many research projects, this study also had limited resources in terms of time and money. The sites for the study were therefore chosen with these factors taken into consideration. For the Canadian part of the study, the authors' home university was chosen. For the Pakistani study, the city of Lahore was chosen since it has one of the biggest pirated software markets in Pakistan and also has several IT based institutions. Five universities were chosen in Lahore.

4.2 Sampling Characteristics

Students were chosen as the target population in order to conform to the existing research, most of which is based on samples of college and university students. Students at both undergraduate and graduate levels from information technology and computer science departments were included in this study.

4.3 Pilot & Actual Studies

A self-administered survey instrument/questionnaire was developed. This questionnaire consisted of closed-ended questions that were used to collect demographic details about the research participants. The questionnaire also consisted of 31 items, each rated on a 5-point Likert scale to assess respondents' attitude towards ethical, economical and demographic implications of software piracy. Negatively worded items were included to detect response patterns. Various items in the questionnaire were adopted from current literature including Moores & Dhaliwal (2004), Siegfried (2005) and Al-Jabri et al. (1997). Based on the feedback of a pilot study (conducted in Canada), minor changes were made to the format and content of the questionnaire, and it was also modified to make it adaptable in Pakistan.

While conducting the study in Pakistan, hard copies of the questionnaire were physically distributed at the same time in four classrooms and one computer laboratory at each of the five universities. The questionnaire at the university in Canada was administered through the Internet with the use of a secure program written in PHP/CGI to capture responses.

5. DATA ANALYSIS

5.1 Descriptive Statistics

The online survey conducted at the university in Canada returned 208 responses, out of which 196 were usable. Most of the Canadian respondents were under the age of 26 (n=172, 88%)[4]. There were 122 (62%) males and 74 (38%) female respondents. The survey in five Pakistani universities returned 365 responses, out of which 339 (n=339) were usable. As was the case in Canadian data, most of the respondents were under the age of 26 (n = 325, 96%). There were 221 (65%) males and 118 (35%) female respondents.

Table 1. Composite variables in the study

Pakistani Study – Variable (Group) Names	Canadian Study – Variable (Group) Names
Availability	Availability
Legal	Price
Intent	Norms
Norm-attd (i.e. socially or culturally mediated attitudes)	Ethical beliefs and Attitudes
Price	Legal Knowledge
-	Piracy Behavior
-	Intent

5.2 Hypotheses Testing

For testing hypotheses, the questionnaire items in both Pakistani and Canadian questionnaire were grouped together to make the statistical tests feasible. The groupings were made based on 1) the face validity, i.e. interpretability; 2) factor loadings; and 3) reliability aka Cronbach's alpha, sometimes also referred to as 'internal consistency', of the Likert items. This grouping is shown in table 1.

Structural Equation Modeling (SEM) with LISREL was used to test the relationships between the above groups/variables. Based on composite scores, the 'Norm-attd' group in the Pakistani data was further split into 'socnorm' for 'social norms' and 'attit' for 'attitude'. In the SEM for the Pakistani group, a latent variable called 'sociomor' was created which was composed of 'socnorm' and 'attit'.

In the Pakistani data, four of the six 'price' items (i.e. questions from the questionnaire grouped together as 'price' factor) loaded on one factor with internal validity of 0.719 (Cronbach's $\alpha = .719$). Similarly the reliability of the Canadian 'price' factor was high ($\alpha = .69$). All four 'availability' items in Pakistani data loaded on a single factor (Cronbach's $\alpha = .68$). The items were then optimally scaled using multiple correspondence analysis, and Cronbach's α for the four transformed 'availability' items increased to .76. All five Canadian items in this category loaded up with even a higher reliability (Cronbach's $\alpha = .813$). Principal Component Analysis conducted on the Pakistani 'legal' items resulted in a three factor solution that could be interpreted as being composed of the factors 'legal knowledge', 'legal actions', and 'moral principles'. However, this factor decomposition was not as clear cut as in the Canadian study, so for parsimony a one factor solution was retained. 'Legal' items in the Canadian study loaded up as a 'legal behavior' factor (Cronbach's $\alpha = .945$) and a 'legal knowledge' factor (Cronbach's $\alpha = .482$). This implies that the awareness of legal implications of software piracy was more significant among the Canadian respondents.

5.3 Fitting Data on Structural Models

LISREL was used to fit the Pakistani data on a structural equation model.[5] The resulting path coefficients are shown in figure 2. The Canadian data had a poor fit on this model. Therefore another model (shown in figure 3) was made on which Canadian data had a good fit.

The gender → piracy behavior path in the Pakistani model representing a fairly strong relationship with a coefficient of 0.23. hypothesis 7 is therefore rejected in this case. The same path in the Canadian model has a coefficient -0.13 implying acceptance of hypothesis 7. In the Pakistani model, the price factor (price → piracy behavior, 0.03) does not seem to have any effect at all on the piracy behavior, therefore rejecting hypothesis 2. However, it has strong negative relationship (-.047) with the intent variable, thus rejecting hypothesis 1. In the Canadian model, price has very weak relationships with both intent and piracy behavior, having path coefficients of 0.01 and 0.02 respectively. Thus both hypothesis 2 and hypothesis 1 are rejected in this case. Legal issues have a strong influence on both intent (0.54) and the sociomor variable (0.40) in the Pakistani model. Therefore, hypothesis 5 and hypothesis 6 are accepted in this case. The Canadian legal construct has a weak relationship with intent (0.07) and a significant relationship with ethical beliefs and attitudes, thus rejecting hypothesis 5 but accepting hypothesis 6. The availability of pirated software has a very small effect on the intent of Pakistani students (0.13) but has a fairly strong relationship with the sociomor (0.29). Hypothesis 4 is rejected in this case. The correlation between the availability of pirated software and the intent of Canadian students is 0.23. Hypothesis 4 is therefore accepted for the Canadian data. Intentions in the Pakistani model have a very high negative relationship (-0.76) with the piracy behavior. Hypothesis 9 is therefore rejected. The sociomor construct, on the other hand, has a very significant relationship (0.39) with the piracy behavior, thus accepting hypothesis 3. Since ethical attitudes towards piracy were included in sociomor variable in the Pakistani model, Hypothesis 8 is also accepted. As far as the Canadian model is concerned, the norms variable has a strong influence (0.52). The norms however do not have any effect on the piracy behavior as is evident with a very small path coefficient of 0.05 between the two. Intent on the other hand has a significant relationship (0.34) with the piracy behavior of the students. Hypothesis 9 and 3 are therefore accepted and rejected respectively.

Figure 2. Pakistani structural equation model

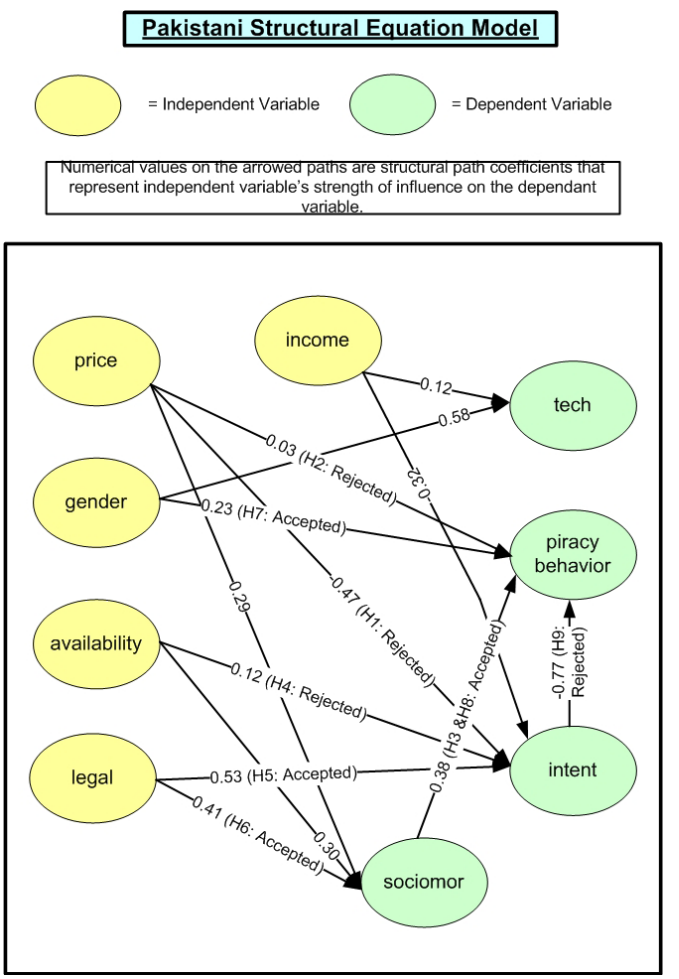
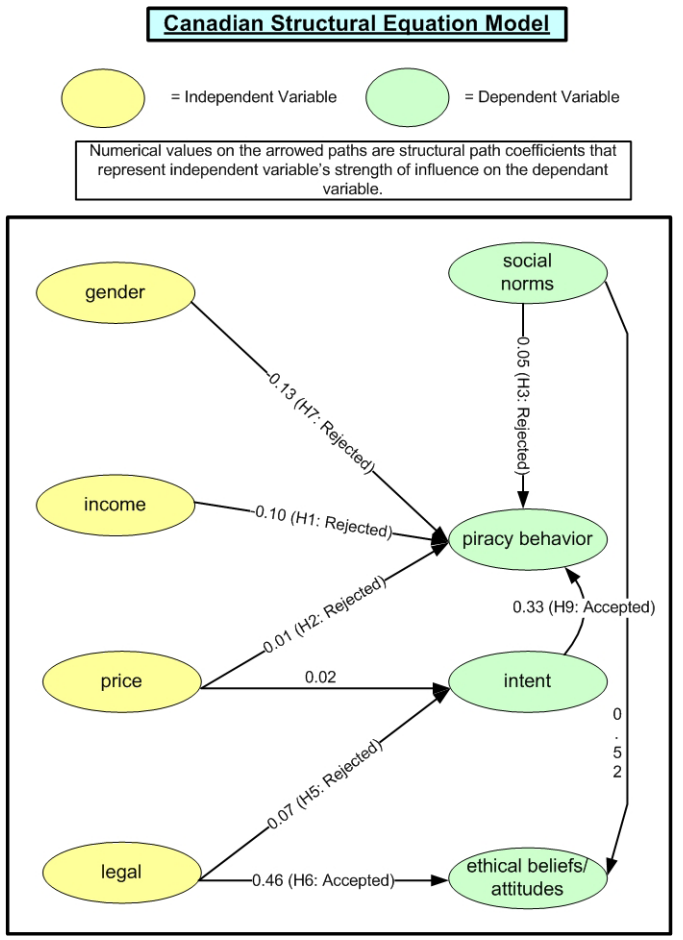


Figure 3. Canadian structural equation model



6. DISCUSSION

The analysis of economic factors (high price of legal software and low income) in this study provides a rationale for the reluctance of the Pakistani government to enforce intellectual property rights. Despite being aware of the rampant software piracy, governments of countries such as Pakistan are aware of the economic conditions of the mass population. People (students, in the context of this research) in the developing countries need to have cheap access to resources (software) in order to keep up with the rapid pace of technological advancement in the Western world. It can therefore be assumed that governments of developing countries are aware of this and therefore are always reluctant to enact and enforce strict IP protection laws.

The empirical evaluation provides strong support that social norms and positive attitudes are correlated with the actual piracy behavior of Pakistani students. This finding is similar to that of Proserpio et al., (2004), Seale et al., (1998), Limayem et al. (1998) and Al-Jabri, I. & Abdul-Gader (1997). On the other hand, intentions proved to be stronger predictors of piracy behavior of Canadian students and this finding conforms to the literature which regards piracy behavior as intentional. The achieved results answer the research question that this study was based upon; that is, it supports the hypothesis that software piracy behavior in Pakistan cannot be regarded as purely intentional. It should rather be conceptualized as a consequential behavior resulting from various elements, with customs or social norms being the strongest of them all.

Swinyard et al. (1990) noted that "the cultural history of Asia does not generally support the notion of protecting proprietary creative work. In many Asian nations the highest compliment one can be paid is to be copied" (p. 657). Due to a lack of IP related awareness (unlike the Western world), this culture of copyright infringement is deeply rooted in the Pakistani society in such a way that one buys and sells pirated software without even realizing that their action might be considered illegal and/or unethical. It is an established norm: a custom; the way an act is supposed to be normally carried by everyone. The abundance of pirated software markets and an almost absent IP related legal enforcement exaggerate an already piracy-favouring environment. Similar conditions are responsible for high piracy rates in other regions of the world as well.

7. CONCLUSION

This study has found that there is no one way of understanding piracy behavior across different countries. Although poor national economy plays a substantial role in software piracy rates, culture is also part of the equation. This study has also suggested that software piracy behavior in a developing country such as Pakistan cannot be conceptualized as an intentional behavior, but it can be in the case of a developed country such as Canada. Caution should be practiced in all future research that attempts to study piracy behavior as the applicability of Western constructs such as 'attitudes' and 'intentions' to collectivist societies must always be critically examined. Based on previous research results and the results of this study, authors of this study are confident that the structural models presented here represent a reasonable explanation of software piracy activity in the student population of Canadian and Pakistani universities included in the study. However, due to limited resources, this research was restricted. Subjects from more countries should be included in future cross-country studies of software piracy behavior so that the results of this study could not only be generalized for the general student population but also to the population at large. There is also a lack of longitudinal research and also of other forms of electronic piracy, such as the availability of pirated e-books on the Internet. Future research could therefore attempt to study both of these domains as well.

REFERENCES

Ajzen, I. (1991). The Theory of Planned Behavior. Organizational Behavior and Human Decision Processes, 50(2), 179-211.

Al-Jabri, I. & Abdul-Gader, A. (1997). Software Copyright Infringements: An Exploratory Study of the Effects of Individual and Peer Beliefs. Omega, 25, 335-344.

Business Software Alliance (BSA). (2005). Second Annual BSA and IDC Global Software Piracy Study. Retrieved January 7, 2006 from http://www.bsa.org/globalstudy/upload/2005-Global-Study-English.pdf

Butt, A. (2006). A Cross-country Comparison of Software Piracy Determinants among University Students: Demographics, Ethical Attitudes & Socio-Economic Factors, Emerging Trends and Challenges in Information Technology Management, Proceedings of the 2006 Information Resources Management Association International Conference. Hershey: Idea Group Publishing.

El-Sheikh, A., Rasheed, A. A. and Peace, A. G. (2005). Software Piracy: Possible Causes and Cures. Chapter VI in Information Ethics: Privacy and Intellectual Property, Freeman, L. and Peace, A. G. (Eds.), (pp. 84-98). Hershey, PA: Idea Group Inc.

Fishbein, M., and Ajzen, I. (1975). Belief, Attitude, Intention and Behavior: An Introduction to Theory and Research. Reading, MA: Addison-Wesley.

Geert-Hofstede.com (2006). Geert Hofstede Cultural Dimensions: Canada. Retrieved April 3, 2006 from http://www.geert-hofstede.com/hofstede_canada.shtml

Gopal, R. D. & Sanders, G. L. (1998). International Software Piracy: Analysis of Key Issues and Impacts. Information Systems Research, 9(4), 380-397.

Gopal, R. D. & Sanders, G. L. (2000). Global software piracy: You can't get Blood out of a Turnip. Association for Computing Machinery. Communications of the ACM, 43 (9), 82-89.

Higgins, G. E. and Makin, D. A. (2004). Does Social Learning Theory Condition the Effects of Low Self-Control on College Students' Software Piracy? Journal of Economic Crime Management, 2(2), 1-22.

Husted, B. W. (2000). The Impact of National Culture on Software Piracy. Journal of Business Ethics, 26, 197-211.

Jones, T. M. (1991). Ethical Decision Making for Individuals in Organizations: An Issue Contingent Model. Academy of Management Review, 16(February), 366-395.

Kini, R. B., Ramakrishna, H.V. and Vijayaraman, B. S. (2003). An Exploratory Study of Moral Intensity Regarding Software Piracy of Students in Thailand. Behavior & Information Technology, 22(1), 63-70.

Lau, E. K. W. (2003). An Empirical Study of Software Piracy. Business Ethics, 12(3), 233-245.

Limayem, M., Khalifa, M., and Chin, W. W. (1999). Factors Motivating Software Piracy: A Longitudinal Study. In International conference on Information systems (pp. 124-131). Association for Information Systems.

Marron, D. B. and Steel, D. G. (2000). Which Countries Protect Intellectual Property? The case of software piracy. Economic Inquiry, 38, 159-174.

Moores, T. T. & Dhillon, G. (2000). Software piracy: a view from Hong Kong. Communications of the ACM, 43, 88-93.

Moores, T. T. and Dhaliwal, J. (2004). A reversed context analysis of software piracy issues in Singapore. Information & Management, 41, 1037-1042.

Proserpio, L., Salvemini, S. and Ghiringhelli, V. (2004) Entertainment Pirates: Understanding Piracy determinants in the Movie, Music and Software Industries. In 8th International Conference on Arts & Cultural Management. Retrieved January 7, 2006 from http://www.hec.ca/aimac2005/PDF_text/ProserpioL_SalveminiS _GhiringhelliV.pdf

Rahim, M. M., Abd. Rahman, M. N. and Seyal, A. H. (2000) Softlifting Intention of Students in Academia: A Normative Model. Malaysian Journal of Computer Science, 13(1), 48-55.

Rapp, R. and Richard P. (1990). Benefits and Costs of Intellectual Property Protection in Developing Countries. Journal of World Trade, 24, 75-102.

Seale, D. A., Polakowski, M., & Schneider, S. (1998). It's Not Really Theft: Personal and Workplace Ethics that Enable Software Piracy. Behavior & Information Technology, 17, 27-40.

Shin, S. K., Ram, D. G., Saunders, G. L., & Whinston, A. B. (2004). Global Software Piracy Revisited. Communications of the ACM, 47, 103-107.

Siegfried, R. M. (2004). Student Attitudes on Software Piracy and Related Issues of Computer Ethics. Ethics and Information Technology, 6, 215–222

Simmons, L. C. (2004). An Exploratory Analysis of Software Piracy Using Cross-cultural Data. International Journal of Technology Management, 28(1), 139-148.

Simpson, P. M., Banerjee, D. and Simpson Jr., C. L. (1994). Softlifting: A Model of Motivating Factors. Journal of Business ethics, 13(6), 431-438.

Sims, R. R., Cheng, H. K., & Teegen, H. (1996). Toward a Profile of Student Software Piraters. Journal of Business Ethics, 15, 839-849.

Swaidan, Z., Rawwas, M. Y. A. and Al-Khatib, J. A. (2004). Consumer Ethics: Moral Ideologies and Ethical Beliefs of a Micro-culture in the US. International Business Review, 13, 749-761.

Swinyard, W. R., Rinne, H., & Kau, A. K. (1990). The Morality of Software Piracy: A Cross-Cultural Analysis. Journal of Business Ethics, 9(8), 655-664.

Wang, F., Zhang, H., Zang, H. and Ouyang, M. (2005). Purchasing Pirated Software: An Initial Examination of Chinese Consumers. Journal of Consumer Marketing, 22(6), 340-351.

ENDNOTES

1. There was only one Canadian empirical (scholarly) study found in the literature (see Limayem et al., 1999). This study however relied on 98 research participants only and therefore cannot be considered very extensive.
2. It is important to emphasize here that the model shown in Figure 1 presents a very basic structure which represents the theoretical base of this research.
3. This model is an adaptation from one of the author's earlier work (Butt, 2006).
4. All percentages are rounded off.
5. Regression analysis of the data was also conducted using SPSS but due to word limitations is not presented here. Complete data analysis is given in the main author's graduate thesis available through his website: www.sfu.ca/~abutta

Knowledge Process Modeling in SME and Cost-Efficient Software Support: Theoretical Framework and Empirical Studies

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ABSTRACT

Current research in knowledge management is concentrated on concepts for large companies. In this article the focus lies on the modeling of knowledge processes for small and medium-sized enterprises (SME). In the first part of this paper an empirical study conducted at the Department of Information Systems (University of Innsbruck) illustrates the key knowledge processes (knowledge identification, knowledge acquisition, knowledge arranging and knowledge transfer) for SME. The result of this survey is a knowledge process model which links efficient methods of the knowledge management to SME. Furthermore, this paper reports the findings of the empirical study designed to allocate cost-efficient software products to each of the four knowledge processes in SME. This paper analyzes knowledge processes and gives a framework of methods and cost-efficient software tools.

1. INTRODUCTION

Business process modeling [Hammer & Champy, 1993] has become a major research field in the information systems discipline in the last ten years. Davenport sees the term business process as "a structured, measured set of activities designed to produce a specified output from a particular customer or market" [Davenport, 1995]. However, in recent years, not only business process management, but also knowledge management is developing into a new research field [Probst et al., 2005; Rao, 2004]. The linkage of these two research fields is called knowledge process modeling. For Richter-von Hagen et al. "a process is knowledge intensive if its value can only be created through the fulfilment of the knowledge requirements of the process participants" [Richter-von Hagen, 2005, p. 358]. Gronau describes the following facts of knowledge intensive processes: diversity of sources and media, variance and dynamic development of the process organization, a plenty of process participants with different expertises, use of creativity, high level of innovation and influence on the area of the decision [Gronau, 2004, p. 410]. Edwards and Kidd [Edwards & Kidd, 2003, p. 124] named the following five characteristics to enforce the argument that knowledge management and business process management should be integrated:

- Knowledge management is important for business if the initiative implied an advantage for the customers. The idea to implement the customer's requests – may be internal or external – is the base for including the customer [Fink et al., 2006].
- Knowledge doesn't follow the business borders. Business processes also model activities by global trading companies and build the base for modeling knowledge intensive processes.
- Knowledge management can only be efficient if it follows a structured model. Business processes are modeled by structured actions and they are necessary to deduce knowledge intensive processes.
- The success of knowledge management depends on the measurement of knowledge. There exists a similarity to the measurement of business processes. The measurement of the knowledge potential provides a central position and biases the success [Fink, 2004].
- Knowledge management is affected by a holistic approach. Every part of the business process modeling is important for success but every aspect should be considered.

In addition, knowledge management and business process modeling initially focused on large companies. The knowledge economy has to shift from the view of large companies to small and medium-sized enterprises (SME) because of their importance for the industrial economics. A definition of SME will be given in the next chapter. The driving reason behind today's shift from large companies to SME is that all businesses are depending on methods and tools of knowledge management in order to gain competitive advantages and deal with the knowledge potential of their employees [Fink, 2004]. In western industrial economies SME have a share on the market of more than 95% and supply more than 60% of the employees [Statistical Yearbook Austria, 2005]. Therefore, in this paper the focus lies on the impact of knowledge process modeling for SME to help them getting a framework to be more innovative [Donnellan, 2006]. In Chapter Two the theoretical framework for the identification of knowledge processes in SME will be discussed. Chapter Three covers the use of cost-efficient software products for the implementation of knowledge processes in SME. Chapter Four gives an outlook of future research by the determination of innovation underlying knowledge processes.

2. THEORETICAL FRAMEWORK

This chapter introduces the framework for the definition of knowledge processes in SME and the realization of these processes through the use of cost-efficient software products – in this case the main focus lies on the investment costs.

2.1 Definition of SME

In the literature of business management there is a variety of about 200 different definitions of SME. A cause therefore can be the huge amount of possibilities of operationalization of the term SME. For this study it was not necessary to define SME qualitatively. So a quantitative definition was chosen by the use of the definition of the European Union which was established in the year 2005 [European Commission, 2006].

SME are quantitatively determined by three factors: (1) the number of employees, (2) the total assets and (3) the annual turnover. SME can be divided into three more detailed categories: (1) *middle enterprises* (less than 250 employees AND less than 50 Mio. EURO annual turnover OR less than 43 Mio. EURO total assets), (2) *small enterprises* (less than 50 employees AND less than 10 Mio. EURO annual turnover OR less than 10 Mio. EURO total assets) and (3) *tiny enterprises* (less than 10 employees AND less than 2 Mio. EURO annual turnover OR less than 2 Mio. EURO total assets).

This research focuses on SME which have less than 250 employees and less than 50 Mio. EURO annual turnover or less than 43 Mio. EURO total assets. The next sub-chapter will show the development of the knowledge processes for SME.

Figure 1. Theoretical concept of knowledge processes for SME [Fink et al., 2006]

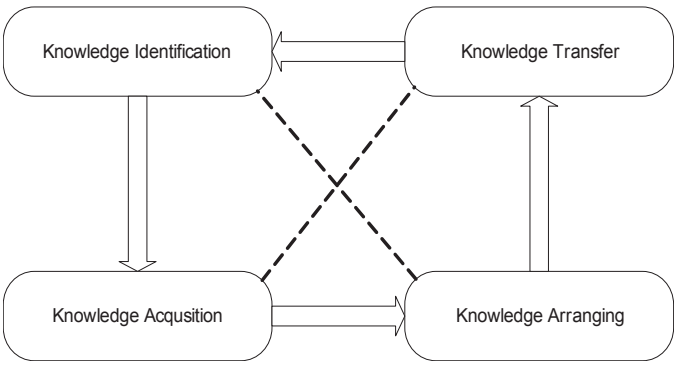


Table 1. Research sample for knowledge processes in SME

Knowledge Identification	
Balanced Scorecard	Tobin`s q
Market - Asses Value - Method	Knowledge Balance
Skandia Navigator	
Knowledge Acquisition	
Brainstorming	"Synektik"
Mind Mapping	System Simulation
eMail System	Scenario Technique
Business Game	Knowledge Network
Search Engine	
Knowledge Arranging	
Document Management System	Conceptualization
Checklist	Mind Mapping
Content Management	Neural Network
Database	Project Review
Experts System	
Knowledge Transfer	
Knowledge Maps	Lessons Learned
Questionnaire	eMail System
Best Practice	Microarticle
Chatroom	Story Telling
Communities of Practice	Handbook
Groupware	FAQs
Checklist	

2.2 Knowledge Processes in SME

To make knowledge usable for all stakeholders of an organization a knowledge base must be implemented. This base covers all the knowledge which an organization needs to operate and solve problems: It should include individual but also collective parts of knowledge like abilities, skills, norms, routines experiences and myth. The theoretical approach of Probst, Raub, Romhardt [Probst et al., 2005] is the basic framework for the identification of knowledge processes in SME for this paper. [Probst et al., 2005] defined eight "building blocks of Knowledge Management" which are: (1) identification of knowledge, (2) acquisition of knowledge, (3) development of knowledge, (4) sharing of knowledge, (5) use of knowledge, (6) conservation of knowledge, (7) evaluation of knowledge and (8) aims of knowledge.

In the first step the authors conducted a study with the objective to find the key knowledge processes – based on the framework of [Probst et al., 2005] – for SME. The detailed research design is described in [Fink & Ploder, 2006]. In short, 20 expert interviews were conducted by the Department of Information Systems at the University of Innsbruck in summer 2005 [Fink & Ploder, 2006]. Ten experts from science and ten experts from practice were asked about the most important knowledge processes in SME. The result of the interviews was a knowledge process model for SME. Figure 1 illustrates the four key knowledge processes: (1) Knowledge Identification, (2) Knowledge Acquisition, (3) Knowledge Arranging and (4) Knowledge Transfer.

2.3 Quality Model (ISO/IEC 9126) for the Evaluation of Software Products

This knowledge process model for SME was the first step in the research work and the general research framework. The second step was to find out which process can be supported by which knowledge method. After a literature analysis [Coakes & Clarke, 2006] the following methods were identified to support the four processes [Fink et al., 2006].

In a third step, the objective was to match a cost-efficient software product to each knowledge method which are usable in practice. In the research design the focus lies on Freeware and Shareware software products in order to fulfil the presetting of cost-efficient software support. The research method was an online research with the result of a list of evaluated cost-efficient software products. The evaluation of each software product was conducted by applying the ISO/IEC 9126 norm. The Quality Model of the norm (ISO/IEC 9126-1) is divided into two parts which are important for the evaluation of the software products to support knowledge methods:

- the internal and the external quality of the software as well as
- the quality for use.

The ISO norm lists five characteristics to evaluate software products: (1) functionality, (2) reliability, (3) usability, (4) efficiency and (5) assign ability. For each characteristic a different number of items were assessed by a likert scale from -2 up to +2. The process how the authors did the assessment is shown in the appendix. The data sample of the quality model was more than 200 different software products. A key research finding was that some of the software products can not be used in practice because their quality was not sufficient. Finally there were 45 software products which are efficient for use in SME.

The following research question can be formulated: Which of the methods are efficient for use in SME and which software products will be implemented by SME? Therefore the authors formulated two key hypotheses:

Hypothesis 1: Knowledge Management Processes can be realized in SME with more than a 30% support of office similar software.

Hypothesis 2: More than 50% of the SME which can image to invest into Knowledge Management in the next year will invest more than 3.000 EURO per year.

2.4 Data Collection Procedure

The survey 2006 was developed and executed by the Department of Information Systems at the University of Innsbruck and is an update and extension of the empirical study conducted in 2004/2005 [Fink & Ploder, 2005a; Fink & Ploder, 2005b]. The objective of the empirical study was to find out which cost-efficient software products can support the efficient methods of the four knowledge processes (see chapter 2.1). For this approach the authors differ between two categories of software. At the one hand side there are the standard software products which are already in use in SME (for example: MS Office, Internet Explorer, Operating System and so on.) and at the other hand side there are software products like Shareware, Freeware and Open Source products characterized by the issue of cost-efficient software installation in SME. This described issue is the key objective of the empirical study. The research method for this study was the online question technique. The questionnaire was built with HTML, PHP and based on a MySQL database.

The data sample of 537 SME was average allocated over the regional federal states of Austria, Switzerland and Liechtenstein to get a representative result for

Table 2. Ranking of cost-efficient software products

	absolute adequate +2	adequate +1	less adequate -1	not qde-quate -2	no answer	Ranking	Supporting cost-efficient software products	ISO Ranking	Ranking Survey
Knowledge Identification									
Knowledge Balance	25	98	36	10	51	92	no cost-efficient software product		
Balanced Scorecard	17	107	38	7	51	89	no cost-efficient software product		
Skandia Navigator	17	102	42	10	49	74	no cost-efficient software product		
Market - Asses Value - Method	11	76	61	21	51	-5	no cost-efficient software product		
Tobin`s q	16	63	58	26	57	-15	no cost-efficient software product		
Knowledge Acquisition									
Search Engine	100	76	22	11	11	232	Google Desktop Search; MSN Toolbar; Yahoo Dektop Suche	not possible	25; 12; 10
Brainstorming	83	96	15	11	15	225	Brainstorming Toolbox; Concept X7	6;17	44; 88
Knowledge Network	77	87	20	9	27	203	no cost-efficient software product		
Mind Mapping	66	102	23	8	21	195	Free Mind; Think Graph, Tee Tree Office	16; 12; 8	69; 53; 28
eMail System	72	71	45	18	14	134	Pegasus Mail; Thunderbird Mail; Amicron Mailoffice 2.0	21; 21; 12	63; 165; 26
Scenario Technique	39	107	39	10	25	126	no cost-efficient software product		
System Simulation	32	106	52	10	20	98	no cost-efficient software product		
Business Game	40	92	51	15	22	91	Gamma	15	75
Synektik	12	63	56	24	65	-17	no cost-efficient software product		
Knowledge Arranging									
Database	100	79	19	9	13	242	MySQL; MSDE		86; 44
Mind Mapping	68	103	25	7	17	200	Free Mind; Think Graph, Tee Tree Office	16; 12; 8	69; 53; 28
Document Management System	74	94	23	12	17	195	Office Manager; UDEX dotNETContact; QVTutto	15; 15; 14	74; 35; 22
Checklist	60	95	29	11	25	164	CUEcards 2000	8	128
Content Management	44	99	29	16	36	126	CONTEX; ContentKit; VIO MATRIX	16; 13; 13	0; 47; 13
Project Review	56	85	39	18	22	122	no cost-efficient software product		
Experts System	30	94	46	17	32	74	KnowIT; KnowME	10; 7	38; 52
Conceptualization	25	79	47	21	48	40	no cost-efficient software product		
Neural Network	20	63	55	29	53	-10	no cost-efficient software product		
Knowledge Transfer									
eMail System	81	76	33	10	20	185	Pegasus Mail; Thunderbird Mail; Amicron Mailoffice 2.0	16; 12; 8	63; 165; 26
Handbook FAQs	60	97	36	11	16	159	no cost-efficient software product		
Communities of Practice	53	100	32	11	24	152	no cost-efficient software product		
Groupware	47	98	37	8	30	139	eGRoupware1.2; AlphaAgent 1.6.0; Tiki CMS - Groupware	15; 14; 16	40; 26; 24
Questionnaire	43	99	33	21	24	110	Easy Survey	10	61
Best Practice	49	84	42	16	29	108	no cost-efficient software product		
Checklist	38	99	44	14	25	103	CUEcards 2000	8	128
Lessons Learned	40	93	48	11	28	103	no cost-efficient software product		
Knowledge Maps	32	101	45	19	23	82	InfoRapid KnowledgeMap	13	69
Story Telling	26	80	58	16	40	42	no cost-efficient software product		
Chatroom	40	69	62	29	20	29	Skype; MSN, ICQ	not possible	71; 33; 25
Microarticle	20	73	61	25	41	2	no cost-efficient software product		

the whole sector and were opted stochastically. The population for the survey can be described as all SME in the three countries and got a number of about 540.000 SME. The online questionnaire was carried out in summer 2006 after a successful pre-test with 20 respondents. The online questionnaire was partitioned into three parts:

- Generally questions referring to the IT support and application of knowledge management within the enterprise itself.
- Rating relevance of the methods concerning the four knowledge processes for SME and get an idea of the favor supporting software tool.
- Information about future capital investment plans referring to knowledge management.

The return quote of the survey was about 40 percent. This means that 220 SME filled out the questionnaire. The failure rate was calculated as 6.63%. So all statements out of the survey are correct at a percentage of 93.61%. In the following chapter the research findings of the methods and the supporting software tools are presented and discussed.

3. RESULTS

The distribution of industries can be described as follows. The bigger part of the SME was from industrial SME with 30% and from Consulting and Information Technology with 22%. The bargaining SME got a level of 13% and the Handcraft 19%. The rest of 16% were divided to Banks and Affirmations 9%, Transport 2% and Tourism 5%. Fifty-seven percent of the SME already use knowledge management and 85% of the SME use a connected infrastructure. A web space is (hosted intern or extern) available in 78% which is necessary to deal with software products which need such an infrastructure.

3.1 Mapping of Cost-Efficient Software Products with Knowledge Processes

Table 2 gives an overview of all methods supporting the four knowledge processes for SME and the corresponding cost-efficient software products. Table 2 lists the absolute number of each method in the likert scale. The ranking of each method is the calculated value based on the likert scale. The "ISO Ranking" illustrates the assessment of the software based on the quality model (chapter 2.3). The absolute frequency of naming of the software through the respondents can be seen in the last column.

As the highly ranked method for the first process of the *identification of knowledge* the Knowledge Balance (92) was named. 56% of SME think that this is the best method to identify knowledge. Further methods are the Balanced Scorecard (89) and the Skandia Navigator (74). The methods Market-Asses Value-Method (-5) and Tobin`s q (-15) were rated by less than 30% of good use in SME.

Brainstorming (225) and Knowledge Network (203) are popular methods of the *acquisition of knowledge*. Also the Mind Mapping (195), eMail System (134), Scenario Technique (126) and System Simulation (98) are proper methods for this knowledge process. Business Games (91) are also a possibility. The method of "Synektik" was rated very bad because of the complexity of this method. The absolute star for acquisition of knowledge was the Search Engine (232) with a percentage of over 70% for efficient use in SME. In the case of the Search Engine the Google Desktop Search Engine was the prior selection of the software. eMail-Systems can be supported by the software Thunderbird1.5 which was chosen by 60% of the respondents. For Brainstorming a good tool will be Concept X7, for Mind Mapping the tools Free Mind (42%) and Think Graph (41%) were well rated. Gamma is software to support a Business Game and this product is well rated by 64%.

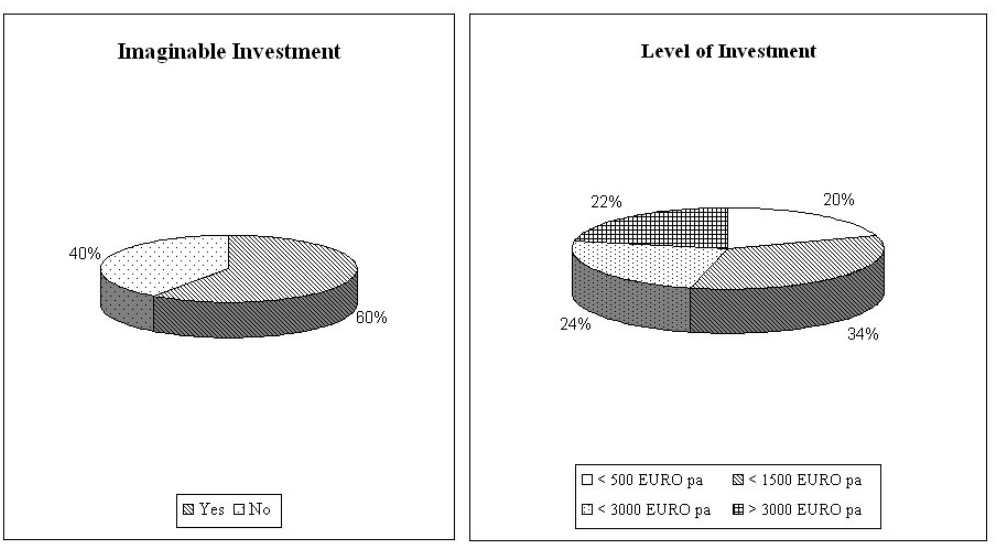
To realize the *arranging of knowledge* databases (242) are a proper method. 80% of the SME think that they will arrange their knowledge by databases. Mind Mapping (200), Document Management System (195) and Checklists (164) are further efficient methods. Content Management Systems (126), Project Review (122), Expert Systems (74) and Conceptualization (40) are methods which can be chosen but are not the favorite choice. Neural Network (-10) is no adequate method for arranging knowledge in SME. There were a lot of different software products to support the arranging of knowledge. These software products and the ratings of them are shown in table 2. MySQL is the favorite database software followed by the MSDE from Microsoft. Document management can be done by the Office Manager, the UDEX dotNETContact or the QVTutto. There are also software tools for the other methods which are described in table 2.

As it is illustrated in table 2 the methods eMail-System (185), Handbook FAQs (159), Communities of Practice (152), Groupware (139), Questionnaire (110) and Best Practice (108) are the favorites of the *transfer of knowledge*. It has to be pointed out that the methods Micro Article (2) and Chatroom (29) are rated not as well by the survey. The software products for the methods of the transfer of knowledge are InfoRapid supporting Knowledge Maps, EasySurvey supporting Questionnaire, Skype and MSN supporting Chatroom, eGRoupware1.2 and AlphaAgent1.6.0 supporting Groupware, CUCards 2000 supporting Checklists and Pegasus Mail, Thunderbird1.5 and Amicron Mailoffice 2.0 for the support of eMail-Systems.

3.2 Investment Allocation

75% of the respondents assumed that they are still using knowledge management in their SME. As it is shown in figure 2 the attendance to invest into knowledge

Figure 2. Investment allocation



management in the next year exists for 60% - 40% can not image to invest into knowledge management in the next year. 20% of SME which can fancy an investment in the next year want to spend less than 500 EURO, 58 % will spend between 500 and 3.000 EURO and only 22% will invest more than 3.000 EURO. The last question in the online questionnaire was about the knowing of the methods by the respondents. 49% of the respondents did not know one ore more methods which was not a problem for the survey because at every method it was possible to get a description of the method.

3.3 Hypotheses Test

The two hypotheses explained in Chapter One should be tested by the survey. For testing these hypotheses the authors choose a chi-square test at a level of confidence of 95%. The hypotheses are:

- *Hypothesis 1:* Knowledge Management Processes can be realized in SME with more than a 30% support of office similar software.
- *Hypothesis 2*: More than 50% of the SME which can image to invest into Knowledge Management in the next year will invest more than 3.000 EURO per year.

If the calculated chi-square score for the hypothesis is less then the score of a comparison table than there is a significant relationship between the two factors.

For the first hypothesis the calculated chi-square score was 2.58 and this is less than 9.49^{463} from the comparison table. In the next step the content must be valuated. 21.82% of the SME which use knowledge management already think that only less than 30% of the methods can be supported by Office products. So the hypothesis can be verified.

The second hypothesis was rated with a chi-square score of 3.89 and this is less than the score of the comparison table with 7.81^{466}. Because of the fact that only 18.11% of the SME which can image to invest into knowledge management will invest more than 3.000 EURO this hypothesis is incorrect.

4. CONCLUSION AND OUTLOOK

Knowledge process management is a research field that has attracted academic and practitioner's attention. The paper shows up a framework to implement knowledge management cost-efficient in SME and not only in large companies which can invest a large amount of money. The four important knowledge management processes in SME can also be supported by a large number of efficient methods which are supported by cost-efficient software products.

One future problem for the implementation of different software products could be the interfaces of the different applications. With Service Oriented Architecture (SOA) it would be possible to solve the problem of interoperability and the problem of security [Kang et al., 2006]. Future research will deal with SOA and should also consider Open Source Software (OSS).

REFERENCES

Coakes, E., Clarke, S. (2006). Communities of Practice. In Schwartz, D. (Ed.), *Encyclopedia of Knowledge Management*, Hershey: Idea Group, 30-33.

Davenport, T. (1995). Process Innovation: Reengineering Work through Information Technology. Boston: Harvard Business School Press.

Donnellan, B., Conboy, K., Hill, S. (2006). IS to Support Innovation: Weapons of Mass Discussion. In Khosrow-Pour, M. (Ed.), *Emerging Trends and Challenges in Information Technology Management*, IRMA06, Hershey: Idea Group, 623-626.

Edwards, J., Kidd, J. (2003). Bridging the Gap from the General to the Specific by Linking Knowledge Management to Business Processes. In Hlupic, V. (Eds.), *Knowledge and Business Process Management*. Hershey: Idea Group Publishing, 118-136.

European Commission (Ed.) (2006). Businesses in Europa. Fourth Report of the SME Project, Luxembourg: Agency for publication of the European Union.

Fink, K. (2004). Knowledge Potential Measurement. Wiesbaden: DUV.

Fink, K., Ploder, C. (2005). Wissensmanagement muss nicht teuer sein. *Wissensmanagement, 7/2005, Bielefeld, 25-27*.

Fink, K., Ploder, C. (2005). Knowledge Management in SME. Research paper, Department of Information Systems, University of Innsbruck.

Fink, K., Ploder, C. (2006). The Impact of Knowledge Process Modelling on Samll and Medium-sized Enterprises. In Maurer, H. et al. (Ed.), *Proceedings of I-Know06*, Graz, 47-51.

Fink, K., Ploder, C. (2006). Keckeis, J., Lehner, O.: Software supporting Knowledge Management, working paper, University of Innsbruck.

Fink, K., Roithmayr, F., Ploder, C. (2006). Mulit-Functional Stakeholder Information System for Strategic Knowledge Management: Theoretical Concept and Case Studies. In Khosrow-Pour, M. (Ed.): *Emerging Trends and Challenges in Information Technology Management*, IRMA06, Hershey: Idea Group, 152 - 155.

Gronau, N. (2004). Modellierbarkeit wissensintensiver Geschäftsprozesse mit herkömmlichen Werkzeugen. In Horster, P. (Ed.): *Elektronische Geschäftprozesse 2004*, Sysses, 408-421.

Hammer, M., Champy, J. (1993). Reengineering the Corporation: A Manifest for Business Revolution. New York: Harper Business.

Statistical Yearbook Austria (2005). URL: www.statistik.at, 06-03-2006.

Kang, M., Kim, A., Lo, J., Montrose, B., Khashnobish, A. (2006). Ontology-Based Security Specification Tools for SOA, in: Khosrow-Pour, M. (Ed.): *Emerging Trends and Challenges in Information Technology Management*, IRMA06, Hershey: Idea Group, 619-622.

Probst, G., Raub, S., Romhardt, K. (2005). Wissen Managen, 5. Auflage, Wiesbaden: Gabler Verlag.

Rao, M. (2004). Knowledge Management: Tools and Techniques, Oxford: Elsevier.

Richter-von Hagen, C., Ratz, D., Povalej, R. (2005). A Genetic Algorithm Approach to Self-Organizing Knowledge Intensive Processes. In Maurer, H. (Eds.): *Proceedings of the 5th International Conference on Knowledge Management*, Graz: J.UCS, 358 – 364.

APPENDIX

Assessment of the Software by ISO/IEC 9126 (example):

Functionality	ISO Ranking	Reliability	ISO Ranking	Usability	ISO Ranking	Efficiency	ISO Ranking
Accuracy	2	Maturity	2	Comprehensibility	1	Time Responsebility	1
Adequacy	2	Fault Tolerance	1	Lernability and Usability	2	Ressource Responsibility	1
Interoperability	1						
Subtotal	5		3		3		2

Assignability	ISO Ranking
Installation	1
Conformance	1
Compatibility	2
Subtotal	4

Summation	17

Process:	Knolwedge Acquisition
Method:	Brainstorming
Software:	Concept X7

Costs:	€ 149
Disk Space:	74,7 MB
Licence:	Licence for one PC/User
Annotation	supporting tablett computers, great functional range, also usable for other methods

Automating Customer Complaints Management Through Trust Accounts

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ABSTRACT

The automation of business processes by the use of paper-free EDI transmissions between business partners can be an incentive to advance the exchange of orders, invoices, and customer complaints without human interruptions by integrating and embedding trust mechanisms. This paper analyzes the applicability of automatically updated trust accounts for customer relationship management for the handling of customer complaints. The model introduced in this paper can help to reduce handling and shipping costs significantly and thereby improves customer benefits, resulting in higher customer loyalty.

1. INTRODUCTION

A promising application area to realize yet unexploited automation benefits in the area of customer relationship management is the handling of customer complaints. While empirical research and therefore data are very limited in this area, two figures might provide an idea of how much money possibly can be saved by an improved complaints handling process: Eastman Chemicals was able to save $2 million after improving its business processes associated with investigating and responding to complaints. They were able to cut expenses for waste removal and rework caused by off-quality products or incorrect paperwork (Hallen and Latino 2003). According to Schilling and Sobotta (1999), a medium-sized enterprise with approx. €5 million annual revenue, calculated the average processing costs with € 837.47 for each complaint handling process in 1997.

A major impediment to increasing the degree of automation in this area is the need for human interaction and decision, e.g., to check complaints or to prevent opportunistic customer behavior. Since the handling of complaints is costly not only for suppliers but also for customers, only 5-10% of all dissatisfied customers decide to complain at all (Tax and Brown 1998). But dissatisfied customers very likely switch their provider with consequential revenue losses higher than the costs caused by complaints in the first place (Fornell and Wernerfelt 1987). Therefore, suppliers have to cope with two dilemmas: Firstly, to date the suppliers they cannot automate or standardize the complaint-handling since opportunistically acting customers may benefit from this and, secondly, they might never get notice from a dissatisfied customer who has switched to another supplier because the manual complaint-handling is too expensive in comparison to the value of the defective or missing delivery. The remainder of the paper is organized as follows: an overview of relevant related research in trust and reputation is provided in section 2, followed by a modified customer complaints handling system in section 3. We discuss and conclude the paper in section 4.

2. REPUTATION AND CUSTOMER RELATIONSHIP MANAGEMENT AUTOMATION

Automation-Oriented Business Process Reengineering

Apart from the standardized exchange of electronic order or invoice messages there are further customer-related business processes which are so far not fully standardized and utilized. Most of those processes are related to trust or reputation aspects, i.e. are the data submitted up-to-date, is the sender or receiver reliable and solvent, or is a partner's claim justified? Costly human interaction is necessary to fix occurring problems, especially when it comes to irregularities in the value chain not covered by standardized processes. A common problem in every day product delivery is the handling of customer complaints of missing or broken items from an ordered lot. The customer complaints management process itself might be more expensive than the replacement value of the product, especially where missing or broken low-value products such as office supplies are concerned,. The customer has to decide whether to claim or not. If she does not, she has to pay for the incomplete delivery and the supplier cannot adjust its distribution because its quality management never gets the information that products have reached customers in an unsatisfactory condition.

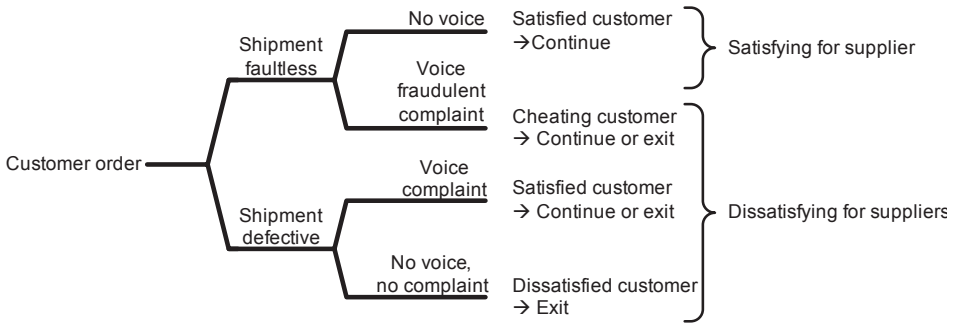
Reputation and Trust

Reputation reflects an aggregated ratio incorporating multiple factors: quality of merchandise, reliability of financial transactions, and/or level of customer service. It is often observed that reputation and trust acquire fundamental importance in long-term business relations. According to Mui et al. (2002b),, reputation is a "perception that an agent creates through past actions about its intentions and norms" and trust is a "subjective expectation an agent has about another's future behavior based on the history of their encounters". It can be shown that reputation reduces the complexity of the decision process through a better estimation of the likelihood of failed orders and through a reduction in the number of quality tests needed for a product (Marsh 1992). A broad overview of approaches to the use of reputation, e.g., in multi-agent systems, is provided by Mui et al. (2002a). Sabater and Sierra (2001) introduce a reputation model that takes the individual and social dimension of reputation into account. Carter, Bitting, and Ghorbani (2002) propose a formalization of reputation for multi-agent systems, applying the sociological concept of role fulfillment for establishing a positive reputation and for examining the link between reputation and trust. The role of trust in supply relationships and the underlying implications are addressed in an empirical study of business relationships in Germany and Britain (Lane and Bachmann 1996). As they point out, trust relations are highly dependent on stable social, institutional, and legal structures. Moorman et al. (1992) investigate the specific relationship between providers and users of market research reports and provide a good introduction to the role of trust in relationships. Das and Teng (1998) argue that trust and control are the two pivotal sources of confidence in the cooperative behavior of business partners in strategic alliances. Both sources of confidence are highly interdependent. A high level of control reflects a low level of trust and vice versa. Without any control, the trusting party takes the whole risk of the trustee's opportunistic behavior. As they point out, trust or control are two completely different kinds of approaches to business relationships.

Customer Complaint Alternatives and Implications

In order to discuss the complaint process both on the customer and supplier sides in more detail, the alternatives and relevant business cases are depicted in the following. Drawing from the "exit, voice, and loyalty" model provided by Hirschman (1970), and the customers "problem impact tree" framework of Rust, Subramanian, and Wells (1992), a problem tree of voice a complaint or exit without making a complaint is utilized. According to Hirschman, customers have two potential feedback options: (1) to voice complaints and thereby express the dissatisfaction directly to the supplier or (2) to stop buying and exit the relation. Both options have different, but always unfavorable impacts on suppliers: After submitting an order, the incoming orders are checked by the customer's receiving department. In the case of a faultless shipment, one expects that customers have no reason to complain (upper branch of Figure 1). This is true in nearly all cases: customers receiving correct deliveries will be satisfied, continue with the supplier, and will not place any complaints. The situation is different if complaints are not too costly and the supplier does not ask for the defective items to be sent back in order to validate the complaint. If customers do not perceive the recall of defec-

Figure 1. Customer action alternatives



tive items as a credible threat, then they might be tempted to cheat and complain about faultless shipments. Avoiding such an incentive is a pivotal element when designing an automated customer complaint-handling solution.

In the case of defective or partially missing items in the shipment (lower branch of Figure 1), the supplier must be contacted and/or the broken parts sent back. Afterward, the supplier sends the defective parts again and the customer tracks the complaint until all replacement parts are received. If the supplier handles the complaint satisfactorily, the customer will buy again. If this is not the case and the customer is dissatisfied with the process management, then the exit strategy might be chosen. In the latter case, the supplier has no chance to contact the dissatisfied customer if a defective shipment is delivered and the customer decides not to complain. This can be the case if the complaint process is more costly then the value of the defective products. Dissatisfied with the delivered quality, it is likely that such a customer will discontinue the business relationship.

3. CUSTOMER COMPLAINT ALTERNATIVES AND IMPLICATIONS

A Simplified Customer Complaint Process

In this section, a simplified customer complaint process is described to reduce the handling costs for suppliers and customers. It will be shown that from a game-theoretical point of view the simplified customer complaint-handling process dominates the conventional process if customers are always truthful. If customers cannot be assumed to be acting truthfully, a trust mechanism is introduced to inhibit cheating behavior by customers.

Our model is based on the following assumptions:

- Neither supplier nor customer knows the exact value of the defectiveness ratio "*d*". The exact quality of the products is not known (e.g., due to unknown conditions during the shipment).
- There is a long-term recurring business relationship between supplier and customer. Products are exchanged frequently between both of them.
- The value of a single order is relatively low, as can be observed for raw materials or office supplies.
- The customer complaint-handling costs of the new simplified process can be ignored. In the simplified process, the customer only has to send a notification to the supplier; the supplier does not have to perform a check if the products are indeed defective.

We will use a game-theoretical approach to analyze the trade situation for the conventional and the simplified complaints handling process. In a conventional complaint-handling process, the customer checks the shipment and if there are defects, the defective parts of the shipment are sent back to the supplier. The supplier has to check whether the complaint is justified or not. Both partners have expenses due to the manual processing and shipment of products. Table 1 depicts the cost matrix in a game with a conventional customer complaint process. If the shipment is indeed defective and the customer decides to reclaim, both customer and supplier have to pay for the cost-intensive manual handling of the customer complaints (c_C^C and c_S^C), respectively. Additionally, the supplier will not get paid for her defective products and the value "*v*" (ranging from 0 to the total value of the shipment if all parts are defective) of these parts is lost for her. When the customer decides not to reclaim the defective products, her loss equals the value of the defective shipped products *v*. If the shipped products have only minor defects, the consumer may be able to use the products partly, thereby reducing her loss to a fraction of *v* indicating the shipments remaining utility. Nonetheless, compared to flawless products, the consumer encounters loss costs ranging from 0 for minor defects to the value of the shipment *v* for major defects.

Table 1. Conventional customer complaint process cost matrix

Shipment defective?	Customer complaints ? Yes	Customer complaints ? No
Yes (d)	Customer: complaint costs (c_C^C) Supplier: {0; fraction of defective shipment (*v*)+} complaint costs (c_S^C)	Customer: {0; fraction of defective shipment (*v*)} Supplier: 0
No (1-d)	Customer: complaint costs (c_C^C) Supplier: complaint costs (c_S^C)	Customer: 0 Supplier: 0

Table 2. Simplified customer complaint process cost matrix

Shipment defective?	Customer complaints ? Yes	Customer complaints ? No
Yes (d)	Customer: 0 Supplier: fraction of defective shipment (*v*)	Customer: {0; fraction of defective shipment (*v*)} Supplier: 0
No (1-d)	Customer: - fraction of defective shipment (-*v*) Supplier: fraction of defective shipment (*v*)	Customer: 0 Supplier: 0

If the shipment is not defective and the customer decides to issue a complaint, both partners will have to pay complaint costs (c_C^C and c_S^C). After the order is sent back, the supplier checks the products and finds them non-defective, so she may re-ship them or sell them to another customer, so there are no further costs despite the complaint processing costs. In regular cases when the shipment is not defective and the customer does not decide to reclaim, the transaction is completed as originally intended.

Now a simplified customer complaint-handling process is implemented, significantly reducing complaint costs for both partners. In cases where the customer decides to complain about a shipment, the supplier trusts her customer, assuming the products are indeed defective without testing. The customer subtracts the invoice accordingly or a new shipment is immediately scheduled and the supplier does not audit the complaint any further. This new setting is described in Table 2.

If the shipment is not defective and the customer decides not to reclaim, the situation is unchanged. In cases where the products are defective the situation is unchanged despite the lack of complaint costs. The critical case is a cheating customer who pretends to complain for a shipment which is not defective at all. In this case, the customer does not have to pay for the products although she receives faultless products. She immediately earns the value of the products ("negative loss costs (-v)"). On the other hand, the supplier loses the value of the products shipped. Comparing both situations reveals that for defective product shipments, the second scenario with a simplified customer complaint process is advantageous in all situations. If supplier-side complaint costs are less than the value of the shipments, only the lower left quadrant of the cost-matrix is disadvantageous. This outcome, which implies a cheating customer, must therefore be avoided. Despite the savings by skipping reclaim checks, it can be rational for the supplier to ask the consumer to return the defective goods in order to be able to determine the source of the defects and improve quality by taking appropriate counter measures. Even if consumers are always acting truthfully or a reputation mechanism is applied, a random sample of claimed shipments should be returned to the supplier to analyze the source of defects. The costs of shipping and handling complaints in a specific market are also important for the applicability of the simplified customer complaints process. In the case of low or negligible shipping and complaint-handling costs, it might be rational to always return defective shipments. It depends on the relationship of total complaint costs to the individual value of a shipment whether the simplified complaint process is applicable or not. If total complaint costs are high in relation to the shipment's value, the simplified complaint process can realize substantial cost savings.

A Reputation Mechanism to Inhibit Fraudulent Behavior

In the case of accurate shipments, there is a significant difference between the conventional and simplified scenario. If the customer decides to complain for faultless shipment, then she will not have to pay for the faultless products and immediately gains their value. On the other hand, the supplier loses the equivalent value because she trusts her customer and does not perform a quality check on the reclaimed products. If there is no additional monitoring or control structure, the customer will always reclaim the delivered shipments, independent of the actual status of the shipment (whether it is indeed defective or not). It is the best strategy for the customer to complain always. The supplier therefore always loses the equivalent value of the shipment if no mechanism to counter cheating behavior is applied.

In an idealized world, a truthful acting customer would be the optimum to reduce transaction costs. Both partners could improve their respective position in all cases, because only the upper left and lower right sections in Table 2 would be relevant. If one can assume that a customer is always telling the truth, then the conventional complaint-handling mechanism is dominated by the simplified automated complaint handling. Both parties benefit from the reduction of transaction costs when processing complaints automatically. Nevertheless, the customer might be tempted always to complain about defective products even if this is not justified. The pivotal question is how to assure that the customer has no interest in cheating the supplier by applying an inexpensive mechanism at the same time. At this point, an automated complaint-handling mechanism might be suitable. Reputation in this context is based on business transactions with a certain customer in the past. The more orders successfully processed in the past, the higher the reputation account. Contrariwise, the customer withdraws from her reputation account on the supplier side if transactions failed in the past. For example, in the simplest case the supplier could estimate the defectiveness ratio d of his/her products r and adjust the customer's reputation account if her complaints rate significantly differs from the estimated quality, e.g., by applying a χ^2 test. The supplier's plausible threat is to switch back to the conventional customer complaints handling mechanism, inducing complaints processing costs on future transactions. This threat only works for infinitely repeated games as assumed for this model. Nevertheless, this assumption seems to be appropriate for our setting, since B2B-relationships can often be characterized as long-term, frequently recurring relations. The supplier can implement several strategies to ensure that the customer is truthful. The following strategies can be applied, if the supplier knows the defectiveness ratio d with high accuracy:

- The supplier can randomly select reclaimed shipments and request the customer to return the products for an intensive test. If the products are faultless, the customer cannot be trusted and she is removed from the simplified customer complaints handling process. The process is immediately switched back to the traditional handling process. This trigger-strategy is misleading if the customer accidentally complains about products that are not defective.
- The supplier can switch back to the conventional complaints handling process if the ratio of complained products significantly exceeds the defectiveness ratio d. This mechanism only works, if the supplier knows d with high accuracy.
- Each customer receives a reputation account for a given period, calculated as the product of the mean ordered value and the defectiveness ratio d. If a customer reclaims a shipment, the shipment's value is subtracted from this account and if the account is exhausted, the customer has to justify her behavior. This mechanism also relies strongly on the accuracy of the parameter d.

The threshold for identifying cheating behavior on the part of a customer should be chosen according to the accuracy with which d is known. If d is not exactly known and is subject to changes, this threshold should be increased or decreased accordingly. If the supplier herself does not know the defectiveness ratio d, she can improve the reputation mechanism by taking the responses of all other customers for each product into account. Each customer has individual reputation accounts for each product. If a customer reclaims a shipment, the value of this shipment is subtracted from her account, which refers to the affected products. Afterwards, the reputation accounts of all customers receive a bonus. This bonus for product r and customer i is calculated as an adjusted ratio of the mean quantity ordered by the customer. This value can be regularly recalculated for all orders of a given period (e.g., monthly). The following equation calculates the reputation bonus for each customer i and product r.

$$bonus_r^i = \frac{q_r^i}{\sum_{j=1}^{n} q_r^j} * p_r q_r^d$$

p_r : price of product r

q_r^i : aggregated quantity of product r ordered by customer i in a given period

q_r^j : aggregated quantity of product r ordered by customer j in a given period

n: number of customers with reputation accounts

q_r^d : quantity of defective product r that is reclaimed

If all customers are acting truthfully, the individual reputation accounts for every product will be zero on average. A brief example should illustrate the mechanism: a defectiveness ratio of 10%, a price of 1 for a given product r and three customers are assumed. The first customer regularly orders 1000 units, customer 2 orders 50 units and customer 3 orders 200 units. Each customer reclaims truthfully 10% of the shipments. When the first customer reclaims in total 100 units, her reputation account is immediately reduced by 100, equivalent to the total value of the complaint. Afterwards, all customers' reputation accounts are given a bonus (including the customer initiating the claim), resulting in 80 bonus points for customer 1, 4 bonus points for customer 2 and 16 bonus points for customer 3. This process is also applied for the complaints of the other customers, leading to neutral reputation accounts at the end of the selected period. If one of the customers decides to cheat and complains with a higher ratio, e.g., 15%, then her reputation account will be negative while the accounts of the other customers will be positive. If the first customer complains 15% of her shipments and the other customers complain about

10%, their respective reputation accounts for the illustrative example will be -10, +2 and +7.2. Customers with a higher complaint ratio than other customers can be identified by their negative reputation accounts. The first cheating customer will put herself into an inferior position compared to truthful customers. This system can only be cheated on if all customers together increase their complaints ratio. Furthermore, it does not work with a small number of customers. If there were only one customer, then this reputation account would always be neutral. From a macroeconomic and individual perspective, both partners can reduce their costs when the simplified mechanism is applied and supported by reputation accounts to foster truthful behavior of customers.

4. SUMMARY AND CONCLUSIONS

The combination of information systems and game-theory inspired trust accounts in a customer relationship management system establishes new solutions to automate business transactions where human decisions were formerly necessary. Through the reduction of manual handling and shipping costs, quality of the complaint-handling process may be increased both for customers and suppliers, resulting in higher customer retention.

A game-theoretic analysis of the order and customer complaint process has yielded insights into undesired outcomes of the interaction of suppliers and customers. While faulty deliveries will always remain a problem, costs associated with customer complaint-handling can be reduced significantly if substituting human decision competence with an automated information system. Thus, we believe that an economic interpretation of existing information systems may help to uncover as-yet unrealized potential for computer-mediated customer relationship management approaches. The system allows firms to deploy a simplified customer complaint-handling process while preventing customers from acting opportunistically.

In general, applying trust and reputation mechanisms can guard against otherwise unfavorable situations and create outcomes where all participants can benefit. The use of information systems mitigates the threat of opportunistic behavior in business transactions that could not be achieved previously.

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REFERENCES

Carter, J., Bitting, E., and Ghorbani, A.A. "Reputation Formalization within Information Sharing Multiagent Architectures," *Computational Intelligence* (18:4) 2002, pp 515-534.

Das, T.K., and Teng, B.-S. "Between trust and control: Developing confidence in partner cooperation in alliances," *Academy of Management Review* (23:3) 1998, pp 491-512.

Fornell, C., and Wernerfelt, B. "Defensive Marketing Strategy by Customer Complaint Management: A Theoretical Analysis," *Journal of Marketing Research* (24:4) 1987, pp 337-346.

Hallen, G., and Latino, R.J. "Eastman Chemical's Success Story," *Quality Progress* (June) 2003, pp 50-54.

Hirschman, A.O. *Exit Voice and Loyalty: Responses to Decline in Firms, Organizations, and States* Harvard University Press, Cambridge, MA, 1970.

Lane, C., and Bachmann, R. "The Social Constitution of Trust: Supplier Relations in Britain and Germany," *Organization Studies* (17:3) 1996, pp 365-395.

Marsh, S. "Trust and Reliance in Multi-Agent-Systems: A Preliminary Report," Department of Computer Science and Mathematics, University of Stirling, 1992.

Moorman, C., Zaltman, G., and Deshpande, R. "Relationships between providers and users of market research: The dynamics of trust within and between organizations," *Journal of Marketing Research* (29:3) 1992, pp 314-328.

Mui, L., Halberstadt, A., and Mohtashemi, M. "Notions of reputation in multi-agents systems: a review," Proceedings of the First International Joint Conference on Autonomous Agents and Multiagent Systems, ACM Press New York, Bologna, Italy, 2002a, pp. 280-287.

Mui, L., Mohtashemi, M., and Halberstadt, A. "A Computational Model of Trust and Reputation," Proceedings of the 35th Hawaii International Conference on System Science (HICSS), Big Island, Hawaii, USA, 2002b, p. 188.

Rust, R.T., Subramanian, B., and Wells, M. "Making complaints a management tool," *Marketing Management* (1:3) 1992, pp 40-45.

Sabater, J., and Sierra, C. "REGRET: A reputation model for gregarious societies," Proceedings of the fourth Workshop on Deception Fraud and Trust in Agent Societies, Montreal, Canada, 2001, pp. 61-70.

Schilling, V., and Sobotta, A. "Prozesskostenrechnung der mittelständischen Industrie," Betriebswirtschaftliches Forschungszentrum für Fragen der mittelständischen Wirtschaft e.V., Bayreuth, Germany, 1999.

Tax, S.S., and Brown, S.W. „Recovering and Learning from Service Failure," *Sloan Management Review* (40:1) 1998, pp 75-88.

Supporting Visual Access to a Distributed Organizational Memory Warehouse in the Web Environment

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ABSTRACT

Organizational memories play a significant role in knowledge management but several challenges confront their use. Artifacts of OM are many and varied. Access and use of the stored artifact is influenced by the user's understanding of these information objects as well as their context. Topic maps are used in this implementation to represent user cognition of contextualized information. Topic maps allow for access and analysis of stored memory artifacts. The paper presents the design and development of an organizational memory warehouse with web access via topic maps.

1. INTRODUCTION

Today an organization has to be able to make use of all of its available information in order to be competitive. In particular researchers have noted that organizational knowledge may be accumulated and retained using several organizational memory systems [6, 14, 15]. Advances in information technologies have helped in accumulating knowledge but the paradigms applicable to collecting and storing the knowledge do little to motivate its use by managers and decision makers. Accessing and using organizational memories, have been a challenge because of the multifaceted nature of memories and knowledge sources. Moreover, characteristics of the decision tasks where the knowledge and memory support are used, pose interesting challenges in designing and developing knowledge management systems. In this paper we describe the use of topic maps to navigate the network of organizational memory and employ appropriate knowledge management and analysis tools.

2. ORGANIZATIONAL MEMORY

Organizational memory (OM) is a stored, interrelated collection of organizational history reflected among the many parts [19]. It includes both stored records and tacit knowledge and covers the various facets of organizational tasks, employees, and their task environments [3, 5, 10, 16]. Because it can grow rapidly and become a vast repository of information and knowledge, several researchers have recognized the import of this organizational memory in effecting organizational performance [2, 4, 8, 9, 11]. Ackerman and Halverson [1], however, take a critical view of prior research on OM and argue for a theoretical base to properly define and empirically validate future research. They state that as socio-technical systems, organizations and their memories conform to social structures and norms while employing technical models. They use the theory of distributed cognition to develop a theoretical foundation for organizational memory. The basic tenets of this theory are that knowledge evolves from a community of practice and that cognition and inferences result from the shared meaning among the participants (hence the distribution) [7]. Communities of practice fulfill a number of functions with respect to the creation, accumulation, and diffusion of knowledge in an organization through exchange and interpretation of information, by retaining knowledge, by stewarding competencies, and providing homes for identities [20]. Collective thinking creates knowledge that otherwise would not be evident. Using empirical data and qualitative methods, Ackerman and Halverson [1] illustrate application of the theory of distributed cognition to validate the use of organizational memory in decision making.

Our paper presents the design and development of an organizational memory warehouse that supports the distributed cognition theory. We have adopted the design-science research paradigm to present our system design. Hevner et. al [25] argue that design-science research must addresses important unsolved problems in unique or innovative ways or solve problems in more effective or efficient ways[25]. Design-science research proponents identify six nominal process steps, namely problem identification and motivation, objectives of a solution, design and development, demonstration, evaluation, and communication [17]. The first four process steps are considered suitable for doing design research. In addition, when systems are built for testing and validating theory, the appropriate entry point for design research is indeed the design and development process. At this stage an artifact is built and theory is tested using the artifact. The main purpose is to yield a proof of concept of the theory and the system that supports it.

As social and linguistic dimensions of knowledge become pertinent, users need appropriate tools to support the search and analysis of knowledge. Topic maps are one such tool.

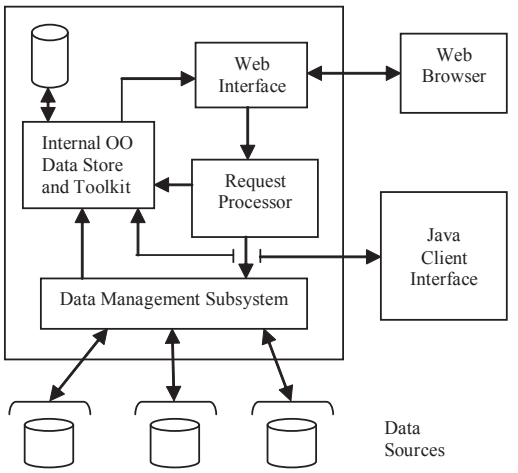
2.1 Topic Maps

Smolnik and Erdman [18] state that topic maps provide strong paradigms and concepts for the semantic structuring of link networks and therefore, they are a considerable solution for organizing and navigating large and, continuously growing network of organizational memories. Topic maps provide a subject based classification of resources where each resource represents a real world object. In topic maps, three constructs are provided for describing the subjects represented by the topics: names, occurrences, and associations. These describe the names, properties, and relationships of subjects, respectively. A name may be assigned to more than one topic and a topic may have more than one name. In addition by defining scope and types a name can become rich and complex. An occurrence links to one or more real knowledge sources. An occurrence, however, is not part of the topic map. Associations describe relationships among topics and are independent of the real knowledge objects. Associations add value through the relationships. An object in topic map would be a knowledge object such as a memory collection or a resource (e.g., an email analysis tool) that acts on the information object (e.g., an email collection).

3. WAREHOUSE MODEL

The goal of any organization is to make optimal use of the business knowledge that it has accumulated over the years. To do this, it is necessary to determine the sources of business knowledge and provide members of the organization access to it in a timely matter. Here we focus on the latter issue of providing access and assume that business knowledge sources are employee knowledge and artifacts (both internal and external).

Figure 3.1. Block diagram of the distributed organizational memory data warehouse model



The proposed environment has been designed to provide support for accessing and analyzing the collective memory of the organization. We start by providing a simplistic overview of the model and then briefly examining the important components in more detail.

3.1 Overview

An organization's memory can be seen as consisting of a space that includes knowledge of the expertise of current employees, artifacts, and the tools required to locate and/or interpret available information. The memory space is distributed across the organization and beyond.

Any organizational memory warehouse must be able to deal with the distributed nature of the memory space and be able to fully integrate the memory's information with the necessary tools. To deal with this problem, we introduce a distributed organizational data warehouse.

We see our contribution as being the development of an environment that provides a complete and easy to use solution to making the most of an organization's memory. The distributed format of the proposed warehouse provides a realistic mapping into the organizational memory space that is typical in organizations. Perhaps more important, the proposed model is highly scalable.

A block diagram of the complete model is shown in Figure 1. Artifacts and information about the expertise of current employees can either be stored in the data sources or in the Internal Object-Oriented Data Store and Toolkit. Artifacts in the data sources can be stored in any format to take advantage of existing software or compression techniques. To simplify communication between components and provide for standardization within the model, object views [21] are used to define data types. Data from the data sources are converted into object view instances using local interface views [21].

A topic map that supports visual access to the organization's memory space via a combination of search terms and tool interfaces serves as the user's entry point to the warehouse. Use of the topic map interface provides the user with an easy to use mechanism for defining search terms and choosing the appropriate interpretation/analysis/learning tools.

The remainder of this section briefly examines the main components of the model.

3.2 Object Views

The object view type [21] is defined as being an extension of the object model (EOM). The views have a traditional object structure (attributes and methods) with the restriction that they support a derivation method. The derivation method is used to generate the public and private attributes of each object instance created through a local interface view

3.2.1 Local Interface Views

The individual data sources are expected to have local control. The local interface view [21] is a view object type that is used by the local data administrator to provide a mechanism to make the local data accessible to the proposed model in object form. The local interface allows distribution transparency and representation transparency, while hiding or converting (mapping) some of the data from the data source. The local interface view belongs to the data source. It interacts directly with the data source and passes the result to the wrapper which controls communication with other components of the proposed model. A given data source and its wrapper can support multiple local interface views in order to present its data in different ways to different applications or users.

3.3 Topic Map

A topic map is used in the model to provide users with visual access to both search and analysis. It is this interesting blend of semantic search and analysis that motivates its use in the model.

Here we define a topic map to be the directed acyclic graph T = (N,E), where N is the set of topic map terms, data types, or search/analysis tools. The directed edges in E are of the type (n1,n2), where n1 is a topic map term or a data type and n2 is a topic map term, a data type, or a search/analysis tool. An implicit node, called the root, points to the topic map terms, data types and/or tools that make up the first level of the topic map. Nodes with out degree zero are said to be leaves of the topic map. Leaves point to the information in the organization's memory and carry any search terms and/or data types accumulated on the path form the root of the topic map to the leaf. Note that leaves that are either search terms or data types make use of an implicit search tool. In addition each non-leaf level of the topic map has a search tool that can be used to initiate a search based on the topic map terms that have been traversed to get to the topic level. To implement the topic map, we use duplication of nodes to convert the directed acyclic graph into a tree structure.

Topic maps are presented to the user via either the Web Interface or the Java Client Interface depending on the access mode chosen by the user. Regardless of the user's access mode the visual structure and use of the topic map interface remains unchanged. The primary difference between the modes is in the details of their respective implementations.

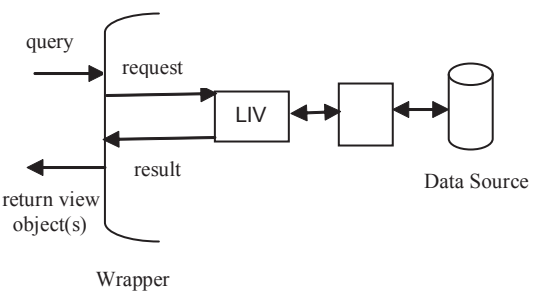
3.4 Data Types

The data types supported will depend to some extent on the nature of the organization. Typically, the data types will include the people that the organization relies on for expertise and the artifacts that make up the organizations' memory. In the implementation described in Section 4, the data types used are the typical artifacts, e.g., emails, meeting minutes, reports, and presentations. Extending the supported data types is simply a matter of ensuring that the appropriate tools for search and analysis are available in the set of supported tools.

3.5 Data Sources

A block diagram of the transformation of a data source is shown in Figure 2. The query is translated to the appropriate request string and passed to the local interface view (LIV). The LIV passes the request string to the data source and converts the response into the objects defined by the LIV view type. The set of

Figure 2. Data source node layout and request/data flow for retrieval



result view objects are then passed back to the Data Source Access Module and cached in the Internal Object Data Store for analysis.

3.6 Internal Object Data Store

The Internal Object Data Store is based on our earlier work on object-oriented data warehouses [13]. The Internal Object Data Store combines tools and the cached data to allow in depth analysis of artifacts. The tool set consists of a set of built in (kernel) tools for managing tools and data and a set of user added tools for creating and analyzing data [12].

3.7 Request Processor

The request processor receives a Request object from the User Interface Controller that defines the search criteria and the result format required to complete the request. The tool type and action required is built into the class structure by employing the Polymorphic design pattern. Each tool that is added either implicitly or explicitly to the topic map requires the definition of a class that extends the Request class. These new classes add any additional information/actions required by the tool.

4. IMPLEMENTATION

To illustrate the feasibility of the proposed model a prototype has been developed. Figure 4.1 shows the initial screen encountered by a user via his/her web browser. The topic map nodes are shown as either ovals or rectangles. Figure 3 shows the nodes in first level of the topic map. Any rectangles shown represent tools and the ovals represent topic nodes containing topics. Note that either type of node can occur at any level in the topic map.

Navigation in the topic map is flexible and can be controlled either by clicking on a topic map node (oval or rectangle) or using the level navigation icons at the top of the screen. Clicking on an oval moves to the next level below the oval and adds the associated topic to the path label for the user's current topic map search.

The icons have the normal meaning, i.e., the house allows the user to return to the starting topic map screen (Figure 3), the back arrow allows the user to move back one level in the topic map, and the forward arrow allows the user to move forward in the topic map. The actual forward move depends on the user's previous operation. If the previous operation was the result of clicking either the home or the back arrow, clicking on the forward arrow will return the user to her/his previous location in the topic map. If the previous operation was a click on a topic map node, then the forward arrow moves the user one level down in the topic map using one of the nodes as the default node. For example in both Figure 3 and 4, the default node is the Search By Topic node.

As expected, using the back and home icons strips the term(s) from the path label so that it is correct for the resulting topic map level. Using the forward arrow icon either reestablishes the previous path label or adds the topic associated with the default node to the current path label depending on the type of operation used before clicking on the forward arrow icon.

The two additional icons represent a keyword search (magnifying glass icon) and help (question mark icon), respectively. The keyword search initiated by clicking on the search icon generates a search tool screen that allows the user to use a vector space search of the organizational memory artifacts [22]. The search tool screen uses the current topic map path label to set up current conditions. Any topics that are in the path label are added to the search keyword list in the screen. If the topic map session was started by clicking on the Search Memory Collection oval, then the topic map moves to the level depicted in Figure 4. The Search Memory Collection topic is set as the current path label. When the user clicks on the Email, the topic map level shifts to the topic map screen shown in the top portion of Figure 5 and the artifact type (Email) is added to the path label. The artifact type in the path label will be used by the search tool to provide an initial choice of artifact type to search.

Figure 3. Initial screen representing the first level of the topic map

Figure 4. Screen shot of the topic map level for memory artifacts

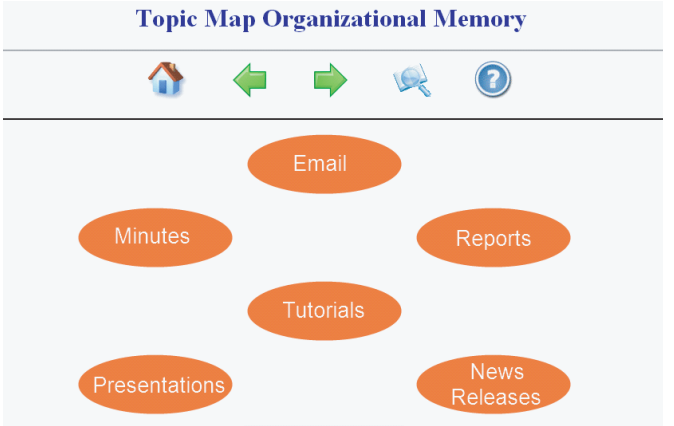


Figure 5. Screen shot showing the results of using the email frequency analysis tool

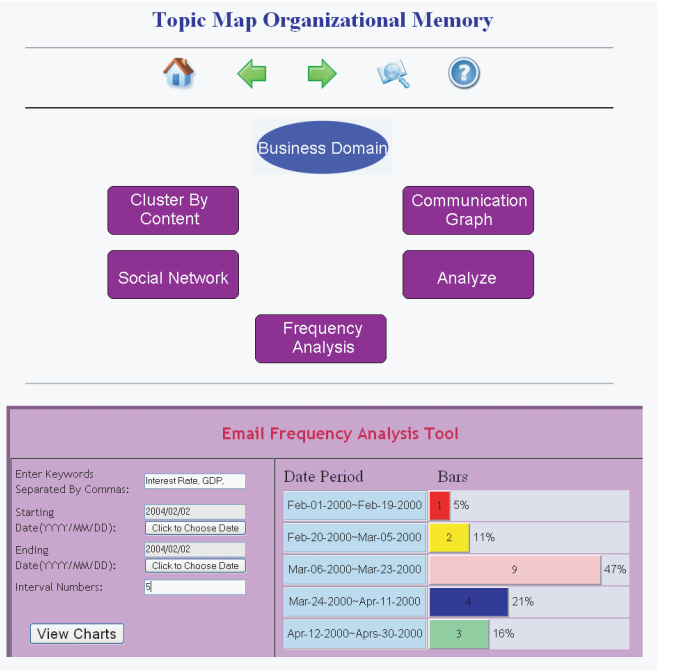


Figure 5 illustrates the use of a topic map tool in the web environment. To reach the topic map illustrated in Figure 4, the user would have clicked on the Search Memory Collection oval and then chosen the Email artifact type. Clicking on the Email Frequency Analysis tool rectangle opens up the input screen shown on the lower left corner of the screen. The tool allows the user to choose the keywords used to search the email collection, the start and stop dates of the time interval that the user is interested in and the number of intervals that the user wants the total interval divided into. Clicking on the View Charts button generates the bar graph shown in the lower right hand corner of the screen (Figure 5).

The topic map interface has been implemented using Ajax to simplify its use. As a result, the input page and the resulting bar graph for the Email Frequency Analysis tool are added to the same page and the status of the topic map remains unchanged. The Google Web Toolkit [23] has been used to generate the JavaScript that supports the generation of the topic map interface and the navigation with in the topic map. In the Email Frequency Analysis tool bar graph, the Date Period fields are viewed by the JavaScript for the page as buttons that bring up a new window containing the list of emails indicated by the associated bar.

The Web Interface has been implemented using Struts[24]. The Internal OO Data Store and Toolkit has been implemented in Java and Poet based on our earlier work on object-oriented data warehouses [12].

5. CONCLUSIONS AND FUTURE CONSIDERATIONS

A model of a distributed data warehouse using a topic map to access knowledge from an organization's collective memory has been presented. An initial version of the model has been implemented using Java as the programming language, Poet to store the objects, and Soap to communicate to data sources external to the system.

Future releases will make use of either Java Data Objects or a tool like Hibernate to replace the Poet database system.

6. REFERENCES

[1] Ackerman, M. and C. Halverson (2004). "Organizational Memory as Objects, Processes, and Trajectories: An Examination of Organizational Memory in Use." Computer Supported Cooperative Work (CSCW) 13(2): 155-189.

[2] Akgun, A. E., J. C. Byrne, et al. (2006). "Transactive memory system in new product development teams." IEEE Transactions on Engineering Management 53(1): 95-111.

[3] Argote, L., B. McEvily, et al. (2003). "Managing Knowledge in Organizations: An Integrative Framework and Review of Emerging Themes." Management Science 49(4): 571-583.

[4] Brockman, B. K. and R. M. Morgan (2003). "The role of existing knowledge in new product innovativeness and performance." Decision Sciences 34(2): 385-419.

[5] Choy, K. L., W. B. Lee, et al. (2005). "A knowledge-based supplier intelligence retrieval system for outsource manufacturing." Knowledge-Based Systems 18(1): 1-17.

[6] Haseman, W. D., D. L. Nazareth, et al. (2005). "Implementation of a Group Decision Support System Utilizing Collective Memory." Information and Management 42: 591-605.

[7] Hollan, J., E. Hutchins, et al. (2000). "Distributed Cognition: Toward a New Foundation for Human-Computer Interaction Research." ACM Transactions on Computer-Human Interaction (TOCHI) 7(2): 174-196.

[8] Jennex, M. and L. Olfman (2002). "Organizational memory/knowledge effects on productivity, a longitudinal study. " Proceedings of the 35th Annual Hawaii International Conference on System Sciences, 2002.

[9] Ji, Y. G. and G. Salvendy (2004). "Interface methods for using intranet portal organizational memory information system." Ergonomics 47(15): 1585-1597.

[10] Lee, T., M. Chams, et al. (1999). "Information Integration with Attribution Support for Corporate Profiles." Proceedings of the eighth international conference on Information and knowledge management., Kansas City, Missouri, United States, ACM Press.

[11] Lesser, E. L. and J. Storck (2001). "Communities of practice and organizational performance." IBM Systems Journal 40(4): 831-841.

[12] L.L. Miller, Ying Lu, Yeping Zhou, A.R. Hurson. (2000). "A Data Warehouse Based on Materializing Object-Oriented Views." International Conference on Computers and Their Applications. New Orleans, LA. pp. 68-71.

[13] Miller, L.L., V. Honavar, J. Wong, and S. Nilakanta, (1998). "Object-oriented data warehouse for information fusion from heterogeneous distributed data and knowledge sources." IEEE Information Technology Conference. pp 27-31.

[14] Nemati, H. R., D. M. Steiger, et al. (2002). "Knowledge warehouse: An architectural integration of knowledge management, decision support, artificial intelligence and data warehousing." Decision Support Systems 33(2): 143.

[15] Nevo, D. and Y. Wand (2005). "Organizational Memory Information Systems: A Transactive Memory Approach." Decision Support Systems 39: 549-562.

[16] Nonaka, I. and N. Konno (1998). "The Concept of "Ba": Building A Foundation for Knowledge Creation." California Management Review 40(3): 40-54.

[17] Peffers, K., T. Tuunanen, et al. (2006). "The Design Science Research Process: A Model for Producing and Presenting Information Systems Research." International Conference on Design Science Research in Information Systems and Technology, Calermont, CA.

[18] Smolnik, S. and I. Erdmann (2003). "Visual navigation of distributed knowledge structures in groupware-based organizational memories." Business Process Management Journal 9(3): 261.

[19] Walsh, J. P. and G. R. Ungson (1991). "Organizational Memory." The Academy of Management Review 16(1): 57.

[20] Wenger, E. (1998). "Communities of Practice: Learning as a social system." The Systems Thinker 9(5).

[21] Yen, C. H. and L. L. Miller (1995). "An extensible view system for multidatabase integration and interoperation." Integrated Computer-Aided Engineering, 2(2):97-123.

[22] Hu, Wen, L. L. Miller, and S. Nilakanta (1998). "PROMIS: A Profiler of Organizational Memory and Institutional Systems." Proceedings of the International Conference of Information Resources Management Association, Boston, MA, 399-405.

[23] Google Web Toolkit, http://code.google.com/ webtoolkit/.

[24] Struts Framework, http://struts.apache.org.

[25] Hevner, A., March, S., Park, J., & Ram, S. (2004). Design Science in Information System Research. MIS Quarterly, 28(1), 75-105.

Adoption of Internet Banking in Hong Kong Using Stakeholder Analysis

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1. INTRODUCTION

The Internet is revolutionizing the banking industry by providing an innovative services channel (Dewan, Freimer, & Seidmann, 2000; Seitz & Stickel, 1988). With the impact of the Internet on the industry, Internet banking has emerged and is defined as a service that allows customers to perform a variety of banking transactions on the Internet via a bank's web site (Tan & Teo, 2000). Previous research studies have generally agreed that Internet banking offers advantages for both customers and banks (Birch & Young, 1997; Dannenberg & Kellner, 1998). Internet banking is an information technology tool that re-defines the way banks interact with their customers. Yet, it has not been as thoroughly investigated and researched in the IS literature as one would have expected. There are a rather limited number of research studies on the issue (Aladwani, 2001; Liao & Cheung, 2002; Mols, 2000; S. Liao & Y.P. Shao, 1999; Tan & Teo, 2000).

Being a major international financial center in the world, Hong Kong is witnessing a rapid growth of Internet banking. Hong Kong has a high concentration of banking institutions. By the end of September 2006, there were 137 licensed banks, 32 restricted license banks and 34 deposit-taking companies in business in Hong Kong (Hong Kong Monetary Authority, 2006e). These 228 authorized banking institutions operated a huge network of 1,301 local branches. In addition, there were 87 local representative offices of overseas banks in Hong Kong (Hong Kong Monetary Authority, 2006e). The density of local bank branches is so high that there is roughly one branch for every 4634 aged 19 or above Hong Kong citizens (Census and Statistics Department (HKSAR), 2006). Table 1 shows the top 6 licensed banks in terms of number of local branches in Hong Kong.

Among the 137 licensed banks in Hong Kong, 42 of them are offering online banking services. They manage around 90% of total customer deposits in Hong Kong (Hong Kong Monetary Authority, 2006c). The number of Internet banking accounts has also witnessed an uninterruptedly increasing trend. In 2005 alone, there was a 17.9% increase (Hong Kong Monetary Authority, 2006d). The top six banking institutions in Hong Kong, in terms of number of local branches, account for 77% of all Internet banking accounts (Hong Kong Monetary Authority, 2006b). One trend, which is shared among the first 5 banks, is that their number of branches has all dropped from as much as 28.7% to 11.5%. It is argued that such a decrease is attributed to the adoption and implementation of Internet banking in Hong Kong. One compelling reason for that is the total amount of deposits have increased with a decreased number of branches, from HK$3,527.8 billion (or US$452.3 billion) in 2000 to HK$4,067.9 billion (or US$521.5 billion) in 2005. There must be a channel other than branch that allows customers to manage their larger amount of fund. Online banking is definitely the alternative.

Many banks in Hong Kong have already seized their early Internet banking adopters. The next logical step will be to capture "wait-and-see" customers. It is definitely not an easy task and requires sufficient incentives to be provided. However, before banks take Internet banking even more seriously, there is a central question to ask. Will Internet banking best be a market-share game (with the possibility of a negative-sum game) (Beckerling, 2000)? Will it just become another banking channel, a strategic tool – a new and cost-effective distribution channel or competitive necessity? The answer to these questions comes down to a key issue: how likely will those "wait-and-see" customers adopt Internet banking eventually? According to the ACNielsen Financial Services Study conducted in 2004 and 2005 in Hong Kong (ACNielsen, 2005), around 1/5 of the respondents indicated that they had used online banking. The adoption intention of the non-users is crucial to how banks in Hong Kong should formulate their Internet banking strategies in both short and long-run.

An insight into the possible large scale adoption of Internet banking in Hong Kong is of significant interest to at least three entities: (i) leading Internet banking operators are eager to find out where they should be prepared for larger online banking customer base; (ii) local banks that are lagging behind or adopting a follower strategy on Internet banking frontier need to know if Internet banking is a zero, positive, or negative sum game before they jump on the bandwagon; and (iii) HKSAR government, especially the Hong Kong Monetary Authority, needs to estimate the proliferation of Internet banking so that it can more effective serve one of its financial obligations – "promoting the safety of Hong Kong's banking system" (Hong Kong Monetary Authority, 2006a).

2. RESEARCH FRAMEWORK

The proposed research and the research framework to be adopted are grounded in the literatures of strategic management. The notion of stakeholder is no newcomer in information systems research. It does not represent a "paradigm shift" in information systems implementation. Rather, it signifies maturity of information systems research as it reflects a shift towards approaches that can afford a more holistic representation of parties (stakeholders) involved.

2.1 Stakeholder Analysis

Stakeholder (or multi-stakeholder) analysis can be defined as "an approach and procedure for gaining an understanding of a system by means of identifying the key actors or stakeholders in the system, and assessing their respective interests in that system" (Grimble & Chan, 1995).

Table 1. Top 6 licensed banks in terms of number of local branches in Hong Kong (Hong Kong Monetary Authority, 2006e)

Rank	Licensed Bank	No. of Local Branches		Drop in %
		2002	2006	
1	Bank of China (Hong Kong) Limited	281	225	20%
2	HSBC Limited	175	125	28.6%
3	Hang Seng Bank Limited	142	122	14.1%
4	The Bank of East Asia Limited	115	87	24.3%
5	Standard Chartered Bank Limited	78	69	11.5%
6	DBS Bank (Hong Kong) Limited (acquired Dao Heng Bank Limited which was ranked No. 6 in 2002)	0	62	N.A.

2.1.1 Stakeholder Analysis in Information Systems Literature

The use of the stakeholder concept has been extended to information systems research. The stakeholder term in the information systems literature was initially used to describe the knowledge gap between users and technical specialist (Currie, 2000). Three groups of stakeholders – users, managers and system developers are typically considered as the most important. Like stakeholder analysis in the management literature, the information systems literature employ stakeholder analysis to resolve the conflicting interests of these groups (Lacity & Hirschheim, 1995; Lyytinen, 1988; Ruohonen, 1991). It is evident that the consideration of the widest range of stakeholders is imperative for effective system management and implementation.

2.1.2 Using Stakeholder Analysis in Proposed Research

Large scale adoption of Internet banking by customers in Hong Kong is undoubtedly a multi-stakeholder problem. Identifying these stakeholders and exploring their perspectives is an essential task for understanding the complexity of the research subject. The stakeholders are likely to interact and influence each other, trying to promote their own interests. Stakeholder analysis facilitates a holistic view of stakeholders, reflecting multi-faceted concerns.

Stakeholder analysis in this research is to provide a tool for stakeholder modeling and analysis of interests, powers, and impacts of various stakeholders in the context. All in all, an investigation of adoption of Internet banking typically requires and benefits from the study of multiple and possibly conflicting stakeholder viewpoints, which in turn helps identify and understand success and failure factors for large scale adoption of Internet banking.

It is evident that from the divergence of definitions that are currently in use in both the management and information systems literature that the meaning of "stakeholder" is not straightforward and needs to be explicitly defined. Based on Freeman's (Freeman, 1984) definition of stakeholders, the following definition for stakeholder is recommended for the proposed research:

A stakeholder is any individual, group, organization or institution who can affect or be affected by large scale adoption of Internet banking by customers in Hong Kong.

3. RESEARCH OBJECTIVE

This research aims at applying stakeholder analysis to the study of information systems adoption – Internet banking in Hong Kong in this case as stakeholder analysis provides a mechanism to consider adoption issues from multiple perspectives.

4. RESEARCH METHODOLOGY

This research was a case study on the adoption of Internet banking in Hong Kong. Researchers (e.g. (Kaplan & Maxwell, 1994)) advocate qualitative research approach for its ability to understand a phenomenon from the point of view of the participants, which is largely lost when textual data are quantified. Such a research methodology is deemed appropriate for this study as it investigates a contemporary phenomenon within its real-life context (Yin, 2002). Data of this study came from secondary sources. The analysis was conducted by the researcher's evaluations and observations with the help of the analytical framework developed.

5. STAKEHOLDER ANALYSIS

5.1 Composing a Stakeholder Table

5.1.1 Defining Stakeholder Characteristics

The following information about stakeholders is assessed:

1. Knowledge: the level of accurate knowledge that stakeholders have regarding Internet banking, and how each stakeholder defines Internet banking. This is important for identifying stakeholders who oppose adopting Internet banking due to misunderstanding or lack of information.

Table 2. Stakeholder table

	Knowledge	Position	Interest	Alliances	Power	Leadership
Banks	Best knowledge	6 major banks support	Ample interest	Possible strong alliances	Strong	Strong
Customers	Moderate	Gaining support	Moderate	Not possible	Moderate	Weak
HKMA	Good knowledge	Passive support	Relatively strong interest	Possible with banks	Strongest	Relatively strong

Table 3. Cross-references of multiple dimensions

	Knowledge	Interests
Relative Importance	There is around 31% of the population in Hong Kong who are not Internet users (Miniwatts Marketing Group, 2006). Their attitude and intention to adopt of these Internet laggards (Cavaye, 1995) are critical to an extended proliferation of online banking. However, they will not stop online banking from penetrating further in Hong Kong since history has already proven that the number of online banking users has been increasingly in a healthy manner. Their resistance, if any, or non-participation will only lessen the chance of adoption of in an accelerated speed in future.	With all the stakeholders identified, a larger scale of adoption of online banking in Hong Kong benefits all of them. In particular, the authority – HKMA would welcome further development of online banking in Hong Kong. Hong Kong is a developed economy, where GDP and GDP per capita were US$177.2 billion and US$25,546 in 2005, respectively (Census and Statistics Department (HKSAR), 2005). A sustained development of online banking can help strengthen the financial position of Hong Kong in the world economy. It can also demonstrate that the financial system of Hong Kong is capable of staying abreast of technological development.
Positions	There is probably no stakeholder who opposes to online banking in Hong Kong. The major reason for those Hong Kong citizens who choose not to adopt online banking is a lack of computer self-efficacy and confidence (Chan & Lu, 2004). Education is probably the best way to encourage the potential adopters to try out the service. Success stories of online banking users are an effective measure for promoting intention to use.	Continued and further adoption of online banking in Hong Kong is to the advantages of both supporter and laggards of the service. With a growing customer base, network externalities will be achieved to attain economies of scale (Milne, 2006). As such, banks are to be able to provide improved online banking services in a more cost-effective manner. Existing and potential users will have incentives to continue or consider employing the service.

2. Position: whether a stakeholder supports, opposes, or is neutral about large scale adoption, which is key to establishing whether or not he or she will block such an adoption.
3. Interest: a stakeholder's interest in the advantages and disadvantages that large scale adoption may bring to him or her or his or her organization. Determining a stakeholder's vested interests helps better understand his or her position and address his or her concerns.
4. Alliances: organizations or persons that collaborate to support or oppose large scale adoption. Alliances can make a weak stakeholder stronger, or provide a way to influence several stakeholders by dealing with one key stakeholder.
5. Power: the ability of a stakeholder to affect large scale adoption.
6. Leadership: the willingness to initiate, convoke, or lead an action for or against large scale adoption. Establishing whether or not a stakeholder has leadership will help target those stakeholders who will be more likely to take active steps to support or oppose large scale adoption (and convince others to do so).

5.1.2 Obvious Stakeholders

The obvious stakeholders of large scale adoption of Internet banking include the following entities:

1. Banks in Hong Kong offering Internet banking at the moment are the *sponsors*, who are also *innovators* (Cavaye, 1995).
2. Banks in Hong Kong *not* offering Internet banking at the moment are the *adopters*, who may range from *innovators* to *laggards* (Cavaye, 1995).
3. Bank customers in Hong Kong are the *adopters*, who may range from *innovators* (active Internet users) to *laggards* (less-active and non-Internet users) (Cavaye, 1995).
4. HKSAR government, in particular HK Monetary Authority (HKMA), is a *policy maker* and *regulator*. It is utmost important for the government to consider all possible stakeholders in their policies regarding Internet banking (Hong Kong Monetary Authority, 2006a).

A stakeholder table is presented in Table 2 summarizing the characteristics of various stakeholders.

Stakeholder analysis can be more than just *descriptive* (Donaldson & Preston, 1995) – facilitating the description of the often conflicting interests and providing a richer understanding of who *all* the relevant stakeholders really are but also both *predictive* – foreshadowing the outcome of that innovation (e.g. degree of adoption), and *explanatory* – providing a rationale for the outcome. The descriptive aspect is particularly important to information systems implementation (Pouloudi, 1999).

5.2 Analyzing Stakeholder Table

Once a stakeholder table is completed, the information needs to be analyzed by cross-referencing multiple dimensions.Such an analysis focuses on comparing information and developing conclusions about the stakeholders' (i) relative importance (power and leadership provide the bases for determining relative importance), (ii) knowledge, (iii) interests, (iv) positions, and (v) possible allies. In this study, only relative importance, knowledge, interests and positions are cross-referenced as they are regarded as most appropriate in this case.

5.2.1 Cross-Referencing Multiple Dimensions

Cross-referencing multiple dimensions can provide more insights into the information collected. Table 3 shows the cross-referencing performed for the research.

6. CONCLUSIONS

According to the stakeholder analysis conducted, there is no obvious opposition to online banking in Hong Kong from the stakeholders identified. Internet banking is here to stay and will become more prevalent in Hong Kong. Relevant stakeholders in Hong Kong cannot afford not to embrace it. The growth of Internet banking is evidenced by increasing number of Internet banking customers, banks offering Internet banking services, and services available on existing Internet banking websites. Leading Internet banking operators seek to find out what can be done to attract laggard Internet banking customers, retain its own customers, or lure customers who are already banking online with competitors through marketing, education, re-assurance, better design of Internet banking website,…etc. Banks that are adopting a follower strategy are eager to find out the predicted growth of Internet banking so that they can decide whether to re-align their strategies. HKSAR government needs to forecast the growth of Internet banking before it strengthens its policies to regulate Internet banking to promote the safety of Hong Kong's banking environment.

The role of stakeholder analysis is significant in this research as it helps identify *all* stakeholders involved and assess their importance, knowledge, interests, positions, and alliances related to adoption of Internet banking. By doing so, the analysis provides a macro-analysis of the issue. It helps identify *key* stakeholders.

7. FUTURE RESEARCH DIRECTION

It is suggested stakeholder analysis be conducted *before* a technology acceptance model which is able to assess the likelihood of adoption at individual level. An appropriate model is the well-established Technology Acceptance Model (TAM) (Davis, 1989). Using a model such as TAM after stakeholder analysis is suggested because the analysis yields useful and accurate information about those persons and organizations that have highest relevance to successful large scale adoption. With the help of stakeholder analysis, stakeholders are identified and further analyzed by mapping multiple dimensions. After such a systematic analysis, it becomes clear who key stakeholders are. TAM is then applied to examine the adoption intentions and the reasons behind of each individual key stakeholder. In essence, the framework provides a micro-analysis of each stakeholder. Once the adoption intentions and the reasons behind are determined, a rather definite prediction of large scale adoption would emerge as it is argued that key stakeholders' adoption inclinations are the most vital determining factors of large scale adoption. Such a two-step analysis guarantees no key stakeholders are left out of the equation and adoption intention of each key stakeholder is thoroughly analyzed. Recommendations on how to accelerate adoption can also be formulated as antecedents of adoption decisions of key stakeholders are revealed. Sponsors of adoption can acquire information about what can be done to attract laggard Internet banking customers, retain existing customers, or even customers from competitors.

8. REFERENCES

ACNielsen. (2005). Internet Banking An Increasing Trend in Hong Kong. Retrieved 16 March, 2006, from http://www2.acnielsen.com/news/20050714_ap.shtml

Aladwani, A. M. (2001). Online banking: a field study of drivers, development challenges, and expectations. *International Journal of Information Management, 21*, 213-225.

Beckerling, L. (2000). Online cost saver – or necessary evil. *Banking World Hong Kong*, 14-18.

Birch, D., & Young, M. A. (1997). Financial services and the Internet – what does cyberspace mean for the financial services industry? *Internet Research: Electronic Networking Applications and Policy, 7*(2), 120-128.

Cavaye, A. L. M. (1995). The sponsor-adopter gap – differences between promoters and potential users of information systems that link organizations. *International Journal of Information Management, 15*(2), 85-96.

Census and Statistics Department (HKSAR). (2005). Hong Kong Statistics. Retrieved 13 July, 2006, from http://www.censtatd.gov.hk/hong_kong_statistics/statistical_tables/index.jsp?tableID=030

Census and Statistics Department (HKSAR). (2006). Statistical Tables. Retrieved 28 August, 2006, from http://www.censtatd.gov.hk/hong_kong_statistics/key_economic_and_social_indicators/index.jsp#pop

Chan, S. C., & Lu, M. T. (2004). Understanding Internet Banking Adoption and Use Behavior: A Hong Kong Perspective. *Journal of Global Information Management, 12*(3), 21-43.

Currie, W. (2000). *The global information society*. London: Wiley.

Dannenberg, M., & Kellner, D. (1998). The bank of tomorrow with today's technology. *International Journal of Bank Marketing, 16*(2), 90-97.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*(3), 319-339.

Dewan, R., Freimer, M., & Seidmann, A. (2000). Organizing distribution channels for information goods on the Internet. *Management Science, 46*(4), 483-495.

Donaldson, T., & Preston, L. E. (1995). The stakeholder theory of the corporation: concepts, evidence, and implications. *Academy of Management Review, 20*(1), 65-91.

Freeman, R. E. (1984). *Strategic Management: A Stakeholder Approach*. Cambridge, Mass.: Ballinger Publishing Co.

Grimble, R., & Chan, M. K. (1995). Stakeholder Analysis for Natural Resource Management in Developing Countries. *Natural Resources Forum, 19*(2), 113-124.

Hong Kong Monetary Authority. (2006a). About the HKMA. Retrieved 15 January, 2006

Hong Kong Monetary Authority. (2006b). E-Banking in Hong Kong - Internet banking accounts of top six major institutions. Retrieved 3 September, 2006, from http://www.info.gov.hk/hkma/eng/consumer/ebanking/ebanking.htm

Hong Kong Monetary Authority. (2006c). E-Banking in Hong Kong - no. of institutions offering Internet banking services. Retrieved 3 September, 2006, from http://www.info.gov.hk/hkma/eng/consumer/ebanking/ebanking.htm

Hong Kong Monetary Authority. (2006d). E-Banking in Hong Kong - no. of Internet banking accounts. Retrieved 3 September, 2006, from http://www.info.gov.hk/hkma/eng/consumer/ebanking/ebanking.htm

Hong Kong Monetary Authority. (2006e). List of Licensed Banks in Hong Kong as at 30 September 2006. Retrieved 2 October, 2006, from http://www.info.gov.hk/hkma/eng/bank/three_tier/addr.xls

Kaplan, B., & Maxwell, J. A. (1994). Qualitative Research Methods for Evaluating Computer Information Systems. In J. G. Anderson, C. E. Aydin & S. J. Jay (Eds.), *Evaluating Health Care Information Systems: Methods and Applications* (pp. 45-68). Thousand Oaks, CA: Sage.

Lacity, M. C., & Hirschheim, R. (1995). Benchmarking as a strategy for managing conflicting stakeholder perceptions of information systems. *Journal of Strategic Information Systems, 4*(2), 165-185.

Liao, Z., & Cheung, M. T. (2002). Internet-based e-banking and consumer attitudes: an empirical study. *Information & Management, 39*, 283-295.

Lyytinen, K. (1988). Stakeholders, Information System failures and Soft Systems Methodology: An assessment. *Journal of Applied Systems Analysis 1*(5).

Milne, A. (2006). What is in it for us? Network effects and bank payment innovation. *Journal of Banking & Finance, 30*(6), 1613.

Miniwatts Marketing Group. (2006). Hong Kong Internet Usage Stats and Market Report. Retrieved 2 April, 2006, from http://www.internetworldstats.com/asia/hk.htm

Mols, N. P. (2000). The Internet and services marketing – the case of Danish retail banking. *Internet Research: Electronic Networking Applications and Policy, 10*(1), 7-18.

Pouloudi, A. (1999). *Aspects of the stakeholder concept and their implications for information systems development.* Paper presented at the Thirtieth-second Hawaii International Conference on Systems Sciences (HICSS-32), Maui, Hawaii.

Ruohonen, M. (1991). Stakeholders of strategic information systems planning: theoretical concepts and empirical examples. *Journal of Strategic Information Systems, 1*(1), 15-28.

S. Liao, & Y.P. Shao, H. W., A. Chen. (1999). The adoption of virtual banking: an empirical study. *International Journal of Information Management, 19*, 63-74.

Seitz, J., & Stickel, E. (1988). Internet Banking: An Overview, Journal of Internet Banking and Commerce. Retrieved 3 March, 2006, from http://www.arraydev.com/commerce/jibc/9801-8.htm

Tan, M., & Teo, T. S. H. (2000). Factors Influencing the Adoption of Internet Banking. *Journal of the AIS, 1*(5), 1-42.

Yin, R. K. (2002). *Case Study Research, Design and Methods* (3rd ed.). Newbury Park: Sage.

A Web Portal for Early Warning and Risk Management

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ABSTRACT

The universal concept and the general technical implementation of a Web Portal for Early Warning and Risk Management are described in this paper. As a prototype example for public access to a modern environmental monitoring and surveillance system, the Web Portal of a system for the remote monitoring of nuclear power plants is presented here in more detail. The concept, the architectural design and the user interface of this system had to meet high demands. Fulfilling the imposed requirements, a solution was developed which is universally suitable for environmental monitoring and surveillance, for early warning and for emergency management.

INTRODUCTION

Almost every day TV news reports on disastrous environmental events from somewhere in the world. Earthquakes, tsunamis, volcanic eruptions, hurricanes, heavy thunderstorms, floods and avalanches alternate with tanker collisions, oil spills, coastal pollution, wildfires, accidents in chemical or nuclear plants (related to the emission of toxic gases or radioactive nuclides) and terrorist attacks.

The loss of human life and the tremendous damages caused by those catastrophes as well as the increasing sensitivity of the general public make it reasonable to protect the population and the environment by means of a new generation of intelligent surveillance, information, early warning and emergency management systems. This includes a highly sensitive monitoring, fast and reliable prognostic calculations, but also a timely dissemination of the relevant information to the general public within the endangered area and in adjacent regions. A most comprehensive way to do this is to foresee public access to those systems via a dedicated web portal.

BACKBONE: THE OPERATIONAL SYSTEM

Due to the complexity of the challenge, it is obvious that only a network of computers with dedicated individual tasks and appropriate communication structures will provide a promising approach to solve the problem of monitoring, surveillance, threat prediction, decision support, early warning and emergency management. However, defining an adequate logical structure for those networks, a variety of subtasks and prerequisites have to be fulfilled in each case in order to include intelligence in various ways and to reach the goal of an integrated operational system:

- Development/integration of adequate sensor systems and sensor networks (autonomous or remotely controlled) providing data and background information. This may include mobile sensory platforms and remote sensing systems (air space surveillance and satellite systems).
- Advanced modelling, i.e. development/improvement of scientific prediction models for prognostic calculations of each disaster type supporting interpretation and extrapolation of data, e.g. calculation of the atmospheric dispersion in case of NBC releases, taking into account the current meteorological situation and the expected forecast values
- Integration of scientific prediction modules into operational systems and definition of adequate interfaces to allow for fast response actions even under critical conditions
- Integration of GIS functionality for an online situation display, using various types of geographical maps to facilitate the recognition of affected areas
- Development and implementation of risk analysis and decision support systems based on sensor data, prognostic calculations and disaster specific experience
- Development/improvement and inclusion of knowledge management components (in general and disaster specific) to integrate the long-term experience of experts and observations made in the past
- Definition of adequate information, alarm and warning strategies, using the full range of state-of-the-art technology, such as satellite communications, web technologies, radio broadcast, TV, telephone (fixed network and mobile systems), siren systems and loudspeakers
- Definition of appropriate interfaces to catastrophe handling and resource management subsystems (transport facilities, shelters, medical care....)

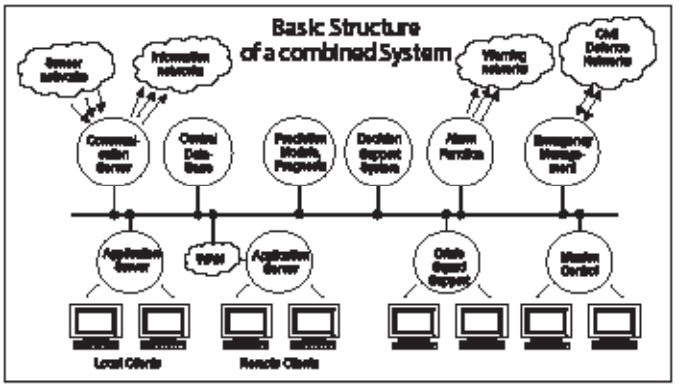
The proposed logical structure of such a combined system is shown in Figure 1 in the form of a Local Area Network (LAN), although some components may be linked together physically by means of a Wide Area Network (WAN), depending on the actual needs of the system under construction.

It is strongly recommended to use a communication server to handle the input data streams from various sensor systems and sensor networks and to convert different data formats, if necessary. This server may also handle the connection to external information networks. In case of higher system loads or larger systems, a specific server computer may be used for this purpose, e.g. a dedicated web server.

Since most of the data are usually needed for central access, the concept of a central database has been confirmed by practical experience. The distribution of specific subsets of the data for decentralized use (e.g. remote application servers) can be achieved by means of dedicated replication functions.

Prediction models and prognostic calculations, such as those for the atmospheric dispersion of toxic gases or radionuclides, tend to need large sets of data and

Figure 1. Structure of the system



therefore are also best served by a central access. Agent technologies and service accesslayer ontologies have proven to be most suitable for the integration of the various scientific components into an operational system.

Decision support systems, based on data describing the actual situation as well as the prognostic development, will reflect the implications for the population in the affected areas and thus help the crisis squad to make their decisions. These systems will have to include advanced knowledge management components and sets of metadata providing access to the long-term disaster specific experience of experts and to observations made in the past.

REQUIREMENTS AND BASIC CONCEPTS FOR THE WEB PORTAL

It is obvious that various user groups and stakeholders have their specific needs and therefore emphasize different aspects of the system. The following user groups can be identified and categorized (see Fig. 2):

- Administrative Sector
- Operational Sector
- Restricted Public Sector
- Public Sector

The administrative sector covers the system administration, maintenance of configuration lists, adaptation and optimization of the system itself and of the related workflows.

The operational sector deals with the main task of the system, i.e. surveillance and monitoring functions, display of the current and prognostic situation, risk assessment and decision support.

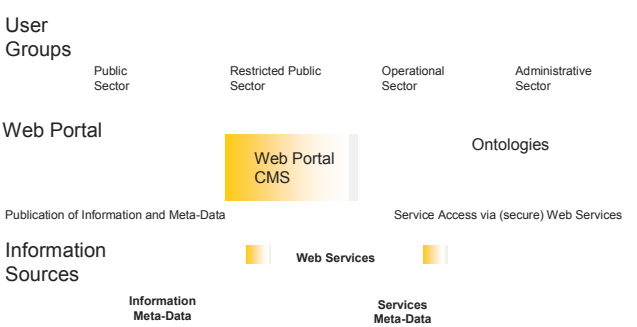
The restricted public sector will provide the necessary information for the crisis squad, for public services (the staff of rescue forces, fire brigades etc.) and all other authorities responsible for civil protection. This may contain confidential information or security related orders which are not foreseen for public disclosure, e.g. in order to avoid panic reactions and pillage.

Finally, the public sector will serve as an information platform for the general public, giving an overview about the current threat situation, exposure risks and the development of these risks. The public sector will also provide general and specific recommendations in case of an imminent dangerous situation. Special attention will have to be drawn onto the web accessibility according to W3C WAI, Section 508, and corresponding national laws.

The large extent and the complexity of the available information combined with various views of diverse user groups call for specific selection and preparation of the data for display in graphical and/or tabular form (depending on the user group). This is the core point for the design and implementation of the Web Portal: to provide for each user group a specific set of web pages which contain all information that is needed to achieve the assigned tasks in the best possible way.

By analyzing the required functionalities and the customer needs, a set of requirements can be derived. The main aspects are:

Figure 2. Basic concept, overview and structure



- Harmonization and matching of the heterogeneous sets of information
- Electronic situation display, incl. animation features
- Simplicity of the user interface
- Modern display capabilities, especially for graphical representations
- Possibility to combine various representations
- Easy-to-use approach by offering well structured information
- Definition of user groups by means of hierarchical access privileges
- Well targeted preparation of the presentations ("generated by experts, to be viewed by anybody")
- Automated, timely publication of (selected) information and metadata
- Publication of reports via secure web services (e.g. in alarm situations)
- Implementation of an "intelligent" public warning system
- Improvement of the emergency management capabilities by introducing workflow tools and corresponding templates
- High quality standards with respect to safety, security and system availability – even under emergency conditions

A first approach is to derive the coarse structure of the Web Portal from the structure of the various user groups, as indicated and illustrated in Fig. 2. Moreover, it may be useful to adapt the basic concept of different access privileges which may have been (successfully) applied in the Operational System, e.g. with respect to individual configuration capabilities for accessible data sets, allowed functionalities (function groups) and accessible server resources.

Further requirements can be deduced from the demand for reliability and high performance of the portal. According to the structure described above, the core functionality of the Web Portal will be allocated to a central Web Server. Therefore, a highly reliable network infrastructure with good performance will have to be provided.

THE IT CONCEPT

Again, it is logical and consistent to set up the IT design for the Web Portal on the basic system concept as described in the previous section and to make use of the existing structure of the Operational System.

This system is typically conceived in form of a client/server architecture with the following components:

- Communication Server (CS)
- Central Database (CDB)
- Application Server (AS)
- PC based User Interface (Clients)
- Integrated Information System (based on HTML)

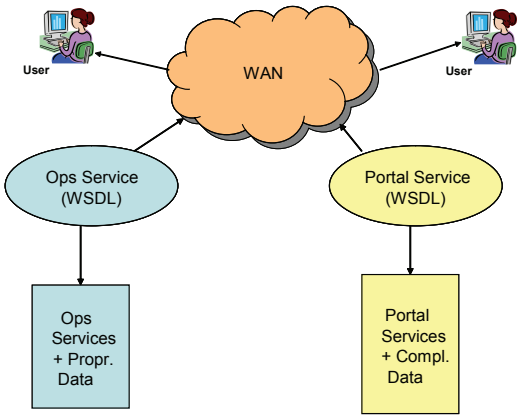
A web based solution is also conceivable for the Operational System (Intranet). However, for safety and security reasons, proprietary communication links would have to be provided.

Development costs for the Web Portal can be reduced by reusing existing facilities of the Operational System to the largest possible extent (provided that the requested views are already available) and to realize the connection with the Web Portal by means of a web service interface.

Given the current state-of-the-art, it is recommendable to use ontologies for modelling, classification, structuring of and navigation within the Web Portal. After a market analysis for adequate content management systems, a decision will have to be taken with respect to the product to be used, preferably one that is based on semantic-web technologies (like OWL-compliant ontologies) and web services for the development of content, knowledge and community management solutions. Due to the ontology based approach and open interfaces, those products allow for the modelling and input (distributed or automated) of very complex information as well as for maintenance, search/navigation and presentation of the information.

The publication of a report will now be realized by means of the communication between two web services (see Fig. 3). Proprietary data and operational services will be provided by the Operational System, whereas complementary data (originating from external sources) will be fed in by the Portal Service. The corresponding interfaces have to be implemented on both sides and have to be published by means of a so called WSDL specification (WSDL = Web Services Description Language; cf. W3C , 2002).

Figure 3. Publication of a report



Typical reports may a.o. include the following information:

- Protective measures, including their representation on geographical maps
- Evacuation areas/safe areas and their current availability status
- Overview of arterial roads, traffic flow and means of transportation (incl. status information)
- Layout plans for assembly and collecting points in case of collective transports
- Emergency stations for medical care, including hospital trains and hospital ships
- Overview of regular hospitals and medical centres (incl. status and capacity information)
- Layout plans of schools, kindergartens and retirement homes
- Layout plans of emergency sheltering capabilities, such as gymnasiums, roof covered stadiums

THE REFERENCE SYSTEM: A WEB PORTAL FOR RADIATION PROTECTION

As a prototype example for public access to a modern environmental monitoring and surveillance system, the web portal of a system for the remote monitoring of nuclear power plants (RM/NPP) will be presented here in more detail.

This system includes the collection of radiological and meteorological variables that have an influence on the diffusion and deposition of radioactive nuclides. A central role of the monitoring system is the use of these variables in the calculation of radiation exposure values and areas. These results are used for decision support, dissemination of information and the issuing of public warnings.

In the event of an imminent, occurring or already terminated release of radioactive nuclides, safety measures pertaining to disaster control and the provision of radiation protection could be required. For instance, the distribution of iodine tablets or a precautionary evacuation are included among these measures.

In its role as a supervisory authority for the nuclear facilities (Obrigheim, Philippsburg and Neckarwestheim) in the Federal State of Baden-Württemberg, Germany, and for foreign facilities close to the German border (Fessenheim/France and Leibstadt/ Switzerland), the Ministry of Environment in Baden-Württemberg has been operating such a remote monitoring system for nuclear power plants for almost 20 years. Recently, the system has been completely renewed using modern hardware platforms and software technologies (Obrecht et al., 2002, Hürster et al., 2005).

As described by Hürster et al. (2005), the RM/NPP is a complex measuring and information system which records and monitors approximately 20 million data sets per day. The actual operational state of the nuclear facilities including their radioactive and non-radioactive emissions are automatically recorded around the clock, independently of the operator of the nuclear power plant. In addition, the RM/NPP system continuously collects meteorological data at the sites and also receives data from external measuring networks (national and international). It provides numerous possibilities to visualize the data and to check them against threshold values and protection objectives. In the case of a radioactive leak, potentially affected areas can be determined at an early stage by a transport calculation (Schmidt et al., 2002) and protective measures can be adopted by the Ministry in cooperation with the authorities responsible for civil protection.

In order to allow for a broader but selective access to the information kept within the Operational System, the decision was taken by the Ministry to establish a web access function by means of a dedicated Web Portal (Hürster et al., 2006). Similar applications are envisaged by the Federal States Baden-Württemberg and Saxony-Anhalt in order to open the access to general environmental information, as imposed by legislation (Schlachter et al., 2006).

Both, the operational system and the web portal have been designed and developed in accordance with the logical structures described above (see Land Baden-Württemberg, 2004; Wilbois and Chaves, 2005). The client software offers numerous possibilities to visualize the data by means of a modern graphical user interface with GIS functions. Also, it provides standardized export interfaces to office and graphical applications.

As a result of a market analysis for adequate content management systems, the decision was taken to rely on WebGenesis®. This product fulfils the requirements mentioned above and it provides web service capabilities for external use, e.g. to establish or to shut down connections, for upload and download of data files etc. For this type of external access, WebGenesis® offers a Java subclass that can also be used from other programming languages, e.g. from C#/.NET (cf. Moßgraber et al., 2005).

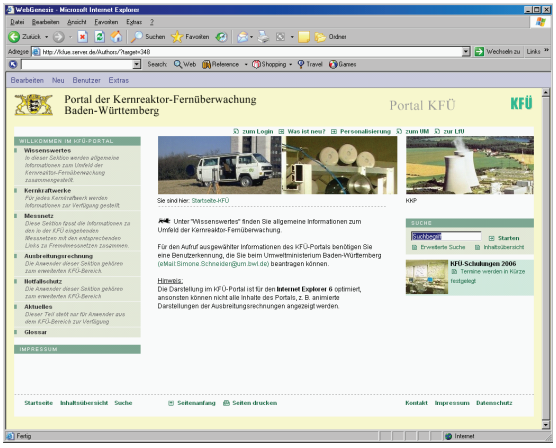
The production system itself is a dynamic web application based on .NET technologies (.NET Framework is a product by Microsoft Corporation). Reports are conceived as independent (or neutral) with respect to server platforms and are stored in the form of XML files. The graphical representation (layout) and the user interface of animated reports are separated from the contents and stored in the form of so called transformation templates (XSLT). This is achieved by using ECMA conformal Java Scripts and HTML+TIME (based on W3C SMIL2.0; cf. W3C, 2005).

PROTOTYPING

For demonstration purposes, a first prototype version has been implemented. Fig. 4 shows the current start page of the Portal which is being intensively used and is therefore considered to be highly accepted by the user groups. A specifically selected representation (generated in the Operational RM/NPP System) is automatically transferred to the Web Portal and thus made available to the connected user groups. Actually, an animated presentation of a propagation cloud has been

Figure 4. Current start page of the portal (prototype version)

Figure 5. Propagation cloud on the background of a topographical map



selected thus illustrating the results of a Dispersion Modelled Transport Calculation (DMTC) for radio nuclides. This type of calculation has to be carried out in case of a radioactive incident or accident and the result is of greatest importance for radiological protection and emergency management.

From a technical point of view, this demonstration prototype realizes the implementation of an interface (preferably via web services) between the .NET based applications on the side of the Operational RM/NPP System and their counterpart within the Content Management System (CMS) WebGenesis® of the Web Portal (based on JAVA Servlets). Navigation within the Web Portal can be achieved either by direct selection or via specific search masks.

In order to make sure that only authorized users have access to the propagation reports (see Fig. 5) the principles of access privileges, as described in the basic concept, have been implemented by using the corresponding features and mechanisms provided by WebGenesis®.

FUTURE TRENDS

The pilot installation of the Web Portal received a great deal of interest from the user groups. The good cooperation with all of them produced an optimistic view for further developments and implementations. The next steps will be:

- Evaluation of the pilot phase (experience and best practices)
- Workshops for dissemination of the results and extension of the user community
- Completion of the IT concept in accordance with the evaluation results
- Implementation of the full system and final acceptance test
- System clearance for full public access to the Web Portal

Due to the increasing importance of early warning and emergency management systems and recognizing the great attention paid to the subject by a sensitive general public, a large number of initiatives and projects on national, international and even global scale are searching for adequate solutions. Therefore, a demand for the commercial availability of such systems is foreseen in the near future.

CONCLUSION

Based on a detailed requirements analysis, the basic concept for a Web Portal for Early Warning and Risk Management has been derived. In a logical sequence, an IT concept has been produced in accordance with the basic concept and with the aim to fulfil the identified requirements to the largest possible extent. The feasibility of the concepts has been proven by the prototype implementation of the Web Portal for the Remote Monitoring of Nuclear Power Plants (Chaves et al., 2005; Hürster et al., 2006).

This Web Portal allows for public access to the monitoring functions, but also enables effective action to be taken in case of an incident or accident. It provides numerous possibilities to visualize data and to check them against threshold values and protection objectives. In case of a radioactive leak, potentially affected areas can be determined at an early stage by a transport calculation and thus protective measures can be adopted by the Ministry and by the public in cooperation with the authorities responsible for civil protection.

Having started with an improvement of radiation protection and the related emergency management, we are confident that the system presented here can significantly contribute to finding a general solution to the indicated problems. The proof will be left to international multi risk scenarios and corresponding across border exercises, supported by the Web Portal capabilities described above.

ACKNOWLEDGMENTS

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REFERENCES

Chaves, F., Wilbois, T., & Grinberg, E. (2005): IT-Konzept für die Erstellung eines KFÜ-Portals, Fraunhofer IITB, Karlsruhe (Germany) / T-Systems GEI GmbH, Ulm (Germany), 2005

Hürster, W., et al. (2005): Remote Monitoring of Nuclear Power Plants in Baden-Württemberg, Germany, In L. Hilty, E. Seifert & R. Treibert (Eds.), Information Systems for Sustainable Development, Hershey , PA (USA) and London (UK): Idea Group Publishing, 2005

Hürster, W., et al. (2006): A Web Portal for the Remote Monitoring of Nuclear Power Plants, In A. Tatnall (Ed.), Encyclopaedia of Portal Technology and Applications, Hershey , PA (USA) and London (UK): Idea Group Publishing, 2006

Land Baden-Württemberg (2004): Das Corporate Design im Internet, Styleguide für das Landesportal und die Ministerien-Websites, mit allgemeinen Regelungen zur Gestaltung weiterer Auftritte, Land Baden-Württemberg, Stand 07/2004, Stuttgart (Germany), 2004 http://www.baden-wuerttemberg.de/internetstyleguide

Moßgraber, J., et. al. (2005): Entwicklungshandbuch für WebGenesis Version 7.10, Fraunhofer IITB, Karlsruhe (Germany), 2005

Obrecht, R., et al. (2002): KFÜ BW - Erneuerte Kernreaktorfernüberwachung in Baden-Württemberg; In R. Mayer-Föll, A. Keitel & W. Geiger (Eds.), Projekt AJA, Anwendung JAVA-basierter Lösungen und anderer leistungsfähiger Lösungen in den Bereichen Umwelt, Verkehr und Verwaltung – Phase III 2002, Wissenschaftliche Berichte FZKA-6777, Karlsruhe (Germany), Forschungszentrum Karlsruhe, 2002 http://www2.lfu.baden-wuerttemberg.de/lfu/uis/aja3/index1.html

Schlachter,T., et al. (2006): Environmental Portals of the federal states of Baden-Wuerttemberg and Saxony-Anhalt with access to the administrative environmental information, In A. Tatnall (Ed.), Encyclopaedia of Portal Technology and Applications, Hershey , PA (USA) and London (UK): Idea Group Publishing, 2006

Schmidt, F., et al. (2002) : KFÜ-ABR – Weiterentwicklung des Dienstes Ausbreitungsrechnung in der Kernreaktor-Fernüberwachung Baden-Württemberg, In R. Mayer-Föll, A. Keitel & W. Geiger (Eds.), Projekt AJA, Anwendung JAVA-basierter Lösungen und anderer leistungsfähiger Lösungen in den Bereichen Umwelt, Verkehr und Verwaltung – Phase III 2002, Wissenschaftliche Berichte FZKA-6777, Karlsruhe (Germany), Forschungszentrum Karlsruhe, 2002 http://www2.lfu.baden-wuerttemberg.de/lfu/uis/aja3/index1.html

Wilbois, T., & Chaves, F. (2005): Fachkonzept für die Erstellung eines KFÜ-Portals,T-Systems GEI GmbH, Ulm (Germany) / Fraunhofer IITB, Karlsruhe (Germany), 2005

W3C (2002): Web Services Description Language (WSDL), World Wide Web Consortium (W3C) / Web Services Description Working Group, http://www.w3.org/2002/ws/desc/

W3C (2005): The Synchronized Multimedia Integration Language (SMIL 2.0) – Second Edition, World Wide Web Consortium (W3C), Recommendation 07 January 2005, http://www.w3.org/AudioVideo/

How World Leading Manufacturers Can Achieve Differentiation Through E-Business: New Services, Enhanced Relationships, and Reduced Costs

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ABSTRACT

E-business development is today driven by mature and established companies and is becoming an important tool to increase competitive advantage and to sustain profitability. This paper investigates how world-leading manufacturers can achieve differentiation through their use of e-business. Many companies use e-business as vehicles to launch new information-based service, as an important enabler to enhance and deepen customer relationships, and to reduce costs associated with customer management. Using e-business in this way will increase the opportunities for differentiation and create sustainable competitive advantage. Successful employment of e-business creates services that retain current customers and attract new ones as well as justifies premium prices and keeps low-cost competitors in check.

Keywords: E-business, Differentiation, Value creation, Offerings, Services

INTRODUCTION

Today mature and established companies, as opposed to start-ups, are driving e-business development and are using these technologies, now often incorporated in the concept of Information and Communications Technologies (ICT), to increase competitiveness by the integration of e-business into their business. Evidence shows that e-business is making big strides into most aspects of companies' businesses and is enabling new avenues in business development (Kindström, 2005; Earl, 2000; Hackbarth and Kettinger, 2000). Using e-business to create new information-based services and offerings to increase possibilities for differentiation and profitability is one of the major areas of interests in industry.

One aspect of particular interest is to study how e-business can increase competitive advantage by the expansion of industrial offering through services. E-business can be used to improve the companies' existing service processes and develop new, more advanced services and solutions (Normann, 2000), thereby increasing customer value and keeping competitors in check. As it is becoming increasingly difficult to maintain market leadership based on product sales, due to the trend toward product commodization in many business markets (Ulaga and Eggert, 2006) and competition from low-cost competitors (Lovelock, 1995) many companies turn to the provision of services in order to increase profits and customer value. On many industrial markets, services are likely to give higher margins than manufacturing activities do and services are becoming a critical factor of competitiveness for targeting new customer segments as well as to retain existing customers (Henkel et al., 2004; Oliva and Kallenberg, 2003). When conducting a quantitative study among purchasing managers in US manufacturing firms, Ulaga and Eggert (2006) found that the core product and its price become less important differentiators for product suppliers and they identified service support, the customer-supplier relationship, and suppliers' know-how as core differentiators. In the context of this study, market leading manufacturing companies pursuing a premium price strategy, this is particularly interesting.

The objective of this paper is to address how market leading industry incumbents can use e-business services to create value through differentiation and thereby increase their competitive advantage. Four world-leading manufacturers are analyzed using a qualitative case study approach.

THEORETICAL BACKGROUND

Early on, e-business initiatives focused on transactions, reducing costs and the relatively low-risk and comparable, easily appropriable benefits that were possible from that perspective (see eg Kindström, 2005). This is to certain extent supported by Dilworth and Kochhar (2004) that found that companies in the UK (in particular large ones) seem to have emphasized a simpler, transaction-focused, use of e-business (such as e-mails and web-site access). Transactional efficiencies and inherent cost reductions are often tangible aspects of introducing e-business into companies (Kaefer and Bendoly, 2004).

However, e-business can also provide the platform for many organizations to engage in new marketplace strategies and to generate and deliver additional value (Amit and Zott, 2001; Zwass, 2003), and increase competitive advantage in novel ways (Fahey et al., 2001; Porter, 2001). Thus, e-business should make it possible for companies to both reduce the costs for providing services (internal efficiency) and increase service revenues by injecting higher value into the customers' value-creating processes (external effectiveness) (Anderson et al., 1997; Kowalkowski, 2007). When discussing value creation, Wikström and Normann (1994) refer to these two dimensions as cost efficiency and market efficiency. Market efficiency can be achieved by either relieving the customer (i.e. reducing customer costs) or enabling the customer (i.e. increasing customer business performance) (Ravald and Grönroos, 1996). Thus, a premium price can be justified through the use of either of the two mechanisms (Porter, 1985).

Because e-business has become commoditized and is not a differentiator by itself (Carr, 2003), differentiation lies in the new practices it enables (Brown and Hagel, 2003). Many processes can be dematerialized and services can be unbundled in terms of where and when they take place and who performs them, and thereafter be re-bundled into new offerings (Normann, 2001).

Hence, e-business, as a resource, may initiate a radical transformation of traditional customer-provider relationships (Nambisan, 2002) and the company's internal service processes through standardizing (and possibly automating or eliminating) processes (Koskela, 2002). Close proximity to the customer enable bonding and thus customer lock-in possibilities (Hax and Wilde, 1999), and customer relationship longevity improve the efficiency and effectiveness of service provision (Grönroos and Ojasalo, 2004). A perennial problem with differentiation is to make it sustainable. By using e-business technologies as vehicles for new services (based on knowledge residing within the company) and differentiation purposes (Kim et al., 2004), companies are also effectively raising the barriers for imitators as well as locking out competitors.

In the framework proposed by Porter (1985), *differentiation* is one of three distinct, generic strategies, the other two being *cost leadership* and *focus*. Treacy and Wiersema (1993) argue, close to Porter's discussion, that there are three competitive advantages that companies can pursue; *operational excellence*, *product leadership*, and *customer intimacy*. Both product leadership and customer intimacy holds great potential for e-business through new information-based services.

Hax and Wilde (1999) argue that Porter's strategic framework is insufficient to describe all the ways companies compete and instead they suggest three strategic options; *best product* (representing a continuum from low cost to differentiation), *customer solutions*, and *system lock-in* (by e.g. proprietary standards). Hence, the best product option includes Treacy and Wiersema's operational excellence and product leadership whereas customer solutions bear a close resemblance to customer intimacy, with focus on customer economics and lifetime value. Consequently, differentiation possibilities consist not only in enhanced product attributes.

To sum up, four main competitive advantages can be derived. The system lock-in dimension has little bearing on mature, established manufacturing companies' offerings (the context of this study) if related to e-business, as e.g. few dominant design proprietary standards for offerings exist. The remaining three dimensions are presented in Table 1. Offering leadership is not only goods-oriented, but refers to parts of or the total offering. For market-leading industry incumbents, low cost differentiation is not a strategic option (although cost efficient operations are critical) and the main potential for differentiation lays thus in offering leadership and customer intimacy.

It is especially worth noting the fact that customization is now possible without the often associated cost increase (Hitt et al., 2001). When focusing on customer intimacy and relationship longevity (in opposite to arm's-length relationships), emphasis lies on retaining customers (Grönroos, 2000). Accordingly, attracting new customers is achieved mainly through offering leadership.

According to Huizingh (2002) there are four strategic choices a company has when using e-business for value creation and thus differentiation purposes; *customize products*, *attract new customers*, *retain current customers* by providing added value, or to *reposition the company* in its business network. These choices primarily aim at increasing profitability through increasing revenue streams and adding value as opposed to decreasing costs. Amit and Zott (2001), in their useful framework, come close to the same notions when forwarding their four dimensions *novelty*, *efficiency*, *complementarities*, and *lock-in*.

RESEARCH METHOD

The research approach was, largely, exploratory and for our purpose, case study research was considered a useful strategy (Gummesson, 2000; Yin, 1994). The research process was an iterative process matching theory and reality, where advantage of the systematic combining of both the empirical world and the theoretical models was taken (Dubois and Gadde, 2002).

A multiple case study was adopted because, compared to a single case study, a multiple case study is often considered more compelling and robust (Yin, 1994). Specifically, cases were chosen that met four primary criteria: (1) the company is an international market leader, (2) the company pursues differentiation strategies, (3) e-business is used to increase the competitive advantage, and (4) access to key informants was possible. Eventually, four multinational, Swedish companies were selected for in-depth studies. Thus, the choice of companies was a deliberate research design parameter to ensure some degree of general applicability (Glaser and Strauss, 1967; Gummesson, 2000) and replication logic may be claimed (Yin, 1994). Accordingly, our findings are believed to apply also in other companies and industries.

The interviews were loosely structured with the help of an interview guide (i.e. a semi-structured approach) (Yin, 1994). Respondents were managers that worked with developing e-business and/or services within these companies. Furthermore, intranets, internal documents, project meetings and discussions were used as sources of information. In total, more than 30 meetings with respondents took place. Data collection and data analysis did, to a certain extent, overlap and thus a fruitful interaction resulted (Eisenhardt, 1989). A case study protocol was established to increase reliability and validation of the cases has been made with key respondents in order to ensure correctness (Pettigrew, 1997; Yin, 1994).

VOLVO BUS AB

Volvo Bus is the world's second largest bus manufacturer and most of their business is directed to large customers with extensive fleets of buses. In total, Volvo Bus estimates that there are approximately 130,000 company buses in operation worldwide.

Volvo Bus creates new information-based services (such as e.g. advanced online search functions for lead generation and skill location) through analyzing, understanding, and supporting customers' processes and needs. Volvo Bus does not just deliver "raw" information to their customers; instead, they provide ways and functions to use the information for e.g. business intelligence purposes. For example by allowing service bulletin (both tentative and official) to be distributed online turn-around time in workshops, both Volvo's own and independent, is reduced.

One of the most obvious added value for Volvo Bus internally as well as the customers is the fact that ICT has the potential of speeding up processes and making them easier, faster, more accurate, and hence cheaper. The better use of information as well as the new services has eg cut calls and created more trust between the parties, and is thus also strengthening the relationship. Furthermore, by empowering its customers by shifting information and tasks to them, Volvo Bus frees up time internally and instills a sense of ownership of the process and activities in the customers. Through this Volvo Bus manages to achieve lock-in effects and also switching costs can be raised. One example is allowing customers to print out their own bills directly from the system instead of sending them via fax/mail/e-mail reducing enquiries.

SANDVIK COROMANT AB

Sandvik Coromant is the world leading manufacturer of cutting tools and inserts for the metalworking industry with a catalogue of more than 25 000 products. They have a wide range of customer organizations ranging from major automotive companies to small metal workshops with just a few employees.

Sandvik Coromant's range of customers and products creates challenges since different customers demand different things from an e-business solution. For example, large customers, having their own e-exchange systems, have diametrically different demands than small metal work shops. Sandvik Coromant has not been efficient at handling very small customers (called micro customers). By adding e-functionality for e.g. credit card payments and making small orders directly on the Internet (in their web-based Shop-Online solution) Sandvik Coromant is able to capture the unrealized value that these small customers hold. Earlier these smaller orders were made through the telephone on an ad hoc basis making it hard to understand, and

Table 1. Strategic options for industry incumbents

Cost efficiency	Offering leadership	Customer intimacy
Cost leadership (Porter, 1985)	Differentiation (Porter, 1985)	Differentiation (Porter, 1985)
Operational excellence (Treacy and Wiersema, 1993)	**Product leadership (Treacy and Wiersema, 1993)**	**Focus (Porter, 1985)**
Low cost (Hax and Wilde, 1999)	Best product (Hax and Wilde, 1999)	Customer intimacy (Treacy and Wiersema, 1993)
		Customer solution (Hax and Wilde, 1999)

profit from, this group of customers. Because of this added information, a better segmentation of the customers also becomes possible. For the larger companies Sandvik is able to provide customized catalogues with a richness of details and information not possible without a sophisticated e-business solution.

By developing new e-enabled tools for the sales force that provide direct links to the company's legacy system as well as business intelligence applications Sandvik are able to increase productivity of the sales force and thus become more profitable.

BT INDUSTRIES

BT Industries Group is a global manufacturer and supplier of warehouse trucks and services, and part of the Toyota Group. Often, contracts with customers are gradually becoming increasingly advanced as the relationships develop and mutual knowledge improves, and customers are used in the service development process.

Since 2002, BT's service organization is using EASY, a mobile business system. Service technicians each have a PDA linked to the ERP system through GPRS where they receive and report work orders and have access to customer fleet data and spare parts information. While BT benefits from reduced administration cost and increased cash flow, customers have benefited from faster response to service calls. Administration is also reduced for the customer, who signs the completed work order digitally directly on the PDAs display. Several synergies have derived from the EASY implementation and one of the most appreciated things was the possibility for customers to receive work reports electronically.

Furthermore, value can be created by offering report packages and consultative services that enable customers to view the real-time utilization of the fleet, to view how trucks are driven, and how different customer sites perform.

ELECTROLUX LAUNDRY SYSTEMS

Electrolux Laundry Systems (ELS) is a worldwide supplier of professional laundry products and services. Managers have pointed at opportunities to increase the knowledge component in the service offerings through e-business. ELS has also recognized a need of knowing the knowledge profile of each individual, authorized service technician. Therefore, an online certification program has been launched to assure a homogeneous service quality worldwide.

ELS' management information system for laundries, CMIS, substitutes personnel for dematerialized information. With a CMIS port on the machine, it is possible to make changes to the laundry processes and still obtain more laundry per day, thereby obtaining better process optimization. Either CMIS can be run as a local network only or there can be a gateway to ELS so the company can monitor the processes. By governing the customer's process through CMIS, ELS can help to improve the laundry programs and maximize equipment uptime.

The creation of an installed base database, which provides the company with information about machinery type, actions taken, etc., has given ELS better knowledge about the customers and the database can thereby be used to support the provision of customized services.

DISCUSSION

E-business has a substantial effect on the Offering leadership dimension in establishing a differentiated offering to, especially new, customers (see Figure 1 below). This can probably be attributed to a traditional focus in most companies of emphasizing tangible offering features based e.g. on what technology allows. Furthermore, this has a primarily inside-out focus with companies creating services in a rather traditional fashion resembling product development. That is e-business is used to create *new services* from a perspective of what is possible and not necessarily what is needed and value creating. These new services can also either be bundled with existing offerings or provided as stand-alone unbundled services to both the installed-base and previously unrelated customers.

In the Customer intimacy dimension we see many activities regarding the *enhancing,* and deepening, of the *relationship* with the customer. This implies that companies are not just creating new services and offerings (as hinted above) but also addressing specific customer needs and processes, customization, with new services and offerings and are thus unlocking the true potential of e-business as a vehicle for value creation by both relieving customers (ie reducing cost) and enabling customers' business (ie increasing productivity) (cf Ralavd and Grönroos, 1996).

Finally we can see that e-business refines and extends the companies' core business (cf Kraemer et al., 2000) and is used to create new customized offerings and create new value not only for external customers (cf. Huizingh, 2002), but also internally (e.g. mobile business systems) through process automation and elimination, i e *cost reductions*. The cost reduction aspect also means that a company can profitably approach previously unprofitable customer segments such as small customers with low transaction value versus cost ratio.

By adding new value-creating services to the company's core products and enhancing the relationship with the customer, it seems possible to reduce the changeability of the offerings by e.g. increasing switching costs. This is possible due to e.g. increased lock-in effects as well as an enabling of deeper relationships between buyer and supplier, thus increasing customer retention. We can also see that this enables the companies to escape the product commoditization trap by establishing themselves as solution suppliers and thus creating new differentiation opportunities. Many companies do indeed try to differentiate themselves through improved customer interactions instead of through product features (Vanderbosch and Dawar, 2002).

E-business can improve relationships in two distinct ways touched upon above. First, it decreases the cost of upholding an existing relationship and secondly, it

Figure 1. The effects of e-business on differentiation within the studied companies. The upper part of the figure shows the general aspects and the lower part some specific examples. 1) – 3) are the synthesized mechanisms

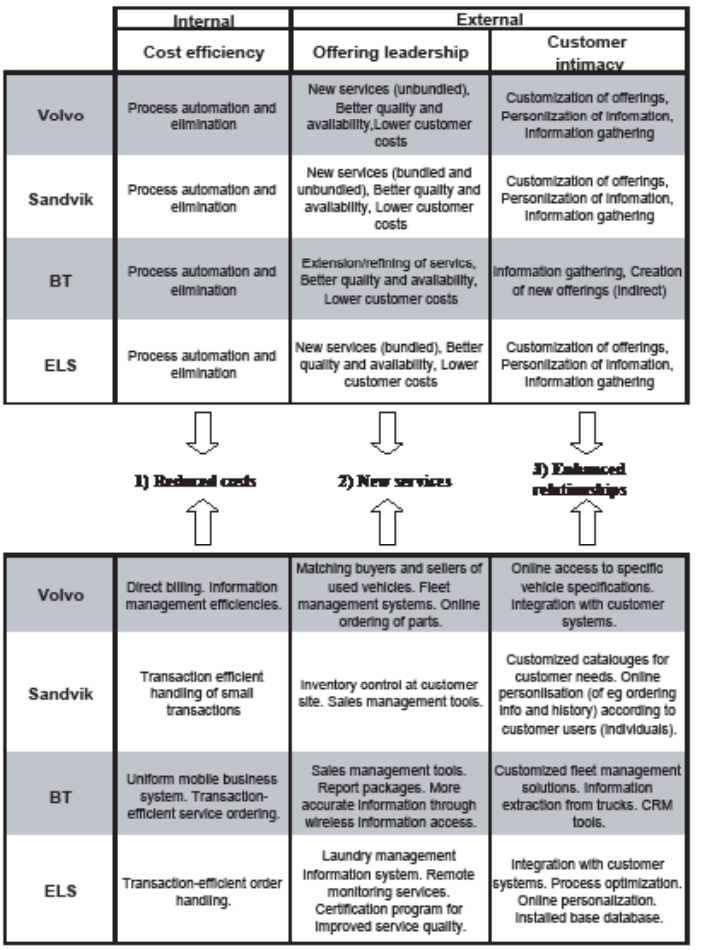
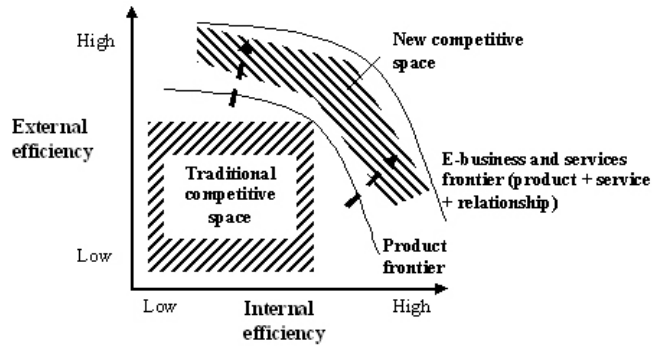


Figure 2. E-business and services can shift the competitive space



expands the width of the relationships by increasing contact points and integration by e.g. the inclusion of value-adding services in the offerings (based primarily on information gathering, analysis and distribution).

Through e-business, the case organizations have been able to cut administrative costs by re-engineering and even eliminating some administrative processes, typically the order process. This last point also has effects on the customer since an automated order process often can reduce costs for the customer as well. Furthermore it also increases the availability and simplicity of the interaction with the supplier thus creating value.

The three mechanisms discussed are not unrelated and can provide positive feedback loops to each other. For example, a customized solution provided to one customer can be generalized, and to a certain extent standardized, and rolled out as a new service in the company's total offering thus having a positive effect on offering leadership.

NEW COMPETITIVE SPACE

By using e-business and services, the studied companies stay ahead of competitors by effectively moving the competitive frontier further out into areas not covered by product features (these features are increasingly seen as qualifiers) but by "softer" issues (cf. Ulaga and Eggert, 2006). This new frontier is out of reach by low-cost competitors since they lack the necessary resources, such as well-functioning distribution and service networks, and can thus constitute a sustainable competitive advantage. If staying in the traditional competitive space, competitors will move closer and closer to the product frontier and thus erode any competitive advantage, whereas focus on service flows and customer processes (cf e.g. Day, 1994) enables companies to cross the traditional, technology-oriented chasm and increase both internal and external efficiency (see Figure 2) (cf also Normann, 2000).

In the traditional competitive space, value is largely created by technological advances regarding the products, and thus rather easily imitated, whereas in the new competitive space new services, information, and relationships (e.g. knowledge of customers and their processes) become of essence (Vargo and Lusch, 2004). Naturally, the company must have a reasonable cost level as well, thus not neglecting the cost-reduction aspect. This however is not a differentiator for the premium price strategy that the companies in this study have.

CONCLUSIONS

E-business can be used as a driver for new value in order to support differentiation strategies towards new customers as well as to retain current customers. Furthermore, e-business strengthens and adds value to the business model and enables its expansion and extension. An increasing part of all business development within companies today can be attributed to the development and inclusion of e-business and associated services into any companies (cf. Kindström, 2005).

One of the main purposes of e-business in this study is to create new services, for differentiation purposes, based on information gathering, analysis, and distribution. E-business supports and furthers the competitive position because it makes it possible to strengthen differentiation strategies (cf. Hackbarth and Kettinger, 2000). By using e-business to create new, often information-based, services and by tying customers closer, the companies establish and position themselves better on the marketplace by focusing on the customer relationship. This in turn enables the companies to understand their customers and the processes better and thus construct more attractive offerings tailored to the specific needs.

E-business can also enable the creating of more business and expand sales, i.e. increasing revenue, by e.g. being able to address previously unprofitable smaller customers with low transaction cost solutions and also to sustain new revenue streams based on services and complete offerings.

REFERENCES

Anderson, E., C Fornell and R. Rust (1997). Customer Satisfaction, Productivity and Profitability. *Marketing Science* 16(2),129-145.

Amit, R and Zott, C (2001), Value Creation in E-business, *Strategic Management Journal*, 22(6-7),493-520.

Barua, A, Konana, P, Whinston, A and Yin, F (2001), Driving E-Business Excellence, *Sloan Management Review*, Fall,36-44.

Brown, J. and J. Hagel (2003), Does IT Matter?, *Harvard Business Review*, 81(7),109-12.

Carr, N. (2003), IT Doesn't Matter" *Harvard Business Review*, 81 (5),41-49.

Coltman, T, Devinney, T, Latukefu, A and Midgley, D (2001), E-Business: Revolution, Evolution, or Hype?, *California Management Journal*, 44(1),57-86.

Day, G. (1994), The capabilities of market-driven organizations, *Journal of Marketing*, 58(4),37-52

Dilworth, J and Kochhar, A (2004), Hype or Reality? A Survey of E-business, *IEE Manufacturing Engineer*, April/May, 16-19.

Dubois, A. and Gadde, L.E. (2002), Systematic combining, *Journal of Business Research*, 55(7),553-560

Earl, M (2000), Evolving the E-business, *Business Strategy Review*, 11(2),33-38.

Eisenhardt, K, Building theories from case study research, *Academy of Management Review*, 14(4),532-550.

Fahey, L, Srivastava, R, Sharon, J and Smith, D E (2001), Linking E-business and Operating Processes, *IBM Systems Journal*, 40(4),889-907.

Glaser, B. and Strauss, A. *The Discovery of Grounded Theory*, Aldine,New York

Grönroos, C. (2000), *Service management and marketing*. Wiley,Chichester

Grönroos, C and K Ojasalo (2004). Service productivity. *Journal of Business Research* 57,414-423.

Gulati, R and Garino, J (2000), Get the Right Mix of Bricks & Clicks, *Harvard Business Review*, May-June,107-114.

Gummesson, E. (2000), *Qualitative Methods in Management Research*, Sage,Thousand Oaks

Hackbarth, G and Kettinger, W (2000), Building an E-business Strategy, *Information Systems Management*, Summer,78-93.

Hax, A and D Wilde (1999). The delta model, *Sloan Management Review* 40(2),11.

Henderson, J and Venkatraman, N (1999), Strategic Alignment: Leveraging Information Technology for Transforming Organizations, *IBM Systems Journal*, 38(2-3),472-484

Henkel, C, O Bendig, T Caspari and N Hasagic (2004). Industrial Services Strategies, Monitor Group.

Huizingh, E (2002), Towards Successful E-business Strategies: A Hierarchy of Three Management Models, *Journal of Marketing Management,* 18,721-747.

Kaefer, F and Bendoly, E (2004), Measuring the Impact of Organizational Constraints on the Success of Business-to-Business E-commerce Efforts, *Information and Management*, 41,529-541.

Kim E, Nim D and Stimpert J (2004), The Applicability of Porter's Generic Strategies in the Digital Age: Assumptions, Conjectures, and Suggestions, *Journal of Management*, 30(5),569-589.

Kindström, D (2003), *Rearranging a Business Model towards Market Orientation*, Licentiate Thesis, Linköping Universitet.

Kindström, D (2005), *Integrating E-business into Mature and Established Companies*, Dissertation, Linköping Universitet.

Koskela, H (2002), *Customer Satisfaction and Loyalty in After Sales Service*. Dissertation, Helsinki University of Technology.

Kowalkowski, C. (2007 in press), Service Productivity Gains through Information and Communication Technology Applications, *International Journal of Knowledge Management Studies*.

Kraemer, K, Dedrick, J and Yamashiro, S (2000), Refining and Extending the Business Model wit Information Technology: Dell Computer Corporation, *The Information Society*,16,5-21.

Kumar, R (2004), A Framework for Assessing the Business Value of Information Technology Infrastructures, *Journal of Management Information Systems*, 21(2),11-32.

Matthyssens, P and K Vandenbempt (1998). Creating competitive advantage in industrial services,*Journal of Business and Industrial Marketing* 13(4/5),339-355.

Nambisan, S (2002) Designing Virtual Customer Environments for New Product Development, *Academy of Management Review* 27(3),392-413.

Normann, R (2000), *Service Management*, Wiley,Chichester.

Normann, R (2001), *Reframing Business*, Wiley,Chichester.

Oliva, R and R Kallenberg (2003). "Managing the transition from products to services." *International Journal of Service Industry Management* 14(2),160-172.

Pettigrew, A (1997), What is processual analysis, *Scandinavian Journal of Management*, 13(4),337-348.

Porter, M (1985), *Competitive advantage*, Free Press, New York.

Porter, M (2001), Strategy and the Internet, *Harvard Business Review* 79(3),62-78

Porter, M and Millar, V (1985), How information gives you competitive advantage, *Harvard Business Review*, 63(4),149-160.

Subramaniam, C and Shaw, M (2002), A Study of the Value and Impact of B2B E-Commerce, *International Journal of Electronic Commerce*, Summer, 6(4),19-40.

Treacy M and F Wiersema (1993), Customer intimacy and other value disciplines, *Harvard Business Review*, Jan/Feb,84-93

Ulaga, W. and A. Eggert (2006), Value-Based Differentiation in Business Relationships, *Journal of Marketing*, 70(1),119-36.

Vargo, S. and R. Lusch (2004), Evolving to a New Dominant Logic for Marketing, *Journal of Marketing*, 68(1),1-17

Venkatraman, N and Henderson J (1998), Real Strategies for Virtual Organizing, *Sloan Management Review*, Fall.

Weill, P and Ross, J (2004), *IT Governance*, HBS, Cambridge.

Wikström, S. and R. Normann (1994), *Knowledge and Value*. London: Routledge.

Yin, R, (1994), *Case Study Research*, Thousand Oaks,Sage

Zwass, V (2003), Electronic Commerce and Organizational Innovation, *International Journal of Electronic Commerce*, 7(3),7-37.

Evaluating Students' Acceptance of the Discussion Forum in the E-Learning Context

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ABSTRACT

Recently, the popularity of e-learning systems has been growing in the academic and technical training world. Some academic and technical training organizations are adopting e-learning systems to support distance education, while others use these systems to supplement their traditional way of teaching. This pilot study evaluated the students' acceptance of the use of discussion forum in the context of using e-learning system as a supplementary tool, based on the technology acceptance model (TAM2). Data was collected through a questionnaire from undergraduate students in an academic institution in Oman. This study found that perceived usefulness is significantly determined by job relevance, image, result demonstrability and perceived ease of use of the system, but not by subjective norm and output quality. In addition, the use of the discussion forum in the e-learning context is determined by its perceived usefulness and perceived ease of use.

INTRODUCTION

Recently, the adoption of e-learning systems has been growing in the academic world. In 2004, the e-learning market was worth more than US $18 billion worldwide (Saady, 2005). In the Middle East, e-learning projects are expected to exceed a compound average growth rate of 32% by 2008, based on the Madar research group (Saady, 2005). Several international reports from the World Bank (2003) and the World Summit on the Information Society (2005) emphasized that the use of information communication technology (ICT), to build human resources is a vital prerequisite for the development of knowledge-based economy especially for developing country.

To be able to succeed on the deployment of e-learning systems, it is very essential to understand the determinants of this technology's acceptance. The technology's acceptance can be assessed at macro level (organizations or governments) or micro level (students and instructors). This study aimed to investigate this phenomenon from the students' perspective. Factors affecting information system usage are best investigated at the individual users' level (DeLone & McLean, 2002). Evaluating individual users' acceptance of the e-learning systems is a "basic marketing element" (Kelly & Bauer, 2004). Middle Eastern organizations are hesitant to adopt e-learning systems because of the limited Individual users' acceptance (Saady, 2005).

This study empirically examined factors that enhances students acceptance of e-learning initiative (specifically the use of discussion forum). Discussion forum is an online discussion group where people with similar interests engage in discussion, share and debate ideas. This study adopted Technology Acceptance Model (TAM2), which was proposed by Venkatesh and Davis (2000).

The next section provides a literature review of e-learning and technology acceptance models. The literature section is followed by sections on study framework, study methodology, data analysis, and discussion and conclusions.

LITERATURE REVIEW

E-Learning

E-learning is defined as "instruction delivered through purely digital technology using the Internet or private networks" (Laudon & Laudon, 2003, p. 268). It is the use of a web-based communication, collaboration, learning, knowledge transfer and training to add values to the learners and the businesses (Kelly & Bauer, 2004). Some academic and technical training institutions adopt the e-learning system to support distance learning, while others adopt this technology as a supplementary tool to their traditional way of teaching. E-learning provides several benefits for individuals and organizations. Such benefits are cost-effectiveness, consistency, timely content, flexible accessibility and customer value (Cantoni, Cellario & Porta, 2004; Kelly & Bauer, 2004). However, e-learning may cost a lot to develop, requires new skills on content producers and requires more responsibility and self-discipline from the learners (Cantoni et al, 2004); thus students might be intimidated to use the e-learning systems.

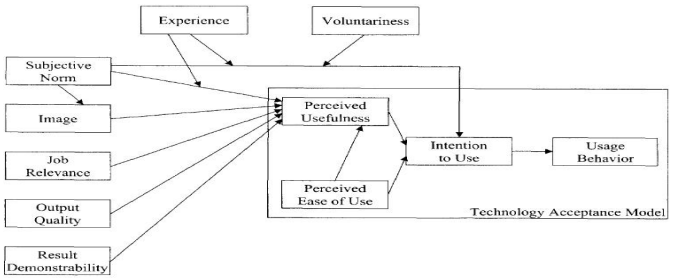
Thus, understanding the determinants of the learners' acceptance of the e-learning systems is vital to the promotion and exploitation of these systems. Limited studies investigated the e-learning acceptance such as those of Ashrafi, Al-Moharby and Salman (2005) and Abouchedid and Eid (2004). However, these studies assessed the instructors' acceptance of e-learning systems. Some Western studies empirically investigated the students' acceptance of e-learning. For instance, Roca and colleagues (2006) found that Information quality, ease of use, perceived usefulness, information quality, service quality and system quality determine the students' satisfaction and consequently their e-learning continuous intention. Gotthardt and colleagues (2006) indicated the success of e-learning strategy depends on content quality, system and content flexibility, system ease of use and others. Nevertheless, these two studies evaluated the individuals' acceptance of the entire e-learning system. However, an e-learning system incorporates various tools (such as online quizzes, files upload/download, chat rooms, discussion forums, instant messaging and email, quizzes, surveys etc.) that have diverse features. Thus, the determinants of these tools' acceptance may be different.

Technology Acceptance

User acceptance is a multidimensional attitude affected by various technical and social factors (Bailey & Pearson, 1983; DeLone & McLean, 2002). Technology acceptance has been assessed in the literature based on perceived usefulness, user's satisfaction, intention to use, and actual usage of the technology. Various frameworks, such as those of Bailey and Pearson (1983), Davis et al. (1989), Doll and Torkzadeh (1998), DeLone and McLean (2002), investigate the determinants of this individuals' acceptance. Baily and Pearson' and Delone and McLean's models focus mostly on the effects of information system's technical characteristics on IS effectiveness. However, discussion forum is a knowledge exchange tool. Knowledge management (KM) is a social and technical process (Scholl, Konig, Meyer & Heisig, 2004). Thus, investigating the social factors is as important as the technical factors. Venkatesh and Davis's TAM2 model (2000) is more suitable because it focuses on social and technical factors to measure the user's acceptance of information technology. *Figure 1* illustrates this model.

TAM was originally developed in 1989 based on the theory of reasoned action (TRA) in psychology, and was extended in 2000 (Venkatesh & Davis, 2000). Based on TAM2, user acceptance is determined by two factors: perceived usefulness (the extent to which a person perceives that using the system will improve his or her work performance), and perceived ease of use (the degree to which a person believes that using the system will be effortless). According to TAM, the effects of external variables on the intention to use are mediated by perceived usefulness and perceived ease of use; perceived ease of use also directly affects the perceived usefulness. TAM2 extends the external variables to include social influences (subjective norm, voluntaries and image) and cognitive influences (job

Figure 1. TAM2 (Source: Venkatesh & Davis (2000))



relevance, output quality, result demonstrability and perceived ease of use). The study framework section below provides more discussion on TAM2 model.

STUDY FRAMEWORK

This study examined the factors that determine the students' acceptance of the discussion forum use in the e-learning system based on TAM2. *Figure 2* illustrates the study framework. This study did not measure voluntariness because the use of the system in the participating sample is discretionary not mandatory. Experience was also excluded because to test the moderation effect of experience, a larger sample size is needed.

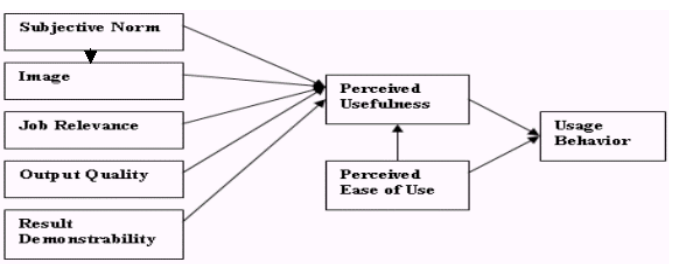
Based on TAM2, there are several factors that may contribute to the perceived usefulness of an information system (Venkatesh & Davis, 2000). These factors are subjective norm, image, job relevance, and output quality and result demonstrability.

Subjective norm and image are two social influences that may affect the perceived usefulness of a system. *Subjective norm* is defined as the individual's perception that most people who are important to him think he or she should or should not do a specific behavior (Fishbein and Ajzen, 1975). The rationale behind this effect is that a person tends to conduct a behavior just because other important contacts (superiors or colleagues) believe s/he should do it even s/he is not favoring doing it. Very limited studies investigated the influence of subjective norm on IS acceptance; one of these studies that found a significant relationship is Taylor and Todd (1995). *Image* is another social factor that affect perceived usefulness. Image is the degree to which an individual believe the use of an innovation will improve one's position in one's social system (Moore & Benbasat, 1991). Thus, an individual may perceive that the use of a specific system is useful because its usage enhances his image. TAM2 also theorizes that subjective norm affect image because if important figures in one's social network believe s/he should conduct a behavior, then conducting it will enhance his/her standing in the social group. Thus, the study hypothesized:

Hypothesis 1: Subjective norm improves perceived usefulness of the discussion forum in the e-learning context.

Hypothesis 2: Image improves perceived usefulness of the discussion forum in the e-learning context.

Figure 2. Study framework



Hypothesis 3: Subjective norm improves image.

TAM2 also theorizes that four "cognitive instrumental" factors determine perceived usefulness; they are job relevance, result demonstrability, output quality and perceived ease of use. Based on TAM2, people perceive the system's usefulness by cognitively comparing system's capabilities with what they need to get done in their job. Job relevance means that the use of a system is relevant to an individual job. Based on task-technology fit research, job relevance is an important influence on the acceptance of a technology (Goodhue, 1995). *Output Quality*, which is the perception of how well the system performs its tasks, affects the perceived usefulness. This effect has been empirically tested and confirmed in the literature (Venkatesh & Davis, 2000). *Result Demonstrability* is the "tangibility of the results of using the innovation" (Moore & Benbasat, 1991). An individual perceives the usefulness of the system if "the covariation between usage and positive results is readily discernable" (Venkatesh & Davis, 2000). *Perceived ease of use* means that the system is simple and effortless for the end user to use. Researchers indicate that perceived ease of use affects usage directly and indirectly through perceived usefulness (Bailey & Pearson, 1983, Venkatesh & Davis, 2000). In the e-learning context, research indicates that ease of use positively affect the system use (Gotthardt et al., 2006), and perceived usefulness (Pituch and Lee, 2006). Thus, the study hypothesized the followings:

Hypothesis 4: Job relevance improves perceived usefulness of the discussion forum in the e-learning context.

Hypothesis 5: Output quality improves perceived usefulness of the discussion forum in the e-learning context.

Hypothesis 6: Result demonstrability improves perceived usefulness of the discussion forum in the e-learning context.

Hypothesis 7: Perceived ease of use improves perceived usefulness of the discussion forum in the e-learning context.

Hypothesis 8: Perceived ease of use improves the discussion forum use in the e-learning context.

Using the system's intention-to-use or actual use to measure the IS acceptance has been debated in the literature (DeLone & McLean, 2002). The intention-to-use is useful in the context where the system use is mandatory. The investigated system use in this study is voluntarily. Thus, measuring the system actual use is more appropriate. In The e-learning context, Pituch and Lee fount that perceived usefulness positively affect the use of e-learning system (2006). Thus, the study hypothesized:

Hypothesis 9: Perceived usefulness improves the discussion forum use in the e-learning context.

STUDY METHODOLOGY

Investigated System and Sample

The study questionnaire was distributed to students in a public academic institution in Oman. The institution is one of the largest universities in the country. The medium of instruction is English in all science fields including commerce where the sample was selected. The university is currently deploying Moodle and WebCT e-learning systems. Instructors may voluntarily use these systems and incorporate them in their teaching. The e-learning systems are used as supplementary tool to support the traditional learning system enrich the learning experience. Some Instructors mandates the students to use the system; others leave its use voluntarily. The study sample is selected from the volunteer use context. One of tool that is utilized by instructors in the e-learning system is the discussion forum. Discussion forums are online discussion groups where people with similar interests engage in discussions, share and debate ideas. Instructors regularly post topics (questions) related to the course subject, and students are allowed to reply, share their ideas and debate others' ideas.

The questionnaire was distributed to about 136 students, but only 92 responded. The sample included about 49% male students and 51% female students. About

54% of student described their English level as average and 36% of them above that. 63% of the students were first and second year student and 37% were major students. About 41% of the students described their computer skills as average, and 40% of them described as above average. All participants had an experience before with the e-learning system. About 32% of students had 1 semester of e-learning experience, 36% had two semesters experience, 23% had three semesters experience and 9% had at least four semesters experience. 24% of the students had used only WebCT e-learning system and 48% of them used only Moodle e-learning system and 28% used both WebCT and Moodle.

Data Collection

Data was collected by a questionnaire. Instructors personally handed the questionnaires to the students. Students were asked to return their completed questionnaires to instructors' mailboxes. The cover letter asked the students to fill out the questionnaire for their use of discussion forum in a specific course. The letter identified the e-learning systems used by the university and the definition of the discussion forum. The questionnaire included some demographic questions and the questions related to the measurements of the study constructs. The measurement scale of constructs was based on 5-point Likert scale: 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, and 5=strongly agree. The questionnaire uses 4 items for usage behavior, 3 for Perceived usefulness, 3 for perceived ease of use, 2 for subjective norm, 2 for Image, 2 for Study-relevance, 2 for Output-quality, and 2 for result demonstrability. The measurements were developed based on Venkatesh and Davis (2000), and adjusted for the use of discussion forum in the e-learning context. For instance, one of the image indicator was "People in my organization who use the system have a high profile" in Venkatesh and Davis (2000). For this study, it is adjusted to "Students who use the discussion forum have a high profile". Two self-reported frequency measurements were also used to measure usage behavior: minutes per week and posts per week.

DATA ANALYSIS

Analysis Methodology

The data was analyzed using the partial least square (PLS) methodology, a structural equation modeling (SEM) based methodology. The study used PLS-Graph Version 3.0 software. With PLS, the rule of thumb suggests that the sample size is to be 5-10 times the larger of the following: (1) the scale with the largest number of formative (i.e., causal) indicators (note that scales for constructs designated with reflective indicators can be ignored), or (2) the largest number of structural paths directed at a particular construct in the structural model (Chin & Newsted, 1999). Reflective indicators are developed based on the assumption that they all measure the same underlying phenomena or construct, hence they all covary. Formative indicators are considered to be uncorrelated; indicators are assumed to be causing rather than being caused by the latent variable. This study investigated the model in reflective mode because it's the most applicable. Thus, a sample size of 30 to 60 is needed to evaluate the investigated model.

Measurement Reliability

The Model in PLS is evaluated based on several statistics. The R-square for dependent latent variables illustrates the predictive relevance of the model. The r-square of perceived usefulness and usage were 0.44 and 0.32 respectively. In PLS, the measurement internal reliability is measured by the composite reliability; the recommended acceptable level is 0.70 (Braclay, Higgins & Thompson, 1995; Hair, Anderson, Tatham & Black, 1998). The construct validity is measured by "Average variance extracted" (AVE) (Braclay et al., 1995). AVE refers to the amount of variance that a latent variable component captures from its indicators; the acceptable level is at least 0.50. *Table 1* shows that all the investigated factors satisfied the reliability and validity standards. PLS also provides the loading of each indicator on their factor, but because of the limited space they are not included here. The correlations among the investigated determinants of perceived usefulness were below 0.50.

Hypotheses Testing

The hypotheses testing were conducted by examining the path coefficients of the independent latent variables and their significance. The path coefficients are used to measure the relationship's importance and the direction of an independent variable and a dependent variable (Hair et al., 1998). *Table 1* shows the t-test results of constructs based on 95% confidence. To test the significance of the PLS estimates, bootstrapping technique was utilized with a re-sampling of 200 as suggested in the PLS-Graph user's guide. The statistical significance of the hypothesized paths was measured by t-values. As indicated in *Table 1*, the significant determinants of perceived usefulness are in order of their b*etas* are Job relevance (0.32), image (0.22), result demonstrability (0.21) and perceived ease of use (0.16). Subjective norm (0.10) and output quality (0.06) are not significant determinants of perceived usefulness. However, subjective norm is a significant determinant on image (0.21). Perceived usefulness (0.48) and perceived ease of use (0.20) have significant effects on the usage of discussion forum. Thus, hypotheses 2, 3, 4, 6, 7, 8 and 9 are supported, while hypotheses 1 and 5 are not supported.

DISCUSSION & CONCLUSION

Review of Findings

The popularity of e-learning systems has been growing in the last few years. The e-learning system offers several tools that can be incorporated to improve the teaching quality and efficiency in academic institutions. One of these tools is the electronic discussion forum. This study aimed to measure the students' acceptance of the discussion forum use in the e-learning system. The study adopted TAM2 model for this evaluation. Based on TAM2, the user acceptance of an information system is measured by perceived usefulness and usage. Perceived usefulness is determined by subjective norm, image, job relevance, output quality, result demonstrability and perceived ease of use. Usage is determined by perceived usefulness and perceived ease of use. However, this study found that perceived usefulness is significantly determined in order of their b*etas* by Job relevance

Table 1. Measurements and t-test statistics

Construct	Total indicators	Reliability	AVE	Beta	t-value	Significance
Usage	4	0.76	0.50	NA	N/A	
Perceived usefulness (H9)	3	0.91	0.78	0.48	6.22	0.005
Perceived ease of use (H7, H8)	3	0.85	0.658	0.16 0.20	1.31 1.90	0.10 0.10
Subjective norm (H1, H3)	2	0.90	0.81	0.10 0.21	1.02 1.79	NS 0.05
Image (H2)	2	0.90	0.82	0.22	2.61	0.01
Job relevance (H4)	2	0.87	0.80	0.32	3.10	0.005
Output quality (H5)	2	0.71	0.59	0.06	0.38	NS
Result demonstrability (H6)	2	0.81	0.68	0.21	1.95	0.05

(0.32), image (0.22), result demonstrability (0.21) and perceived ease of use (0.16). Subjective norm and output quality were not significant on perceived usefulness. Another study on e-learning context also found insignificant relationship between interpersonal influences (subjective norm) on user satisfaction (Roca et al., 2006). However, subjective norm as hypothesized was a significant determinant of image. The insignificance of output quality on perceived usefulness may be traced to the fact that it has a significant correlation with job relevance (0.334) and result demonstrability (0.326). Thus, subjective norm and output quality have indirect effect on perceived usefulness. The perceived usefulness (0.48) and perceived ease of use (0.20) of the discussion forum were significant predictors of discussion forum usage.

Study Limitations and Implications

There are some limitations of the study. First, the sample was selected based on accessibility. A random selection would increase the strength of external validity. Second, this study did not investigate the moderation effect of experience and voluntariness. Future research may test that effect and include more indicators to investigate the study construct, and explore other factors that might be significant to the acceptance of e-learning systems and the benefits of this usage. Third, this study examined only the use of the discussion forum. Other tools in the e-learning system might be also investigated in future studies. Finally, future studies may also have a closer look to the effects of other system characteristics such as reliability, and speed on perceived usefulness.

The study offered useful implications for practice and research. This study provided empirical quantitative evidence of the significance of TAM2 in the e-learning context which is a very limited in the IS research. The study also provided useful insights for the practitioners (Instructors and academic institutions). Instructors should ensure in their course design that the use of e-learning tools should be relevant to the students' studying tasks. They also should constantly encourage the students to use the e-learning system. Developers should ensure that the system provides tangible results that are useful. Some recent research in Oman indicates that one of the challenges of the instructors' adoption of the several tools in the e-learning system in their courses because of the student's attitudes toward this technology and their low acceptance (Ashrafi et al., 2004). This study added initial insights and on the factors that might affect the students' acceptance of this technology specifically in academic institutions in Oman. Because of the growing adoption of the e-learning systems, the findings of this study could assist organizations to have more successful and effective deployment of these systems. Successful deployment of these systems will encourage training organizations to not only use the e-learning systems as a supplementary tool but also use it them to support distance learning. Consequently, this will increase the capacity of these organizations in building human resources.

REFERENCES

Abouchedid,K. & Eid,G. (2004). E-learning Challenges in the Arab World: Revelations from a case study profile. *Quality Assurance in Education, 12(1),* 15-27.

Ashrafi,R., Al-Moharby,D., & Salman, R. (2005). E-Learning Challenges in an Institute of Higher Education in Oman. *International Conference on Higher Education and Emerging Trends in Information Technology*, Mazoon College, Muscat. Oman 29-30.

Bailey, J., & Pearson, S.(1983). Development of a tool for Measuring and Analyzing Computer User Satisfaction. *Management Science, 29(5),* 530-545.

Barclay,D., Higgins,C., & Thompson,R. (1995). The Partial Least Squares (PLS) Approach to Casual Modeling: Personal computer adoption and use as an illustration (with commentaries). *Technology Studies,2,* 285-323.

Cantoni,V., Cellario,M, & Porta, M. (2004). Perspectives and Challenges in e-learning: towards natural interaction paradigms. *Journal of Visual Languages and Computing, 15*, 333-345.

Chin,W., & Newsted, P.(1999). Structural Equation Modeling analysis with Small Samples Using Partial Least Squares. In Rick Hoyle (Ed.), *Statistical Strategies for Small Sample Research*, Sage Publications, 307-341.

Davis,F.D.(1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly, 13,* 319-339.

DeLone,W., & McLean,E.(2002), Information systems success revisited. Proceedings of the 35th Hawaii International Conference on System Sciences.

Doll & Torkzadeh,G. 1988. The Measurement of End User Computing Satisfaction. *MIS Quarterly, 12(2),*259-274.

Fishbein,M., & Ajzen, I. (1975). Belief, Attitude, Intention and Behavior: An Introduction to Theory and Research. Addison-Wesley, Reading, MA.

Goodhue,D. (1995). Understanding the Linkage between user evaluations of systems and the underlying systems. Management Science, 41, 1827-1844

Gotthardt,M. et al.(2006). How to Successfully Implement E-learning for both Students and Teachers. *Medical Student Application, 13*, 379-390

Hair,J., Anderson, R., Tatham, R., & Black, W.(1998). *Multivariate Data Analysis,* Upper Saddle River, NJ: Prentice Hall.

Kelly,T. & Bauer,D.(2004). Managing Intellectual Capital-via E-learning-at Cisco. In C. Holsapple (Ed.), *Handbook on Knowledge Management 2:Knowledge directions* (pp. 511-532).Berlin, Germany: Springer

Laudon,K. & Laudon,J.(2003). *Essentials of Management Information Systems (5th Ed*). Prentice-Hall USA.

Moore,G. & Benbasat,I.(1991). Development of an Instrument to Measure the Perceptions of Adopting an Information Technology Innovation. *Information Systems Research, 2,* 192-222

Pituch,K. & Lee,Y.(2006). The Influence of System Characteristics on e-learning Use. *Computers & Education, 47,* 222-244.

Roca, J., Chiu,C. & Martinez,F. (2006). Understanding e-learning Continuous Intention: An extension of the technology acceptance model. *Int. J. Human-Computer Studies*.

Saady,A. (2005). E-Learning Curve. ITP Technology. www.ITP.net

Scholl, W., Konig, C., Meyer, B., & Heisig, p. (2004). The Future of Knowledge Management: An international Delphi study. *Journal of Knowledge Management, 8(2),* 19-35.

Taylor,S. & Todd,A. (1995). Understanding Information Technology Usage. A test of competing models. *Information Systems Research.*

Venkatesh,V., & Davis,F. (2000). A Theoretical Extension of the Technology Acceptance Model: Four longitudinal. *Management Science, 46(2),* pp. 186-204.

World Bank: Technical Cooperation Program Brief on GCC. (2003). http://web.worldbank.org/wbsite/external/countries/menaext/bahrainextn/0,,menupk:312668~pagepk:141132~pipk:141107~thesitepk:312658,00.html

The Role of Power Distance in Determining the Effectiveness of Educational Technology

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ABSTRACT

Educational technology is being deployed rapidly all over the world. Correspondingly, there is also an increase in student collaboration from different cultural backgrounds through diversified student populations, institutionalized programs and distance learning. The cultural background of students is thus important in IT and education today. This conceptual paper surmises the effectiveness of educational technology, focusing on the dimension of power distance (Hofstede 1980) due to its relevancy to the context. The focus of this paper is on exploring how educational technology affects learning outcomes, and the role of power distance in influencing the effectiveness of educational technology. We postulate that power distance is a moderating influence on the relationship between educational technology and learning outcomes. In particular, the availability of educational technology increases learning outcomes but the effect will be greater on low power distance learners than on high power distance learners. This paper begins with a review of the effectiveness of educational technology, followed by a discourse on power distance. Anchored by the literature review, a research framework is formulated based upon which propositions are raised.

Keywords: Educational Technology, Culture, Power Distance, Effectiveness, Learning Outcomes

1. INTRODUCTION

Educational technology is being deployed rapidly all over the world. Amidst this progress, globalization has boosted international collaboration of student teams. For example, the virtual collaboration between students in the Netherlands and Hong Kong in the three-year HKNET project (Rutkowski et al. 2002). There has also been an increase in culturally diverse student populations such as the jump of more than 4000 international students at the National University of Singapore from 2000 to 2005 (Annual Report 2005; Lee 2000). In addition, educational institutions are increasingly expanding into international markets via setting up new overseas campuses or distance learning (Cronjé 2006).

With the increasing diversification of student populations and cross-cultural collaborations of student teams, the cultural background of learners has been pointed out as crucial in determining educational technology's effectiveness (Leidner & Jarvenpaa 1995; Chang & Lim 2005). Indeed, culture is part of all learners and affects how they think and value learning, as well as how they respond to educational technology. Chen et al. (1999) urge researchers and educators to appreciate the role of culture in education for "a deeper and more valid understanding of the nature of student learning" (p.219).

Culture can be examined from many perspectives, but seminal research on culture by Hofstede (1980, 2001) is more pertinent to learning outcomes (Wang 2006). Hofstede (2001) constructed a taxonomy of cultural dimensions underlining value orientations of people from various national cultures. Power distance, one of these dimensions, is the focus of this paper. Power distance is the extent to which people respond to inequality in power and consider it as normal (Hofstede 2001). In educational contexts, students from large power distance cultures have large power differentials towards instructors and higher status individuals while students from small power distance societies regard other individuals as equal to them. Power distance might affect the usage of educational technology and the ways of learning with it. For instance, students from low power distance cultures participate actively in traditional classrooms and may find it satisfying to participate via educational technology. On the other hand, students from high power distance cultures who rarely speak up in face-to-face classrooms may not feel as comfortable using educational technology. Hence, the use of educational technology may be more effective for different levels of power distance.

In light of these influences, the research questions are: firstly, how does educational technology affect learning outcomes? Secondly, what is the role of power distance in influencing the effectiveness of educational technology? This paper begins with a review of the effectiveness of educational technology followed by a discourse on power distance. Based on the literature review, the research framework and propositions will be presented before the conclusion.

2. THE EFFECTIVENESS OF EDUCATIONAL TECHNOLOGY

Piccoli et al. (2001) found that the performance outcomes are similar to the traditional learning environment although learners using educational technology reported higher computer self-efficacy and had lower satisfaction with their learning experience. Similarly, Curtis and Lawson (2001) acknowledged that the use of educational technology led to comparable collaboration as face-to-face environments. However they noted that factors like student familiarity with the medium and ease of use of the interface are also important moderating factors. Hence, some studies have revealed that educational technology is only as effective as the face-to-face mode of delivery and is commonly known as the "no significant difference" phenomenon (Hiltz et al. 2002).

On the other hand, there are studies that suggest the effectiveness of educational technology. Kulik and Kulik (1991) found that students who learned with educational technology scored higher than students without it, learned faster, enjoyed their classes more and developed more positive attitudes. Alavi (1994) observed that students with educational technology perceived higher levels of skill development, learning, interest, enjoyment, and resulted in better final grades relative to the traditional mode with the same collaborative learning technique. Chang and Lim's (2005) meta-analysis of 68 studies concluded that educational technology helps to increase the cognitive abilities of students. However, the study observed that the degree of effectiveness depends on a combination of the characteristics of the learner, the course and the instructional design. Researchers also propose that for greater student learning outcomes, what is necessary is a change of learning to new constructivist approaches and in applying technology innovatively for learning (Hiltz et al. 2002). Thus, this paper focuses on educational technology based on the constructivist approach, particularly the collaborative learning theory.

Many of these studies surmise that for educational technology to be more effective, there are a number of influencing factors (Piccoli et al. 2001; Chang & Lim 2005). However, it is neither viable nor useful to review each factor. An important aspect pointed out by several researchers' concerns *cultural background* (Leidner & Jarvenpaa 1995; Morse 2003). ***Power distance***, one of Hofstede's (1980) cultural dimensions, has demonstrated a large influence on student learning (Wang 2006). Power distance is a key cultural factor that affects group relationships and the group's performance in collaborative learning (Paulus et al. 2005; Hofstede

2001). The following section highlights power distance's impact on educational technology.

3. CULTURAL DIMENSION OF POWER DISTANCE

While there has been empirical progress on the impact of culture and IT (Leidner & Kayworth 2006), with regard to IT in education, there has been a lacuna of studies that examine the role of national culture on the effectiveness of educational technology. It is well recognized that different cultures display dissimilar behaviors due to unique developments and assumptions in each society (Morse 2003). This paper focuses on the cultural dimension of power distance (Hofstede 1980) owing to its germaneness to the context at hand. Power distance is one of the cultural dimensions constructed by Hofstede (1980, 2001) - the rest being individualism/collectivism, masculinity/femininity, uncertainty avoidance and time-orientation. These dimensions prescribe the behavior of individuals of a certain culture but have been criticized as demonstrating the idiosyncrasies of one particular organization (Gallivan & Srite, 2005) and reducing and simplifying the concept of culture (McSweeney 2002). Nevertheless, these criticisms have mostly been directed at the research methodology and not at the theory (Ford et al. 2003). These dimensions are theoretically sound (Straub et al. 1997) and make known the collective precepts that people of the same culture will value and act on. These dimensions have been independently verified and replicated by other researchers (Smith et al. 1996).

Power distance is the extent to which the less powerful people in society respond to inequality in power and consider it as normal (Hofstede 2001). Power distance has been considered to have a dominant influence on learning outcomes (Wang 2006; Paulus et al. 2005). In educational contexts, power distance is formalized as the student and teacher relationship. Hofstede (1980) observes that students from small power distance societies will have a low tolerance for inequality and hierarchy and hence regard their teachers as peers. They will also be more interactive in class. On the other hand, students from large power distance societies accept status differences and the hierarchy; they respect their teachers as authoritative figures. These students from large power distance societies will be quieter in class and focus more on absorbing knowledge from the teacher. In sum, small power distance cultures have a more student-centered education while larger power distance cultures are more teacher-centered.

Research has yet to fully examine power distance's impact on the learning outcomes of educational technology. As such, results are equivocal. Both small and large power distance learners seem to enjoy using educational technology (Bauer et al. 2000). However, Bauer et al. (2000) also found that small power distance learners were more confident in using technology than large power distance learners. Other studies report that large power distance learners had more difficulties in using technology (Smith et al. 2005), and were unclear with the rules for online behavior (Wang 2006). Additionally, educational technology might not totally meet learning needs of both cultures and students will differ in their level of learning outcomes. Research based on group support systems demonstrates that educational technology increases the participation of both high and low power distance learners and reduces status effects in high power distance cultures (Watson et al. 1994). While this matches the active learning mode of small power distance learners, large power distance learners prefer a different approach to learning which is more passive (Hofstede 1980; Smith et al. 2005). This might have consequences on their learning outcomes.

Another aspect of power distance is its role in impacting the academic performance of student teams (Hofstede 2001). Paulus et al. (2005) found that decision-making processes and methods to resolve disagreements are influenced by the group's power distance. High power distance groups believe in a rigid power structure and may be inflexible in fast-paced and highly coordinated tasks. Swigger et al. (2004) conceded that groups who had high power distance scores performed worst than teams with low power distance scores via computer-supported collaboration. This was exacerbated when teams collaborated on projects which required close coordination and were time-critical (Swigger et al. 2004). Power distance is thus a key factor that determines the effectiveness of educational technology. Different levels of power distance seem to affect the degree of learning outcomes with educational technology. Hence, research on the impact of power distance on learning outcomes should be established. The following section proposes a research framework to investigate the phenomenon.

4. RESEARCH FRAMEWORK AND PROPOSITIONS

This paper examines the availability of educational technology and its impact on learning outcomes. We define learning outcomes to be the satisfaction, self-efficacy, perceived learning and actual academic achievement of learners. Based on the earlier review, the level of power distance influences the degree of learning outcomes. The role of power distance is then posited to moderate the relationship between the availability of educational technology and learning outcomes. We illustrate the framework in Figure 1 while the definitions of the constructs are presented in Table 1.

Based on the earlier review, this paper asserts that the use of educational technology in innovative ways based on the collaborative learning approach enhances learning outcomes. Although some studies have emphasized that educational technology is only as effective as the face-to-face mode of delivery (Curtis & Lawson 2001; Hiltz et al. 2002), other studies have revealed that learning outcomes are enhanced with educational technology compared to the traditional face-to-face mode of learning (Kulik & Kulik 1991; Timmerman & Kruepke 2006). In a recent meta-analysis, Timmerman and Kruepke (2006) found that educational technology significantly increased the performance of college students compared to traditional instruction. Research has also highlighted that the use of educational technology leads to higher affective reactions, perceived learning and final course grades compared to the face-to-face process (Alavi 1994; Chang & Lim 2005). Hence, the paper proposes:

P1: Learning outcomes, in terms of satisfaction, self-efficacy, perceived learning and academic achievement, will be higher with the availability of educational technology than without.

We next visit the interaction between power distance and the learning outcomes of satisfaction, self-efficacy, perceived learning and academic achievement.

4.1 Satisfaction

This paper examines satisfaction as part of the students' desire to learn, whether the availability of educational technology results in students' satisfaction with the end learning result. With the availability of educational technology, mediated communication reduces the barrier in interaction and encourages egalitarian commitment which is in line with small power distance societies. The desire of small power distance learners to connect with others will then be met. In fact, Wang (2006) found that small power distance learners enjoyed using educational technology to connect with others.

Figure 1. Research framework

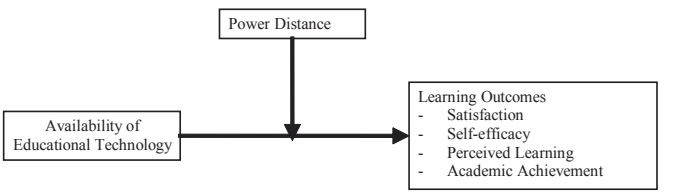

Table 1. Definitions of constructs

Satisfaction	**The extent of fulfillment of a desire or supply of a want (Oxford English Dictionary 1989)**
Self-efficacy	**The degree to which learners feel confident of learning from a given method (Chang & Lim 2005)**
Perceived Learning	**Changes in the learner's perceptions of skill and knowledge levels before and after the learning experience (Alavi et al. 2002)**
Academic Achievement	**Actual cognitive development of learners; related to task performance and typically measured by project or course grades (Chang & Lim 2005)**

On the other hand, although educational technology reduces the barriers for interaction, learners from large power distance cultures do not have the desire to participate in class. The level of status differences perceived by these students is not affected by the medium's affordances. Frank et al. (2004) reported that even when learners from large and small power distance cultures had equal access to educational technology, students from large power distance societies were more likely to use it to socialize with their peers rather than the lecturers and avoided confronting them to prevent conflict over the online medium. Thus we propose:

P2a: The effect of availability of educational technology on satisfaction will be greater on small power distance learners than large power distance learners.

4.2 Self-Efficacy

Bauer et al. (2000) examined student's perceptions of an online course and found that the small power distance group was more confident in using the technology than the large power distance group. The small power distance group also made use of educational technology more while the large power distance students had more difficulties in navigating through the online materials. One explanation could be that the large power distance group lack access to technology. However, Smith et al. (2005) discovered that both groups of students had the same on-campus access to computers and even posted the same number of messages on a bulletin board. The researchers suggest that the predicament of large power distance learners could be due to "a difference in approach to learning" (Smith et al. 2005, p.130).

Due to their higher dependency on the instructor, students from high power distance cultures are less comfortable in independent learning with educational technology and have less self-efficacy than low power distance learners. Large power distance learners on the other hand, have a low dependency on instructors and are familiar with an active mode of learning; educational technology facilitates this and their self-efficacy of learning with it will increase.

P2b: The effect of availability of educational technology on self-efficacy will be greater on small power distance learners than large power distance learners.

4.3 Perceived Learning

Collaborative learning with educational technology stimulates students, encourages participation and the cooperation of students, which increases their perceived learning (Alavi et al. 2002). For example, educational technology allows students to post queries and thoughts at the student's own time and pace. As many high power distance cultures do not speak English as a native language, it supports students who are limited in their English proficiency to give them more time to compose their thoughts (Smith et al. 2005). There is evidence that students from high power distance cultures perceive educational technology to be less inhibiting than face to face classrooms and are more willing to participate using educational technology than in the classroom (Bauer et al. 2000).

However, other studies observe that students from high power distance cultures are constrained by the public nature of the discussions as the rules for online behavior are unclear and the discussions are in full view of the public (Wang 2006). Frank et al. (2004) also found that learners from high power distance cultures were less active in answering questions using educational technology possibly due to anxiety about "lost of face". Additionally, Chang and Lim (2005)'s meta-analysis reported that perceived learning of low power distance learners were larger than high power distance learners. Thus, we postulate:

P2c: The effect of availability of educational technology on perceived learning will be greater on small power distance learners than large power distance learners.

4.4 Academic Achievement

Power distance is a key cultural dimension that impacts the academic performance of teams (Hofstede 2001). For example, decision-making processes and methods to resolve disagreements are influenced by the group's power distance level (Paulus et al. 2005). In a group of high power distance learners, a superior and subordinate relationship may arise because of their desire for hierarchy. Additionally high power distance groups believe in a rigid power structure and may be inflexible in fast-paced and highly coordinated tasks. Swigger et al. (2004) found that computer-supported collaboration of student teams who had high power distance scores performed worst than teams with low power distance scores. This was exacerbated when teams collaborated on projects which required close coordination and were time-critical (Swigger et al. 2004).

On the other hand, low power distance groups have been associated with better academic achievement. Paulus et al. (2005) observed that low power distance learners developed trust to overcome conflicts due to miscommunication, modeled decision-making by consensus, shared in leadership roles and assigned responsibilities based on expertise. This allowed the low power distance group to coordinate their internal processes effectively and produce better solutions. Hence we propose:

P2d: The effect of availability of educational technology on academic achievement will be greater on small power distance learners than large power distance learners.

5. CONCLUSION

The capacity of IT to support the education of students from different cultures is increasingly being relied upon due to globalization and the knowledge economy. At the same time, we are witnessing the collaboration of students of different cultural backgrounds through a diversified student population, institutionalized programs and distance learning. This paper has explored conceptually how educational technology affects learning outcomes and the role power distance can play in influencing the effectiveness of educational technology.

The paper has postulated that power distance is a key moderating linkage between the availability of educational technology and learning outcomes. In particular, the availability of educational technology increases learning outcomes consisting of satisfaction, self-efficacy, perceived learning and academic achievement; but the effect will be greater on low power distance learners than on high power distance learners. Educators, instructional designers, and researchers should not underestimate the significance of power distance in teaching and learning situations. Further work should look into designing and structuring educational technology to become more effective for high power distance learners. Inferences from our propositions would likely stimulate developments in this field. Finally, we advocate future research into other cultural dimensions.

REFERENCES

Alavi, M. "Computer-Mediated Collaborative Learning: An Empirical Evaluation". *MIS Quarterly* 18(2), June 1994, pp.150-174.

Alavi, M., Marakas, G.M. and Yoo, Y. "A Comparative Study of Distributed Learning Environments on Learning Outcomes", *Information Systems Research* 13(4), 2002, pp.404 – 415.

Annual Report 2005, National University of Singapore, Retrieved September 7, 2006 from http://www.nus.edu.sg/annualreport/2005/33staff.htm.

Bauer C, Chin, K-L., & Chang, V., "Web-Based Learning: Aspects of Cultural Differences," in *Proceedings of the Eighth European Conference on Information Systems,* Vienna, HR. Hansen, M. Bichler, and H. Mahrer (eds.), 2000, pp.1396-1402.

Chang, K.T. and Lim, J. "The Role of Information Technology in Learning: a Meta-Analysis," in *Technology Literacy Applications in Learning Environments*, D.D. Carbonara (ed.), Idea Group Publishing, Hershey, 2005, pp.14-36.

Chen A-Y., Mashhadi, A., Ang, D. and Harkrider, N. "Cultural issues in the design of technology-enhanced learning systems," *British Journal of Educational Technology* 30(3), 1999, pp. 217–230.

Cronjé, J.C. "Pretoria to Khartoum - how we taught an Internet-supported Masters' programme across national, religious, cultural and linguistic barriers", *Educational Technology & Society* 9 (1), 2006, pp. 276-288.

Curtis, D.D., and Lawson, M. J. "Exploring collaborative online learning," *Journal of Asynchronous Learning Networks* 5(1), pp.21-34.

Frank, J., Toland, J., and Schenk, K. "The effect of culture on email use: Implications for distance learning," in *Distance learning and University effectiveness: Changing educational paradigms for online learning*, C. Howard, K. Schenk and R. Discenza (eds.), Idea Group Inc, Hershey, 2004, pp.213-234.

Ford, D.P., Connelly, C.E. and Meister, D.B. "Information systems Research and Hofstede's Culture's Consequences: An Uneasy and Incomplete Partnership," *IEEE Transactions on Engineering Management* 50(1), Feb 2003, pp.8-25.

Gallivan, M. and Srite, M. "Information technology and culture: Identifying fragmentary and holistic perspectives of culture," *Information and Organization* 15(4), October 2005, pp.295-338.

Hiltz, R., Zhang, Y., Turoff, M. "Studies of effectiveness of learning networks," in Elements of Quality Online Education: Volume 3 in the Sloan-C™ Series, Needham, MA: SCOLE, 2002.

Hofstede, G. H. *Culture's Consequences: International Differences in Work-Related Values,* Sage Publications, Beverly Hills, 1980

Hofstede, G. H. *Culture's Consequences: Comparing values, behaviors, institutions, and organizations across nations.* Sage Publications, Thousand Oaks, 2001.

Kulik, C-L. C. and Kulik, J.A. "Effectiveness of Computer-Based Instruction: An Updated Analysis," *Computers in Human Behavior* 7, 1991, pp. 75-94.

Lee, G., "International Students in NUS", *CDTL Brief* 3(4), Sept 2000, Retrieved September 7, 2006 from http://www.cdtl.nus.edu.sg/brief/v3n4/default.htm.

Leidner, D. and Jarvenpaa, S. L. "The Use of Information Technology to enhance management school education: a theoretical view," *MIS Quarterly* 19(3), September 1995, pp. 256-291.

Leidner, D. and Kayworth, T. "A review of culture in Information Systems Research: Toward a Theory of Information Technology Culture Conflict," *MIS Quarterly* 30(2), Jun2006, pp. 357-399.

McSweeney, B. "Hofstede's model of national cultural differences and their consequences: A triumph of faith - a failure of analysis," *Human Relations* 55, 2002, pp. 89-118.

Morse, K. "Does one size fit all? Exploring asynchronous learning in a multicultural environment," *Journal of Asynchronous Learning Networks* 7 (1), pp.37-55, 2003, Retrieved August 10, 2006 from http://www.aln.org/publications/jaln/v7n1/v7n1_morse.asp

Paulus, T.M., Bichelmeyer, B., Malopinsky, L., Pereira, M., and Rastogi, P. "Power distance and group dynamics of an international project team: a case study," *Teaching in Higher Education* 10(1), Jan 2005, pp.43 – 55.

Piccoli, G., Ahmad, R. and Ives, B. "Web-based virtual learning environments: A research framework and a preliminary assessment of effectiveness in basic IT skills training," *MIS Quarterly* 25(4), December 2001, pp. 401-426.

Rutkowski, A-F., Vogel, D., Bemelmans, T.M.A. and van Genuchten, M. "Group Support Systems and Virtual Collaboration: The HKNET Project". *Group Decision and Negotiation* 11(2), Mar 2002, pp. 101-125.

"satisfaction" The Oxford English Dictionary, 2nd ed. 1989, OED Online, Oxford University Press, Retrieved September 6, 2006 from http://dictionary.oed.com/cgi/entry/50213771?single=1&query_type=word&queryword=satisfaction&first=1&max_to_show=10.

Smith, P.B., Dugan, S., and Trompenaars, F. "National Culture and Managerial Values: A Dimensional Analysis across 43 Nations", *Journal of Cross-Cultural Psychology* 27(2), 1996, pp. 231-264.

Smith, P.J., Coldwell, J., Smith, S.N., and Murphy, K.L. "Learning through computer–mediated communication: a comparison of Australian and Chinese heritage students," *Innovations in Education and Teaching International* 42(2), 2005, pp. 123 - 134.

Straub, D., Keil, M. and Brenner, W., "Testing the technology acceptance model across cultures: A three country study", *Information & Management* 33 (1), 1997, pp.1-11.

Swigger, K., Alpaslan, F., Brazile, R. and Monticino, M., "Effects of culture on computer-supported international collaborations", *International Journal of Human-Computer Studies* 60 (3), 2004, pp.365-380.

Timmerman, C. E. and Kruepke, K. A., "Computer-Assisted Instruction, Media Richness, and College Student Performance," *Communication Education* 55(1), Jan 2006, pp. 73 - 104.

Wang, M., "Designing online courses that effectively engage learners from diverse cultural backgrounds," *British Journal of Educational Technology*, Published online June 5, 2006, Retrieved July 26, 2006 from http://www.blackwell-synergy.com/, doi: 10.1111/j.1467-8535.2006.00626.x.

Watson, R. T., Ho, T. H., and Raman, K. S. "Culture: a fourth dimension of group support systems," *Communications of the ACM* 37(10), October 1994, pp. 44-55.

Teaching Systems Analysis and Design Using the Process Game

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ABSTRACT

The teaching of systems analysis and design to students with no background in IS development is notoriously difficult. Most students have great difficulty identifying with both the reasons for a development process and its importance. Many different techniques exist to illustrate both the need for process and the effect of poor process. We propose a fun and simple in-class exercise called "The Process Game", a variation on the popular card game Rummy, which can be used to introduce both of these concepts to students. Experience indicates that students readily grasp the effect of changing specifications and processes on achieving the final goal. A pre-test and post-test experiment is proposed to measure the student subjects' understanding of the concept of process in systems analysis and design, along with the importance of following a defined process.

Keywords: Teaching, systems analysis, process learning, experiential learning.

INTRODUCTION

It is a well known adage that experience is the best teacher. The teaching of systems analysis and design to students with no background in IS development is notoriously difficult. Most students have great difficulty identifying with both the reasons for a development process and why it is important. Adding an experiential component to the teaching of software systems analysis and design is also a difficult task as many of the concepts require an in-depth project, case study, or background.

Individuals attempting to teach systems analysis and design to students at all levels, from secondary school to corporate offices, have faced the same dilemma from the beginning: "How can I introduce this subject to my students in such a way that they grasp both the subject itself and its importance to the success of all types of information systems development projects?" The failure to grasp these facts has been shown to be a major contributor to the poor success rates of these projects (Standish 2004).

This paper proposes a method which uses a game to teach students the importance of one aspect of good analysis and design practice, communication, and shows the effect of less than optimal communication on the achievement of project goals. The balance of this paper consists of a brief review of earlier research on teaching systems analysis and design, an introduction to the game, a research question suggested by the use of the game, a proposed experiment to test the perceived effectiveness of the game, and a discussion of our future research agenda.

BACKGROUND

The struggle to teach the concepts of systems analysis and design (SA&D) to students who find it difficult to internalize either the concepts or the processes has been the subject of extensive scholarship spanning the information era. As early as 1982, Golden (1982) was describing how industry leaders were decrying the poor state of the then-current methodologies for teaching SA&D and the steps educators were taking to address the problems. Later, Olfman and Bostrom (1992) proposed expanding the viewpoint of the role of the analyst taught in the classroom to include facilitation skills and creative thinking skills. They also proposed the addition of experiential learning to the classroom. Larmour (1997) surveyed present and former students seeking to identify those areas where SA&D training was adequate and those areas where improvements could be made.

As the methodologies used in industry to develop information systems applications evolved, the course focus in SA&D also changed. Kendall et al. (1996) made a case for expanding the traditional SA&D to include experiential elements as proposed by Olfman and Bostrom (1992).

The move to the object paradigm in industry should be reflected in a change of focus for modern SA&D courses. Although the evidence about the movement of industry to OO is substantial, there is still an ongoing debate with academia concerning whether to teach traditional structured design or OO (Mahapatra et al. 2005). Since the object paradigm seeks to create a representation of the problem space where object characteristics and behaviors model those of the actual objects, it is imperative that new SA&D students learn to use the object paradigm effectively. Brewer and Lorenz (2003) urged that "educational institutions must also begin educating analysts to create informative models based on OO principles" (54). To fully implement the teaching of object principles in the SA&D classes, many different approaches are being proposed, including Appreciative Inquiry (Avital 2005).

THE PROCESS GAME

As a possible remedy to the problem of students failing to grasp the reason and importance of using a defined process in systems analysis and design, we propose the use of a short, hands-on workshop called "The Process Game" to teach students about the importance of good communication and the consequences of insufficient communication. The game is fun, easy to play, and doesn't require an in-depth project or any type of case study. The entire workshop can be completed in less than an hour. The game uses a variation of a well-known card game - something most students have experience with. In our experience, it has consistently proven to drive the point home about the importance of communication. This workshop has been presented in the classroom at the undergraduate level and at several professional conferences. Each time the game is played, students comment that it helped them to see the importance of communication and how a solid process can assist in situations where communication is difficult.

The basic idea of the process game is to divide the students into a number of groups. Each group has a different communication method. Each participant in the group gets an incomplete set of rules for the card game. A few participants in the group get the remaining rules, but the game is set up so that no one individual (except a 'user') has a complete set of rules. Some groups will have a user who has a complete set of rules and variations of the game. The goal of the groups is to figure out how to communicate and play as many rounds of the card game as possible in 25 minutes. After the game is played, each group will have a representative stand up in front of the class and explain their communication mechanism and the problems they had playing the game. After all of the groups have debriefed the class, the instructor must relate the communication methods to real world applications.

Variations Among Groups

There are 2 dimensions that are varied for each of the groups, communication mechanism and user involvement. The following table describes the mix for each group.

Group	Communication Mechanism	User Involvement
Group 1	Via Email Only	No additional user
Group 2	Via Email Only	Additional user involved
Group 3	Via Telephone Only	No additional user
Group 4	Via Telephone Only	Additional user involved
Group 5	Open Communication	User inserted at last 5 minutes
Group 6	Open Communication	User involved until last 5 minutes

Communication Mechanism Descriptions

Groups designated as "Via Email Only" must communicate only in writing - no hand signals or speaking at all is allowed. One person in the group is selected as the mail server, responsible for routing emails between each player. Players do not hand the emails directly to other players, but hand them to the email server. Emails to more than one person will be routed (passed) by the mail server from one person to the next person. Players must also not email the rules between to other, but can email their interpretation of the rules. Note that students can't see each other's hands, the deck itself, or any discarded cards. This information can only be shared via email, therefore one of the participants in the group must be responsible for managing the cards in the deck.

Groups designated as "Via Telephone Only" can only communicate via telephone (speaking). The group cannot show each other diagrams, papers, write-ups, cards, or use hand signals. The groups can hold conference calls with multiple people. Members of this group cannot just read the rules, but must explain them. As with the Email group, students can't see each other's hands, the deck itself, or any discarded cards. This information can only be shared via telephone, therefore one of the participants in the group must be responsible for managing the cards in the deck.

Groups designated as "Open Communication" have free communication, essentially sharing anything the members have or know. As with the other groups, students in this category can't just read the rules or pass them around, but must explain them.

User Involvement Descriptions

Users get an entire set of rules as well as a section of rules designated as variations. The goal of the user is to introduce a different variation for each round. The variations are not cumulative (only one variation per hand). The user is part of the group and can facilitate or assist in any way he/she would like as long as he/she conforms to the communication mechanism.

The group designated as "Open Communication" with a user involved until the last 5 minutes must not be made aware that the user is going to be pulled from the group at the end, it must be unexpected both on the part of the group *and* the part of the user.

The group designated as "Open Communication" with a user inserted at the last 5 minutes must be told that they have no user - the insertion of the user must be unexpected. In order to accomplish this, a student must be removed from all participation and NOT assigned to any group; keep this in mind when determining the groups. Tell this student that he/she is a user and give the student the entire rule set and the variations. Instruct the student to read the rules and practice if needed. This student will become a relative expert on the game when inserted.

Determining Groups

A group consists of 4 to 6 players. It is important to avoid selecting players who are already in informal social groups as that will effect their communication. Ideally, there should be six groups (24 - 36 students). If there are more than 36 students taking part, repeat the six communication methods - don't create groups larger than six participants. If there are less than 24 students, limit the group communication by eliminating Group 6, Group 5, Group 4, and then Group 3, in that order. The game requires at least two groups (8 participants).

Rule Distribution

The rules for the card game are divided into three segments. There is an incomplete set of rules that is distributed to everyone in the group. There are two sets of additional of rules that are distributed to other players in the group. This ensures that nobody in the group has all of the rules. If there are more than 4 players per group, the two sets of additional rules are copied and distributed to four players in the group. For example, if there are six players, two people will have only basic rules, two people will have the basic rules and the first set of additional rules, and two people will have the basic rules and the second set of additional rules. The game cannot be played without employing all of the rules, so distributing the rules insures that the group must communicate. Although all of the groups are actually playing the same game, it is important to tell the groups that each group may have a different game to play so that the groups don't listen in to another group's game.

Playing the Game

The first step in the game is to distribute the instructions for the process game, but not the rules for the card game. These rules describe each group's communication mechanism and user involvement. The actual rules of the card game will be distributed when play begins. As you distribute the instructions, allow the participants to read them, but don't allow them to discuss the instructions until you give them the signal to start organizing.

The groups are given a signal that they have 3 minutes to organize themselves using any means of communication they'd like. Instruct them to determine who is the group leader (if they want one), who is the user (if applicable), and anything else that they need to decide (mail server, names for mail, scribe, etc).

After 3 minutes, distribute the rules, making sure that everyone gets a copy of the partial rules and the additional sections of the rules are distributed. The user instructions are also distributed. The participants are instructed not to read the rules until the instructor signals. Once all of the rules are distributed to all of the groups, the instructor gives the signal to start the game. Tell the participants that they can spend this time organizing more (within the parameters of the communication mechanism), but at the end of 25 minutes, the game ends and the participants must stop all activities.

After the game is over, each group will spend 2 - 5 minutes talking about what happened. The instructor may have to guide the participants to describe the group's communication mechanism and the problems inherent as well as the effects of a user with ever-changing requirements.

The last step of the process game is for the instructor to relate the communication mechanisms to real world situations. Group 1 and Group 2, where communication is only via email, can be related to a geographically dispersed organization. Email is often used as the primary form of communication when a branch office is located in a country such as Australia or India and the main office is in the United States making organized meetings difficult because of time zone considerations. Group 3 and group 4 use only telephone communication and no written documentation. This type of communication can be likened to agile processes where documentation is marginalized and oral communication is emphasized - i.e. extreme programming. Group 5 and 6 are mainly affected by user involvement, which is typical in many large organizations where the user is in high demand.

RESEARCH QUESTION

The Process Game, as a game, provides a fun-based means of interacting with others in various defined ways. The Process Game, as a teaching tool, is designed to expose students to the importance of having defined processes to follow in seeking to accomplish a task. The use of the game in a SA&D class to accomplish this goal suggests the following research question:

R_0: Does the use of the Process Game have a improve students' understanding of the use of process in systems analysis and design?

The pursuit of an effective means to illustrate to students the importance of using a defined process in SA&D has been the focus of a great deal of reasoned thought and research, as illustrated earlier. Our proposal to use a modification of a familiar game setting to draw students into an experiential learning environment

is a new approach, to the best of our knowledge. After playing the game, they can evaluate the benefits realized by having defined communication process to exchange information.

PROPOSED EXPERIMENT

Research questions themselves are generally not testable. As a consequence, it is necessary to define a hypothesis that can be tested with an experiment. The testable hypothesis for our research question is:

H_0: Playing the Process Game will have a positive impact on the student's perception of the importance of process in systems analysis and design.

The Process Game itself does involve any specific outcomes, the value of which can be used as a construct to represent any change in the students' understanding of the importance of process. It is necessary therefore to design a different type of measure that will generate the necessary construct. We intend to create a short questionnaire to be given to the students before and after participating in the Process Game. The questionnaire will list ten project related tasks, one of which is communication, that the students will assign a value representing its importance to the project. Our test for the hypothesis will be to evaluate the changes in the assigned values pre- and post-test.

CONCLUSION

We are currently conducting pilot tests of the test instrument and the experimental process. If we can secure sufficient numbers for statistical validity, we intend to report the full results of our experiment at the conference. If not, we will report the results of the pilot study.

REFERENCES

1. Avital, M. (2005). Innovation in Information Systems Education I: Accelerated Systems Analysis and Design with Appreciative Inquiry – An Action Learning Approach, Communications of the Association for Information Systems, 15, 17.
2. Brewer, J. and Lorenz, L. (2003). Using UML and agile development methodologies to teach object-oriented analysis & design tools and techniques, Proceedings of the 4th Conference on Information Technology Curriculum, October 16-18, Lafayette, IN, USA, ACM Press, 54-57.
3. Golden, D. G. (1982). Development of a Systems Analysis and Design Course, Proceedings of the Thirteenth SIGCSE Technical Symposium on Computer Science Education, February 11-12, Indianapolis, IN, USA, ACM Press, 110-113.
4. Kendall, J. E., Kendall, K. E., Baskerville, R. L., and Barnes, R. J. (1996). An empirical comparison of a hypertext-based systems analysis case with conventional cases and role playing, ACM SIBMIS Database, 27, 1, 58-77.
5. Larmour, R. (1997). A survey into the relevance and adequacy of training in systems analysis and design, ACM SIGCSE Bulletin, 29, 2, 54-64.
6. Mahapatra, R., Nerur, S. P., and Slinkman, C. W. (2005). Special Theme of Research in Information Systems Analysis and Design – III: Teaching Systems Analysis and Design – A Case for the Object Oriented Approach, Communications of the Association for Information Systems, 16, 43, 848-859.
7. Olfman, L. and Bostrom, R. P. (1992). Innovative Teaching Materials and Methods for Systems Analysis and Design, ACM SIGMIS Database, 23, 2, 7-12.
8. Standish (2004). 2004 Third Quarter Research Report, The Standish Group International, Inc., West Yarmouth, MA. http://www.standishgroup.com/sample_research/PDFpages/q3-spotlight.pdf (accessed March 1, 2006).

(Note: Complete Directions for the Process Game are available on request)

Experiences in Ethical Usability Testing with Children

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ABSTRACT

This paper describes the issues in conducting ethical usability testing with children including experiences in developing and testing sign language software on Kindergarten, Prep and Grade five and Grade six children. It considers the unique requirement of researching with children and the process of gaining university approval to conduct research with children. It discusses the difficulties in gaining informed consent from teachers, parents and children, protection of the research subject from harm and the difficulty in empowering children to instigate their right to refuse to participate in the research project. The article also discusses practical issues such as age appropriate practice, the duration of testing and recruitment of participants. Each issue is disused in theory and an example is given from a resent research project Auslan Children.

INTRODUCTION

Auslan Children was a series of research projects that were undertaken to develop high quality software to teach hearing children sign language. There is currently little research specifically in the area of using software to teach young children Sign Language. The target age of children for the first project was four year old children in a kindergarten setting. The target age of the second project was five and six year old children who were in prep at primary school and eleven and twelve year old children who were in grade five and six at primary school. The *Auslan Children* software consisted of direct instruction of Australian Sign Language (Auslan) by three different characters: a female presenter; a super hero and a puppet. The next section of the software had three activities a short story, a song and a game.

In order to develop the best software for learning it was important to take children's preferences into consideration this included researching the most preferred character for presenting new signs, the type of activities that the children liked, the number of sign that children were able to remember in a single session in addition to the differences that age and gender made to the children's preference. The research project ran a number of small scale iterations in order to limit the amount of time spent on non preferred options.

The research was conducted in the context of university research in which researcher was required to meet strict criteria specified by the institutions in order to protect the participants and the credibility of the research and the institution. Private organizations are not subject to the same procedures but should still be considering the following issues in order to protect the best interests of the participating child. It is important to conduct research with children as children can benefit from these activities and the findings from research conducted on adults cannot always be assumed to apply to children. According to the Australian National Statement on Ethical Conduct in Research Involving Humans, "Research is essential to advance knowledge about children's and young peoples' well-being" (2005, p. 4.1). It is by researching children that their voices can be heard and their preferences can be taken into consideration(Burmeister, 2001).. The children that participated in the research were considered valuable to the research as their preferences for learning could be considerably different to adult learners. Hedges states, "Views of children affect the content and process of the education they receive and ways they are researched" (2001, p. 1).

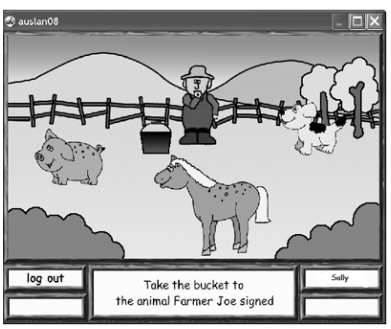
THE COMPLICATIONS PRESENTED BY RESEARCHING CHILDREN

Gaining data from children can be complicated by a number of characteristics that children may exhibit, although not exclusively characteristics of children they are more prevalent in this group. Read and MacFarlane state, "Factors that impact on question answering include developmental effects including language ability, reading age, and motor skills, as well as temperamental effects such as confidence, self-belief and the desire to please" (2006, p. 82). The language and conceptual concepts used in questions is really important to the results for example when children in prep were asked what their most favorite activity and their least favorite activity in *Auslan Children*, eight out of eighteen children (44%) selected the same activity for both showing they either could not make the selection accurately or they did not understand the concepts. False data may be collected if the children can make up answers in order to please the interviewer or if they tell the interviewer what they have been told by adults rather than giving their own opinion (Hedges, 2001). Therefore when it was possible to collect the same data

Figure 1. Direct instruction

Figure 2. Story

Figure 3. Game



from a number of sources this should be instituted. For example when collecting data regarding children's preference for characters between a female presenter, a super hero and a puppet the kindergarten children were able to work for one session with each character, in the fourth session they were able to select the character to take the session, when this preference for character was compared with the character that the children stated was there favorite 4 out of 15 children (26%) changed their preference dependent on the method of asking.

Another reason for using well trained researchers is that young children may have limited ability to express themselves verbally and the accuracy of the data is dependent on the researchers' ability to understand the children (Hedges, 2001). The presence of the researcher can affect the result, especially in the case of children. Read and MacFarlane state, "Even when there is no deliberate intervention the interview has an effect. In one study it was shown that children are likely to give different responses depending on the status of the interviewer" (2006, p. 82). Hedges states "Children behave differently with people they are unfamiliar with" (2001, p. 6). Even the actions of the researcher can effect the willingness of the participants to participate. For example when conducting research at a Kindergarten on using *Auslan Children*, children joined in making the signs with the software when the researcher was just watching, when the researcher had pencil and paper the children behaviour changed and they were less likely to join in at all. Also the presence or absence of a parent or guardian can significantly effect a child's behavior so careful consideration needs to be given to the physical research design.

GAINING UNIVERSITY APPROVAL TO CONDUCT RESEARCH WITH CHILDREN

The process of gaining approval to conduct research on children is quite daunting. At Monash University in Victoria Australia the form that needs to be completed to conduct research on children is twenty one pages, plus a privacy form needs to be completed which is another eight pages. In addition to this explanatory statements and consent forms for the staff, parents and children must be prepared. Written permission must be gained from any organizations involved such as kindergartens. If research is being conducted in schools there is an additional process of gaining permission from the government department of education, and the principle of the school prior to contacting the teachers, parents and students. Filling in the forms is time consuming, and forms need to be sent in three to four weeks before meetings of ethics committees with replies taking and additional two weeks. The main concerns for the Ethics committees seemed only conducting research in the best interest of the children, informed consent from the parents and children, and ensuring that participants are not coerced.

INFORMED CONSENT

The parents or guardians of children are usually required to give informed consent on behalf of the child until the child reaches the age of consent. The parent's or guardian's consent is gained as they are considered more capable of making a decision taking into account all aspects of the research (Hedges, 2001). Field and Behrman state, "informed consent is widely regarded as a cornerstone of ethical research. Because children (with the exception of adolescents under certain conditions) do not have the legal capacity to provide informed consent, the concepts of parental permission and child assent have been developed as standards for ethical research involving children" (2004, p. 7). The Australian National Statement on Ethical Conduct in Research Involving Humans states that consent is required from the "child or young person' whenever he or she has sufficient competence to make this decision" (Commonwealth Government of Australia, 2005, p. 4.2a) and also from the parent or guardian. Parents may only consent if the proposed research is not contrary to the child's best interest.

When research is conducted in schools, the lines of communication between the researcher and the parents are often more complex but acquiring consent from parents must not be compromised. In schools, consent must be obtained from all relevant parties including the child, the parent or guardian, the class teacher, the school principal and the relevant department of education. School staff cannot consent on behalf of students or parents nor can they disclose information for research purposes about any person or group without the prior permission of the individual affected. When sending forms out to children thought a school it is useful to provide a reply paid envelope for the parents to reply directly to the researcher, approximately fifty percent of parents responded in this way when provided with the opportunity.

PROTECTION OF THE RESEARCH SUBJECTS

Designing ethical research is difficult in educational settings as the nature of the experimental process applies different treatments to different groups, which has to disadvantage some groups. Hedges states, "In experiments a researcher ought to verify that children in the control group are not disadvantaged in relation to those in the experimental group who may receive new curricula, new teaching methods or new learning strategies" (2001, p. 8). There are also cases when the control group does not benefit from the treatment and this may be harm by omission (Johnson, 2000). Confidentiality of results can also be an issue as inadvertently revealing a child identity may lead to harm of the child. This may not be releasing a name but having such as small group that the identity can be deduced (Berk, 1997).

Children have the right to expect to be protected from harm in all research conducted on them. The Convention on the Rights of the Child states, "Bearing in mind that, as indicated in the Declaration of the Rights of the Child, "the child, by reason of his physical and mental immaturity, needs special safeguards and care, including appropriate legal protection, before as well as after birth"" (UNICEF, 1989). In addition to this Article 3 of the convention states, "In all actions concerning children….the best interest of the child shall be a primary consideration."

Protection of children in the process of research may not be as obvious as it first seems. If the results of the research is unknown, as is usually the case, then it is necessary to consider the research carefully to predict any harm that may come to children by participating in the research and if there is a possibility of harm then the research should not be conducted (Berk, 1997). For example, harm can be induced in children at different ages in ways that are not relevant to adults (Greenfield, 1984). Older children, for example, are susceptible to harm from procedures that threaten the way they think of themselves (Berk, 1997). People often don't see the value in ethics clearance for Usability testing because it in not medical research but there is unintended harm that can occur if research is not conducted ethically. Children's perceptions of computers could be damaged by participating in research and this could effect their decisions later in life. In addition children should not be made to feel powerless in the process of research so the right to refuse is of critical importance.

Australian National laws governing mandatory reporting of particular issues such as child abuse can pose a dilemma when conducting research. The procedures to be followed in the case of mandatory reporting should be clearly set out so that the researcher knows what their obligations are and the appropriate channels to follow (Newman & Pollnitz, 2002). In order to avoid any issues with this requirement the research on *Auslan Children* was conduced in open areas of the kindergarten and school in order to reduce the likelihood for possible incidence.

REFUSAL TO PARTICIPATE

Voluntary participation is a complex ethical area when working with children. The children may feel coerced into participating in the research if their parent or guardian has given permission even if they do not want to participate in the research. The child's right to refuse to participate in a research project must be respected (Commonwealth Government of Australia, 2005). The language and tone used by the researcher is important as there may be implied coercion when it is not intended. For example, if asking a child to use a computer the researcher could state, "Come and use the computer now" or use a more sensitive statement such as "Would you like to use the computer now". When children elect to participate in research they may change their minds. Hedges states "Children may choose, for example not to answer a question in an interview, or become bored or uninterested" (2001, p. 7). When conducting the Auslan Children research one child refused to take part in the research after the second weeks activity, rather than this being a negative reflection on the research it is a positive outcome that the child felt that they had the right to refuse to participate and was not force to by the researcher. Many children would occasionally refuse to participate because they were currently engaged in another activity the children would then come to the computer when they were ready to have a turn. The right to refuse to participate in a school situation is difficult as students are often not given this option in their normal school situation and may not recognise the right to refuse in a research context.

REPORTING BACK TO THE PARTICIPANTS

Once the research has been completed and analysed the knowledge gained by conducting research with children should then be released to the public (conforming

to the appropriate confidentiality provisions) in order to improve the circumstances of children and thereby justify the conducting of the research (Hedges, 2001). The participants in the research must also be informed of the findings. In the case of children, this should be done in a language that is appropriate to the age of the children involved (Johnson, 2000). The research for these projects was conducted over and extended period and this caused some difficulty in the ability to report back to the participants that were involved. For example when the research was conducted at the kindergarten the children are only involved with the institution for one year and then they move on to school. This makes it difficult to relay the results to the parents and children as to maintain confidentiality the contact details of the children may not be collected so it is not possible to send out the results at a later stage. The best ways to report back may be to make the results available through the organisation for example the kindergarten and also make the results available in a publicly accessible form such as on a web page so that participants and there parents are able to check the results once they have become available.

THE LOCATION OF THE RESEARCH

The location of the research is an important issue: should the researcher go to the children in a home or school setting or should the child come to the researcher? Usability labs offer iterative testing with changes between each test session but the children may not be as comfortable as in the home environment and not as many children can be tested as by testing groups within a school setting. For the experiments on children using the Auslan Software the testing was conducted in the Kindergarten or School. The Kindergarten was selected as it was an environment in which the children were comfortable and they were familiar with using the computer at the kindergarten. The research that was conducted at the school enabled the researcher to work in the environment for which the software was designed to be used in the longer term. It was important to test the likelihood of the software being able to be independently used by the target children in the future. As a result of the research for language learning software the researcher would recommend that any language learning software is loaded onto laptop and controlled by the language teacher to enable consistent control to be maintained over the software by an interested party this means fewer copies of the software could be loaded and maintained well. The three main methods of gathering data are observations, interviews and questionnaires (Hanna, Risden, & Alexander, 1997). One of the advantages with usability testing is that the computer can record some of the data independently such as time on task, response times and selection information in addition to results of testing. Automated data collection may need to be combined with observations is an effective method of collecting data on usability as some duration information may be misinterpreted if only the times are logged.

AGE APPROPRIATE RESEARCH DESIGN

The age of children involved in testing affects the style of testing that is appropriate to gather the required information (Ellis, 2002). Hanna, Risden and Alexander found that "most children younger than 2 ½ years of age are not proficient enough with standard input devices (e.g. Mouse, trackball or keyboard) to interact with the technology and provide useful data" (1997, p. 10). Preschool children should be able to explore the computer independently, however, when conducting usability testing preschool children require extensive adaptation to software because of their limited attention span. In comparison to testing pre-schoolers, elementary school children aged 6 – 10 are relatively easy to test. They can sit and follow directions, are not self conscious of being observed and will answer questions and try new things easily. Six and seven year olds like to be engaged in hands on activities but can be shy (Hanna et al., 1997). When conducting a literature review on two and three year old children the researcher discovered that there was little research on this age group as they are difficult to work with and it is hard to recruit significant numbers for research. This does not mean that research on this group is less important. Working with kindergarten children compared with children of primary school age is much more difficult. It is possible for children in there first year of prep to be shown how to use the software and then work independently, the researcher had to play a much more supportive role with kindergarten children which is time consuming but the competency that this age of child can achieve should not be underestimated.

DURATION OF THE TESTING

Hanna, Risden et al. (Hanna et al., 1997) believe that sessions should not exceed one hour of lab time as preschooler will last thirty minutes and older children will fatigue in an hour. When conducting user testing with children, it is best to select children who can already use a computer. Read and MacFarlane concur stating "Keep it short: Whatever the children are asked to do, make it fit their time span….. For young children, five minutes spent in a written survey is generally long enough, more time can be given, as the children get older" (Read & MacFarlane, 2006). When developing the software Auslan children there were several reasons for developing 10 minute segments such as this is the time that was currently allocated to children to use the kindergartens computer. Also there was concern that kindergarten children would be cognitively overloaded by longer sessions that were introducing new information. The ten minute sessions worked really well; in addition children that were highly engaged had the option of completing more than one session at a time.

RECRUIT OF REPRESENTATIVE CHILDREN

The recruitment of children for research must be considered carefully, as it is quite difficult to not recruit a captive audience through people that are known to the researcher or organisation and who have groups of children of the appropriate age. Hanna, Risden and Alexander (1997) warn against using colleagues' children for usability testing as they are far more exposed to computers than average children and if they don't like the software it can create situation where they feel uncomfortable expressing their true thoughts on the software. A university requirement for conducting research is that both parents and children complete informed consent forms. The explanatory statements for the *Auslan Children* projects were long in order to include all of the information required by the University, these forms are duplicated and combined make quite a thick document. At the start of many of the projects there was less respondents than ideal. Once the project has commenced and peers become aware of the project and want to participate, therefore forms were made available and many more research subjects signed on to participate in the project building a more acceptable number of research subjects.

CONCLUSION

Usability testing with children provides insight into the requirements of software developed for children and the way that they interact with the software however the design of the testing needs to be carefully considered to take into consideration the special requirement of the children. The university approval of research on children is a rigorous process that is designed to protect the best interest of the child and to ensure that the parent and children consenting to participate in research that they are adequately informed about. Careful consideration needs to be given as to the location where the usability testing takes place, the duration of the testing, and how the research participants are recruited. The way that the research is conducted and the language used will effect weather children are able to refuse to participate which is an important right of all research participants. Adequate thought and preparation can ensure that research which children is conducted ethically and provides credible results.

REFERENCES

Berk, L. E. (1997). Ethics in Research on Children. In *Child development, 4th ed* (pp. 64-69): Allyn and Bacon.

Burmeister, O. K. (2001). *Usability Testing: Revisiting Informed Consent Procedures for Testing Internet Sites.* Paper presented at the Australian Institute of Computer Ethics Conference, Canberra, Australia.

Commonwealth Government of Australia. (2005). *National Statement on Ethical Conduct in Research Involving Humans*: National Health and Medical Research Council.

Ellis, K. (2002). *Modeling interface metaphors: developing multimedia for young children.* Monash University, Melbourne.

Field, M. J., & Behrman, R. E. (2004). *Ethical Conduct of Clinical Research Involving Children*. Washington, D.C.: The National Academies Press.

Greenfield, P. M. (1984). *Mind and media : the effects of television, video games, and computers*. Cambridge, Mass.: Harvard University Press.

Hanna, L., Risden, K., & Alexander, K. (1997). Guidelines for usability testing with children. *Interactions: New Visions of Human-Computer Interactions, 4*(5), 9-12.

Hedges, H. (2001). A Right to Respect and Reciprocity: Ethics and Educational Research with Children. *NZ Research in ECE, 4*(1), 1-18.

Johnson, K. (2000). Research Ethics and Children. *Curriculum Perspectives, November*, 6-7.

Newman, L., & Pollnitz, L. (2002). *Ethics in action: Introducing the Ethical Response Cycle*. ACT: Australian Early Childhood Association Inc.

Read, J. C., & MacFarlane, S. (2006, June 7-9). *Using the Fun Toolkit and Other Survey Methods to Gather Opinions in Child Computer Interaction.* Paper presented at the Interaction design for children, Tampere, Finland.

Convention of the Rights of the Child, General Assembly Resolution 44/25 1-15 (1989).

A Usability Framework for the Design of Assistive Technology to Promote Aging in Place

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ABSTRACT

A usability framework is proposed for designing assistive technology that meets the needs of older adult users. The framework is comprised of both requirements and profile components. The requirements component focuses on requirements specification from the perspective of technology, utility, and usability. The profile component encapsulates user requirements in terms of personal characteristics, normal aging factors, chronic health conditions, and other user characteristics that need to be accounted for in the design of assistive technology.

1. INTRODUCTION

Extraordinary societal changes in the U.S. have taken place in recent decades from both human and technological perspectives. Life expectancy continues to increase due to improvements in both medical care and technology. Older adults, 65 years plus, comprise 12.4% of the U.S. population with about one in every eight Americans being in this age group (U.S. Administration on Aging, 2002). By 2030, the percentage will have increased to 20% of the total population representing twice the number as in 2000. Those 85 years and older represent the fastest growing group (He, et al., 2005).

Information and communication technologies (ICT) have entered a new era of automated support through assistive technologies. The U.S. Administration on Aging (2005) defines assistive technologies as being services or tools that help the elderly or disabled do the activities they have always done but must now do differently. These technologies often determine whether a sixty years or older adult is able to live independently or must move to an institutionalized environment. Many older adults view quality of life as being dependent on aging in place in their own homes (Population Reference Bureau, 2002). This is reflected in 83% of older adults owning their own homes (Gitlin, 2003), even though 58% need help with daily living activities (U.S. Department of Health and Human Services, 2001). Given their stage of life, many seniors are motivated to hold onto a home for as long as possible (Sneeding, et al., 2006).

Research in assistive technologies is needed to promote aging in place with a focus on independent living and control over everyday activities. This includes automated support for managing medication, performing daily tasks, staying socially active, supporting cognitive functions, and maintaining a healthy diet, among others. With these support systems in place, older adults not only have an opportunity to stay in their homes longer but to improve the overall quality of their lives.

Research efforts in assistive technologies have been ongoing for several decades. But, it appears that a lack of commercialization persists in turning research outcomes into viable products. Smart homes, for example, have been studied since the early 1990's. Yet from a practical point of view, it is difficult to assess the benefits of smart homes in achieving aging in place objectives. Hurst et al. (2005) suggest that not only is there resistance in product development but also user resistance. From an older adult perspective, expense, invasiveness, lack of control, complexity, difficulty in operations, and lack of aesthetic appeal impact the acceptance and use of technology. Many older adults have already conceded control over various aspects of their daily living to family, friends, and healthcare personnel. They resist conceding control to technological devices that are viewed as invading privacy and lack perceived personal utility to warrant their use.

An understanding of diversity issues associated with aging is needed in order to develop assistive technologies that are universally accessible. To achieve this, usability factors associated with aging and chronic illnesses need to be accounted for in the design of such technologies. This requires a comprehensive understanding of the targeted user group and technological opportunities as well as constraints.

We present a usability framework that became the basis for designing assistive technology as part of an ongoing research project. The design objective was to account for user diversity associated with aging adults often burdened by caregiving responsibilities.

2. BACKGROUND

There is widespread agreement that assistive technologies offer great potential in dealing with quality of life challenges for an aging population. Older adults face physiological changes that increasingly impact daily living. These changes affect vision, cognition, hearing, and motor skills.[1] Figure 1 shows the degradation of vision due to normal aging illustrating one of the many technology design challenges. In order to produce technologies that meet the needs of older adults, it would be important to integrate aging considerations into the design process. Yet there are few guidelines for designing technologies for older adults with and without chronic health conditions. The U.S. National Institute on Aging (2001) offers guidelines for senior-friendly Web sites, this is a step in the right direction. However, more research is needed to address universal access of assistive technologies for an aging population.

Forty percent of older adults over 70 years of age deal with one or more chronic illnesses that affect daily living (Nehmer et al., 2006). Table 1 shows the percentage of the U.S. aging population suffering from chronic conditions. The significance of this data is that chronic illnesses are relatively pervasive in the aging population; and as such, have to be taken into account during the design of assistive technologies. Arthritis, Fibromyalgia, and other neuromuscular diseases, for example, may affect the use of data entry mechanisms due to degraded finger and hand dexterity. Type II diabetes may affect readability of text presented in a small font size due to

Figure 1. Simulation of the impact of aging vision. (Degradation in visual acuity affects ability to see objects clearly, thickening of lens impacts color perception, and decreased light sensitivity affects adaptation to changes in light levels (American Foundation for the Blind, 2004))

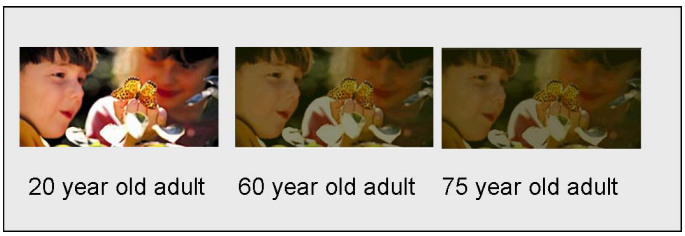


Table 1. U.S. Health and Human Services (2004) statistics on chronic conditions for older adults 65 years plus

Chronic Condition	Percentage
Hypertension	51.9
Arthritis (as diagnosed by doctor)	50.0
Chronic joint systems	46.0
Heart disease	31.8
Cancer	20.7
Diabetes	16.9
Stroke	9.3

lost peripheral vision. Alzheimer's disease[2] may impact cognitive abilities needed for recall of complex tasks associated with using assistive devices.

Figure 2 illustrates two different designs for a PocketPC screen --one of which is a standard user interface. The keyboard design, shown on the left, is part of Microsoft's Windows Mobile 5.0 software system. Data entry on this keyboard requires the use of a small stylus pen with a high level of accuracy in order to successfully tap a targeted key. Due to vision and motor skill degradation, older adults may experience difficulty using this user interface and data entry mechanism. Those older adults suffering from chronic or age-related illnesses with impacts on vision and motor skills may find this keyboard design virtually impossible to use.

The keyboard interface, shown on the right, has been designed as part of our research with input from older adult subjects. The keyboard can be switched to an alphabetical one with even larger key sizes to accommodate vision and physical impairments. (The alphabetized keyboard is not shown in Figure 2.) The senior-friendly design was intended to support the use of finger tip or fat stylus pen to perform a data entry task[3]. Thus, the PocketPC keyboard could be used by older adults to support daily living activities; such as making lists, composing email messages, and setting reminders, among others.

Gregor et al. (2002) have developed the concept of Design for Dynamic Diversity (DDD) when addressing the usability issues associated with the aging population. They suggest that the development of accessible interfaces is unique and a multi-faceted challenge given the diversity of the targeted user group and its ever-changing needs (p. 151). They have developed an informal taxonomy of older adult users that includes: healthy older adults, older adults who are frail due to age-related disability, and disabled older adults who suffer from chronic illnesses. This taxonomy allows for the characterization of user groups based on normal aging factors and the impact of both age-related and chronic diseases. We integrate this taxonomy in a usability framework to support our assistive technology research project.

3. USABILITY FRAMEWORK

The framework proposed in this paper is an expanded version developed by Becker et al. (2000) whereby user and technology characteristics became part of the system requirements. User characteristics, in the original framework, included age, gender, computing experience, education, and typing skills. The technology characteristics included browser type, network access speed, screen size, and specific data entry mechanisms, among others. These characteristics ensured that software applications accounted for hardware and software constraints that if unknown might impede usability by targeted users.

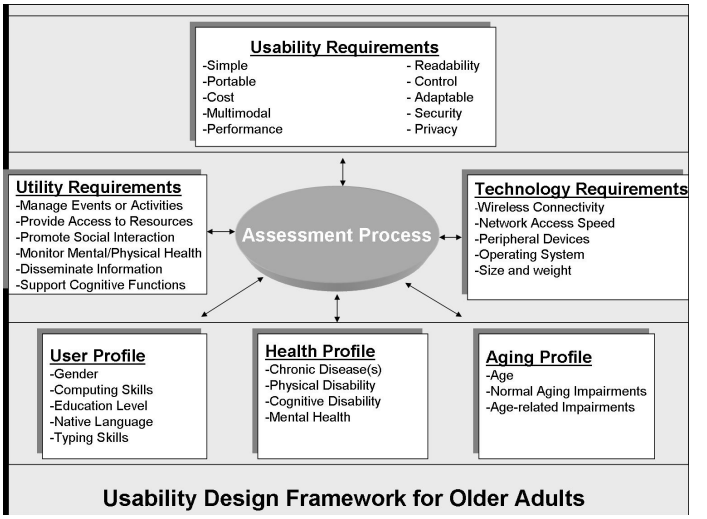
The usability framework includes a comprehensive set of requirements to support the design of software applications as part of our assistive technology research project. These PocketPC applications bundled together are called PocketBuddy; and they target a diverse group of older adult caregivers. The intention is that PocketBuddy, with novel user interface designs, would provide automated support for managing medication, reporting on daily activities, scheduling appointments, monitoring a loved one for whom care is provided, promoting social interaction, and disseminating information.

Framework components were formalized through usability studies involving older adult subjects ranging in age from 65 to 90 years. Feedback from health-care personnel, working closely with older adult subjects, also provided insight regarding factors that might impede or promote usability. Early in the research, it was determined that the framework would encompass the usability needs of older adults who are homebound, isolated, and burdened with caregiving activities in order to promote universal access. It would also capture usability requirements associated with vision, cognition, hearing, and motor skill degradation associated with normal aging; and as much as possible, degradation due to age-related illnesses and health conditions.

Figure 3 shows the framework decomposed into two major components. The requirements component focuses on requirements gathering from the perspective of technology, utility, and usability. The profile component encapsulates user requirements in terms of personal characteristics, normal aging factors, chronic health conditions, and other user characteristics to be accounted for in the design of assistive technologies.

Figure 2. User interface design as part of the assistive technology research project

Figure 3. Proposed usability framework used in the design of PocketBuddy



3.1 Requirements

Usability Requirements

The usability framework shows a set of requirements used in the design of PocketBuddy technology. In our design of a timer application, portability became a usability requirement to promote usage within and external to the home environment. The timer application had a multimodal requirement to ensure events are made known to the older adult as they fire. Audio support, as part of the multimodal requirement, accounted for normal hearing loss associated with aging through the design of appropriate sound frequencies, melody lengths, and volume. A readability requirement accommodated aging vision such that content was highly visible while taking into account screen size. The readability requirement also ensured appropriate use of foreground and background colors to maximize content visibility while accounting for screen glare.

Each of the usability requirements in the framework is further described from a more general perspective.

Simple – This requirement encompasses user recall after initial training and when the technology is not used regularly. The required learning curve must be minimal in order to provide utility to an older adult user. Complex technologies with long learning curves are often not well accepted by adults in later stages of life.

Portable – Portability requirements ensure that technology components are lightweight, readily found when misplaced, and easy to handle if transported by an older adult user. To promote portability, few or no installation or setup requirements are needed when the technology is used in alternate settings.

Cost – Cost requirements ensure that assistive technologies are affordable to those on fixed incomes inclusive of reimbursement potential through federal, state, or private healthcare resources. Affordability and reimbursement requirements would include the cost of licensing, software maintenance and upgrades, and support services.

Multimodal – Multimodal requirements support multiple mechanisms for relaying information to an older adult user. Vision, hearing, cognition, and motor skill degradation associated with both normal aging and chronic conditions would be taken into account. Text-to-speech technology, for example, supplements text display on mobile or handheld devices to account for small screen size, screen glare, and other hardware or software constraints.

Performance – Performance requirements focus on minimizing user discomfort associated with reliability and robustness issues. A usability barrier is encountered, for example, when software or hardware recovery steps must be taken by older adult inexperienced in the use of computing and related technologies. Performance requirements may also be mandated by patient safety and security guidelines put forth by the U.S. Health Insurance Portability and Accountability Act of 1996.

Readability – Readability requirements take into account vision degradation due to normal aging as well as chronic illness and diseases. These requirements ensure that text, buttons, links, and other screen objects are readily visible to the older adult user.

Control – Control requirements take into account normal aging factors and chronic illnesses in the level of control provided to the end user. Control over technology can range from none (invasive) to full (noninvasive). For frail elderly, for example, invasive technologies (e.g., sensing devices) may provide home monitoring capabilities necessary to allow the person to age in place.

Intuitive - These requirements are based on existing user interface (UI) designs that have been traditionally used by older adults (e.g., radio buttons, television remotes). Existing UI designs minimize the learning curve associated with new UI designs. They also promote a high comfort level in using newly developed technologies because they have a familiar look and feel to them. This is especially important to older adults with minimal or no experience in using computing, Web, and communication technologies.

Security – Security requirements ensure personal information is not vulnerable to being stolen or unknowingly shared or sold.

Privacy – Privacy requirements ensure personally identifiable information remains under the control of the individual and is shared only with those who have access rights.

Adaptable – Adaptable requirements promote integration of emerging technologies with existing ones to promote widespread acceptance and use by the targeted user.

Utility Requirements

The utility requirements associated with assistive technologies take into account potential resistance by the targeted user. In particular, the life stage of an older adult may impact tolerance of certain technological designs perceived as complex and invasive with little value added to everyday living.

Manage Events or Activities –Automated support for managing daily events add value to everyday living. Automated medication reminders, for example, promote long-term health and wellness given that such support promotes consistent, correct, and complete adherence to medication management.

Fast Information Dissemination – Fast and transparent information dissemination (e.g., older adult has fallen in the home) promotes longevity of life and aging in place.

Promote Social Interaction - Automated support of social interaction minimizes older adult isolation primarily due to being homebound. Online journals, blogs, email and text messaging, and other interaction-based tools offer a means of remaining virtually connected thus eliminating physical and geographic boundaries.

Monitor Mental or Physical Health –Automated monitoring support for those with chronic and age-related diseases promotes early intervention with the potential for improved quality of life.

Support Cognitive Functions – Memory loss is a normal part of aging. Technologies that support memory recall add value in performing daily tasks. For those with memory loss due to chronic illnesses, memory aids may prolong a move to an institutionalized care setting.

Technology Requirements

The technology requirements component focuses on profiling hardware and software for home use of assistive technologies. Internet access may be required for assistive technologies that transmit data from the home to family or healthcare personnel. Home sensor devices may be connected to existing security systems for continuous monitoring of movement within the home. Other technologies may require personal computers with a particular version of an operating system to utilize software applications. Weight and size may play a role in whether a device is a viable one especially for mobile or handheld technologies.

3.2 Profiles

User Profile

The user profile encompasses personal characteristics that traditionally have been part of usability studies. These characteristics often include age, gender, education, and reading comprehension. They may also include computing experience, Web and mobile technology usage, and typing skills, among others. The user profile provides a means of assessing assistive technologies in terms of ease-of-use, learning curve, memory recall, and other usability factors.

Health Profile

The health profile encompasses characteristics that might impede the use of technology due to chronic illnesses or diseases and the resulting impacts on vision, cognition, motor skills, and hearing. For users suffering from Fibromyalgia, arthritis, or other neuromuscular diseases, for example, typing on a small device may be impossible when designs are not made accessible to those with lost sensitivity in fingertips or lost dexterity in fingers and hands.

Aging Profile

Vision, hearing, motor skills, and cognition are continuously affected by the normal aging process. These impairments can have a profound impact on the use of technology that hasn't been designed with the aging user in mind. Age-related diseases (e.g., cataracts) can compound impairments associated with normal aging. Technologies that are difficult to use by healthy older adults become virtually impossible to use by those with age-related diseases.

4. CONCLUSION AND FUTURE RESEARCH

Assistive technologies offer great potential in supporting daily living activities, improving quality of life, and enhancing social interaction by older adults who are homebound, isolated, disabled, or chronically ill. The need for such technologies will continue to grow with the impending explosion of the aging population and

Table 2. National goals associated with the development of assistive technologies for older adults

Develop creative products to support older adult independence. Research is needed to identify innovative technologies to promote aging in place given the high cost of institutionalized care. These include noninvasive technologies for which the older adult user maintains control over information gathered and disseminated.
Create public awareness of available technologies. A national infrastructure is needed for public awareness of innovative technologies to promote aging in place. This includes the effective dissemination of research outcomes that can be readily expanded into the realm of product development.
Design technology products that assist the broadest range of consumers. Additional research is needed in the area of universal access so that all technologies are made available to those with and without disabilities. The promotion of universal access, at both national and international levels, ensures the broadest range of users have access to technologies.
Assure innovative and competitive leadership of U.S. technology to meet rapidly-increasing global demand for aging-related products and services. With national support, research and innovation infrastructures could be utilized to promote universal access from an international perspective. This would be inclusive of older adults with and without disabilities regardless of geographic location.

its strain on health care personnel, facilities, and other resources. This critical need is being recognized at a national level, as shown by the outcomes of the White House Conference on Aging (2005). Table 2 expands upon several of the national goals.

It became apparent in our compilation of a usability framework that novel interface designs were needed if handheld devices were to be viable as assistive technologies for older adults. As such, research has been initiated on interface designs that focus on universal access by a diverse group of users. A few of the lessons learned are summarized below.

Multimodal Capabilities - The significance of multimodal support became apparent in PocketBuddy usability studies involving older adult subjects. A number of subjects relied on multimodal feedback to ensure a task was completed. Though the button changed color, the subject would listen for a supplemental sound as an indicator that a button had been successfully tapped.

Novel Interface Designs - The design team designed a novel keyboard, as shown in Figure 2, as a means of promoting successful data entry by older adult users. Unfortunately, it was still inaccessible by 14% of the older adult subjects in the usability study. These subjects found the use of the keyboard frustrating given they could not accurately tap on a key. The design team is exploring other novel interface designs to promote usability by all older adult subjects.

Transparent Data Transmission - The usability framework uncovered the need for transparent Internet connectivity for transmission of data gathered on PocketBuddy by an older adult user. In our research, adult caregivers who are seventy years plus comprise a large percentage of targeted users. Many have minimal computing skills and are often consumed with caregiving responsibilities. These caregivers would have little time to learn new technologies and even less time to deal with complex aspects of a user interface.

Future research will study the integration of the usability framework with design space research conducted by Maciuszek et al. (2005). The objective would be a common frame of reference, which maps specific aspects of older adult life to be supported via new or enhanced assistive technologies. The usability framework would provide the means to characterize a user, technology constraints, and usability goals. This would provide a foundation upon which technology could be assessed in terms of user requirements to support aging in place goals.

REFERENCES

American Foundation for the Blind. (2004). Normal changes in the aging eye. Retrieved September 24, 2006, from http://www.afb.org/Section.asp?SectionID=35&TopicID=212 &SubTopicID=39.

Becker, S.A., Berkemeyer, A., and Roberts, N. (2000). A Web usability assessment tool. *Proceedings of the 2000 Information Resource Management Association (IRMA) Conference,* Anchorage, Alaska, 538-541.

Becker, S.A., and Webbe, F. (2006). Designing for older adult users of handheld technology. *28th Annual International Conference IEEE Engineering in Medicine and Biology Society (EMBS),* New York City, New York, 1327-1329.

Gitlin, L. (2003). Next steps in home modification and assistive technology research. In N. Charness and K. W. Schaie (Eds.), *Impact of Technology on Successful Aging,* (188-202), New York, NY: Springer Publishing Company, Inc.

Gregor, P., Newell, A. F., and Zajicek, M. (2002). Designing for dynamic diversity – interfaces for older people. *Proceedings of the Fifth International ACM Conference on Assistive Technologies (ASSETS'05),* Edinburgh, Scotland, 151-156.

He, W., Sengupta, M., Velkoff, V. A., and DeBarros, K. A. (2005). 65+ in the United States: 2005. Special report issued by the U.S. Department of Health and Human Services and the U.S. Department of Commerce, Washington, DC.

Hurst, A., Zimmerman, J., Atkeson, C., and Forlizzi, J. (2005). The sense lounger: establishing a ubicomp beachhead in elders' homes. Conference *on Human Factors in Computing Systems, CHI'05*, Portland, Oregon, 1467-1470.

Maciuszek, D., Aberg, J, and Shahmerhri, N. (2005). What help do older people need? Constructing a functional design space of electronic assistive technology applications. *Proceedings of the 7th International ACM Conference on Computers and Accessibility (ASSETS'05),* Baltimore, Maryland, 4 – 11.

Nehmer, J., Karshmer, A., Becker, M., and Lamm, R. (2006). Living assistance systems – An ambient intelligence approach. *Proceedings of the 28th International Conference on Software Engineering*, Shanghai, China, 43- 50.

Population Reference Bureau (2002). Bulletin #2, Washington D.C.

Sneeding, T., Torrey, B. B., Fisher, J., Johnson, D.S., and Marchand, J. (2006). No place like home: Older adults and their housing. CRR Working Paper 2006-16, Center for Retirement Research at Boston College. Retrieved September 26, 2006, from http://www.bc.edu /centers/crr/papers/wp_2006-16.pdf.

White House Conference on Aging (2005). Annotated agenda. Washington DC. Retrieved September 25, 2006 from http://www.whcoa.gov/about/policy/meetings /annotated_agenda.pdf.

U.S. Administration on Aging. (2002). A profile of older Americans. Administration on Aging, U.S. Department of Health and Human Services. Retrieved September 24, 2006, from http://www.aoa.gov/prof/Statistics/profile/2002profile.pdf .

U.S. Administration on Aging. (2005). What is assistive technology fact sheet. U.S. Department of Health and Human Services. Retrieved June 22, 2006, from http://www.eldercare.gov/eldercare/Public/resources /fact_sheets/assistive_tech_pf.asp.

U.S. Department of Health and Human Services (2001). Delivering on the promise: U.S. Department of Health and Human Service self evaluation to promote community living for people with disabilities. Report to the President On Executive Order #13217.

U.S. Department of Health and Human Services (2004). Trends in aging and health. Retrieved September 24, 2006, from http://www.cdc.gov/nchs/agingact.htm.

U.S. National Institute on Aging. (2001). Making your web sites senior-friendly. Retrieved September 27, 2006, from http://www.nlm.nih.gov/pubs/staffpubs/od/ocpl/ agingchecklist.html.

ENDNOTES

1. Refer to Becker and Webbe (2006) for an overview of aging factors and use of assistive technology.
2. A Statistic for Alzheimer's disease (AD) as a chronic condition is not part of the Central for Disease (CDC) Control's report. Hence AD does not appear in Table 1. However, the CDC reports AD as a leading cause of death (3.2%) for those 65 years and older.
3. The keyboard shown on the right is part of a user interface design filed in a patent disclosure.

Critical Success Factors in "Best of Breed" ERP Implementation

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ABSTRACT

The research on ERP project challenges and critical success factors deals with large-scale ERP implementation using a single, organization-wide ERP package. The integrated nature of ERP software provides an incentive to implement a single ERP solution. However, the "best of breed" approach where the organization picks and chooses ERP modules which best support its business processes from various vendors is an alternative strategy. By examining the experiences of two organizations, this study identifies the critical success factors associated with the "best of breed" approach and the differences between these critical success factors and the critical success factors associated with implementing a single vendor ERP.

Keywords: Enterprise resource planning systems, best-of-breed ERP systems, critical success factors.

INTRODUCTION

The research on ERP critical success factors deals with large-scale ERP implementation using a single, organization-wide ERP package. The "best of breed" approach to ERP implementation is an alternative strategy. One of the significant issues with ERP is the need to re-engineer business processes to "fit" the best practices supported by the software. In the "best of breed," approach, the organization picks and chooses ERP modules which best support its business processes from various vendors. For example, one vendor may provide an optimum solution to HR practices, while another supports production and manufacturing processes better. In the "best of breed" approach, the organization mixes and matches ERP modules to support its business practices most effectively. These companies follow an approach of integrating multiple enterprise systems using a "best of breed" solution.

There is limited research on the "best of breed" approach. Light et al. used a case study approach to compare "best of breed" ERP implementation with single vendor ERP. In their analysis, the "best of breed" approach enabled the organization to support functionality and unique business process requirements (Light, Holland, and Wills, 2001). In their case study of an organization in the entertainment industry, these unique processes included release management, copyright and royalties management, and invoicing. In addition, the "best of breed" approach is less disruptive to organizational processes because it supports existing processes. However, the "best of breed" approach presents a number of difficulties, including the costs of developing interfaces among a suite of applications and higher degrees of maintenance due to complex connections between various components.

Another study indicated that users prefer a "best-of-breed" solution when each department has a unique mission, information transfer among departments is minimal, data translation across systems is easy, and the discount on purchasing the uniform solution is small (Dewan, Seidmann, & Sunderesan, 1995).

RESEARCH QUESTIONS

This paper will provide case studies of two organizations implementing "best of breed" ERP projects and will provide insight into each of these questions based upon their experiences:

1. What are the critical success factors associated with implementing "best of breed" ERP?
2. What are the differences between these critical success factors and the critical success factors associated with implementing a single vendor ERP?

LITERATURE

ERP and IT literature were reviewed using the five functions of management theory as a lens. Possible critical success factors were identified in the areas of planning, organizing, staffing, leading and controlling.

Planning

Integration of business planning and IS planning is a top problem reported by executives and IS managers (Reich & Benbasat, 1996). An A. T. Kearney study indicates that firms that integrate IS plans with business planning outperform other firms (Das, Zahra, & Warkentin, 1991). Most executives do not understand the connection between modern business and technology and "leave technology compartmentalized within the I/T department with disastrous effects (Severance & Passino, 2002)." This literature suggests that the higher the level of integration of ERP planning with business planning the more likely the ERP implementation will be successful.

H1. The level of integration of ERP planning and business planning is positively related to implementation project success.

Organizing

Organizations must deploy resources to attain goals. A common view is that a user must head the project team and it must be a full-time job (Wight, 1974). Another view is that systems knowledge is the least important skill of the project manager (Flosi, 1980).

H2. Organizing the ERP implementation project under the direction of a project manager whose sole responsibilities are the project is positively related to ERP implementation project success.

H3. An organizational structure in which the project manager reports to the business unit's senior manager is positively related to implementation project success.

Staffing

Tasks associated with staffing include recruitment, selection, appraisal and development of employees. Current literature emphasizes the business skills of the project manager. Project leaders must be veterans who have 'earned their stripes' leading projects (Brown & Vessey, 2003) .

H4. Staffing the ERP project manager position with an individual with extensive experience is positively related to project success.

A positive initial experience with a new software package is important to users. A tendency to cut training budgets can result in negative user attitudes (Lassila & Brancheau, 1999).

H5. The quantity and quality of training are positively related to implementation project success.

In most ERP implementations consultants are retained to assist with the project. One practitioner states "the success of the project depends strongly on the capabilities of the consultants…" (Welti, 1999)

H6. Use of an ERP consultant for guidance is positively related to implementation project success.

Leading

Executive support is generally regarded as critical to implementation of management information systems. Senior management communicates direction, allocates resources, delays conflicting projects and deals with organizational resistance (Laughlin, 1999).

H7. CEO involvement in the planning and implementation of ERP systems is positively related to implementation project success.

A champion is critical to new systems. Champions "are more than ordinary leaders…(they) inspire others to transcend self-interest for a higher collective purpose (Burns, 1978). "Successful champions can break down bureaucratic barriers…(Beath, 1991)."

H8. The existence of a champion is positively related to implementation project success.

ERP implementation projects involve change in almost every area of business process. These major changes result in "resistance, confusion, redundancies and errors (Somers, Ragowsky, Nelson, & Stern, 2001)." Change management must be rigorously planned and generously resourced (Brown & Vessey, 2003).

H9. Management's effectiveness in reducing user resistance to change is positively related to implementation success.

Controlling

A process of systematic controls regulates organizational activities. A common method of control in information systems projects is management steering committees. These committees can be viewed as a method to get top management involved, ensure IS/BP planning fit, improve communications and change user attitudes toward IS (Gupta & Raghunathan, 1989). A study of 12 manufacturing firms found that steering committees with executive leadership were a characteristic of projects that stayed on time and on/under budget (Mabert, Soni, & Venkataramanan, 2003).

H10. The use of a steering committee that a.) is headed by the CEO, and b.) meets at least every four weeks is positively related to implementation project success.

Table 1. Case study site characteristics

	Case 1-M-I	Case 2-Boeing
Project start date	1995	1993
Software vendors	Oracle, Datalogix	Manugistics (was Western Digital), Baan, Oracle, Peoplesoft
Revenue	Approx. $1 billion	Approx. $6 billion (defense)
Project cost	$7 million, US only	$16 million, ongoing
Data Source	Multiple interviews and archival data	Multiple interviews (CIO, project leaders)

RESEARCH METHODS

A multiple case study method is used in this research. An open-ended questionnaire was developed. In some cases multiple in-person interviews were conducted, in other cases questionnaires were completed by e-mail with e-mail or phone follow up was used. The validity of the data collected was verified by conducting multiple interviews and by making enhancements to assure completeness and consistency. Interviewees were asked to read case summaries and offer corrections.

CASES

Case 1

M-I Drilling Fluids is a global energy services company. Before the ERP project the company was using home grown information systems on an outsourced IBM platform. The legacy systems were islands of automation. The information provided by these systems was accounting oriented, not operations oriented. Even inventory data was of limited use because of incomplete, inaccurate and late data for receipts and shipments. M-I's aging legacy systems would be very costly to upgrade and would still leave the company with an outdated system The ERP project, begun in 1995, was the company's effort to get up to date and improve the scalability of IT costs, reducing the need for cycles of layoffs and hiring as the economy fluctuated.. The impetus was the foreseeable Y2K problems in the legacy systems. Computer Science Corporation was selected as consultants on the feasibility study and implementation project. The project would be the most significant change effort the company with deeply embedded organizational practices had started.

M-I decided on a "best of breed" solution to their information needs because their drilling mud production required a process manufacturing package. Oracle did not provide a process cost solution at the time the project was begun in 1995, so Datalogix's Global Enterprise Manufacturing System (GEMMS) was selected for purchasing, manufacturing, inventory, cost accounting and sales order entry. The interface software between Oracle and GEMMS was the source of many implementation problems. It is interesting to note that Oracle acquired Datalogix in the midst of the implementation project at M-I. This acquisition actually impeded the project as an exodus of Datalogix employees after the acquisition created a shortage of knowledgeable customer support for the GEMMS software.

The application of the proposed critical success factors to the M-I implementation is now examined.

H1. Business and IT planning. At the time of the ERP adoption decision, IT planning supported business planning at M-I but was not integrated with it. The business plan called for cost control in IT, scalability of IT costs, more transparency of information throughout the organization, and improved financial and operating information. The IS department proposed the ERP system to accomplish these goals.

H2. Full time project manager. Computer Science Corporation was hired as consultants and full time project managers. In addition, two M-I employees, one from the IT department and one from the accounting department, were selected and full time co-managers.

H3. Reporting level of project manager. The project managers did not report to directly to top management at M-I. The project managers reported to the IT director who in turn reported to the CFO.

H4. Project manager skills. The project manager for CSC is described as having excellent project management skills and a good working knowledge of the Oracle financial software, but limited knowledge of the GEMMS manufacturing and distribution software. Also, the CSC project manager had little knowledge of M-I's business process. The M-I co-managers provided the team knowledge in that area.

H5. Training. M-I provided employees primarily keystroke and data entry training. Business process training was not conducted. A major deficiency in training materialized on implementation start-up. On the advice of the consultants, employees were provided with training on the report writer software and were expected to write their own reports. The complexity of the Oracle report writing software proved too much for the average user, so few reports were available in the first few months after implementation.

M-I's IT staff scrambled to design reports for individual users resulting in a proliferation of reports, rather than the fewer multi-purpose reports the company had anticipated.

H6. Consultants. Consultants participated in M-I's ERP feasibility study and implementation project. Consultants drove the project forward, but M-I employees knew the business processes and customer needs. A project co-manager observed that the project really started going well when the company started managing the consultants, rather than the consultants managing them.

H7. CEO role. M-I's CEO did not play an active role in the project, but supported it fully. Top management team members involved in the project were the CFO and VP-Supply Chain Management.

H8. Champion. Project team members identified the two M-I co-managers as the champions for the project. The co-managers worked to reduce user resistance and coordinate the needs of the various functional areas of the business.

H9. User Resistance. Management used an active employee communications program to inform the employees of the importance and progress of the ERP project. The culture at M-I is a top down style of management. Management made it clear to employees that the project was going to succeed so they "might as well get on board." Reduction of user resistance was key to project success. Few M-I employees had any IT sophistication or vision of how a well-designed system could help them do their jobs better.

H10. Controlling the project. The steering committee included the CFO, VP-Supply Chain Management, IT Director, CSC project manager and the IT Director from M-I's majority owner. One member complained that spotty attendance at committee meetings by some functional members contributed to the lack of a broad base consensus to decision making. The finance operation drove the implementation with operations playing a minor role.

MI management considered the implementation successful. The project was completed on time and on budget and met management's expectations of improved transparency, better scalability of IT costs and improved operating efficiency.

Case 2

Boeing is an aerospace-defense industry company with their Integrated Defense Systems (IDS) based in St. Louis. Boeing IDS is a $6 billion division supporting 140 applications provided by 23,000 separate software contracts costing $250 million each year. As background, the systems before ERP were a series of legacy non-integrated mainframe systems. The overall goal in acquiring ERP and commercial off-the-shelf packages (COTS) is to reduce the overall number of systems. For example, Boeing had 16 different procurement systems before acquiring several common procurement systems.

Boeing decided upon a "best of breed" solution because the company did not feel that one ERP system could be used to integrate 140 different applications. They decided to use multiple ERP packages from different vendors. Since Boeing was not willing to change its processes to fit the best practices supported by a package, the company required the software vendor(s) to customize the ERP packages to meet its unique business requirements. Since government contracting entails unique processes, Boeing required its vendors to customize and to maintain specific government contracting modules to meet its needs.

Using the "best of breed" approach, Boeing acquired a variety of commercial off-the-shelf software supporting different applications, including: Procurement/Manufacturing: Manugistics (e.g. was Western Digital); Commercial Procurement: Baan; Financial: Oracle; and HR: Peoplesoft. In each case, Boeing selects large vendors, because they contract with these vendors to customize the software to meet their needs. Every time an upgrade is installed, the software must be customized again. Once a vendor is selected, the partnership can last for as long as ten years.

The overall success strategies for ERP implementation at Boeing were: (1) ERP project leadership by end-users; (2) building capability (e.g. enhancements) into the ERP implementation; and (3) the vendor partnership. As one executive put it, "Boeing is not in the software business, so we have created a partnership with a vendor who can meet our ERP software needs and work with us to modify their package to meet our needs."

The application of the proposed critical success factors to the Boeing implementation of "best of breed" ERP systems is now examined.

H1. Business and IT planning. ERP is a critical strategy to achieve lean manufacturing, and ERP planning is important to achieving these business outcomes. The actual business objective to be achieved was inventory reduction, which is key to lean manufacturing and supply chain management. Management was committed to the value of ERP based upon this business case.

H2. Full time project manager. A customer leads each ERP project. Three ERP project leaders represent core business functions, including Production, Engineering, and Operations. A co-lead from IT handles administration and project management.

H3. Reporting level of project manager. The ERP project leaders were end-user managers at Boeing with extensive experience and business knowledge. The project was continuously reviewed by a Steering Committee, led by the project managers. They reported to senior division management.

Table 2. Findings in "Best of Breed" ERP

	MI	Boeing
H1. IT and business planning integration	IT plan supports the business plan	IT plan supports the business plan
H2. Full time project manager	Consultant served as project manager	ERP project managers are business leaders representing Production, Engineering, and Operations
H3. Reporting level of project manager	Steering committee headed by IT director	Steering committee led by the project managers
H4. Experience of project manager	CSC project leader with excellent project management and software skills	ERP project managers had extensive business knowledge
H5. Training	Limited to keystroke/ data entry	Extensive training on relevant modules
H6. Consultants	Used heavily	Used extensively
H7. CEO Involvement	Limited to approvals, support	Management was committed to the value of ERP based upon the business case
H8. Champions	Two co-managers	ERP project managers were the champions
H9. Management effectiveness in reducing user resistance	Heavy employee communications and top down support	ERP project managers were the change agents. Strategies included education and communications
H10. Steering Committee	Steering committee used, but not headed by CEO.	Steering Committee continuously reviewed the business case for ERP. Steering Committee was headed by the project leaders

H4. Project manager skills. The project managers had extensive business knowledge in Production, Engineering, and Operations.

H5. Training. Software vendors provided training to Super-Users within each business area, and the Super Users became trainers within specific areas. The project managers noted that the importance of training could not be under-estimated. If anything could have been done differently, it would be to provide more extensive training.

H6. Consultants. Some of the team members represented consulting firms, including Ernst and Young and Anderson Consulting. Consultants were active in requirements planning and testing. The change management issues were dealt with by the management team, not by external consultants.

H7. CEO role. Top management drove and communicated the need for change. Management was committed to the value of ERP based upon the business case. Top management said that they could not live with disparate systems and did not see any alternatives to ERP.

H8. Champion. Project leaders were the champions.

H9. User Resistance. The project leaders were the change agents. Management dealt with user resistance through education, continual reviews, and communications. The implicit assumption was that people needed to make the change, or else move on.

H10. Controlling the project. The Steering Committee met regularly to review the business case for the ERP projects, including the business value of the investment. According to one of the project leaders, "the Steering Committee reviews the cost if we don't do the project, and the cost if we do the project." There are ongoing measures of the impact of the project on achieving business results. The major business benefit of the manufacturing ERP project was inventory reduction.

COMMON CRITICAL SUCCESS FACTORS

Several common critical success factors emerged in the "best of breed" projects, and several "new" critical success factors emerged in importance. In each case, ERP was aligned with business objectives, and the ERP projects had full top management support. Top management received briefings on these projects, and the Steering Committees were responsible for closely monitoring these projects. In each case, the project manager(s) were end-user managers with extensive business knowledge, including knowledge of production, manufacturing, and operations management processes. In each case, the champions were the ERP project managers. Steering Committees in both cases continuously reviewed the projects, including the business case.

UNIQUE CRITICAL SUCCESS FACTORS

Boeing and M-I Drilling decided to use the "best of breed" approach because they did not want to change their business practices. Instead, they wanted to select vendor packages that fit their business requirements. The most significant challenge with the "best of breed" approach is the need to integrate ERP modules from different vendors. This requires building interfaces between different ERP modules (e.g. Peoplesoft to Oracle). In addition, if any of the modules are customized, then upgrading to new versions of vendor-supplied modules requires creating new customizations and building new interfaces. The cost implications of the "best of breed" approach are significant and must be continuously justified in terms of business results.

CONCLUSIONS

An analysis of "best of breed" ERP projects, using two case studies, reveals that certain critical success factors in "best of breed" projects are common to vanilla ERP implementations, including alignment with business objectives, effective project management, the role of the champion, and the role of the Steering Committee in monitoring project issues and in measuring project results. In "best of breed" projects, supplier management is magnified in importance because vendors are entrusted with customizing their software to fit the unique business requirements of the customer. Interface management between multiple vendors requires effective vendor management and cost justification—since this approach is more costly to negotiate and more costly to maintain. In Boeing's case, experience with the "best of breed" approach between 1993 and 2006 drove them to justify customization only for "must-have" processes. These customizations were handed over to the vendor, so that the vendor was responsible for building unique modules and for integrating these unique modules with common systems. Leadership by end-user managers assures that only "must have" processes are customized and that these customizations have a business case associated with them.

REFERENCES

Beath, C. M. (1991). Supporting the Information Technology Champion. *MIS Quarterly*(September 1991), 355-372.

Beshnahan, J. (1996). Mixed messages. *CIO Magazine, 9,* 74-78.

Bradley, J. (2005). *Are Critical Success Factors in ERP Implementation Created Equal?* Paper presented at the Americas' Conference on Information Systems, Omaha, Nebraska.

Brown, C. V., & Vessey, I. (2003). Managing the Next Wave of Enterprise Systems: Leveraging Lessons from ERP. *MIS Quarterly Executive, 2*(1), 65-77.

Burns, J. M. (1978). *Leadership* (Harper Paperback ed.). New York: Harper & Row.

Das, S. R., Zahra, S. A., & Warkentin, M. E. (1991). Integrating the content and process of strategic MIS planning with competitive strategy. *Decision Sciences, 22*, 953-984.

Davenport, T. H. (1998). Putting the Enterprise into the Enterprise System. *Harvard Business Review, 76*(4, July-August), 121-131.

Dewan, R., Seidmann, A., & Sunderesan, S. (1995). *Strategic Choices in IS Infrastructure: Corporate Standards Versus "Best of Breed" Systems.* Paper presented at the ICIS, Amsterdam.

Flosi, T. (1980). *How to Manage an MRP Installation.* Paper presented at the Management Seminar.

Gupta, Y. P., & Raghunathan, T. S. (1989). Impact of Information Systems (IS) Steering Committees on IS Planning. *Decision Sciences, 20*(4), 777-793.

Lassila, K. S., & Brancheau, J. C. (1999). Adoption and Utilization of Commercial Software Packages: Exploring Utilization Equilibria, Transitions, Triggers, and Tracks. *Journal of Management Information Systems, 12*(2), 63-90.

Laughlin, S. P. (1999). An ERP game plan. *Journal of Business Strategy, 20*(1), 32-37.

Light, Ben, Holland, Christopher P. and Wills, Karl. (2001). ERP and Best of Breed: A Comparative Analysis, *Business Process Management Journal*. 7, 3, 216-224.

Mabert, V. A., Soni, A., & Venkataramanan, M. A. (2003). Enterprise resource planning: Managing the implementation process. *European Journal of Operational Research, 146*, 302-314.

Markus, M. L., Petrie, D., & Axline, S. (2000). Bucking the Trends: What the Future May Hold for ERP Packages. *Information Systems Frontiers, 2*(2), 181-193.

Nah, F. F.-H., Lau, J. L.-S., & Kuang, J. (2001). Critical factors for successful implementation of enterprise systems. *Business Process Management, 7*(3), 285-296.

Reich, B. H., & Benbasat, I. (1996). Measuring the Linkage Between Business and Information Technology Objectives. *MIS Quarterly*(March 1996), 55-81.

Severance, D. G., & Passino, J. (2002). *Making I/T Work*. San Francisco: Jossey-Bass.

Somers, T. M., Ragowsky, A. A., Nelson, K. G., & Stern, M. (2001). *Exploring Critical Success Factors across the Enterprise Systems Experience Cycle: An Empirical Study* (Working Paper). Detroit, Michigan: Wayne State University.

Stedman, C. (1999, November 1). Failed ERP Gamble Haunts Hershey: Candy maker bites off more than it can chew and 'Kisses' big Halloween sales goodbye. *Computer World,* 1.

Sumner, M. (1999). *Critical Success Factors in Enterprise Wide Information Management Systems.* Paper presented at the American Conference on Information Systems, Milwaukee, WI.

Sumner, M. (2000). Risk Factors in Managing enterprise-wide/ERP projects. *Journal of Information Technology, 15*, 317-327.

Welti, N. (1999). *Successful SAP R/3 Implementation: Practical Management of ERP Projects*. Harlow, England: Addison-Wesley.

Wight, O. (1974). *Production and Inventory Management is the Computer Age*. Boston, MA: CBI Publishing Co,.

Mobile Data Technology (MDT) Adoption Process in Canadian Micro and Small Enterprises: An Exploratory Study

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ABSTRACT

Mobile Data Technologies (MDT) are a natural extension to the traditional office computing environment. It is predicted that more than two thirds of the active workforce will rely heavily on mobile data technologies for business related activities by 2007 (IDC, 2005). However, very little research is available on how MDT adoption decisions are taken by Micro and Small Enterprises (MSEs). In this paper, we present the results of an exploratory study on MDT adoption process in MSEs. The results presented are based on structured interview data collected from MDT adoption decision makers in 33 micro and small business enterprises. The study highlights some major ways in which the MDT adoption process in MSEs can differ significantly from Medium and Large sized organizations.

1. INTRODUCTION

Business use of computing has evolved consistently at a fast pace in the last few decades with the advancements in Information and Communication Technologies. The traditional method of accessing and managing information through a stationary desktop personal computer (PC) is close to obsolescence with an ever-increasing miniaturization of electronic devices and widespread diffusion of advanced wireless standards and technologies. The mobility extended to computing and communication devices by these technologies allows employees the prospect of information exchange anytime/anywhere. From the globe-trotting CEO to the traveling sales representative, *Mobile Data Technologies (*MDT) have radically changed the way employees work. Consequently, MDTs have experienced tremendous growth in the last few years. The market research firm Canalys reported recently that worldwide shipments of smart mobile devices rose 55% year-on-year in Q2 2006 (Canalys, 2006). This growth in MDT adoption has motivated several researchers to study the phenomenon, however, very little research is available on MDT adoption in the context of Micro and Small Enterprises (MSEs) (Riemenschneider *et al*., 2003; Paul *et al*., 1995; Yap *et al*., 1992).

In this paper we explore MDT adoption process in Canadian MSEs. MSEs are a major contributor to any nation's economy. According to a 2006 Statistics Canada's report, 94.5 % of all businesses operating in Canada employed fewer than 50 employees while 73.7 % of all businesses employed fewer than ten employees (Industry Canada, 2006). The problems, opportunities, and management issues encountered by small business are unique (Premkumar, 2003; Kuan & Chau, 2001). MSEs face different challenges in adopting Information Technology (IT) compared to large organizations (Harker & Van-Akkeren, 2002). For example, recruiting and retaining personal could represent a significant resource allocation for MSEs in comparison with medium and large organizations that could have an entire department dedicated to IT (Kuan & Chau, 2001; Dankbaar, 1998). Significant differences in operating conditions and concerns of MSEs prescribe differences in how the decision to adopt an MDT is initiated, evaluated, and approved within MSEs..

We explore the typical activities in the MDT adoption process of MSEs such as *adoption initiation*, *business case development*, *criteria for selection of product,* and *decision to proceed*. The theoretical foundation is based upon the innovation process theory approach wherein we adapt the Markus and Tanis (2000) framework to delineate the MDT adoption process. The next section provides the theoretical background of the study by defining the key concepts used in the study and developing the theoretical framework. Section 3 describes the methodology used in collecting data for the study. Section 4 presents findings and managerial implications and Section 5 presents our conclusions and recommendations for further research.

2. THEORETICAL BACKGROUND

Micro and Small Enterprises

Defining MSEs is not an easy task. Throughout the world, there is no standard or universal definition of MSEs; rather, it is clear that many countries use a variety of different types of criteria to define MSEs (Amboise, 1991). While some criteria are applicable to all industry areas, others are relevant only to certain types of business (Longenecker *et al*., 1998). In Canada, there is no clear guideline or definition for classifying MSEs (Balderson, 2003; Longenecker *et al.*, 1998; Amboise, 1991). For example, legislators may exclude small firms from certain regulations if they fall below a certain number of employees. Statistics Canada usually classifies an organization as a small business when there are fewer than 500 employees, and Revenue Canada uses a minimum profit amount to define small enterprises. Furthermore, a business may arbitrarily be described as "small" when compared to larger firms, but "large" when compared to smaller ones.

There are four commonly used criteria to distinguish the size of an organization (Balderson, 2003; Longenecker *et al.*, 1998; Amboise, 1991). They are: number of employees, total revenue, profit, and type of management-ownership structure. This study will employ the most widely used criterion to size a business: number of employees (Balderson, 2003; Longenecker *et al.*, 1998; Amboise, 1991). This criterion is justified by the abundant adoption studies that have classified enterprises through 'number of employees' (Harker & Van Akkeren, 2003; Fink, 1998; Harrison *et al*., 1997; Igbaris *et al*., 1997; Paul *et al*., 1995; Iacovou *et al*., 1995; Paul *et al*., 1993; Raymond, 1985;). Table 1 illustrates how this paper has defined MSEs.

Mobile Data Technology

Mobile computing and communication devices have radically changed the way organizations conduct their day-to-day business. Increased mobility offers a significant opportunity for businesses, by improving customer service, increasing employee productivity, or allowing for shorter decision approval cycles. In any

Table 1. MSE classifications

Category	Size Definition	Source
Micro Enterprises	1 - 4 employees	(Industry Canada, 2006)
Small Enterprises	5-50 employees	(Industry Canada, 2006; Statistics Canada, 2004; B.-C.-Stats, 2003; Harfield, Driver, & Beukman, 2001; Longenecker et al., 1998; Philp, 1998)

Table 2. Mobile device spectrum

	Price (per month)	Portability (weight in grams and size in centimeters)		Functionality
MDT Basic Basic Cell Phones - a sophisticated radio transceiver used to make phone calls. Basic PDA - a scaled down PC. Basic features include: address book, notepad, appointments diary, calculator and phone list.	$20 - $75	60 – 100 grams	5(w)*10(h)*2(d)	limited
MDT Handhelds Integrated Handhelds - digital wireless devices that can send and receive voice, data and video as well as operate software programs. Able to connect to the internet for e-mail and web access.	$50 - $200	120 – 140 grams	12(w)*7.5(h)*2(d)	Medium
MDT Robust Laptops - a small mobile computer capable of doing the same tasks a desktop computer can do. Tablet PCs - allows the user to write directly on the screen, making it easier for the user to capture, access, and utilize information.	$100 - $500	1.8 – 3.5 kg	30(w)*26(h)*3(d)	High

Table 3. Project chartering phase: Typical activities

Key Activities	
▪ Idea of adopting MDTs surfaced ▪ Business case for investment developed (may be highly informal) ▪ Current state analysis (may be deferred or not done) ▪ Selection of mobile device ▪ Initial plans for how the device will be used, supported, and maintained, upgraded, etc. (may be deferred) ▪ Communication to organization ▪ Organizational changes and/or incentives related to mobile devise and/or organizational performance improvement, if any (may be deferred) ▪ Decision to proceed; approval of MDT adoption plan	**Can you explain how the idea of adopting the MDT was initiated?** ▪ Who initiated it? ▪ Why was it initiated? ▪ When was the idea initiated? **Can you explain how the MDT was evaluated?** ▪ What was the main reason for adopting the MDT? ▪ Was a business case used in the evaluation? ▪ Were any criteria set to help evaluate the device? ▪ What is your level of information technology awareness? ▪ Was the ever changing technological environment evaluated? ▪ Were other additional costs associated with the adoption of the MDT? ▪ Did you test pilot the MDT before the decision was made? ▪ Were plans created to support, train, maintain and upgrade the MDT? ▪ Was there a plan created for how the MDT was going to be rolled out within the organization? ▪ Were the end users consulted about the MDT? ▪ Was there a plan created for how the MDT was going to be communicated to the organization? ▪ When deciding to adopt the MDT's, to what extent would re-engineering have to take place in your work process after the adoption? **Can you explain how the decision to adopt the MDT was approved?** ▪ What was the time period from initiation to evaluation to approval? ▪ How many were involved in making the approval? ▪ Was the MDT approval method the same as other technology acquisitions?

modern business employees routinely require technology to work away from the office and on the move. Leung & Antypas (2001) noted that MDTs can enhance business efficiency by distributing information to the workforce remotely and by offering new channels through which employees can interact with customers and work processes even when they are on the move. Examples could include sales representatives at a client's location or maintenance crews on service calls.

A search through the literature provides only limited results on the definition of Mobile Data Technologies. This is not surprising given the recent emergence of these technologies. Harker & Van Akkeren (2002) describes MDT as being a mobile device, whether it is a mobile phone, PDA, or an integrated handheld that is associated with services. These authors also suggest that MDT 'marries' the two components of mobile phones and e-commerce technologies, hence, helping to eliminate time and distance barriers for organizations. In Computer Associates (2002, p. 2) White Paper mobile devices are defined as "portable electronic components that are used by mobile people to do their work". Schmidt *et al.*(1998, p. 2) defines a handheld computer as "an unobtrusive computing device that is accompanying the user most of the time and provides assistance in different situations and for a wide range of tasks." In this paper we define Mobile Data Technology as an *End user technology which enables the mobility of employees in order to provide functionality for the organization anytime/anywhere.*

An issue that arises in referring to these mobile devices is how to classify the devices into categories. Devices differ in size, weight, performance, storage capacity, display (screen) and input (Keyboard) dimensions, and other so-called cost form-factors (Gebauer & Shaw, 2002). Gebauer & Shaw's propose to position devices along a portability continuum, where portability is determined by the weight and size of a device. We use three evaluation criteria that categorize mobile devices into three groups. The three criteria are as follows: price, portability and functionality. Price is simply defined as the estimated total monthly cost of operating each device. MSEs are price sensitive when adopting new technologies, hence price is our first consideration. Portability is determined by weight and size of the device. Functionality determines the sum of what a product can do for the user (Whatis.com, 2005). Three mobile device categories are thus developed and used in this research are MDT Basic, MDT Handhelds, and MDT Robust. Table 2 highlights how the three evaluation criteria[1] are used to derive the three devices categories.

THEORETICAL FRAMEWORK

The theoretical foundations of this study are based on the process theory approach (Mohr, 1982). Process theories are acclaimed for providing powerful explanations even when strong causal relationships cannot be demonstrated between possible change factors and outcomes. These attributes makes process theories useful to practitioners interested in implementing effective change and to researchers interested in developing comprehensive frameworks of determinants and consequences of innovation adoption.

A common practice in studies using process theory approach is to inductively develop models that identify a set of sequential stages through which organizations pass when implementing change. For example, Soh and Markus (1995) developed a model to explain how investments in information technology, a primary example of discontinuous change, create business value. Their model includes three stages: development, implementation, and ongoing operation. The outcomes of the first stage become the starting conditions for the second stage, and the outcomes of the second stage become the basis for the third stage. Performance in each successive stage is contingent, at least to a degree, on the actions taken in the preceding stage, as well as on the environmental conditions prevailing at the time. Markus and Tanis (2000) extended the Soh and Markus model by adding the fourth stage, dealing with predevelopment activities and by broadening the definition of performance to encompass multiple performance dimensions. We adapt Markus and Tanis's (2000) process theory framework for the purpose of this study and focus on the adoption phase. Markus and Tanis (2000) argue that a business decision to adopt an innovation is not an instantaneous act, rather, it is a process that occurs over time, which can be characterized by key players, typical activities, characteristic problems, appropriate performance metrics, and a range of possible outcomes.

The process model used in this study is a adaptation of the first of four stages (Project Chartering, The Project Configure & Rollout, Shakedown, and Onward and Upward) of Markus and Tanis's (2000) innovation process framework. The focus of this paper is on understanding how MDT adoption decision is initiated, evaluated, and approved in MSEs. Using the typical activities described by Markus and Tanis (2000) in the chartering phase which corresponds to adoption, we illustrate the MDT adoption process as consisting of three prime activities of initiation, evaluation and approval and develop the main investigative questions for this research (Table 3).

3. METHODOLOGY

This paper focuses on empirically exploring the typical activities and issues in the MDT adoption process including *adoption initiation*, *business case development*, *criteria for selection of product,* and *decision to proceed*. Results presented are based on interview data collected from key people responsible for making the MDT

Table 4. Characteristics of respondents (n=33)

	Micro Enterprise	Small Enterprise	*Total*
MDT Basic	6	5	11
MDT Handheld	8	6	14
MDT Robust	3	5	8
Total	17	16	

adoption decision in thirty-three MSEs. Most of the questions asked were open-ended, which helped in soliciting top of the mind concerns and avoiding choice bias. The sample frame used for this study was Canadian MSEs that have already made the decision to adopt an MDT device. The survey instrument was pre-tested with three organizations and did not result in any significant changes.

The respondents represent seven industries. A majority of our respondents (71%) were also the owners of the organization while the rest are at a management level, which is not unusual given the nature of micro organizations. Table 4 describes the characteristics of the survey respondents.

4. FINDINGS AND MANAGEMENT IMPLICATIONS

MDT Adoption Initiation

Adoption initiation is strongly influenced by the expected benefits of technology adoption in medium and large organizations (Kumar *et al.,* 1995). Different organizations may adopt an innovation for entirely different reasons. Recognition of a need or an opportunity may initiate the idea of MDT adoption. In our study respondents were asked about the main reasons which prompted adoption initiation.

Access anywhere/anytime, enhancing productivity, and ability to communicate/online flexibly appeared as the three prime reasons. Access anywhere/anytime was a key driver for more than 63% organizations. Productivity enhancement was an important motivational factor for more than 51% organizations, and more than 30% of the organizations cited ability to communicate and get online as their main reasons (Table 5). Interestingly, about 48% of the MSEs did not consider MDTs they adopted as a productivity increasing technology. Few respondents indicated that they were also motivated by the innovative nature and newness of the devise as a reason for adoption initiation. As one of the respondents commented, "Frankly I went looking for a laptop for productivity enhancement and ended up with a state-of-the-art Tablet PC for innovation. It was also recommended by my niece's husband"

Not surprisingly, 76% owner-managers initiated the idea of MDT adoption. The prime role of owner-manager in making adoption decisions in MSEs has been acknowledged by several studies (Harker & Van Akkeren, 2003; Kumar *et al*., 1995) and we found that the same sentiments were echoed in our study. In most cases, the adoption of an MDT was likely to affect them directly as they were also going to use the MDT and possessed the autonomy to subsequently implement the decision. In other cases the ideas were initiated by end users. Interestingly, the percentage of end user initiated adoptions was less than 25% which may also be a reflection on the centralization of the decision making authority in MSEs with the owner-manager.

There was a large lag between initiation and adoption of devices in many organizations. More than 50% organizations waited 24 months or more before adopting the MDT (Table 6). Some of the respondents attributed this to the reason that some of these devices are expensive to acquire, maintain and support when initially introduced and it made sense for them to wait until the devices were more affordable. The fact that most MSEs have fewer funds for these types of capital purchases than larger organizations may also explain the large time lag. Alternatively, in a few cases, when the owner-managers were interested in reasons like esteem value and innovation they adopted the device in the very first months of its introduction. These owner-managers also indicated a high level of technology awareness.

Table 5. Main reasons for initiating/adopting MDT (n=33)

	Frequency	Percent
Access anywhere/anytime	21	63.6%
Productivity	17	51.5%
Communication/Online	10	30.3%
Innovation and newness	2	6.1%

Table 6. How long ago was the idea initiated before purchased of MDT (n=33)

	Frequency	Percent
In the last 6 months	4	12.1%
More than 6 months and less than 12 months	6	18.2%
More than 12 months and less than 18 months	2	6.1%
More than 18 months and less than 24 months	15	45.5%
More than 24 months and less than 30 months	6	18.2%

MDT Evaluation

Once the idea of MDT adoption is initiated, the next steps in the adoption process are justification, identification of risks, mitigation of risk, evaluation and selection of product, communicating the idea to the organization, and having an initial plan. Markus and Tanis (2000) groups these activities under developing the business case for adoption. Building a business case is the hallmark process in technology adoption decisions of large firms. Business cases are extremely important as they lead to definition of strategic objectives and diagnosis of implementation difficulties. Interestingly, only two (6%) MSEs in our study indicated developing a formal business case for MDT adoption. In most cases (70%), the business case made was informal at best and about 24% of the organizations acknowledged not making a business case at all.

Respondents who prepared an informal business case used a variety of components considered as part of the business case development, which were not documented. More than 53% of the respondents were concerned with the changing technological environment and more than 56% estimated the additional costs associated with the purchase, while the majority of the respondents (76%) consulted the end-users about the adoption.

Some of the components which are common for large organizations were not used by the MSEs. For example, more than 61% of the respondents did not perform a test pilot while about 64% had created no plans to support, maintain, or train their MDT adoption. Almost half of the respondents (48%) had no formal plan to communicate about the MDT adoption to the organization and more than half of the respondents estimated no business re-engineering was required to adopt the MDT. Interestingly, about 35% acknowledged doing some re-engineering post adoption. Major re-engineering was only required in about 14% of the cases.

Most respondents also acknowledged informally evaluating the MDT device. Functionality (70%) and Price (55%) were the most frequently cited criterion for

Table 7. Criteria set to help evaluating the device

	Frequency	Percent
Functionality	20	69.7%
Price	18	54.5%
Portability	9	27.3%
Availability	7	21.2%
Ease of Use	4	12.1%
Quality and Service	4	12.1%
Compatibility with other Devices	2	6.1%

evaluating the mobile device (Table 7). Interestingly, few organizations considered compatibility (6%) with other devices and service quality (12%). This seems to support the view that MSEs are mostly concerned with what a device does and with how much it costs.

Most of the respondents had a high level of IT knowledge. Over 50% of the organizations evaluated the external technology environment and, given that most of the respondents had a high level of IT knowledge, they probably had the capabilities and did this well, even though informally. Although our respondents were not too concerned with test pilots, communications to the organization, maintenance, or roll-out plans, they did make sure that MDT end-users were involved and consulted.

MDT Approval

Project approval was a relatively easy and straightforward exercise, as in more than 44% of the cases one person was involved in the decision-making process. Two people were involved in the approval decision in 27% of the cases, and three or more people were involved in the decision approval in just 29% of the cases.

We asked the respondents about the time lapse between the approval and final purchase. Interestingly, in more than 50% of the cases the final purchase of the device happened within one month of the evaluation (Table 8). One of the owner-managers commented that he is an impulse buyer, and his buying impulse also applies to some of his business technology acquisitions. However, there were an equally large number of cases where the final purchase was delayed due to several reasons. For example, in one case the shipment of the laptops was delayed due to unavailability of the number of pieces required for the model approved. Ultimately, the supplier agreed to provide a higher version at same terms and conditions.

Interestingly, more than 75% of the respondents used the same methodology of approving MDT acquisition as any other types of technology purchases, while only 9% considered this MDT acquisition process more rigorously.

5. CONCLUSIONS

This research is at an exploratory level as not much empirically supported research is available on MDT adoption in MSEs. While it does not produce generalizable results, the reasonably representative sample selected provides valuable insight into the MDT adoption process and documents some critical MDT adoption issues in MSEs. This study bridges the gap in literature with regards to the understanding of MDT adoption in MSEs. The analysis indicated that the adoption process in MSEs is often informal and is significantly influenced in many cases by the owner-manager. The sample studied showed an average time lag of about 24 months or more between when the idea to adopt the device was originated and the adoption decision was made. Evaluation of the adoption decision also was conducted very informally and sometimes not at all. Interestingly, firms did not create a formal business case for adoption which is a regular practice in large organizations.

Business cases are tools that support planning and decision-making (Schmidt, 1999). A good business plan outlines tangible benefits, resources, cost, and risk (Wee, 2000). Respondents did a good job of discussing the MDTs with end-users; this is likely because the organizations were so small that it would be difficult not to discuss the purchase with end-users. Even though the users were contacted, it does not mean that a plan was in place or communicated to support, maintain, and upgrade the MDT post-adoption. The final step, approval, was marked by the lack of a significant time lag, most often taking a month or less. MSEs involved very few people, in most cases two or fewer, in the approval process, and they evaluated this technology acquisition as they would any other.

Table 8. What was the time period from approval to purchase (n=33)

	Frequency	Percent
Right Away	5	15.2 %
Within Two Weeks	8	24.2 %
Within One Month	5	15.2 %
Within Six Months	11	33.3 %
One Year and Greater	4	12.1 %

This study has uncovered a key finding that we feel is pertinent and relevant to the literature: the general absence of a formal business case to evaluate MDTs. This research showed that MSEs generally did not prepare formal business cases and most respondents prepared no businesses case at all.

This research provides a base for further research in focused areas of the adoption process in MSEs. More detailed research can be performed on the need analysis, systems scoping and selection of MDTs, and on the thoroughness of the decision process and its impact on the realization of business benefits. As a high percentage of MSEs are also managed by their owners, we think it would be interesting to explore the affect of ownership structure on MDT adoption in future studies.

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REFERENCES

Amboise, G. D. (1991). *The Canadian Small and Medium-Sized Enterprise*. Halifax, Nova Scotia, CA: The Institute for Research on Public Policy.

Balderson, D., Wesley. (2003). *Canadian Entrepreneurship and Small Business Management*. Toronto, Ontario: McGraw-Hill Ryerson Limited.

Canalys. (2006, July 25). *Smart mobile device market growth remains steady at 55%.* Retrieved Oct. 1, 2006, from http://www.canalys.com/pr/2006/r2006071.htm

Computer Associates. (2002, April 22). *White Paper, Enabling Mobile eBusiness Success*. Retrieved Sept 18, 2004, from http://www3.ca.com/Files/WhitePapers/enabling_mobile_ebiz_wp.pdf

Cragg, P., & King, M. (1993). Small-Firm Computing: Motivators and Inhibitors. *MIS Quarterly, 17*(1), 47-60.

Dankbaar, B. (1998). Technology Management in Technology-Contingent SMEs. *International Journal Technology Management, 15*(1/2), 70-81.

Fink, D. (1998). Guidelines for the Successful Adoption of Information Technology in Small and Medium Enterprises. *International Journal of Information Management, 18*(4), 243-253.

Gebauer, J., & Shaw, M., J. (2002). *A Theory of Task/Technology Fit for Mobile Applications to Support Organizational Processes*. Retrieved July 20, 2004, from http://citebm.business.uiuc.edu/B2Bresearch/TTF-theory.pdf

Harfield, T., Driver, P., & Beukman, C. P. (2001). Managing Conflicting Issues: A Decision-Making Tool for Technology Adoption by VSEs. *Journal of Management Development, 20*(10), 830-841.

Harker, D., & Van Akkeren, J. (2003). Mobile Data Technologies and Small Business Adoption and Diffusion: An Empirical Study of Barriers and Facilitators. In *Mobile Commerce: Technology, Theory and Applications* (pp. 218-244). Hershey: Idea Group Publishing.

Harker, D., & Van Akkeren, J. (2002). Exploring the needs of SMEs for Mobile Data Technologies: The Role of Qualitative Research Techniques. *Qualitative Market Research: An International Journal, 5*(3), 199-209.

Harrison, D. A., Mykytyn, P. P., & Riemenschneider, C. K. (1997). Executive Decisions About Adoption of Information Technology in Small Business: Theory and Empirical Tests. *Information Systems Research, 8*(2), 171-195.

Iacovou, C., Benbassat, I., & Dexter, A. (1995). Electronic Data Interchange and Small Organizations: Adoption and Impact of Technology. *MIS Quarterly, 19*(4), 465-485.

Igbaris, M., Zinatelli, N., Cragg, P., & Cavaye, A., L. M. (1997). Personal Computing Acceptance Factors in Small Firms: A Structural Equation Model. *MIS Quarterly, 21*(3), 279-305.

Industry Canada. (2006). *Key Small Business Statistics*. Retrieved Oct. 1, 2006, from http://strategis.ic.gc.ca/epic/internet/insbrp-rppe.nsf/vwapj/KSBS_July2006_Eng.pdf/$FILE/KSBS_July2006_Eng.pdf#search=%22Key%20Small%20Business%20Statistics%22

Kuan, K. K. Y. & Chau, P. Y. K. (2001). A Perception-Based Model for EDI Adoption in Small Business using a Technology-Organization-Environment Framework, *Information and Management*, 38, 507-521.

Kumar, V., Murphy, S., & Loo, S., (1996). An Investment Decision Process: The Case of Advanced Manufacturing Technologies in Canadian Manufacturing Firms. International Journal of Production, 34(4), 947-958.

Leung, K., & Antypas, J. (2001). Improving Returns on M-Commerce Investments. *Journal of Business Strategy*(September/October), 2.

Longenecker, J., G, Moore, C., W., Petty, J., William, & Donlevy, L., B. (1998). *Small Business Management: An Entrepreneurial Emphasis. Canadian Edition*, Scarborough, Ontario.

Markus, M. L., & Tanis, C. (2000). The Enterprise System Experience: From Adoption to Success. In R. Zmud, W. (Ed.), *Framing the Domains of IT Management: Projecting the Future through the Past* (pp. 173-207): Pineflix Educational Resources Inc.

Philp, N. (1998). The Export Propensity of the Very Small Enterprise (VSE). *International Small Business Journal, 16*(4), 79-93.

Premkumar, G. (2003). A Meta-Analysis of Research on Information Technology Implementation in Small Business. *Journal of Organizational Computing and Electronic Commerce*, 13(2), 91-121.

Raymond, L. (1985). Organizational Characteristics in the Context of Small Business. *MIS Quarterly, 9*(1), 37-52.

Riemenschneider, C. K., Harrison, D. A., & Mykytyn, P. P. (2003). Understanding IT Adoption Decisions in Small Business: Integrating Current Theories. *Information & Management, 40*(4), 269-285.

Schmidt, A., Lauff, M., & Beigl, M. (1998). *Handheld CSCW*. Retrieved Sept 18, 2004, from http://www.teco.edu/hcscw/sub/120.Schmidt/120.Schmidt.pdf

Schmidt, M. (1999). *What's a Business Case?* Retrieved January 12, 2005, from www.solutionmatrix.com

Wee, S. (2000). *Juggling Towards ERP Success: Keep Key Success Factors High*. Retrieved April 20, 2005, from www.erpnews.com/erpnews/erp904/02.thml

Whatis.com. (2005). *Definition of Functionality*. Retrieved March 25, 2005, from http://searchwebservices.techtarget.com/sDefinition/0,,sid26_gci335477,00.html

Yap, C., S., Soh, C., P., P., & Raman, K., S. (1992). Information Systems Success Factors in Small Business. *Omega, 20*(5/6), 597-609.

ENDNOTE

[1] Web sources were used to estimate facts on each device category. It should be noted that these facts change quickly over time. While the format remains useful, the searched facts can soon become outdated.

Indian Agricultural Data Warehouse Design

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ABSTRACT

Data warehouse implementations at the sector levels, especially at the national agricultural level are non-existent. Designing an agricultural data warehouse poses unique and significant challenges because traditionally the collection and dissemination of information have been extremely parochial. Moreover, there has been very little adoption of information technology. Recently the Government of India has embarked on an ambitious project of designing and deploying a data warehouse for the agricultural sector with the intent of using the system for macro level planning decisions. The paper presents some of the design challenges the project has faced and solutions undertaken. It is hoped that the paper will help other such large scale, sector level warehouse designs learn from our experiences.

Keywords: Data warehouse, agriculture, dimensional model, warehouse architecture

INTRODUCTION

Since the 1990s, data warehouses have been an essential information technology strategy component for many medium and large sized, global organizations. Data warehouses provide the basis for management reports, decision support, and sophisticated on-line analytical processing and data mining. A data warehouse is a repository of data that is aggregated and summarized from operational systems to provide decision making support and is subject-oriented, integrated, time-variant, and nonvolatile [7].

Historically, data warehouses have been implemented in banking and financial institutions, retail marketing of consumable and non-consumable goods/services, and telecommunication services. The architectural designs for these types of warehouses are similar with differences usually occurring due to warehouse size and system analysis complexity [9]. A major reason for the similarity in designs of data warehouses across these industries is the ability of each organization to collect data at the finest level of granularity. Another reason for data warehouse similarity is the stability of the organizations and their respective industry sectors.

Data warehouses are often developed to address the business process requirements of a single organization or division. While many unique architectural designs exist across a myriad of companies and industries, these designs all share a common single company or division scope characteristic, and for good reason. Despite the growth in data warehouse development, there is little evidence for warehouses addressing the needs of large holding companies (having multiple organizations) or entire industry sectors and government agencies. Industry sectors and specifically, government agencies have data sources and decision requirements that are significantly different from other firms [6].

The government sector is one area that data warehouse technology can benefit tremendously to support regional, national and global decision making. Of particular interest to this research within the government sector is agriculture. Roughly 70% of the India's population depends on agriculture for its livelihood. Policy decisions within this sector not only directly or indirectly affect its people but also its agri-business industries such as seeds, fertilizers, plant protection, etc. Given the diversity of sources, formats, and subject areas, collecting and integrating such heterogeneous information poses a challenging task for data warehousing. There are few examples of data warehouses at sectoral levels. The earliest development of a sectoral level data warehouse is perhaps by the National Agricultural Statistics Service of the US Department of Agriculture. Their warehouse brought together data from agricultural surveys and census data from ranchers, farmers, agri-businesses, and secondary sources [12]. Another example of a sectoral level data warehouse contains data on pest, pesticides, and meteorological data for the government of Pakistan [13].

While the need for sector level data warehouses for macro economic planning and decision-making has been great, these types of warehouses have been almost non-existent because of the difficulty in coordinating flow and integrating data from the many member organizations. Almost every government sector collects vast quantities of data, but only a fraction of those data are used for planning and decision making. Several factors contribute to this problem; member organizations are often independent, autonomous entities with their own data requirements – namely formats, naming conventions, measurement units, etc. Furthermore, little, if any interaction exists among the different members. Escalating the problems of data integration is that these organizations may collect data at different granular levels. Moreover, many governmental bodies rely on different government, semi-government, non-government and private organizations for data collection, and when the information is collected from one organization's perspective and not from a sector or national perspective, data and systems may exhibit a parochial and protectionist perspective. Therefore, data integration for sector level use becomes a formidable challenge [6].

In this paper we investigate and present the challenges in designing and deploying a data warehouse for the Indian agricultural sector. The observations and classifications made in this research are important at two levels, (1) other sector level organizations may use the information presented to avoid pitfalls when designing data warehouses, and (2) researchers interested in large scale, multi-organizational data warehouses may use the information and actual working data warehouse to direct their research.

AGRICULTURAL SECTOR IN INDIA

Indian agriculture is highly diversified in its climate, soil, horticultural crops, plantation crops, livestock resources, fishery resources, water resources and so on. The diversity of its agricultural sector is a bane and boon to the social, economic, and cultural bases of India's vast population. Moreover, the diversity among resources generates interactions among many different macro and micro factors, and is further complicated with the interdependencies that exist among these. The Indian Council of Agricultural Research, New Delhi under World Bank funded National Agricultural Technology Project has developed a data warehouse for some of these agricultural resources to (1) improve the Indian Council of Agricultural Research's organizational and management system efficiency, (2) enhance scientific research performance and effectiveness to benefit farmers, and (3) encourage farming community participation through innovation and improved technology management. Objectives one and two are being implemented by the Indian Council of Agricultural Research, and objective three is being implemented by the Ministry of Agriculture in 28 districts of seven states. The implementation of the third objective, innovation of information technology, is the impetus for this research, and the Indian Agricultural Statistics Research Institute, New Delhi has been charged with building the data warehouse.

Sources of Information

India is divided into 28 states and six union territories (UT). Each state/UT is further divided into districts (elementary administrative unit) [5]. The district is the basic unit of administration for all purposes. The collection of Indian agricultural information is conducted through multiple organizations throughout the country. There are many national and state level boards and organizations for each agricultural sector. These information collecting agencies operate in the interest of their client organization, often specific to a region or state. Because there are many different data collection agencies and equally diverse resources for which the information is collected, there exists information heterogeneity. This problem is compounded by a lack of common standards applied to data collection. To use the information at the macro planning and decision making level, data must be integrated and aggregated properly [4].

Critical Dimensions

National level planning and decision support processes require access to data on many different resources, such as crops, livestock and fisheries, at varying levels of detail [2]. Information on production (demand and supply), price levels, and population and migration statistics is also expected. Location, Time, and Product are a few of the common dimensions that transcend all warehouse models, but Location and Time pose the biggest problems in integrating data from the varied sources in the agricultural sector. The integration problem may be categorized into one of four common dimensional issues, (1) granularity of Location differs among the different sources, (2) granularity of Time varies among the different sources, (3) several overlapping time domains and (4) aggregation and disaggregation of information at different dimensional hierarchies. These dimensional issues lead to the design the fact table and, therefore, the architecture of the data warehouse.

Location granularity: Similar to sectors such as retail and telecommunications, the agricultural sector uses the Location dimension extensively for its warehouse applications. In the Indian agricultural sector, the Location dimension presents many interesting issues. Location, also known as the Geography dimension, usually has a clearly defined hierarchical structure. In our case this hierarchy is determined by administrative mechanisms and put into effect by the Indian government. Level one is the National level. Level two is State. India is divided into 28 states, often on a linguistic basis. Each State is further divided into Districts (Level three) which may be further divided into Villages (Level four). This level is the lowest that agricultural sector information is collected through agricultural surveys.

Organizations may collect information at any or all levels of the Location hierarchy. Different sample surveys are conducted to acquire production figures of commodities such as fruit crops, plantation crops, etc. at the State level. Statistics of national accounts and different sectors of economy are mostly available at this level. Because each state is somewhat autonomous, the information collected at Level two is very important for state level planning and decision making. Production information is available at the District level for crops, livestock products, fisheries products, land use statistics, etc. Due to its detailed measure of factors, information at this level is very important to planners and decision makers at all levels. The Village level has data such as land use, census data, livestock, and demographic and static parameters such as land ownership and employment. Another Level four attribute is agricultural commodity trades available in Agricultural markets or Mundi (trading place). Price data from many important markets are collected on daily or weekly basis depending on the season of the crop or commodity. Finally, different agro-meteorological stations produce information on climate and weather conditions on a daily basis and form another fourth level hierarchy attribute.

Another challenge presented with the Indian agricultural data warehouse is historical data. Information on production of some commodities is available at the district level, but historical data are only available at the State level. Availability of resources, requisite need for information, and governmental policies present at that time affect the collection at any given level. These resources include human and financial capital and time. The following issues are associated with creation of dimensions in the development of data warehouse:

- The number of levels needed for any location.
- The integration of information coming from different sources (organizations) at different grain levels.
- The definition of fact table for these dimensions.

Aggregation rules to roll up each of the fourth level hierarchy of the Location dimension to the next higher level are different. In the case of villages, it may be a simple aggregation, but in agricultural market where the condition is price, a simple aggregation does not work. Availability of agricultural markets in different states for a commodity depends on its area, production, and consumption.

Integrating information from different sources, especially from various organizational sources, is also a big challenge in the design of the warehouse. Data collection takes place at different levels (e.g. National, State, District) using different methods (e.g. surveys, census, observations) and by different organizations, each with its own formats, procedures, and objectives. Further, definitions, concepts, and purpose are likely to be different for different parameters. Moreover, each source and method contributes to different types of errors. Despite these issues, if information is available at the lower level it is possible to aggregate (roll up) to the higher level. However, when information is only available at a higher level it is very difficult to disaggregate (drill down) to lower level [3, 11]. Most information about agriculture is collected through agricultural surveys or census, which are designed to elicit responses at the National or State level. Regional or lower level estimates can not be obtained from these with reliable precision.

PROTOTYPE

Warehouse Architecture

We propose the use of multiple dimensions to resolve the problems described above. A similar solution is also recommended in click stream data warehouses for enterprise relationship management (eRM) applications [10]. In a click stream data warehouse, the focus is on capturing the mouse clicks, sites and products visited, as well as the time and decisions taken by the consumer. We differ from the click stream warehouse implementation in that we use different fact tables for each type of dimension associated with the Location dimension and its hierarchy. We use the livestock data mart to illustrate our solution.

The data warehouse design employs the Star schema concept in which the central fact table is connected to the dimensions in a star like fashion. The foreign key links from the fact table to the primary keys of the dimension tables yield the star configuration. Each star schema configuration yields a data warehouse cube. Because the software supported only star schema the resulting cubes appear disconnected. Otherwise, they are connected through the respective common dimensions. Integrated livestock surveys are conducted every year for collecting data about the production of livestock products. The Census or complete enumeration for livestock is conducted after every five years. Some of the information in this data mart has been collected only once. Among the data collected, the period over which the data falls differs. Time at which data are collected differ because of the different calendars used. Three calendars, namely Calendar year (January 1 to December 31), agricultural year (July 1 to June 30) or financial year (April 1 to March 31) are employed. Since each time measure is important, it raises the possibility of three independent time hierarchies.

In data warehouse design, fact table grain has to be decided first [8]. In most warehouse designs, the decision is dependent on the level of detail the fact should address, namely, the business process performance measure. Because we do not have all available measures at the lowest level of detail, several fact tables have to be designed. For example, if measures corresponding to the Location dimension are available only at the State level then the grain of the fact table will be fixed at that level. So the granularity of the dimensions will result in many fact tables.

Granularity of Time

Generally, for time dimension in the agricultural sector the lowest grain level is day but many measures are available only at the weekly, monthly, quarterly, and half yearly, or yearly level. Climatic data such as rainfall, humidity, and temperature are available daily. Prices for different commodities and products from different agricultural markets of the country may be available at daily, weekly or monthly for a calendar year. Production measures of food crops, horticultural crops, and plantation crops are always available annually based on the agricultural year. Some of these crops are perennial and others are produced in one, two or three seasons in different parts of the country depending on the climatic, soil and water conditions. Information from human census is available after every ten years while for livestock it is available after every five years. All other socio-economic data are available annually based on the financial year. Keeping in view the above diversified grain level of the time dimension it is a challenging task to develop a data warehouse in

which all these sectors of agriculture are integrated on a common homogeneous platform. The complexity is further raised when availability of information for time levels follows different definitions. In India information about agriculture is available following three definitions of a year as follows:

Calendar Year
Years start from January 1 and ends on December 31. The months are in accord with the Julian calendar months. The first week starts from January 1 irrespective of name of the day and weeks are generated by counting seven days in a week. Last week, 52nd week of the year, consists of eight days to make 365 days in a year. For leap year last week of February consist of eight days.

Agricultural Year
Year starts from July 1 and ends at June 30. The first month of the year is July and the last month of the year is June. Months are assembled similar to the calendar year. The first week of the year will start from July 1 and it will be generated as per the procedure of calendar year. Similarly, first quarter and half year will start from July and generated as per the rule of calendar year.

Financial Year
Year starts from April 1 and ends March 31. The first month of the year is April and last month is March. Months are as per calendar year. The first week of the year will start from April 1 and it will be generated as per the rule of calendar year. Similarly, the first quarter and half year of the year will start from April and generated as per the rule of calendar year.

Because the three types of years have different start and end times, our data warehouse needs three independent hierarchies in the time dimension. The overlapping time periods poses significant difficulties in integrating data from the sources. The following table shows the month number of each year i.e. calendar, agricultural and financial year with respect to the months of calendar year.

Table 1. Time dimension properties

S.No.	Name	Calendar Year Number	Agricultural Year Number	Financial Year Number
1	January	1	7	10
2	February	2	8	11
3	March	3	9	12
4	April	4	10	1
5	May	5	11	2
6	June	6	12	3
7	July	7	1	4
8	August	8	2	5
9	September	9	3	6
10	October	10	4	7
11	November	11	5	8
12	December	12	6	9

Table 2. Time dimension quarterly

S.No.	Starting Month	Ending Month	Calendar year quarter No.	Agricultural Year Quarter No.	Financial year quarter No.
1	January	March	Q1	Q3	Q4
2.	April	June	Q2	Q4	Q1
3.	July	September	Q3	Q1	Q2
4.	October	December	Q4	Q2	Q3

Table 1 shows that integration of the information available at the grain level of months for different year types will not have any problem irrespective of their definitions. Let us consider Table 2 for quarters for each type of year, namely calendar, agricultural and financial year with respect to calendar year:

The integration of the information from different sources at grain level of quarters may not have problems in case of India as the definitions of different year such as calendar, agricultural and financial years are offset from each other by multiples of three months. If the offset is different, as it may be in other countries, it may not be feasible to integrate the information available at the grain levels of quarters for the different year types.

In case the information is available at grain level of half year with respect to any year type, it is possible to integrate the information of the half years of calendar year with half year of the agricultural year because as per the definition, the offset between calendar year and agricultural year is six month. Therefore, the first half year of the calendar year corresponds to the second half of the agricultural year. Any information available at the grain level of half year with respect to financial year may not be integrated with the information of the half year of other two year types.

The information available at the weekly grain level of any type of year may not be integrated between weekly information with any other week of year type. The beginning or the ending of weeks of one-year type does not correspond to the beginning or ending of the weeks of any other year type.

The Current Status of the Project
The data warehouse project was developed with funding from the World Bank and under the National Agricultural Technology Project (NATP) initiative. Several goals and users had been defined for the project. Three types of users were identified for the system. They were (i) research managers, (ii) research scientists, and (iii) general users at IASRI and other research institutes and agencies. At one level, the system was to provide systematic and periodic information about the entire agricultural sector to research scientists, planners, decision makers, and development agencies. At a different level, different users would have the capabilities to use various decision support capabilities through an on-line analytical processing (OLAP) application.

The data warehouse project has been carried out with active collaboration of 13 institutions that operate under Indian Council of Agricultural Research (ICAR), New Delhi. Each of these institutions deals with one or more areas of agriculture. Fifty-nine different databases have been used as source feeds for the data warehouse. The data in these databases are gathered from council and research projects on various agricultural technologies in operation and from published official sources (related agricultural statistics). At a minimum, data from year 1990 onwards, at the district level, are integrated into this system. Many of these databases have statistical information dating to year 1950. In building the central data warehouse, we started by creating subject-oriented data marts and multi-dimensional data cubes. These are published and now available by way of Intranet and Internet access. The validation checks have been put into effect wherever possible.

The data warehouse system also provides spatial analysis of the data with the help of a Geographic Information System (GIS). Data mining and ad-hoc querying are also extended to a small set of users. The web site of the project is already launched (www.inaris.gen.in) and the multidimensional cubes, dynamic reports, GIS maps and information systems are already available to the users.

CONCLUSION

Data warehouses at sector levels are seldom seen. Governments at national and state levels and industry groups and regulatory organizations have begun to realize the potential of integrating data from many sources and using data warehouses to implement such solutions. We have presented here some of the problems that arise in integrating data collected in the Indian agricultural sector. We discuss specific problems associated with granularity of location and time, two key dimensions for an agricultural warehouse. We then present one solution in our prototype using Oracle software.

REFERENCES

1. Agency, A.-A.T.M. NATIONAL AGRICULTURAL TECHNOLOGY PROJECT - NATP, 2001, Describes the NATP project.
2. Azad, A.N., Erdem, A.S. and Saleem, N. A Framework for Realizing the Potential of Information Technology in Developing Countries. International Journal of Commerce & Management, 8 (2). 121-133.
3. Feijoo, S.R., Caro, A.R. and Quintana, D.D. Methods for Quarterly Disaggregation without Indicators; A Comparative Study using Simulation. Computational Statistics and Data Analysis, 43 (1). 63-78.
4. Hollihan, M. The Relationship between Inflation and Relative Prices. Studies in Economics and Finance, 6 (1). 29.
5. India, N.I.C. Districts of India: A Gateway to Districts of India on the web, 2004, Districts of India.
6. Inmon, B. BI in the Government DM Review, 2003, 26-27.
7. Inmon, B. What is a Data Warehouse? PRISM, Prism Solutions, Inc., 1995.
8. Kimball, R., Reeves, L., Ross, M. and Thornthwaite, W. The Data Warehouse Lifecycle Toolkit: Expert Methods for Designing, Developing, and Deploying Data Warehouses. John Wiley & Sons, 1998.
9. Lou, A. Data Warehouse Size Depends on the Size of the Business Problem DM Review, 2003, 16.
10. Sweiger, M., Madsen, M.R., Langston, J. and Lombard, H. Clickstream Data Warehousing. John Wiley & Sons, 2002.
11. Waichler, S.R. and Wigmosta Development of Hourly Meterological Values from Daily Data and Significance to Hydrological Modeling at H. J. Andrews Experimental Forest. Journal of Hydrometerology, 4 (2). 13.
12. Yost, Mickey, "Data Warehousing and Decision Support at the National Agricultural

Statistics Service, United States Department of Agriculture," www.advance-datatools.com/BrioUserGroup/mtg200404/3_pillars2.pdf, accessed August, 10, 2005.

13. Abdullah, A, Brobst, B., Umer, U, " The Case for an Agri Data Warehouse: Enabling Analytical Exploration of Integrated Agricultural Data," in Proceedings of IASTED International Conference on Databases and Applications, Innsbruck, Austria, Feb. 2004.

Figure 1. Yearly animal population mart

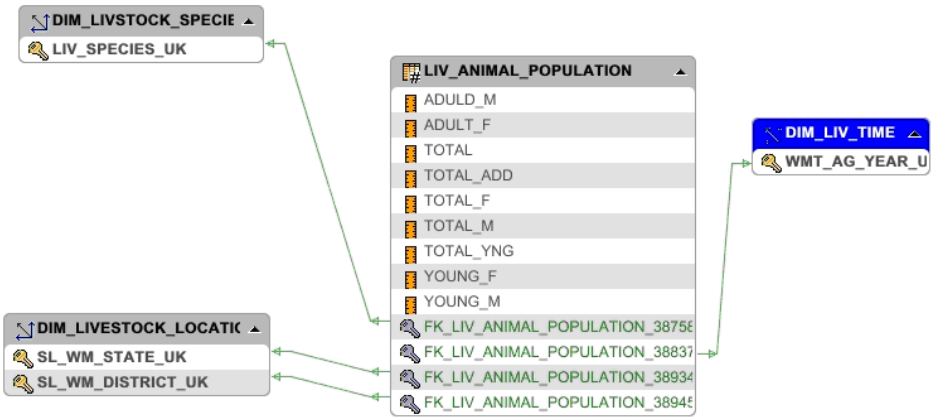
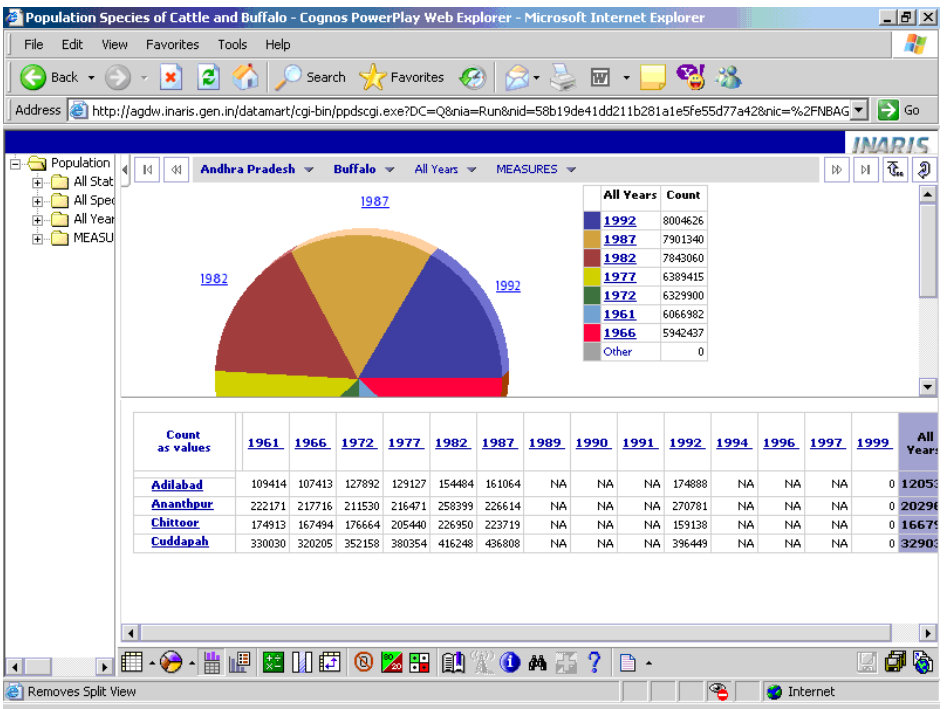


Figure 2. Graphical representation of buffalo over time



Towards a Framework of Biometric Exam Authentication in E-Learning Environments

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ABSTRACT

In the past fifteen years the use of Internet technologies has been substantially growing for delivery of educational content. E-learning environments have been incorporated in many universities for the delivery of e-learning courses. However, opponents of e-learning claim that a central disadvantage of such teaching medium is the growing unethical conduct in such environments. In particular, opponents of e-learning argue that the inability to authenticate exam takers is a major challenge of e-learning environments. As a result, some institutions proposed to take extreme measures including asking students to take exams in proctor centers or even abandon completely the offering of e-learning courses in their institutions. This paper attempts to address this important problem by proposing a theoretical framework that incorporates available fingerprint biometric authentication technologies in conjunction with e-learning environments to curb unethical conduct during e-learning exam taking. The proposed framework suggests practical solution that can incorporate a random fingerprint biometric user authentication during exam taking in e-learning courses. Doing so is hypothesized to curb exam cheating in e-learning environments. Discussions on future research and possible implications of the proposed theoretical framework for practice are provided.

Keywords: E-learning Environments, Biometric Systems, Unethical Conduct, Academic Misconduct, Online Exam Security, Secured Exam Submission.

1. INTRODUCTION

This paper proposed a theoretical framework for fingerprint biometrics authentication of exam takers in e-learning environments. The following section provides literature review on the increase use of e-learning environments in higher educational institutions. Additionally, the subsequent section provides a review of literature on issues related to unethical conduct in educational settings and in e-learning environments. The subsequent section provides a review of literature related to security issues in e-learning environments, biometric solutions and fingerprints biometric solutions. Subsequent section suggests the theoretical framework combining existing technologies into electronic exams (e-exams). The final section addresses the conclusions with expected contribution of the proposed framework, review of some observed limitations of the proposed theoretical framework, and proposed future research.

2. THEORETICAL BACKGROUND

2.1 E-Learning and E-Learning Environments

Teaching via the Internet has become a popular choice for academic institutions as well as business organizations (Hiltz & Turoff, 2005). Advances in information systems have enabled educational institutions to implement electronic learning (e-learning) systems as a teaching environment (Alavi & Leidner, 2001). Furthermore, e-learning has become a powerful medium for academic institutions and corporate training due to the incorporation of cutting edge technologies. Hiltz and Turoff (2005) have commented that e-learning is "the latest of social technologies that ... has improved distance learning" (p. 59).

The spectacular growth in e-learning in the past decade has been documented in numerous studies. The U.S. National Center for Education Statistics (NCES) reported that "56 percent of all 2-year and 4-year degree-granting institutions offered distance education courses…during 2000–2001 academic year" (US NCES, 2005, p. 3). The dramatic growth in distance and e-learning is evident in the number of institutions that offer e-learning. US NCES reported that "undergraduate level online courses were offered at 48 percent of all institutions while graduate level online courses were at 22 percent of all institutions" (p. 3). Among these institutions, e-learning courses and video technology were the most common kinds of instruction delivery systems. NCES reported that 90% of institutions employed e-learning courses using asynchronous communication systems. While, only 43% of institutions employed synchronous communication systems for the delivery of e-learning courses (US NCES, 2005).

Gunasekaran, McNeil, and Shaul (2002) described the growth in e-learning as the "new dynamic learning models…and is leading the [academic] market to a significant paradigm and cultural change" (p. 45). Courses and entire degree programs are delivered via the Web anywhere at anytime. In addition, e-learning courses are offered by private, public as well as corporate universities. As a result, new resources such as e-books, books on CD-ROMs and e-exams have been adapted to e-learning courses. Students' enrollment in e-learning courses has proliferated reaching more than three million students in the U.S. in 2005 (US NCES, 2005). About 82% of those online students were enrolled in undergraduate level courses during the year 2000-2001 (US NCES, 2005). As a result numerous academic institutions are planning to increase the number of e-learning courses to meet the growth in this demand. However, security issues related to e-learning systems have been raised by several scholars (Ramim & Levy, 2006). Moreover, opponents of e-learning argue that the inability to authenticate exams takers is one of the major challenges of e-learning medium. Although there is a major growth in e-learning programs, some institutions proposed to take extreme measures including asking e-learning students to take exams in proctor centers (Gunasekaran et al., 2002). However, this requirement may not be feasible for e-learning programs with students in remote locations or under various circumstances such as students who are in military service in remote or combat areas, students with severe disabilities, and working professionals. In order to protect the integrity of exams in e-learning environments, solutions for such a significant problem are warranted.

2.2 Unethical Conduct in E-Learning

Given the development of technologies and the demonstrated growth of e-learning usage in academia, students' unethical conduct in e-learning has become a major concern (Kennedy Nowak, Raghuraman, Thomas, & Dacis, 2000). Pillsbury (2004) argues that students' unethical conduct has intensified as a result of the use of technology and the Internet. Most administrators and instructors focus on one type of unethical conduct, namely plagiarism (Naude & Hörne, 2006). However, students' unethical conduct encompasses a wide array of behaviors including technology enabled behaviors such as cheating during an exam by using technology devices (i.e. PDA, calculator, and cellular phone), engaging in online collaboration when it's forbidden (i.e. groupware like Instant Messenger services, chats, forums, and newsgroups), and deceiving (i.e. logging with another student's username/password). These unethical technology enabled conducts are often undetected by instructors in e-learning courses. Moreover, numerous researchers admit that most e-learning programs adopt policies and practices from traditional learning programs and ignore the technology related issues (Kennedy et al., 2000;

McCabe, 2003; Gunasekaran et al., 2002). Pillsbury (2004) noted a number of Web enabled detection mechanisms such as turnitin.com™ that are available to curb plagiarism. Though, extensive body of knowledge is available on plagiarism detections (Decoo, 2002; Hamilton, 2003; Hannabuss, 2001; McLafferty & Foust, 2004), very little attention has been given to providing solutions to other students' unethical conduct such as cheating on exams in e-learning courses. Pillsbury (2004) noted that detection mechanisms for unethical conduct are necessary not only in the initial portal access. Moreover, additional mechanisms are necessary to authenticate users' access in various e-learning course activities (Newton, 2003). For example, instructors attempt to verify that e-exam submission is truly performed by a given student rather than another one.

According to the Center for Academic Integrity (2005), cheating on exams has been reported at an alarming range of 74%. McCabe and Trevino (1996) reported that 70% of students in their study confessed to cheating on multiple exams. A study by Pincus and Schmelkin (2003) compared faculty members' perceptions on various students' unethical conducts seriousness. They concluded that students' unethical conduct related to exam taking perceived by faculty to be one of the most serious unethical behaviors (Pincus & Schmelkin, 2003). Similarly, Dick et al. (2002) also noted that 24% their study participants believed that "advances on technology have lead … to increase cheating" (p. 173). The perceived seriousness of cheating on exams has led numerous academic institutions to reduce their e-learning course offering and in other instances, cease e-learning altogether. In fact, Gunasekaran et al. (2002) admitted that the inadequate technology has led some academic institutions to cease offering e-learning courses due to concerns over the quality of students' assessment and standards. Thus, the central aim of this paper is to propose a conceptual level security solution for this out-braking phenomenon by suggesting a theoretical framework of biometrics authentication to secure e-exams.

2.3 Security in E-Learning

Given the importance of e-learning environments for academic institutions, security related challenges of such environments are capturing the attention of program administrators. Ramim and Levy (2006) discussed a case study of an academic institution that faced a tragic cyber attach to their e-learning environment by an insider intruder. Other scholars have documented related security problems in academic institutions. Yu and Tsao (2003) discussed security challenges of e-learning environments. However, their exploration focused on shielding the technology infrastructure against unauthorized users. Current security practices in e-learning systems relay principally on the utilization of passwords authentication mechanisms. Similarly, Huang, Yen, Lin, and Huang (2004) discussed aspects of security in e-learning systems and suggested attention to two layers when securing e-learning systems. The first layer addresses security of the technology infrastructure used to facilitate e-learning (i.e. hardware, networks, etc.) and the second layer addresses the various applications employed in enabling e-learning (i.e. learning management systems, rich media communication tools, etc.). Huang et al. (2004) criticized existing proprietary e-learning systems for not paying enough attention to the issue of properly authenticating students, in particular during quizzes and exams. Hugl (2005) noted numerous security related technologies that are not currently employed in e-learning. One such solution can include biometric technologies that may potentially become an integral part of e-learning systems.

2.4 Biometric Solutions

According to Tabitha, Pirim, Boswell, Reithel, and Barkhi (2006) *biometric* is defined as "the application of computational methods to biological features, especially with regard to the study of unique biological characteristics of humans" (p. 3). Such unique biological characteristics relies on individual humane identities such as DNA, voice, retinal and iris, fingerprints, facial images, hand prints, or other unique biological characteristics. Tabitha et al. (2006) note that *biometric* is "a method of identification that has been growing in popularity" (p. 2). Moreover, Pons (2006) notes that *biometric devices* are technological devices that utilize an individual's unique physical or behavioral characteristic to identify and authenticate the individual precisely. Essentially, biometric technologies operate by scanning a biological characteristic and matching it with the stored data. Jain, Hong, and Pankanti (2000) note that a biometric system is "essentially a pattern recognition system that makes a personal identification by establishing the authenticity of a specific physiological or behavioral characteristic possessed by the user" (p. 92).

Coventry, De Angeli, and Johnson (2003) discussed the usability aspect of authentication systems and noted that it is a "tradeoff between usability, memorability and security." (p. 153). Additionally, they note that in order to increase security, traditional PINs and password authentication methods are regularly "increasing their length, ensuring they do not form words and ensuring all are different, makes them more difficult to remember and error-prone" (Coventry et al., 2003, p. 153). Similarly to other scholars such as Jain et al. (2000), Pons (2006) and Tabitha et al. (2006), Coventry et al. (2003) maintained that most biometric systems include a digital identifier, a template and a recognition algorithm and they follow similar matching processes. However, they maintained that biometric systems can be separated into physiological biometric (i.e. finger, iris) as well as behavioral biometric (i.e. voice, key board typing behavior). Biometric systems performance can be assessed by employing statistical methods in which accuracy is calculated. Although biometric systems are relatively reliable, Coventry et al. (2003) asserted that system malfunction stems from users' lack of establishing the biometric during the initial stage as well as potential interruptions during transmission of the biometric image in the validation process. Subsequently, they concluded that although the trade off between security and usability aspects remains, biometric systems can facilitate automatic verification for public environments.

Pons (2006) maintained that fingerprints biometric scans are the most commonly used biometric solution as they are less expansive compared with other biometric solutions. According to Jain et al. (2000), a fingerprint is a unique "pattern of ridges and furrows on the surface of a fingertip, the formation of which is determined during the fetal period" (p. 95). Fingerprints are unique for each individual, where even identical twins have different fingerprints (Jain et al., 2000). Several scholars documented the increase popularity of fingerprint biometric-based systems and their decline in costs (Jain et al., 2006; James et al., 2006; Pons, 2006). For example, fingerprints systems are currently used in the Disney® parks and appear to be useful for its high volume traffic and low price authentication. Full hand fingerprint is also used by the U.S. immigration services. Similarly, fingerprints can be used for authenticating students' submissions of exams via the use of biometric devices. Furthermore, Williams (2002) pointed out that fingerprints have been universally acceptable in the legal system worldwide. Fingerprints are a permanent attribute unique to an individual. Fingerprints can be scanned, transmitted and matched with the aid of a simple device. McGinity (2005) pointed out that biometric have been commonly employed in replacing conventional password systems. She cited examples of ISPs that provide fingerprints based biometric for a small monthly fee (i.e. AOL charges $2 per month). Biometric devices enable portable scanning and rapid identification. Thus, finger biometric can be a suitable solution for rapid authentication of users. Using a portable device, users can scan their fingerprints and send a print image via the Internet to the University's network. The network will consist of an authentication server that will house a database of students' fingerprints images. The server will than process the matching of the transmitted print image with a stored copy of the fingerprint (called "template"). Following that, the server will generate a matching result. Thus, McGinity predicted that fingerprints based biometric would become a household activity in the near future.

Yang and Verbauwhede (2003) proposed a secured technique for matching fingerprints in a biometric system. Similarly to McGinity (2005), they argued that biometric systems enhance security far more than the current systems. Biometric systems are more accurate as well as simpler to operate compared with passwords systems. Yang and Verbauwhede (2003) described a fingerprint based biometric system in which the fingerprint template is kept in a server during initiation. Upon scanning the finger, an input device scans a biometric signal and transmits it to a server where it is processed for matching. In an effort to shield the system against security compromises, they recommended processing the matching of fingerprints images in an embedded device rather than the server and only transmitting the results to the servers. Furthermore, they suggested encrypting the fingerprint template prior to storing it on the server. Fingerprints templates can be decrypted whenever a matching process occurs. Yang and Verbauwhede (2003) provided additional solutions useful for building up multiple layers of security in fingerprint based biometric systems.

2.4.1 Fingerprint Biometric Solutions

In the past decade the price of biometric authentication devices has been falling (Pons, 2006). Currently there are low cost solutions for biometrics authentication via fingerprint recognition. For example, Figure 1 provides an image of a biometrics mouse by JayPeetek Inc. called Scan.U.Match™. This devise is part of a package of fingerprint authentication mechanism. The mouse is about the same

Figure 1. JayPeetek Inc.'s Scan.U.Match™ Fingerprint Biometric Authentication Mouse[1]

Figure 2. JayPeetek Inc.'s Biometric Authentication Server, the Authenteon™ Server[2]

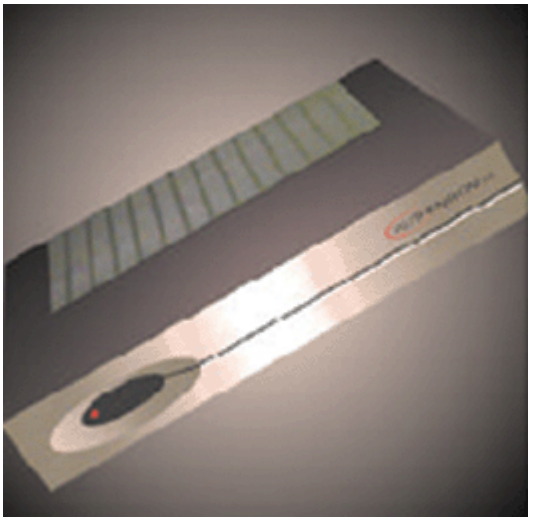


Figure 3. SecuGen®'s Keyboard III™ with fingerprint pad scanners[3]

Figure 4. onClick®'s PCMCIA FingerPrint™ Reader[4]

Figure 5. Sony®'s Puppy® Fingerprint Identity Token by Corp[5]

size as standard mouse, however, it also has an integrated fingerprint scanner that is managed by client side software and controlled by server side software centralized on an authentication server. Figure 2 provides an image of Authenteon™, a biometrics authentication server. JayPeetek Inc. claims that their patented Scan.U.Match™ biometrics mouse solution is unique as it "does not capture the finger image and scrambles the algorithm at the point of scan", rather it "creates a 500 byte secure template that cannot be replicated into a user fingerprint" (JayPeetek Inc.). As such, the Scan.U.Match™ is claimed to be highly reliable with "false rejection rate" that is only 0.01%, or 1 out of 100,000 cases.

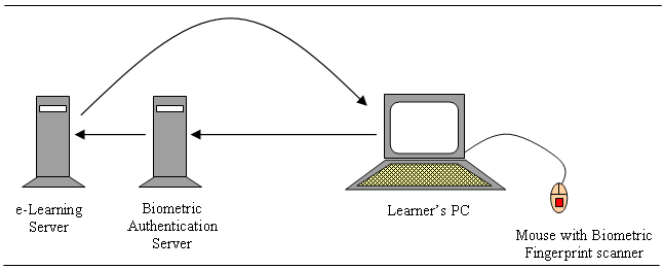
There are numerous other vendors that offer similar solutions in attractive prices. Examples of some of the other vendors include SecuGen® Biometrics Solutions (2005) with their OptiMouse III™, onClick® Corp. (2005) with their VIA™ solution, to name a few.

Aside from the biometrics fingerprint mouse solutions, there are other biometrics fingerprint solutions including keyboard with fingerprint pad scanner (See Figure 3), PCMCIA fingerprint scanner (See Figure 4), and USB fingerprint token scanners (See Figure 5).

3. PROPOSED METHODOLOGY AND DATA COLLECTION

The proposed theoretical framework that this work focuses on is to incorporate biometric fingerprint solutions for user authentication during e-exams. Figure 6 demonstrate the proposed conceptual solution. In standard e-exam, the learner's access is authenticated once by the e-learning server at login for the entire duration of the activity session, while the repeated authentication performed is based on the password cashed in the browser. As such, students are able to login to the e-learning server and have someone else take the e-exam on their behalf. The proposed solution will enhance the current authentication process by adding the fingerprint biometrics solution. For example, in WebCT, during e-exam a random fingerprint authentication can occur to validate the e-exam taker. Although not a foolproof approach, requiring the fingerprint authentication of the learner randomly during

Figure 6. Proposed fingerprint biometric solution for e-exam user's authentication



e-exam with required very short fingerprint scanning response time should provide additional added security. It may discourage learners from having someone else take the e-exam for them. Therefore, the central claim of this proposed approach is that the incorporation of fingerprint biometrics solution in conjunction with e-learning environments will enable a reduction in exam cheating.

5. CONCLUSION AND RECOMMENDATIONS FOR FUTURE RESEARCH

Unethical conduct, in particular cheating in e-exams was documented in literature as a growing concern by many higher educational institutions. The proposed theoretical framework suggested above is unique as it proposed a biometric solution for exam taking in e-learning environments. This theoretical framework may add to the general knowledge of e-learning environments by addressing a major issue of e-exam cheating. Future work in this line of research should incorporate this theoretical approach and conduct a study on the incorporation of biometric solutions in e-exams. One example of a study may include comparison of the same instructor teaching two e-learning sections of the same course, where one section will use regular e-exams and the other section will use the fingerprint biometric approach proposed. The study can propose that:

Proposition 1: Students taking e-exams using the fingerprints biometric solution will have lower grades on the e-exam than their counterparts.

Proposition 2: Students taking e-exams using the fingerprints biometric solution will take longer time to complete their e-exam than their counterparts.

Results of such study can provide initial investigation in an attempt to address the outgrowing phenomena of unethical conduct in e-learning exam taking. If results of this propose study will show that the group of learners who took the exams using the fingerprints biometric solution will have lower grades and take longer time to complete their exam, thus, have a lower cheating rate. Having such results will allow suggesting the proposed framework for higher educational institutions to incorporate it in order to reduce cheating in online exam taking.

Future investigation should be performed by implementing the proposed framework and conducting the experiment proposed above. Additional research can be conducted on the incorporation of biometric solutions to address other academic misconduct behaviors in e-learning environments. However, researchers must be aware of the limitations associated with the theoretical framework proposed here. The first observed limitation deals with the fact that in a remote setting, students may ask to have a subject matter expert seat next to them while they take the exam. The current proposed framework is overlooking this possibility and additional work to address such unethical behavior is warranted. The second observed limitation of the proposed framework is the funding the costs associated with implementing such study in an experimental basis, let alone in a large scale e-learning program. Additional work is needed in exploring the costs and funding sources needed to provide the technological and implementation aspect of this framework. A third observed limitation is related to individual perceptions on the use of biometric systems. For example, Alterman (2003) note several perceived ethical issue with biometric systems, while Tabitha et al. (2006) document a study on the acceptance of such system by individuals. Future research is warranted to further explore issues related to the ethical and acceptance of biometric systems in the context of e-learning.

REFERENCES

Alavi, M., & Leidner, D. (2001). Research commentary: Technology mediated learning-a call for greater depth and breadth of research. *Information Systems Research, 12*(1), 1-10.

Alterman, A. (2003). ''A piece of yourself'': Ethical issues in biometric identification. *Ethics and Information Technology, 5*(3), 139-150.

Center for Academic Integrity (2005). Retrieved September 12, 2006, from http://www.academicintegrity.org/cai_research.asp

Coventry, L., De Angeli, A., & Johnson, G. (2003). Usability of large scale public systems: Usability and biometric verification at the ATM interface. *Proceedings of the Conference on Human Factors in Computing Systems.* Florida, USA, 153-160.

Decoo, W. (2002). *Crisis on campus: confronting academic misconduct*. Cambridge, MA: MIT Press.

Dick, M., Sheard, J., Bareiss, C., Carter, J., Joyce, D., Harding, T., & Laxer, C. (2002). Reports from ITiCSE on innovation and technology in computer science education. *ACM SIGCSE bulletin working group, 35*(2), 172-184.

Gunasekaran, A., McNeil, R. D., & Shaul, D. (2002). E-learning: Research and applications. *Industrial and Commercial Training, 34*(2), 44-54.

Hamilton, D. (2003). Plagiarism: Librarians help provide new solutions to an old problem. *Searcher, 11*(4), 26-29.

Hannabuss, S. (2001). Issues of plagiarism. *Library Management, 22*(6/7), 311-319.

Hiltz, S. R., & Turoff, M. (2005). Education goes digital: The evolution of online learning and the revolution in higher education. *Communication of ACM, 48*(10), 59-64.

Huang, W., Yen, D. C., Lin, Z. X., & Huang, J. H. (2004). How to compete in a global education market effectively: A conceptual framework for designing a next generation eEducation system. *Journal of Global Information Management, 12*(2), 84-107.

Hugl, U. (2005). Tech-developments and possible influences on learning processes and functioning in the future. *Journal of American Academy of Business, 6*(2), 250-256.

Jain, A., Hong, L., & Pankanti, S. (2000). Biometric identification. *Communications of the ACM, 43*(2), 91–98.

JayPeetek Inc. (2005). *Scan.U.Match Biometric Authentication System embedded in a mouse*. Retrieved September 12, 2006, from http://www.jaypeetex.com/products/Biometrics/Fingerprints/Scanumatch.htm

Kennedy, K., Nowak, S., Raghuraman, R., Thomas, J., & Dacis, S. (2000). Academic dishonesty and distance learning: student and faculty views. *College Student Journal, 34*(2), 309-315.

McCabe, D. L. (2003, Sep 10). Caught copying: electronic plagiarism is a new addition to the IT lexicon. *Businessline*, 1-3.

McCabe, D. L., & Trevino, L. K. (1996). What we know about cheating in college. *Change, 28*(1), 28-34.

McLafferty, C. L., & Foust, K. M. (2004). Electronic plagiarism as a college instructor's nightmare-prevention and detection: Cyber dimensions. *Journal of Education for Business, 79*(3), 186-190.

McGinity, M. (2005). Staying connected: Let your fingers do the talking. *Communications of the ACM, 48*(1), 21-23.

Naude, E., & Hörne, T. (2006). Cheating or collaborative work: Does it pay? *Issues in Informing Science and Information Technology, 3*, 459-466.

Newton, R. (2003). Staff attitudes to the development and delivery of e-learning. *New Library World, 104*(10), 412-426.

onClick® Corp. (2005). Retrieved September 12, 2006, from http://www.onclickbiometrics.com/

Pillsbury, C. (2004). Reflections on academic misconduct: An investigating officer's experiences and ethics supplements. *Journal of American Academy of Business, 5*(1/2), 446-454.

Pincus, H. S., & Schmelkin, L. P. (2003). Faculty perceptions of academic dishonesty: A multidimensional scaling analysis. *Journal of Higher Education, 74*, 196-209.

Pons, A. P. (2006). Biometric marketing :targeting the online consumer. *Communications of the ACM, 49*(8), 60-65.

Ramim, M., & Levy, Y. (2006). Securing e-learning systems: A case of insider cyber attacks and novice IT management in a small university. *Journal of Cases on Information Technology, 8*(4), 24-34.

SecuGen® Biometric Solutions (2005). Retrieved September 12, 2006, from http://www.secugen.com/

Tabitha J., Pirim, T., Boswell, K., Reithel, B, & Barkhi, R. (2006). Determining the intention to use biometric devices: an application and extension of the technology acceptance model. *Journal of Organizational and End User Computing, 18*(3), 1-25.

United States Department of Education, National Center of Educational Statistics (NCES) (2005). *Mini-digest of educational statistics*. Retrieved September 20, 2006, from http://nces.ed.gov/pubs2005/2005017.pdf

Williams, J. M. (2002). New security paradigms. *Proceedings of the 2002 Workshop on New Security Paradigms*, Virginia Beach, Virginia, 97-107.

Yang, S., & Verbauwhede, I. M. (2003). A secure fingerprint matching technique. *Proceedings of the 2003 ACM SIGMM workshop on Biometrics methods and applications*, California, USA 89-94.

Yu, C., & Tsao, C. C. (2003). Web teaching: Design, security, and legal issues. *Delta Pi Epsilon Journal, 45*(3), 191-203.

ENDNOTE

1 Source: http://www.jaypeetex.com/products/Biometrics/Fingerprints/Scanumatch.htm

2 Source: http://www.jaypeetex.com/products/Biometrics/Fingerprints/Authenteon.htm

3 Source: http://www.secugen.com/products/pk.htm

4 Source: http://www.onclickbiometrics.com/ebusiness/ocbioweb.nsf/wcontent/productsviacard?opendocument

5 Source: http://bssc.sel.sony.com/Professional/puppy/products.html

Examining Instructional Interaction and Student Persistence in Online Education

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ABSTRACT

Student dropout from online courses is often identified as a major problem in higher education. This study examines how online classroom communication factors impact a student's decision to persist in or dropout of an online course. A survey research methodology was used to examine the relationship between instructional interaction and student persistence among adult students in online courses. The results indicate that student perceptions regarding the contribution of asynchronous discussion forum use combined with frequent use of asynchronous discussion account for 26% of the variance in course persistence rates.

INTRODUCTION

As institutions of higher education launch or expand online course offerings, it is important to identify strategies and techniques that promote student participation in online courses and programs. One obstacle to student success in online courses is student dropout, a failure of students to complete a course and/or program of study. Research suggests that online courses have significantly higher dropout rates than face-to-face courses (Levy, 2005; Simpson, 2004). While numerous factors contribute to a student's decision to withdraw from an online course (McGivney, 2004; Simpson, 2003; Willging & Johnson, 2004) researchers have identified student satisfaction as one correlate of dropout in online education (Jun, 2005; Levy, 2005). More recently, researchers have identified a clear relationship between faculty interaction and student perceptions of learning and student satisfaction in online courses (Jiang & Ting, 2000; Roblyer & Wiencke, 2004; Swan, et. al., 2000; Shea, et. al., 2001). This research study examined the relationship between instructional interaction, student satisfaction and student persistence in online courses.

Interaction in Online Education

Instructional interaction between student and teacher is a critical aspect of this study. Moore (1989) identifies three types of interaction in distance education: learner-content, learner-instructor and learner-learner. Kearsley (2000) suggests a distinction must be made between immediate (synchronous) interaction and delayed (asynchronous) interaction. This distinction regarding the method of interaction is important since it affects the provision of feedback to the learner, a concept that many have identified as critical to the learning process (Freedman et. al., 2003; Smith and Dillon, 1999). For the purposes of this study, instructional interaction is defined as directed communication regarding course content and topics between the instructor and students or among students in the online course (Kearsley; Wagner, 1994).

A defining characteristic of online education is computer-mediated communication (CMC). CMC provides students and teacher with two-way communication methods based on the electronic transmission of text, images and more recently, audio and video data. CMC uses email, chat, discussion forums and other computer conferencing systems to facilitate communication between students and teachers and among students (Kearsley, 2000; Turoff & Hiltz, 1995). Communication methods that support synchronous interaction (e.g. text-chat, audio-chat, desktop video conferencing) can provide immediate feedback to learners, a feature that may serve to motivate some learners. Technologies that support asynchronous interaction (e.g., email, discussion forums) can provide the learner with more control over where and when the instructional interaction occurs as well as provide the learner with more time to reflect on and respond to course content and communications (Collison, et. al., 2000; Kearsley, 2000; Salmon, 2000).

Relationship Between Interaction and Persistence

The importance of interaction between students and teacher in supporting positive learner outcomes among face-to-face undergraduate students is well documented. Numerous studies have found that the frequency and content of formal and informal interaction between instructors and undergraduate students in face-to-face courses are correlated to gains in student achievement (Kuh & Hu, 2001; Pascarella & Terenzini, 1991), student persistence (Pascarella & Terenzini) and degree completion (Tinto, 1987). More recently, a number of researchers examining online college students have found a positive relationship between instructor interaction and perceived student learning (Arbaugh, 2005; Shea et. al., 2001), student satisfaction (Arbaugh; Shea et. al.) and student ratings of online course effectiveness (Hay et. al., 2004).

Student persistence addresses a student's commitment to complete a course and program of study. Persistence is considered a positive outcome measure as compared to dropout, which is the negative equivalent outcome (Ormond, 2003). Much of the literature on persistence and dropout draws it theoretical framework from the research conducted by Vincent Tinto. Tinto's model of college student dropout suggests that persistence is an outcome of the student's academic and social integration into that institution's community (Tinto, 1987). While Tinto's research was conducted primarily on undergraduate students in residential four-year colleges and universities, later researchers applied a similar theoretical framework to different student groups including undergraduate commuter students (Pascarella & Chapman, 1983), undergraduate students enrolled in correspondence courses (Sweet, 1986), distance learners enrolled in video-based college courses (Towles, et. al., 1993) and online college students (Willging & Johnson, 2004). These studies suggest that Tinto's model of college student dropout provides a framework for understanding the relationship between student-faculty interaction and student persistence in environments beyond those examined by Tinto.

METHOD

Research Questions

A quantitative research study was conducted which examined the relationship between instructional interaction and student persistence in online education. Specifically, this non-experimental, correlational study asked:

1. Is there a relationship between the frequency of instructional interaction and levels of student persistence in online courses?
2. Is there a relationship between the method of instructional interaction and student persistence in online courses?
3. Do other variables emerge as correlates of persistence among students in online courses?

This study utilized a survey research methodology and records review to investigate the relationship between instructional interaction and student persistence in online courses.

Participants

The online learning program that participated in this study is operated by a public university located in New England. Online programs offered by the university include education, engineering, management, information science, liberal arts and health professions at the undergraduate and graduate level. The online program enrolled 7300 students in 375 course sections during the 2004 – 2005 academic year.

The online program uses a course management system (CMS) for the development and teaching of online courses. The CMS allows faculty to develop course materials that are then accessed by students online via a web browser. All faculty teaching in the online program participate in a training program that introduces online pedagogy and instructs faculty in how to use the CMS to develop and teach an online course. The CMS used by the program supports both asynchronous and synchronous communication methods. These methods include synchronous text-based chat, asynchronous text-based discussion forums and asynchronous email lists.

Sample

The population for this study included 1569 undergraduate and 51 graduate students enrolled in 76 online courses offered in the fall semester by the continuing education division of a public university. The unit of analysis for this study was the individual online course. Criteria for selection included:

1. The instructor agreed to allow presentation of survey tool to all students in the course.
2. The instructor agreed to allow researcher to review course communications.

Participating courses included all of the disciplines offered online by the program at the time of the study.

Response Rates

Survey data was collected at an individual student level, response rates were calculated and the percentage of students completing the survey data for each course ultimately determined whether course-level data was included in the study. A total of 714 student online surveys were returned for the 52 courses that met the participation criteria, representing an overall 64.0% response rate. Courses that met the response rate criteria closely reflected the distribution of disciplines in the overall online program and included four graduate and 48 undergraduate courses.

Instrumentation

This study utilized a survey research methodology to collect data regarding instructional interaction in online courses and student attitudes to their online course experience. An online survey was developed to collect data regarding the online course experience of students who maintained enrollment in their online course through the 14-week semester (http://frontpage.uml.edu/faculty/stello/survey.htm). This 37-item survey collected data regarding: (a) student demographics and characteristics, (b) the frequency of interaction in each online course, (c) the method of interaction in each online course, (d) student attitudes toward interaction, (e) student attitudes toward the courses, and (f) the contribution of interaction methods to the students' course experience.

During the 3-week survey period, students were presented with the option of completing an online survey for each registered online course. Individual student responses were used to create per course measures for each interaction and attitude variable described below. Students could only submit one online survey per registered online course, preventing repeated measures from skewing per course measures. In order to assure that the student reported interaction measures accurately reflected what occurred in each online course, the dataset was validated against the course interaction archives in 10 (20%) of the courses selected to participate in the study. Student reported data regarding the frequency and method of interaction within courses was found to accurately reflect the course interaction archives.

Independent Variable

The independent variable in this study is instructional interaction. This study examined the frequency of instructional interaction and the method of instructional interaction. Frequency of instructional interaction refers to how often students and instructors, and students and students, interact regarding course related materials. Frequency of instructional interaction was measured by two items on the student survey. One item asked students to report how frequently the course instructor used all course communications methods to interact with the students in the course. A second item asked students to report how frequently students used all course communications methods to interact with other students in their respective courses.

Method of instructional interaction refers to whether the interaction within a course occurred using the discussion forum, email lists, or the online chat tool. For each of the three methods of interaction, a series of items asked students to report the frequency of instructor use, the frequency of student use and the duration of student use. Student responses to these items were used to create three Method of Interaction Indexes, which provided interval level measures of the overall interaction in each course by each method of interaction.

Intervening Variables

Four items on the survey examined student attitudes to: timeliness of instructor feedback, utility of instructor feedback, amount of instructor communication, and amount of student communication. A reliability analysis conducted with these four items resulted in a coefficient alpha of .91, with item to total correlations ranging from .55 to .86, suggesting a high degree of reliability. Student responses to these items were summed at the course level and a mean student Attitude to Interaction value was calculated for each course.

Three items on the survey examined student attitudes toward their overall course experience. These items asked students if the course contributed to their knowledge regarding the subject matter, the course met students' expectations, and they would recommend the course to another student. A reliability analysis conducted with these three items resulted in a coefficient alpha of .89, with item to total correlations between .56 to .92, suggesting a high degree of reliability. Student responses to these three items were summed at the course level and a mean Attitude to Course value was calculated for each course.

A third intervening variable, Course Contribution by Method, examined student attitudes toward the use of each method of interaction. These items examined the strength of student agreement with the following statement, "Overall, would you say (method) contributed to your online learning experience?" Student responses for the three Contribution by Method items were grouped at the course level and descriptive statistics were calculated. An initial review of the distribution of per course responses for each item approximated a normal distribution, supporting the use of these items for correlational analysis.

Dependent Variable

Student persistence, the dependent variable in this study, addresses a student's commitment to complete a course and program of study. A persistence rate was constructed for each course by subtracting the number of students who administratively withdrew from a course along with students who failed or took an incomplete in the course from the total enrolled in the course at the end of the two-week Add/Drop period. The resulting difference was then divided by the total enrollment, creating the course persistence rate. The per course persistence rate provided a useful measure of what percentage of students completed each online course. The 52 courses which met the response rate criterion for this study had a mean persistence rate of .80 (SD = .11), meaning 80% of the students enrolled in online courses selected to participate in this study completed the course with a passing grade. Persistence rates among courses ranged from a low of 42% to a high of 100%.

DATA ANALYSIS

Research Question I

The first research question asked if there is "a relationship between the frequency of instructional interaction and levels of student persistence in online courses?" A series of scatterplots were conducted between the dependent variable, Course Persistence Rate and each of the frequency of interaction variables (Instructor, Student, Interaction Index). A review of the scatterplots did not indicate a linear relationship between the Course Persistence Rate and any of the three interaction variables.

This research did identify significant differences between how frequently instructors interacted with students and how frequently students interacted with other students within each online course. Per course Frequency of Instructor Interaction scores ranged from 2.12 to 4.00, with a mean score of 3.10 (SD = .41) while per course Frequency of Student Interaction scores ranged from 1.25 to 3.86, with a mean score of 2.59 (SD = .54). A paired samples t-test was conducted using the mean

Frequency of Instructor Interaction scores and the mean Frequency of Student Interaction scores for each course. The results of this t-test indicated that per course Frequency of Instructor Interaction scores were significantly greater than per course Frequency of Student Interaction scores, t (51) = 9.125, p=.000, with a mean difference of 0.51. This finding indicates that overall, instructors used the online communications tools to interact with students more frequently than students used these tools to communicate with other students within each course.

A strong positive correlation was observed between the frequency of instructor-to-student interaction and the frequency of student-to-student interaction within the online courses participating in this study. A Pearson Product Moment Correlation conducted between the course scores for Frequency of Instructor Interaction and Frequency of Student Interaction confirmed a positive correlation between frequency of instructor-to-student and student-to-student interaction, significant at $r_{50} = .68$, p<.001. The strength of this correlation suggests that as the frequency of instructor-to-student interaction increases in a course, the frequency of student-to-student interaction also increases.

Research Question II

The second research question asked if "there is a relationship between the method of instructional interaction and student persistence in online courses?" Correlational analysis between the method of instructional interaction and persistence required the creation of three method of interaction indexes. These three indexes, the Chat Method Index, Discussion Method Index, and Email Method Index, reflected the overall interaction on the part of instructors and students within each method of interaction per course. A reliability analysis of the three items composing each index revealed coefficient alphas of .92 for the Chat Method Index, .93 for the Discussion Method Index and .77 for the Email Method Index. Once the three Method of Interaction Indexes were calculated, the distribution of course scores and descriptive statistics were reviewed for each index. Table 1 contains the mean and standard deviation for each of the three indexes.

A series of scatterplots were constructed pairing each of the Method of Interaction Indexes to the Course Persistence Rates. An examination of scatterplots comparing persistence with each of the method of interaction indexes did not identify a linear relationship between these variables; however, a review of the mean Method of Interaction scores suggests some differences in how each course used each method of interaction. This difference is explored further below.

Research Question III

Research Question 3 asked if "other variables emerge as correlates of persistence among students in online courses?" The student survey asked respondents to consider how other aspects of interaction contributed to their online course experience. These data, collected at the course level, were used to examine the relationship between persistence and student attitudes to interaction, student attitudes regarding their online course experience, and student perceptions regarding the contribution of a specific interaction method.

Two attitude indexes were created which examined student attitudes to interaction within their online course and to their online course experience. Strong, positive correlations were observed at the course level between Student Attitudes to Interaction and the Frequency of Instructor-to-Student Interaction, $r_{52} = .62$, p<.001, the Discussion Method Index, $r_{52} = .55$, p<.001 and the Email Method Index, $r_{52} = .43$, p<.01. Similar positive correlations were observed at the course level between Student Attitudes to Online Course Experience and the same three variables. These findings suggest a strong, positive relationship between the use of asynchronous methods of interaction by the instructor within a course (i.e., discussion forum, email lists), and positive student attitudes toward that course. A modest, positive correlation was observed between Student Attitudes to Interaction and Course Persistence Rates, $r_{52} = .30$, p<.05.

Table 1. Means and standard deviations for three method of interaction indexes

Index	M	SD
Chat Method Index	8.08	1.66
Discussion Method Index	9.00	2.00
Email Method Index	6.97	1.02

Three course level measures were created to examine students' perceptions regarding the contribution each method of interaction made to their online learning experience. An initial scatterplot of course scores for each of these three items suggested a positive relationship existed between the discussion contribution item and persistence. A Pearson Product Moment Correlation was conducted to examine the strength of these relationships. A strong positive correlation was observed between Course Persistence Rates and the Contribution by Discussion Method scores, $r_{52} = .41$, p<.01.

A multiple regression analysis was conducted to evaluate how well the contribution by method variables and method of interaction indexes predicted persistence. The predictors included the three contribution of method variables and the three method of interaction indexes. The Course Persistence Rate was the criterion variable. A stepwise multiple linear regression analyses was conducted. The Contribution by Discussion Method variable and the Discussion Method Index were significantly related to the Course Persistence Rate, F (2, 48) =8.87, p=.001. The sample multiple correlation coefficient was .51, indicating that approximately 26% of the variance in the persistence rate in the sample can be accounted for by the linear combination of these two measures. The remaining Contribution by Method and Method of Interaction variables did not add to the predictive value of the equation.

CONCLUSION

The data suggest that student attitudes to interaction and student perceptions regarding the usefulness of particular methods of interaction offer the only statistical evidence of a relationship to persistence in this study. In regard to student attitudes to interaction, the data indicate that positive student ratings regarding the timeliness of instructor feedback, appropriateness of instructor feedback and amount of course communications increased in courses as the use of asynchronous methods of interaction increased (i.e., discussion forum, email lists). Likewise, as the frequency of instructor-to-student interaction in a course increased, student attitudes to interaction and to the online course experience improved. This positive correlation to student attitudes was not observed in courses where the primary method of instructor interaction was synchronous chat.

Student perceptions regarding the contribution that the use of discussion forums made to their online course experience were strongly correlated to course persistence rates. This was not observed for student perceptions regarding the contribution the use of chat or the use of email lists made to the students' online course experience.

Given the positive relationship observed between student attitudes to interaction and student persistence; and between student perceptions regarding the use of the discussion forum and student persistence; this study suggests that frequent use of the asynchronous discussion forum by the instructor and students to share course related materials is one factor contributing to student persistence. These findings also reinforce emerging research which identifies a relationship between positive student attitudes toward their online course experience and a student's decision to persist in, or drop out of the course. While an online instructor cannot necessarily control factors outside of the classroom setting, this study suggests instructional interaction strategies that have a positive impact on persistence within the online classroom.

REFERENCES

Arbaugh, J. B. (2005). Is there an optimal design for on-line MBA courses? *Academy of Management Learning & Education*, 4 (2)., 135-149.

Collison, G., Elbaum, B., Havind, S., & Tinker, R. (2000). *Facilitating Online Learning: Effective Strategies for Moderators*. Madison, WI: Atwood.

Freedman, S. C., Tello, S. F., & Lewis, D. (2003). Strategies for Improving Instructor-Student Communication in Online Education in *Virtual Education: Cases in Learning & Teaching Technologies*, Fawzi Albalooshi (ed.). IRM Press: Hershey, PA. 156-168.

Hay A., Hodgkinson, J., Peltier, W., and Drago, W. A., (2004). Interaction and virtual learning. *Strategic Change,* 13: 194-204.

Jiang, M. and Ting, E. (2000). A study of factors influencing students; perceived learning in a web-based course environment. *International Journal of Educational Telecommunications*, 6 (4), 317-338.

Jun, J. (2005). Understanding E-dropout. *International Journal of E-Learning,* 4(2): 229-240.

Kearsley, G. (2000). *Online Education: Learning And Teaching In Cyberspace.* Belmont, CA: Wadsworth/Thomson Learning.

Kuh, G. D. & Hu, S. (2001). The Effects of Student-Faculty Interaction in the 1990's. *The Review of Higher Education*, 24(3): 309-332.

Levy, Y. (2005). Comparing dropouts and persistence in e-learning courses. *Computers & Education,* 48 (2): 185-204.

McGiveny, V. (2004). Understanding persistence in adult learning. *Open Learning.* 19(1): 33-46.

Moore, M. G. (1989). Three types of interaction. *American Journal of Distance Education* 3(2): 1-6. University Park, PA: Pennsylvania State University.

Pascarella, E. T. & Chapman, P.W. (1983). A multi-institutional, path analytic validation of Tinto's model of college withdrawal. *American Educational Research Journal,* 20: 87-102.

Pascarella, E. T. & Terenzini , P.T. (1991). *How College Affects Students: Findings and Insights from Twenty Years of Research.* San Francisco: Jossey-Bass.

Roblyer, M. D. & Wiencke, W. R. (2004). Exploring the interaction equation: validating a rubric to assess and encourage interaction in distance education. *Journal of Asynchronous Learning Networks,* 8(4): 25-37.

Salmon, G. (2000). *E-Moderating: The Key to Teaching and Learning Online.* London: Kogan Page.

Shea P., Frederickson, E., Pickett, A., Pelz, W. and Swan, K. (2001). Measures of learning effectiveness in the SUNY Learning Network. In J. Bourne and J. Moore (eds.) *Elements of Quality online Education, Volume 2*, Needham, MA: Sloan-C Press, 31-54.

Simpson, O. (2003). *Student Retention in Online, Open and Distance Learning.* London: Kogan Page.

Simpson, O. (2004). The impact on retention of interventions to support distance learning students, *Open Learning*, 19(1): 79-95.

Smith, P. & Dillon, C. (1999). Comparing distance learning and classroom learning: conceptual considerations. *The American Journal of Distance Education* 13(2): 6-23.

Swan, K., Shea, P., Frederickson, E., Pickett, A., Pelz. W. and Maher, G. (2000). Buidling knowledge buidong communities: consistency, contact and communication in the virtual classroom. *Journal of Eduational Computing Research*, 23 (4), 389-413.

Sweet, R. (1986). Student drop-out in distance education: an application of Tinto's model. *Distance Education*, 7(2): 201-213.

Tinto, V. (1987). *Leaving College: Rethinking The Causes And Cures Of Student Attrition.* Chicago: University of Chicago Press.

Towles, D. E., Ellis, J. R. & Spencer, J. (1993). *Student Persistence in a Distance Education Program: The Effect of Faculty-Initiated Contact.* Lynchburg, VA, EDRS. 2001.

Turoff, M. & Hiltz, R.S. (1995). Designing and evaluating a virtual classroom. *Journal of Information Technology for Teacher Education* 4(2): 197-215.

Wagner, E. D. (1994). In support of a functional definition of interaction. *The American Journal of Distance Education* 8(2): 6-28.

Willging, P. A. & Johnson, S. D. (2004). Factors that influence students' decision to dropout of online courses. *Journal of Asynchronous Learning Networks,* 8(4): 105-118.

Business Processes Modeling as Social Systems[1]

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ABSTRACT

Over the past few decades, a number of successful process modeling techniques have been developed. While these modeling techniques are instrumental in process modeling, they seem challenged to capture the deep structure of business process and its social character (commitment, coordination and negotiation). Most of the current modeling methods and techniques are characterized as flowchart-like techniques. Organizations are social systems, where its members communicate and negotiate to carry out different tasks and create results. On the other hand, many of the processes are nested within a super-process that can not be captured by flowchart-like techniques. Another issue of the existing modeling techniques is their semi-formality not lending to model execution (simulation) without further translations. This paper introduces a modeling method and technique that consider organizations and its business processes as a social system. The resulting models are based on the semantics of Petri net, and consequently, the models are fully executable. The proposed method is based on a rather non-traditional concept (the Language Action Perspective), and it adapts graphical notations of traditional modeling formalism (Petri net).

Keywords: social systems, business process modeling, modeling methodology

INTRODUCTION

Business processes have been studied for decades and even longer than that, but the real renaissance of research into business processes started with vanguards of re-engineering revolution such as Davenport, Short, Hammer, Champy (Davenport & Short, 1990; Hammer & Champy, 1993) whose works foregrounded business processes in the mainstream literature. Since then, numerous tools, techniques and methodologies have been developed to study the organizational phenomena and business processes.

A distinctive and important feature of an organization is its social nature –human actors interacting and collaborating to carry out tasks and fulfill the mission of the organization. As such, business process is not merely a sequence or flow of jobs, tasks, or physical materials, but a complex phenomenon involving actors communicating, negotiating, coordinating and agreeing upon certain tasks. As argued by advocates of alternative perspectives for business process study (Winograd & Flores, 1986, Stamper, 1988; Dietz, 1994), the social nature of business process entails a fundamentally different perspective to perceive the reality of an organization and the role (responsibility and authority) of its members. This understanding is difficult to achieve with conventional methods/techniques that are mostly characterized as flowchart-like techniques. One such new perspective was introduced in a framework referred to as the Language Action Perspective, or LAP for short, (Winograd & Flores, 1986). The LAP framework and its philosophical stance inspired emergence of several modeling methodologies and techniques such as SAMPO (Lehtinen & Lyytinen, 1986; Auramäki et al., 1988), Action Workflow model (Medina-Mora et al., 1992), DEMO (Dietz, 1994), BAT (Goldkuhl, 1996), to mention a few. However, since the main emphasis in these methodologies is placed on capturing communication acts and building business process models, their underlying modeling techniques do not lend to further execution or simulation (Rittgen, 2005), which makes it difficult to check the models for dynamic behavior and response to changes. In order to develop executable business process models based on a formalized semantics, this paper introduces a method and technique based on the *business transaction concept* derived from the LAP. The proposed method is further extension of CAP Net developed over the last decade by Dietz (2006), however the modeling technique (graphical notations) introduced is full adherent to the Petri net formal semantics.

Most of the previously introduced Petri net models are dominantly process or workflow oriented rather than business process as a social system. In contrast to prevailing process-oriented and object-oriented models, the introduced method allows not only model processes flow but also take into account the social character of the modeled enterprise such as interacting actors (or actor roles), and the nested structure of activities. This paper further develops the works of (Dietz & Barjis, 1999; Dietz & Barjis, 2000, Barjis & Reichgelt, 2006) on business process modeling deploying the transaction concept supported by Petri net.

In summary, the research finding reported in this paper is hoped to make the following contributions:

1. *Executable models* of business systems based on the *Transaction Concept*. Previous models developed based on this concept are mostly focused on producing well defined and detailed models, so called, *atoms*, *molecules* and *matter* of organizations. Our contribution is to make the resulting models executable to help system designers with model checking and validation, making changes to the model and study the impacts of the changes prior to the intended system development.
2. *Compact models* of complex systems using the transaction concept. Often, in systems modeling designers are either not interested in all the details, or the system under study is too large to be depicted at detailed level, or the designers may spotlight a part of the system while leaving some other parts concealed. In these situations, compact modeling where certain activities are compressed into one well defined component would be of great advantage. Also, when using diagrams, models rapidly get too large to manage.
3. *New knowledge*, generated as a result, contributes to the concepts of Model-Driven System Development, business systems modeling, simulation, modeling methodology, application of modeling and simulation, and advancing the new perspectives of system design and development.

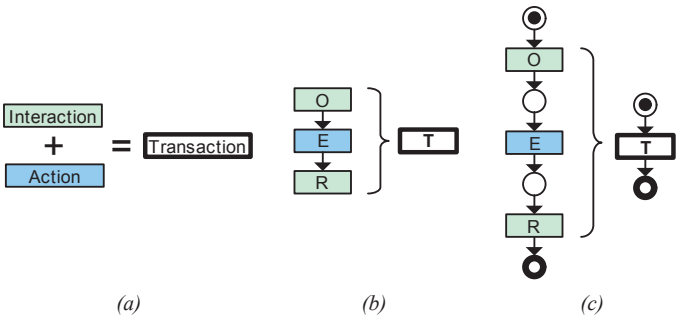
THE TRANSACTION CONCEPT

What follows is an illustrative introduction to the transaction concept using artifacts and constructs adapted by the authors. Readers, interested in more in-depth study about the transaction concept, are referred to the original works by Dietz (1994, 2006). We have adapted the Petri net notations and extended them as modeling constructs. Assuming that readers are familiar with the basic concepts of Petri nets that are widely used in systems analysis and design, we skip their introduction.

Transactions are patterns of interactions and actions, as illustrated in Figure 1a. In the figure, "action" and "interaction" are distinguished by different colors. An *action* is the core of a business transaction and represents an activity that brings about a new result, changing the state of the world. An *interaction* is communicative act involving two actors (actor roles) to coordinate or negotiate. An example of an interaction could be "requesting a new insurance policy", clicking "apply" or "submit" buttons on an electronic form, inserting a debit card into an ATM to withdraw cash, or pushing an elevator's summon button. Replying to the interacting actors and fulfilling their requests is an action, e.g., "issuing a new policy", "dispensing bills", "moving an elevator to the corresponding floor", etc.

Each business transaction is carried out in three distinct phases, the *Order phase*, the *Execution phase*, and the *Result phase*. These phases are abbreviated as O, E and R correspondingly (see Figure 1b), and constitute the OER paradigm (Dietz, 1994). The figure illustrates a business transaction in detailed OER form, and compact transaction form (T). Note that the order (O) and result (R) phases are interactions and the execution (E) phase is an action, therefore they are illustrated using different colors (the Execution phase is represented by a rectangle colored in blue (or gray in grayscale printout)). These three phases are a distinct feature

Figure 1. Transaction: a) pattern of action and interaction; b) sequence of three phases (detailed and compact); c) corresponding Petri net diagram



that entails the discussed method as a business process modeling technique versus just a process modeling. Also, these three phases not only allow for the boundary of an actor (or business unit) to be clearly defined, but also to depict interaction and action as a generic pattern involving (social) actors. Compared to UML, Flowchart, EPC and other conventional modeling methods, the transaction pattern clearly identifies the actors involved as it is discussed below. In other words, in conventional methods, a transaction would be reduced to only one execution phase omitting information about the relevant actors and their role.

Now, we try to introduce the further notions of the transaction concept along with the Petri net notations we adapted. In general, Petri net structure consists of places (graphically illustrated by circles and representing outcome of an activity or process), transitions (graphically illustrated by rectangles and representing an activity or process) and directed arcs (graphically illustrated by arrows and representing flow sequence). Figure 1c depicts a business transaction using the Petri net notations. Again, the figure illustrates a business transaction in detailed OER form, and compact transaction form (T). In the figure, the start and the end places are marked by different circles. These notations will make better sense when a complex process consisting of several related processes is studied and modeled.

Another notion of the transaction concept is the role of actors involved in a transaction. Each business transaction is carried out by exactly two actors (or actor roles), see Figure 2a. The actor that initiates the transaction is called the *initiator* of the transaction, while the actor that executes the transaction is called the *executor* of the transaction. Since the Order (O) and Result (R) phases are interaction between the two actors, their corresponding transitions are positioned between the two actors. The Execution (E) phase is an activity solely carried out by the executor and, therefore, its corresponding transition is positioned within the confines (boundaries) of the executor. In case of multiple actors, they will be conveniently denoted by the letter A and numbered (A1, A2, A#).

A transaction diagram should also represent how the created result (outcome) is recorded. Since each transaction brings about a new result, the Result phase of a transaction is linked to an oval-shaped element representing the new result created (see Figure 2b). For simplicity sake, the depiction of the oval representing a transaction result maybe omitted in the models studied later. If a business transaction is a simple one (not nesting further transactions), it is better to compress its three phases into a compact notation, see Figure 2c. In this case, the transaction is placed within the boundary of the executing actor, while the initiation and ending points are placed within the boundary of the initiating actor.

A distinction is made between simple and composite transactions. Actors' interactions may be arbitrarily complex, nested, extensive and multilayered (hierarchical). A complex collaboration typically consists of numerous transactions that are chained together and nested into each other. *Simple* transactions do not involve, i.e. trigger or cause, other transactions during their execution (like the above figure). In *composite* transactions, on the other hand, one or more phases will trigger further, nested, transactions. For instance, think if actor A1 contacts actor A2 to reserve a hotel room (we denote this request as Transaction 1, or T1). Actor A2 receives the request, checks the room availability, but in order to complete the request, it has to request actor A1 for a payment guarantee (we denote this second request as Transaction 2, or T2). For actor A2 to complete the reservation task, first the payment transaction should be completed. This process is represented in Figure 3a in the form of a nested transaction. Notice that the Execution phase of T1 now has several sub-phases or interactions, where each of the sub-phases is distinguished with a letter of the alphabet attached to the transaction number (e.g., T1a/E denotes "first sub-phase of the Execution phase of Transaction T1"). The process illustrated in the figure starts with the receiving of a reservation request and checking the room availability, then it waits for the payment transaction to get completed, only then the Execution phase gets completed, let say, by conveying a confirmation number to the first actor.

A close look at the reservation process reveals that in fact, the payment transaction, T2, is rather an interaction between the hotel and a credit card company. Thus, the process rather involves three actors (or actor roles): A1 (customer or guest), A2 (hotel receptionist) and A3 (credit card company). The interaction process between the three actors forms a nested transaction structure.

One of the limitations in many modeling techniques is coping with complex real-life systems. Usually models of real systems turn too large using diagrammatic representation. In dealing with this issue, we introduce the "composite" (or nesting) notation graphically represented as a multiple (layered) rectangle. For instance, the model illustrated can be reduced to one composite transaction as shown in 3b. This can be applied to any part of a complex system for the sake of compactness or for spotlighting a specific part of the system while concealing the other parts. The notion of nesting structure is especially helpful in inter-organizational process modeling in which a whole process within an organization or business unit can be reduced to a single composite transaction, thus, keeping the model more manageable.

It should be noted that at any point (phase) an actor may quit the process or decline to proceed or a process is terminated due to internal or external circumstances.

In this manner, any complex process with any number of actors and outcomes can be modeled and illustrated. However, for more complex processes one needs to use the compact notation of a transaction in order to keep the model better managed and controlled. The compact notation is useful for those transactions that are simple (not nesting further transactions). If a compact notation is used, by a convention, the whole transaction is positioned within the confines of the executing actor. Two instances of such a compact modeling are represented in Figure 4a and Figure 4b. In the first case, the two nested transactions are initiated and executed in sequence, and in the second case, the two nested transactions are initiated and executed in parallel.

Another notion, a typical phenomenon in process modeling, is of probability of some activities – optional transactions that may take place depending on some conditions. To indicate that a transaction is an optional one, a small decision symbol (diamond shape) is attached to its initiation (connection) point as illustrated in Figure 5a. In order to transform this optional transaction construct into standard Petri net semantics, a traditional XOR-split that could be modeled by one place that

Figure 2. A process diagram of a business transaction: (a) detailed; (b) with the result; (c) compact

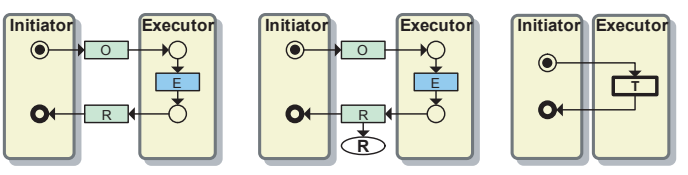


Figure 3. Nested transactions with three actors: (a) detailed; (b) compact

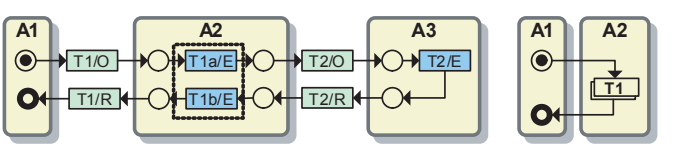


Figure 4. A model with two nested transactions: (a) in sequence; (b) in parallel

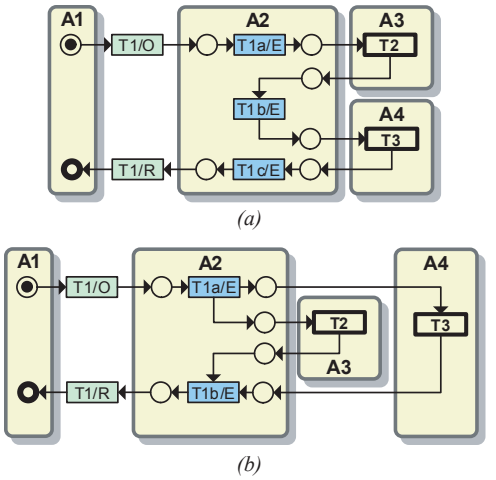
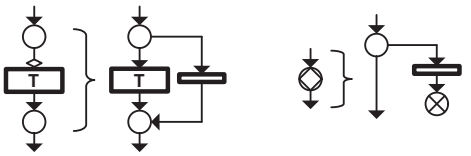


Figure 5. Standard Petri net representation of: (a) an optional transaction; (b) a decision state



leads to two transitions is used. It requires addition of a skip (or dummy) transition as demonstrated in the figure (notice the tiny rectangle with no labels). A dummy transition is meant that it has zero duration and utilizes no resources.

Finally, there are situations that a process may halt and result in a termination. For example, if there is no room available, then the payment transaction is not initiated at all. This situation is modeled through a place identified as "decision state" graphically represented via a circle with the decision symbol (diamond shape) within it, see Figure 5b. As it is seen, for the transformation of a decision state into standard Petri net semantics, a traditional XOR-split that could be modeled by one place that leads to *proceed* or *stop* is used. Depending on the value of the state, the process either proceeds or terminates as indicated by a place filled with a cross.

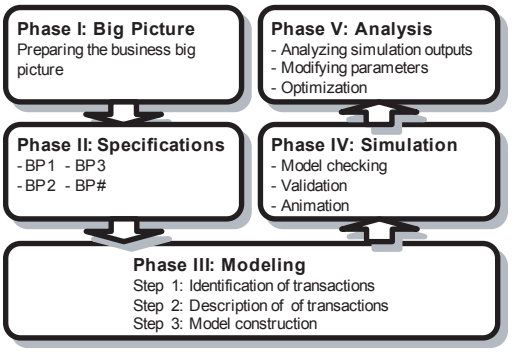
Through these few simplified constructs and mini-models, we aimed to introduce how the proposed method can capture typical situations in business processes, provide sound concept based on communication, and ultimately contribute towards more accurate Business Process Modeling and consequently more adequate IS Design, since the models can be executed several times before it is finalized.

Now that the basic ideas and constructs are introduced, we discuss the underlying framework (guidelines) for deploying the proposed method.

APPLICATION GUIDELINES

Based on practice and application experiments, the following framework (guidelines) was developed. This framework is diagrammatically illustrated in Figure 6, in which both the process flow (block arrows) and feedback loop (circled block arrow) between the phases are depicted. As seen, this is an iterative process where after each simulation and output analysis, the model is refined, some parameters are modified and the experiment is repeated. It may be also required to return to earlier phases (phase I or phase II) for missing pieces of information, if the analysis reveals any flaws or doubts. This is especially important when changes occur for the system under consideration, modifications must be made to the model, and the change impact has to be studied. The entire process consists of the following major phases:

Figure 6. An application framework (guidelines)



Phase I – *Big Picture:* during this phase major processes are identified. Identification of the major processes actually portrays the *"big picture"* of an organization. Also during this phase, scope estimation is conducted – a major process, or focal point, is defined where the main focus will be directed. The perspective taken in this phase considers an organization as a network of business processes (BP). Methods used in this phase are mainly the review of the corporate documents and interview with the business manager if such documentation is lacking or the collected information is vague.

Phase II – *Detailed Picture:* During this phase, each major process of interest is described to fill in the details of the "big picture" previously identified, boundaries of organizational units are defined, and actors and their roles are identified. As a result, an analyst may describe a series of interrelated business processes (BP1, BP2, etc.). Methods used in this phase are mainly based on interviews, observations and review of the documented procedures. However, description can be more articulated so the events, their timelines, and involved actors can be easily distinguished.

Phase III – *Modeling:* For each specific major process of interest:

Step 1: Identification of business transactions using the *transaction concept*.

Step 2: Description of business transactions (actors involved and results created) using the *transaction concept*.

Step 3: Construction of an interaction (process) model using the developed constructs.

Phase IV – *Simulation (Animation, Validation):* In this phase, first the model is checked for absence of semantic flaws and deadlocks. The model is animated for better communication to non-technical users, especially the process manager. Taking the process manager's feedback and input the model is now validated for accuracy and adequacy. Once the model is validated, its behavior is studied through the simulation runs using a discrete-event simulation tools.

Phase V – *Analysis & Improvement:* Finally, the simulation outputs are analyzed for modifications, optimizations, improvements, and comparison of different scenarios. As an objective, at this stage analysts may suggest improvements in the form of redesigning processes, redistributing resources, designing better systems.

This just described framework, and the above discussed modeling method and technique are applied to numerous real world business system. One such a case-study is reported in a separate paper published in these proceedings. Readers interested in the application of the method are referred to the application paper entitled "Business Process Optimization Using Simulation".

CONCLUSION

This paper outlined a modeling method and technique based on the transaction concept and Petri net formalism. This paper studied that the transaction concept derived from the LAP can adequately capture and represent business processes as social systems. The core concept of the transaction concept is its perceiv-

ing of an organization and its business processes as social processes involving interacting actors.

The graphical notations adapted for the transaction concept are based on the formal semantics of Petri nets. This allows modelers to build models that can be directly simulated on computer using Petri net based tools. Simulation of the models benefits in many ways: check the models for deadlocks or flaws; study the model dynamic behavior; analyze and compare different set of model parameters.

However, a few things are not fully investigated. First, we have no evidence how the proposed technique will be understood in comparison with conventional techniques (e.g., UML Activity Diagram). Second, how the resulting models can be mapped into well-known simulation tools (e.g., Arena, Extend). Finally, it is not tested how complex business systems can be dealt with using the proposed method.

As a conclusion, this paper is intended to provide theoretical and practical value for business process analysts, modeling and simulation experts, information system designers, and practitioners of modeling and simulation in general.

REFERENCES

Auramäki E, Lehtinen, E., Lyytinen, K. (1988). A Speech Act Based Office Modeling Approach. *ACM Transactions on Office Information Systems*, Vol. 6, No 2, pp. 126-152

Barjis J., & Dietz J.L.G. (1999). Business Process Modeling and Analysis Using GERT Networks. *In the proceedings of the First International Conference on Enterprise Information Systems* (ICEIS'99), Setubal, Portugal, March 27-30, volume II, pp. 748-756.

Barjis, J., & Dietz, J.L.G., Groenewegen, L.P.J. (2000). Organizational Simulation: Concept & Application. Proceedings of the 2000 Summer Computer Simulation Conference, July 16 - 20, 2000, Vancouver, B.C., Canada, pp. 836-841, ISBN: 1-56555-208-3

Barjis, J., & Reichgelt, H. (2006). A Petri Net Based Methodology for Business Process Modeling and Simulation. In the proceedings of the Fourth International Workshop on "Modeling, Simulation, Verification and Validation of Enterprise Information Systems (MSVVEIS'06)", Paphos, Cyprus, May 23-27, 2006. ISBN: 972-8865-49-X

Davenport, T.H., & Short, J.E. (1990). *The New Industrial Engineering: Information Technology and Business Process Redesign*. Sloan Management Review, Summer 1990, Vol. 31 Issue 4, p11, 17p

Dehnert, J., & Aalst, W.M.P. van der (2004). Bridging the Gap Between Business Models and Workflow Specifications. *International Journal of Cooperative Information Systems*, 13(3):289-332.

Dietz J L G (1994) Business Modeling for Business Redesign. *Proceedings of the 27th Hawaii International Conference on System Sciences*, IEEE Computer Society Press. Los Alamitos, pp. 723-732.

Dietz J.L.G., & Barjis J. (1999). Supporting the DEMO Methodology with a Business Oriented Petri Net. *In the proceedings of the International Workshop on Evaluation of Modeling Methods in Systems Analysis and Design* (EMMSAD'99), Heidelberg, Germany, June 14-15, 1999

Dietz, J.L.G., & Barjis, J. (2000). Petri Net expressions of DEMO Process Models as a rigid foundation for Requirements Engineering. In the proceedings of the 2nd International Conference on Enterprise Information Systems (ICEIS'00), Stafford, UK, July 4-7, pp. 269-274. ISBN: 972-98050-1-6.

Dietz, J.L.G. (2006). *Enterprise Ontology –Theory and Methodology*. Springer

Goldkuhl, G. (1996). Generic business frameworks and action modeling. *In the Proceedings of Conference Language/Action Perspective* '96, Springer Verlag.

Hammer, M., & Champy, J. (1993). *Reengineering the Corporation: A Manifesto for Business Revolution*. Harper Business

Lehtinen, E., Lyytinen, K. (1986). Action Based Model of Information System. *Information Systems*, Vol. 11, No. 4, pp. 299-317

Medina-Mora R., Winograd T., Flores R., & Flores F. (1992). The Action Workflow Approach to Workflow Management Technology. *In the Proceedings of the Conference on Computer-Supported Cooperative Work*, CSCW'92, ACM Press, New York

Rittgen, P. (2005). Language Action-Based Simulation of Business Processes. *The 10th Anniversary International Working Conference on the Language-Action Perspective on Communication Modeling*. Kiruna, Lapland, Sweden, June 19 – 20.

Stamper, R.K. (1988). MEASUR. University of Twente. Enschede, The Netherlands.

Winograd, T.; Flores, F. (1986). Understanding Computers and Cognition: A New Foundation for Design. Ablex, Norwood.

ENDNOTE

[1] Due to the paper length restriction, this paper is accompanied by another paper "Business Process Optimization Using Simulation", published in these proceedings, where a case-study is reported using the proposed method.

Generating Software Requirements Specification (IEEE-Std. 830-1998) Document with Use Cases

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ABSTRACT

The IEEE Std.830-1998 was created to standardize the software requirements specification document. The aim of an SRS document is to capture software requirements in an unambiguous manner in order to facilitate communication between stakeholders. The Use-case approach has become a de-facto standard for capturing functional requirements. The IEEE Std.830-1998 provides a structure (template) for documenting the software requirements. But, it does not show how to leverage the information already captured in Use-cases for generating the specification document. In this paper, we present an approach to prepare SRS with Use-cases. We do this by employing classification schemes (Use-case taxonomy) identified to manage the Use-cases. Our method provides additional support to analysts in preparing a standards compliant SRS document by avoiding redundant specification effort and through reduction in the cognitive load. We demonstrate how this taxonomy is used to develop a standards compliant SRS document with the help of a case study.

1. INTRODUCTION

The SRS document described in IEEE Std.830 is divided into a number of recommended sections to ensure that information relevant to stakeholders is captured. This specification document serves as a reference point during the development process and captures requirements that need to be met by the software product. Basic issues addressed in the SRS include functionality, external interfaces, performance requirements, attributes and design constraints. It serves as a contract between the supplier and customer with respect to what the final product would provide and help achieve. Although the IEEE Std. 830-1998 specifies the structure it does not choose one representation for requirements over the other. Neither does it specify what techniques should be used to populate the various sections of the SRS.

The Use-case approach has become the de-facto standard for capturing functional requirements. Many of the sections of the SRS document contain information that would be otherwise collected in UML Use-case artifacts. A significant amount of effort could be spared if the description of functionality captured in these Use-case artifacts is used to populate relevant SRS sections. For large projects, the number of use cases and the amount of related documentation could quickly become unwieldy without the presence of an organization scheme. It is possible to systematically create and populate several of the SRS document sections if Use-cases are documented using appropriate organization schemes. The advantage of systematic translation is avoiding duplicative specification efforts. After all, if time and effort have been expended creating the Use-case artifacts, it makes sense to reuse the results of those efforts when writing the SRS document. It would also lessen the possibility of introducing inconsistencies that arise during duplication.

Presently, there are no concrete techniques to identify and link Use-cases to sections of the SRS. This process is at best ad-hoc, which generates inconsistencies in the final specification document. In this paper we show a systematic way to leverage existing/discovered Use-cases to populate the SRS document. We do this with the help of various schemes for managing and organizing the Use Cases, and by linking specific use case types to related SRS sections. Our method provides additional support to analysts in preparing a standards compliant SRS document by avoiding redundant specification effort and through reduction in the cognitive load. We demonstrate how this taxonomy is used to develop a standards compliant SRS document with the help of case study.

In Section 2 we provide an overview of the various organization schemes used in our method for managing and organizing Use Cases. Section 3 discusses how specific UML artifacts could be linked to the content requested in specific SRS sections. In Section 4 we demonstrate how the organization scheme has been applied in a case study for developing an SRS, and Section 5 concludes our paper with discussion of future work.

2. SRS AND USE CASE TAXONOMY

The Use-case model is an interpretation of the SRS (Spence & Probasco, 2000). For ease of documentation, at times, the Use-case model along with the supplementary specifications document is used as the formal documentation for the project. This may seem like an efficient system but it cannot be substituted for a formal SRS. The need for an SRS document is usually mandated by the management (Spence & Probasco, 2000). Under such circumstances, when an SRS standards document is unavailable, the Use-case model is dissected and the use case descriptions cannibalized in an attempt to populate the SRS. This process tends to be ad-hoc giving rise to inconsistencies in the final document. It also surfaces traceability issues between the Use-case model and sections of the SRS document. Changes in functional requirements in the specification document need to be reflected in the Use-case model and vice-versa. We should also point out that the Use-case model is an abstraction of the system model. It does not capture all the relevant aspects of the system, especially non-functional requirements, which are required for completing the product documentation. An unstructured process for using Use-cases to populate an SRS is inefficient and lacks traceability. The SRS forms the basis for testing plans at a later stage, further boosting its importance in software development process.

There is an incentive to prepare the SRS in accordance to the standards. It ensures readability of the document by other stakeholders who come on board at a later date. The IEEE Std.830 is understood across organizations facilitating communication between disparate organizations. It also makes sense from Information systems maintenance or systems testing perspective, where convention is preferred over unique formats unless extra-ordinary circumstances exist. At the same time there is also an incentive to avoid duplication effort.

Goldman and Song (2005) reviewed four possible schemes, and proposed one of their own, for organizing and managing use cases. The choice of schemes for managing the use cases depends on the context. The five classification schemes presented were:

a. Business Use Case vs. System Use case
b. Essential Use Case vs. Real Use Case
c. Based on Organizational Goals: Core vs. Administrative vs. Routine Use Cases
d. Based on Importance Level: Primary vs. Secondary vs. Optional Use Cases

e. By Function type- 1.Data Entry/Maintenance, 2.Transaction recording, 3.Calculation, 4.Transformation, 5.Communication, 6.Device Control, 7.System Administration.

The schemes could be used either for organizing Use-cases sequentially, like for e.g. table of contents, or for grouping related Use-cases based on shared attributes or behavior. For a detailed discussion on this we would refer readers to Goldman and Song (2005). For our method we employ organization schemes c, d, and e.

What follows is a proposed systematic guide to the translation of software requirements specifications from UML use case models into the IEEE 830 recommended format. The translation makes use of the multiple use case classifications presented earlier in Section 2.

3. SECTIONS OF THE SRS DOCUMENT

Table 1 gives an overview of how to form each SRS document section from the appropriate information captured in the use case artifacts.

3.1 Product Perspective

In Section 5.2.1 of IEEE 830 (Section 2.1 of the SRS), we are told that "this subsection of the SRS should put the product into perspective with other related products. … A block diagram showing the major components of the larger system, interconnections, and external interfaces can be helpful." A use case diagram establishes the system boundary, and should show the use cases that provide functionality to actors outside the system boundary. To some extent this captures the interfaces needed for actors external to the system to interact with the system.

Table 1. Forming the IEEE 830 SRS document from use cases

IEEE 830-1998 Section **2** of the SRS	**UML Use-cases**
Product perspective	Use Case Diagram; Component and Deployment Diagrams
Product functions	Functional requirements use cases organized by the generic type of functionality provided
User characteristics	List each actor Ûse-case pair with brief explanation how that actor interacts with that use case.
Constraints	Non-functional goal-oriented use cases represent soft goals of the actors that justify/ rationalize the need for a specific functional requirement (Lee and Xu, 1999).
Assumptions and dependencies	Interdependencies between use cases, especially between functional and non-functional use cases.
Apportioning of requirements	Use case names categorized by importance (Primary, Secondary, Optional…)
IEEE 830-1998 Section **3** of the SRS	**UML Use-cases**
External interfaces	All UML actor interactions with use cases at the system boundary. Use case descriptions (narratives).
Specific Functional requirements	Functional requirements use cases organized by the generic type of functionality provided. Use case descriptions (narratives).
Performance requirements	Non-functional goal-oriented use cases related to performance
Design constraints	Non-functional goal-oriented use cases related to design
Organization of functional requirements	Use case classification schemes outlined above

Other sub-systems could be represented as agents and the interaction with the system could still be captured just like for a regular actor.

3.2 Product Functions

In Section 5.2.2 of IEEE 830 (Section 2.2 of the SRS), the major functions that the system will perform are described in a summary form. IEEE 830 offers no guidance on how to organize descriptions of the major functions (although several suggestions on organizing the more detailed functional requirements are included).

One of the classifications mentioned above, that of primary vs. secondary vs. optional use cases, can be used to narrow down the field of the possible use cases so that only primary use cases would be described in the major function summary section. The field can further be narrowed by applying the core vs. administrative vs. routine use case classification scheme to eliminate primary administrative and routine use cases. What is left are only the primary core use cases.

3.3 User Characteristics

Section 2.3 of the SRS describes "general characteristics of the intended users of the product…" In the Use Case model an actor is a role. However, IEEE 830 asks for information about the backgrounds of the intended users, including "educational level, experience, and technical expertise," and these have no corresponding collection point within the Use Case, so will have to be added separately. But, mapping roles to users may aid the discovery process.

3.4 Constraints

Constraints, included in Section 2.4 of the SRS, are "items that will limit the developer's options" (IEEE 830). Constraints are also sometimes called non-functional requirements because they are requirements that the system must meet, yet they do not provide or describe functionality that accomplishes the purpose of the system. Examples include regulatory compliance requirements, performance requirements, and compatibility with externally-specified protocols and system interfaces. Representation of non-functional requirements is topic of research but, presently it is included as business rules governing the interaction.

3.5 Assumptions and Dependencies

Assumptions and dependencies (Section 2.5 of the SRS) come from several places in the use case-based specification process. Some assumptions are stated in the preconditions of the functional use cases, particularly when the preconditions refer to things external to the system, whether they are actors or external systems.

3.6 Apportioning of Requirements

Section 2.6 of the SRS document should "identify requirements that may be delayed until future versions of the system." This information is identified by the primary vs. secondary vs. optional use case categorization described in Goldman and Song (2005).

3.7 Specific Requirements

Section 3 of the SRS document contains the heart of the specification of exactly what the system should do and how. Section 3 revisits some of the areas that were addressed in Section 2, but suggests that this is the appropriate place for inclusion of a higher level of detail. Therefore, essential and business use cases are not appropriate for translation into Section 3, only real system use cases are.

3.7.1 External Interfaces

The external interfaces described for inclusion are a more detailed description of the interfaces mentioned in Section 2.1 of the SRS document. The appropriate place to find the corresponding information is in the narrative description of the use case primary and alternative scenarios. These are typically described in a request-and-response format, where an actor action is followed by one or more system responses, followed by further actor actions and system responses, until the completion of the use case and the satisfaction of the requirement. The set of all actor actions, and corresponding system responses, ought to suffice as "a detailed description of all inputs into and outputs from the software system." (IEEE 830, p. 16)

A use case called "Process Sale Transaction and Payment" might include this partial use case description of a request and response in one of its scenarios:

Actor Action	System Response
Cashier scans barcode on product box.	System displays item description and current price on point of sale terminal.

From the use case description, most of the IEEE 830 items may be extracted, and restated in the following corresponding subsections.

a. Name of item: "Cashier scans barcode on product box."
b. Description of purpose: "System displays item description and current price on point of sale terminal."
c. Source of input: Cashier (actor name)
d. Valid range, accuracy, and/or tolerance: as stated in preconditions
e. Units of measure: as stated in use case summary, or in the scenario narrative.
f. Timing: shown by sequence of steps in the use case scenario narrative.
g. Relationship to other inputs/outputs: The most relevant related inputs/outputs will be those that are also involved in the interactions within the same use case. Others may be separately noted.
h. Screen formats/organization: If required, these should be noted as system responses in the use case scenario narratives where appropriate. For example, a requirement for a credit card entry form could be described by this scenario:

Actor Action	System Response
Cashier indicates credit card payment is desired.	System displays empty credit card entry form in window.
Cashier swipes credit card.	System processes credit card.

i. Window formats/organization: If required, these should also be noted as system responses where appropriate.
j. Data formats: These may be noted either in actor actions or in system responses, depending on where the requirement applies. For example: "System displays customer's zip code left justified; hyphen to appear after first five digits if nine digit zip code on file."
k. Command formats:
l. End messages: These should appear as the last system response in the scenario narrative, and/or as described in the use case post-conditions.

3.7.2 Functions

Each functional requirement of a system has an overall description which should appear as the second item in the use case description, after the use case title. More specific information can be mapped from the use case description as follows. The analyst has the choice of whether to include the UML artifacts directly as elements within the IEEE 830 SRS document or whether to abstract from the UML artifacts the necessary information to fill in these sections.

a. Validity checks on the inputs: These should be explained in the "system response" descriptions within the use case description's scenario narrative
b. Exact sequence of operations: The entire scenario narrative for the expected case may be used to describe an exact sequence of operations.
c. Responses to abnormal situations: Alternative scenario narratives will explain how the system must respond to abnormal situations.
d. Effect of parameters: The effect of parameters may be shown through alternative path scenarios.
e. Relationship of outputs to inputs: Use case description scenario narratives also explain the relationship of outputs to inputs since they explain exactly what the system delivers, or how the system state changes, in response to each actor action document.

3.7.3 Performance Requirements

Such requirements can be documented using UML use cases if the UML is extended slightly to accommodate "goal-oriented" use cases. Currently this information has to be captured explicitly during use case development because "goal-oriented" use cases are not a formal representation in UML model.

3.7.4 Logical database requirements

Unfortunately, use cases do not specifically provide for the specification of logical databases when they are used to define system functionality. Other aspects of database requirements called for by IEEE 830, are not documented in the Use Case and have to be supplemented from class diagrams.

3.7.5 Design Constraints and Software System Attributes

Sections 3.4 and 3.5 of the IEEE 830 SRS document external constraints that are imposed on the system's design and implementation. The constraints are therefore documented as requirements. These include standards and regulatory compliance, along with additional non-performance non-functional requirements. The latter include requirements having to do with reliability, availability, security, maintainability, etc.

All of these requirements are non-functional goal-oriented aspects of the system, and have to be documented explicitly as they are not inherently available in the use case.

3.8 Organizing the Specific Requirements

IEEE 830 explicitly concedes that there are many possible ways of organizing the requirements documentation in Section 3 of the SRS. Several possible examples are shown in the appendix.

In the above mappings, an attempt is made to preserve as much information as possible from UML use case descriptions to create the SRS document in IEEE 830 systematically, if not automatically. Most of the example organizations presented in IEEE 830 can be created from these organizational schemes mentioned in Section 2 of this paper. One possible suggestion offered is to organize the requirements by user class, which would translate as actor in the UML use case model. Another is to organize them by feature, which would suggest the use of the proposed seven generic Use-case function types as a classification scheme, although a domain-specific use case classification might also be helpful for more complex systems. Yet another suggestion is to organize requirements by functional hierarchy, for which a UML system level use case diagram ought to suffice.

If all functional requirements have been detailed in use case diagrams and descriptions, non-functional requirements in supplementary specifications, and the use cases have been properly classified by the various attributes describing them, then the analyst will have collected and organized most of the information necessary to create the IEEE 830 SRS document without much further manual intervention.

4. CASE STUDY

The following fictional system's requirements, expressed as a handful of use cases, will be used to illustrate the expressive power of the use case taxonomies. For this case study, we will consider only system use cases, and not business use cases. For simplicity, we will omit consideration of the target's system's interfaces with other information processing systems.

4.1 System Overview

A periodical publisher wishes to implement a computerized information management system to enable it to manage and grow its business. This publisher publishes several magazines, each of which has its own production schedule, advertising rates, and editorial staff. However, the publisher's magazines cover closely related fields of interest, so the subscriber lists of each of the magazines exhibit large overlap with those of the other magazines. One system is required to handle all transaction, subscriber-servicing, accounting, and fulfillment activities. The system is to handle everything that is needed to publish these magazines, except for support of the editorial (content production) processes, which is handled separately.

4.2 Organization and Classification of the Use Cases

Once the use cases have been identified (refer Table: 2, Pg.7) and briefly described, they are classified by applying heuristics (Question-Method) detailed in Goldman and Song (2005). In this case study we use three of the possible classification schemes that would serve us best for preparing the SRS. The deliverable from this exercise is a classification of a use case along three dimensions:

Table 2. Magazine publisher case study use cases and classifications

Use Case	Brief Use Case Description	C/A/R	P/S/O	G.F.T.
1	Add subscriber information: a new subscriber's information is added to the database.	C	P	1
2	Add new subscription: a new subscription is created in the system.	C	P	2
3	Renew existing subscription: an existing subscription is renewed for additional time.	C	P	2
4	Print fulfillment mailing labels: labels to be attached to magazine issues for mailing.	C	P	5
5	Log in: user identifies self with login ID and password.	A	S	7
6	Add advertiser: a new advertiser's information is added to the database.	R	P	1
7	Add advertisement: an advertisement is received from an advertiser.	C	P	1
8	Schedule advertisement (process insertion order): an advertisement is scheduled to appear in one or more magazine issues.	C	P	2
9	Close issue: total the advertising revenue from scheduled ads in this issue and prohibit further advertisement insertions.	R	S	4
10	Back up certain data.	A	O	7
11	Receive payment: payments are recorded for subscriptions or for advertisements.	C	P	2
12	Cancel subscription.	C	S	2
13	Maintain issue publication schedule: record the dates on which tasks such as closing an issue and printing mailing labels must be completed for each magazine issue.	A	S	1
14	Print circulation report: print a summary report of descriptive statistics.	R	S	5
15	The system must be *n*% reliable: This is an example of a non-functional requirement expressed as a goal-oriented use case.	n/a	P	n/a
16	Initialize the system: configure default settings and start the system application.	A	P	7
17	Print loyalty report: print a report showing customers ranked by longevity and number of magazines	R	O	5

a. Is the use case a core, administrative or routine use case?
b. Is the use case a primary, secondary or optional use case?
c. Which generic function type describes the use case functionality?

Table 2 lists the uses cases identified for the case study along assigned. The "C/A/R" column indicates whether the use case is considered "Core," "Administrative," or "Routine." The "P/S/O" column indicates whether the use case is considered "Primary," "Secondary," or "Optional." The "G.F.T." column indicates the use case's classification within the seven generic function types (Section 2). The number in the "G.F.T." column corresponds to the subsection within Section 2.

4.3 SRS Section 3

Based on this classification, we shall arrange the use cases into the "Specific Requirements" Section 3 of the IEEE 830 SRS document. We will use as our major classification the "Core-Administrative-Routine" distinction, followed by the prioritization (Primary/Secondary/Optional). The order of these classifications could be reversed: IEEE 830, Annex A shows that any of a number of hierarchical arrangements is acceptable.

Using this method, the result is an easily produced, yet organized presentation of the use cases, well suited to guiding the design and implementation process.

4.3.1 Magazine Publisher Case Study -- Sample SRS Section 3 Organization

Core

Primary

Data entry / maintenance (4.6.1)

1. Renew existing subscription
7. Add advertisement

Transaction recording (4.6.2)

2. Add new subscription
3. Renew existing subscription
8. Schedule advertisement
11. Receive Payment

Communication (4.6.5)

4. Print fulfillment labels

Secondary

Transaction recording (4.6.2)

12. Cancel subscription

Optional (Note: an Optional Core use case would be rare.)

Administrative

Primary

System administration (4.6.7)

16. Initialize the system

Secondary

Data entry / Maintenance (4.6.1)

13. Maintain issue publication schedule

System administration (4.6.7)

5. Log in

Optional

System administration (4.6.7)

10. Back up certain data

Routine

Primary

Data entry / Maintenance (4.6.1)

6. Add advertiser

Secondary

Transformation (4.6.4)

9. Close issue

Communication (4.6.5):

14. Print circulation report

Optional

Communication (4.6.5)

17. Print loyalty report

Non-functional requirements

Primary

15. The system must be *n*% reliable

5. CONCLUSION

UML provides a language and notations for identifying, documenting, and communicating system requirements. Use-case descriptions and diagrams are most frequently used during the requirements definition stage of a project using UML. The SRS document prepared in compliance with the Std.830-1998 can ensure unambiguous communication between the stakeholders. The Use-case model alone cannot serve as the core piece of documentation as it gives us only an interpretation of the SRS document. But, it can shorten the time required to generate a standard compliant document if existing Use-case description could be re-used in some manner.

To help avoid duplication of effort, a method for systematic translation of UML use case descriptions into the IEEE 830 recommended format has been outlined. In order to increase the comprehensibility of what would otherwise be linear lists of dozens of use cases, we have proposed that use case descriptions be categorized on five different organization schemes.

Finally, we have presented a step-by-step method based on several of the organization schemes for forming each major requirements section of an IEEE 830-based SRS document. This is achieved by using the information captured in UML use case diagrams and use case descriptions. In the absence of systematic techniques for preparing a standards compliant SRS document with Use-cases, our method presents itself as a practical solution. Future work involves determining the efficiency of our technique when compared to traditional ad-hoc approaches for documenting functional requirements. The extent of cognitive load experienced in preparing the SRS document shall serve as another evaluation metric.

6. REFERENCES

1 Goldman, J. and Song, I.-Y. (2005). "Organizing and Managing Use Cases," in the Proceedings of First International Workshop on Best Practices of UML, Oct. 26-28, 2005, Klagenfurt, Austria, (in *Perspectives in Conceptual Modeling*, LNCS Vol. 3770, Editor: J. Akoka, etc. Springer Verlag, 2005), pp. 43-52

2 IEEE Computer Society. (1998). IEEE Standard 1233a-1998: IEEE Guide for Developing System Requirements Specifications. New York City: IEEE.

3 IEEE Computer Society. IEEE Standard 830-1998: IEEE Recommended Practice for Software Requirements Specifications. New York City: IEEE.

4 Lee, J. and Xue, N. 1999. Analyzing User Requirements by Use Cases: A Goal-Driven Approach. *IEEE Softw.* 16, 4 (Jul. 1999), 92-101. DOI= http://dx.doi.org/10.1109/52.776956

5 Spence, I. and Probasco, L. (2000). Traceability strategies for managing requirements with Use cases. Rational Software White paper.

Impact of the Use of Communication Technologies on the Work-Life Balance of Executive Employees

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ABSTRACT

The Internet, email and mobile communication devices are indispensable today. By creating bridges between work and non-work situations, these technologies appear to contribute to blurring of the boundary between work-family domains. This paper presents the results of an exploratory study assessing the usage patterns of these technologies by executive level employees, and the effect of these technologies on their work-life balance.

Communication technologies are an essential life ingredient to the dwellers of today's fast moving global society. The Internet, emails and portable communication devices[1] such as mobile phones, BlackBerries, and PDAs form a technology group that has blended itself well into everyday lives of the global community. Enabled by such technologies, the generic slogan of "anytime, anywhere, and availability at the press of a button" captures the current work culture trend.

Canada, US and UK have reported that managers worked longer hours and experienced a sense of "working high speed" all the time as reported by HRDC (2005), Patel (2002), and Guest (2002) respectively. This appears as a worldwide trend both in developing and developed countries (Bell & Hart, 1999; Black & Lynch, 2001; Guest, 2002; Healy, 2000). While some employees enjoy compensation for the extended work hours and their 24/7 accessibility, for most executives, who are not covered by the overtime legislation (US_Department_of_Labor, 2006), these extra hours are just an extension of their work demands. The *ICT cluster* seems to be adding on to the virtual hours worked.

Extended work hours are reported to have an adverse impact on work-life balance of employees (Chesley, 2005; Gutek et al., 1991; Parasuraman & Simmers, 2001) and on employee health (Sparks et al., 1997). There is a growing concern on the ability of communication technologies to create an "e-leash" on employees (Rothberg, 2006). Addiction to these technologies is considered comparable to drug addiction (McIntyre, 2006). With increasing concerns on the deteriorating quality of home and family life leading to a variety of social problems, the concept of work-life balance has drown the attention of the workforce, employers, and public policy makers. Therefore, it would be important to assess the true impact of the *ICT cluster* on the work-life balance of modern employees.

Recent literature analyzed the usage patterns of mobile devices addressing diverse issues (Arnold, 2003; Chesley, 2005; Churchill & Munro, 2001; Jarvenpaa & Lang, 2005; Perry et al., 2001; Schlosser, 2002). Schlosser (2002) focused on the meanings assigned by employees to mobile devices while the paradoxes of mobile usage were addressed by Jarvenpaa and Lang (2005). Research has also addressed the concepts of "anytime, anywhere" in the context of teleworking (Nath & Chen, 2005; Perry et al., 2001; Venkatesh et al., 2003).

The current paper contributes by responding to a call for a better understanding of the use of technology (Orlikowski, 2000) by presenting an empirical analysis of the usage patterns of a cluster of communication technologies which are critical to modern employees, and their impact on employee work-life balance. The study aims to address following research questions:

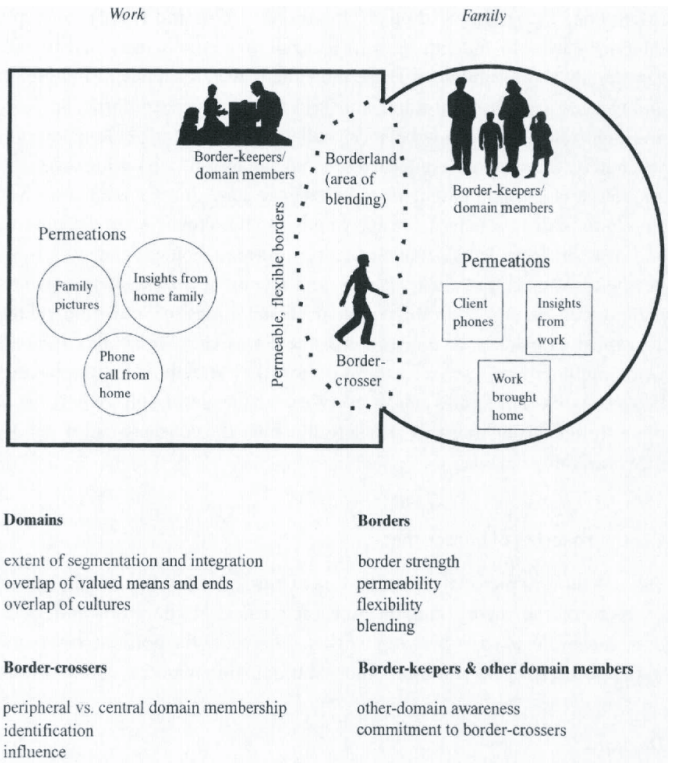
- How do employees actually use the *ICT cluster*? Are there usage differences within the cluster?
- What is the role played by the *ICT cluster* in managing employee work-life balance?
- Do these technologies facilitate a growing blurring of work life and private life, or have employees managed to keep them separate?

THEORETICAL BACKGROUND

The recent explosion of interest in the work-family interface has produced several conceptual frameworks to explain the relationship between these two spheres of life (Greenhaus et al., 2003; Guest, 2002; Gutek et al., 1991; Zedeck & Mosier, 1990). Greenhaus et al. (2003) defined work-family balance as "the extent to which an individual is equally engaged in – and equally satisfied with – his or her work role and family role" (p.513). They proposed three components of work-family balance as time, involvement, and satisfaction, and emphasized the need to have equal weight in work and family roles in each of these components.

In the traditional perspective of work-life balance Zedeck and Mosier (1990) identified five models of representation. *Spillover model* assumes that there are no boundaries in one's behaviour between work and non-work situations and asserts

Figure 1. Work-family border theory: list of central concepts and their characteristics (Clark, 2000, p.754)



that there is similarity between the occurrences in work and family environments. *Compensation model* proposes an inverse relationship between work and family such that work and non-work experiences tend to be antithetical (Staines, 1980). *Segmentation model* hypothesizes that work and non-work are distinct domains of life and individuals can function in each domain without influencing the other. The separation in time, space and function allowed individuals to neatly compartmentalize their lives. *Instrumental model* suggests that activities in one environment will facilitate success in the other. Work outcomes would lead to good family life and life's pleasures. C*onflict model* proposes that the two environments are incompatible with distinct norms, and requirements of one environment entail sacrifices in the other (Zedeck & Mosier, 1990).

Clark (2000) argued that people are daily border-crossers between work and family domains. Although many aspects of work and family are difficult to alter, individuals can shape to some degree the nature of work and home domains and create bridges to attain the desired balance. He provided a pictorial representation of the work-family border theory shown in Figure-1.

The increased usage the *ICT cluster* has enabled location independent working and 24/7 contactability to employees creating 'permeations' across work-family borders. These technologies facilitate border crossings between work and family domains even when the individual is physically in the other domain.

The current research examines the role of the *ICT cluster* as a facilitator for this boundary blurring phenomenon between work and family domains, based on a sample of 26 executive level employees. It also examined how these technologies influenced individuals in achieving their time, involvement and satisfaction balance in work and family roles.

METHOD

The study sample comprised of executive level employees who are usually not covered by overtime legislations and not compensated for additional work time. They would have higher autonomy at work with more cognitive work demands, fulfilling supervisory responsibilities and overseeing the operation of business units or processes. These criteria enable the performance of a portion of job related duties outside work premises and work-time. Initial participants were selected based on available contacts, focusing on the users of the *ICT cluster* and preferably with family commitments. Snowballing technique[2] was used to recruit additional participants for the study. Table-1 summarizes the participant details. The age of participants ranged from 25 to 60 years with 73% of them in the age group 30- 45 years.

Participants were initially contacted through email or telephone. Interviews were held at a location chosen by the interviewees and lasted approximately an hour. Semi-structured interviews were guided by the research questions. The two-way face-to-face communication approach allowed a rich flow of ideas from the participants. Transcribed interviews were coded for common topics which formed the basis of analysis.

Table 1. Participant details

Industries	No of participants	Male	Female
Telecommunication	6	5	1
Railways	1	1	
Manufacturing	1	1	
Banking & Finance	3	2	1
IT/ Software	5	3	2
Legal	1	1	
Education	3	2	1
Consultancy	3	1	2
Chemical Engineering	1		1
Energy	2	2	
TOTAL	26	18	8
Average Age	36.4 years		
Standard Deviation of Age	8.4 years		

THE RESULTS

How Do People Actually Use These Devices?

(a) Emails

Irrespective of the industry all participants highlighted the importance of emails in their work life, identifying it as the main mode of communication at the work place. They used phrases such as, '*indispensable*', '*very crucial*', '*something we cannot live without*', '*my worklife virtually revolves around emails*', '*the work culture in my company is predominantly email driven*', in describing the importance attached to emails at work.

All participants had employer provided email facilities and had remote access to it. However, the majority of the participants maintained separate personal email accounts, and frequently used employer provided Internet facilities in accessing them. Heavy users of emails-at-work claimed to receive over 100 work related emails and spend about 1.5-2.5 hours daily on emails; which amounted to about 15% to 25% of the daily work time. Compared to work-related emails, personal emails were a negligible proportion of 5% to 10%.

(b) The Internet

The use of Internet in work activities mainly depended on the type of occupation. Internet was widely used for research, and participants frequently commented on the *'tremendous time saving ability of the Internet'*. Participants from the software industry highlighted other Internet based technologies such as VOIP (Voice over Internet Protocol) and IM (instant messaging) to be of importance. Many software firms used these services with instant and real-time access to coordinate with overseas partners. Programmes such as MSN Messnger, Skype, and Yahoo Messenger were used to communicate with project teams across the globe and across the room. These IM services performed an important role in maintaining both work and non-work relationships.

Many individuals, who had some form of post graduate studies, highlighted the importance of Internet for education related research as a non-work activity. All individuals had Internet access at home at least through a dial-up facility, but used employer provided Internet access for personal use too. News, sports, banking are some other personal uses of the Internet. Many individuals were not comfortable with using Credit Cards over the Internet.

(c) Mobile Communication Devices (Cellular Phone/ BlackBerry)

Compared to the widespread popularity of cellular phones, BlackBerry use was not prominent. All participants used cellular phones but only two BlackBerry users were in the selected group. In most cases, employers either provided the cellular device, or bore at least portion of the monthly cost. In contrast to the Internet and email technologies, cellular phones played an equally important role in non-working lives of these individuals. They commented:

"I can't even think of a life without a mobile phone. ... Everything is a phone call away from me."

"When you are on such a busy work schedule, how you interlink your family pressures predominantly depends on the mobile phone. By being on the mobile phone you are able to put things together, remotely ... with a schedule of this nature, it is something that you cannot do without."

Participants with a technical background, or in a technology related field tend to use the additional features such as text messaging in a cellular phone. Non-technical and older participants used the devices primarily for voice communication. The users of the additional services appreciated them immensely:

"I think text messaging is a very neat way of not invading into privacy of people. If you don't want to talk but still want to send a message, then just send SMS. Therefore I think SMS really enhance the mobile phone service."

"If you think of MMS (multimedia messaging service), then it is again cool. For example I have a friend with whom I go shopping and we know each other's preferences. So for example when I am in Singapore, I see a nice top, I quickly

take few pictures with prices and send a MMS. She will respond immediately. It is cheaper than a call and we get the work done very satisfactorily".

Many participants exploited ability to be on the phone while on the move, especially in commuting to work:

"I switch on my mobile phone in the morning and would check for any missed calls and send some SMS and make some of the calls while going to office. I do have a driver in the mornings."

"I use the commute time from home to office to make some of the personal calls. I usually drive with a phone conversation or typing a SMS. I don't know if this is good or bad, but I feel it makes me efficient."

"Sometimes while driving to work I would call my support guys to see if there are any issues that need attention, or if I have something in my mind which needs to be looked into. This gives me a head start before I get to the office."

Extended Work Hours: Do These Devices Add to the Work Time?

All participants revealed demanding work schedules requiring them to work beyond the normal 8 hours, to work from home, during weekends and at night. Describing a typical day in their lives, many individuals admitted to checking work emails before going to bed and having the cellular phone on throughout the night to be contactable 24/7.

A divisional manager in a telecommunication company commented:

"My primary task is to provide this infrastructure, and the problem is when there are issues on the system, my staff is the second line of support…. Lately I would say that, thank God I am able to sleep at night. But if I turn back the clock, when I was down the ladder, then I used to be around 24/7 whenever there is an issue. But still I am available over the phone any time of the day."

Another participant commented:

"If you are in the middle of an important project, your might get a call saying that a report has been emailed to you and some feedback is required urgently. So you would just log in to your emails even late at night and see what can be done before you start work next day."

Not all participants agreed on role of technology in extending their work hours. A lawyer commented:

" think the demands of my practice are responsible for that and not the technologies. It would be the same with or without the technologies. But I would view all these technologies as largely positive and since I believe I have a control of them they truly help me in managing my work more efficiently."

Creating Permeable Borders: Work-Family and Family-Work Spillover

Most participants preferred to have a thick border between work and non-work situations. However, work demands have made it difficult to maintain this separation. Research results revealed that the *ICT cluster* played a key role in creating permeable borders between the two domains of work and family. In describing the interactivity of the two domains participants frequently used terms such as *interwoven, overlapping, and interconnected*.

Participants broadly accepted that more work-to-nonwork spillover is present compared to the reverse direction. The main spillover from non-work to work was through cellular phones when it was used in family related matters. This was regarded positively as a means of empowerment since it enabled, for example, the parents to keep track of their children, and attend to household activities through third party intervention. This was described as equipping according to the life style:

"…[cellular phone] is an asset to the lives of people like us. Since we have chosen this life style, we need the necessary equipment to live this life efficiently.

The cases of extended work hours and teleworking described above are classic examples of work-life spilling over to the non-work. However, several individuals considered this as a positive attribute since it allowed them to be present at home while attending to work matters:

"Because of our work assignments, my wife and I live in different locations. So if I start using my laptop when I am with her, then she will definitely complain and grumble. But on the other hand, technology enables me to be with her and work at the same time. And the fact that I have the mobile phone and I can talk to her all the time and she can have access to me anytime is crucial. Without that our lives would have been very difficult."

Described the nature of spillover effect of work and non-work situations, a participant had the following comment to make:

"I work a lot from home and it is possible because I have access to systems through the Internet. This helps me to attend to family matters as and when required. I think my work and family activities are so interwoven and I am almost like a butterfly going from flower to flower- I go from chore to chore, and they could be either family or work related."

Not all were in favour of technology enabled blurred boundaries phenomena. Some participants commented about the invasion of privacy, and the ability of the work life to creep into the family life with the 24/7 accessibility:

"I feel as if I am trapped sometimes and I can't get away and have some peace because of the mobile phone. Yes, I can switch it off, but then, there are situations where you need to have it on."

DISCUSSION AND CONCLUSION

Analyzing the usage patterns of the *ICT cluster* revealed emails to be the most work-centric technology. Although emails may not be critical to all spheres of employment, for the selected executive level employees, emails were the crucial technology in their work life. Cellular phone, the easiest mode for 24/7 connectivity, was recognized as the technology with the strongest association with non-work life. Internet in work and non-work activities depended on each individual and the industry involved.

Providing 24/7 seamless accessibility and ability to attend to work related matters off-worksite and off-working hours, the *ICT cluster* is adding onto work hours of these employees. By blurring the work-family boundary these technologies create spillover in both directions, work-to-family and vise versa. Clark's model (2000) identified these as permeations. Thus, these technologies are facilitating border crossing of individuals between the two domains of work and family.

The study revealed that how people perceived and achieved their work-like balance is very individual-specific and does not necessarily have *equal* distribution of time, involvement and satisfaction in work and family roles. This was in contrast to the definition provided by Greenhaus et al. (2003) in specifying "equal" time, involvement and satisfaction balance. Further, it was observed that an individual could fit into any (one or more) of the five work-life balance models[3] (Zedeck and Mosier (1990) based on their age, industry and individual perception.

Chesley (2005) suggested that cellular phone usage created more spillover compared to computer technology usage. According to the current study, cell phone usage led to more family-to-work spillover. Considering work-to-family spillover, a cellular phone use could act as the sole 'border permeation' or initiate the spillover process with the use of other technologies. For example, an employee could get a call asking him to respond to an urgent email. Although there were only a few users in the study sample, BlackBerry is a device gaining user popularity (Reuteres, 2006). Compared to cellular phones, BlackBerry is equipped to receive emails on the move, anywhere, anytime. Since emails were identified as the most work centric technology by the participants, in the future,

BlackBerry may be recognized as the device creating the greatest amount of spillover in work- family domains.

Convergence of several technologies to miniaturized handheld devices is the current trend (Edur, 2000; Johnson, 2005). However, current research suggests that different functionalities associated with these technologies could have differing impacts on work-life balance. Therefore, future researchers assessing the impact of these convergent technological devices would have to make a distinction among the functionality of these gadgets to correctly ascertain the true impact on individuals. Considering it as a single device may not reveal the intricate details of the impact of each technology within the bundle.

Technology usage varied based on type of industry and the age of participants. Many studies have suggested that women tend to emphasize their family roles more than men (Gutek et al., 1991; Rothausen, 1999; Wharton & Blair-Loy, 2006). Thus it was expected to see a significant gender difference in the usage patterns of these technologies. It was seen that there was a difference in the perceived value towards cellular phone; females perceived it as a security feature compared to men. Other usage patterns didn't highlight any significant differences. This could be due to the increasingly similar roles men and women have in their organizations, resulting in both groups using the technology in a similar manner. On the other hand, the sample of the current study was limited in size, especially in terms of female participation. Therefore, future research could address this issue further. The participants represented a wide range of industries. However, the smaller sample size restricts a wide spread generalization of the results.

Work-life balance of citizens has become an important theoretical, practical, and policy issue. In an era where communication technologies are blurring the boundaries between work and home life, this research provides empirical evidence based on a qualitative assessment of the use of these technologies and their impact on work-life balance of executive level employees. Since different functionalities of the technologies have different implications on the work-life balance issue, the study also suggests that future research should pay attention to these differences rather than simply bundling them together.

REFERENCES

Arnold, M. 2003. On the phenomenology of technology: the "Janus-faces" of mobile phones. ***Information and Organization***, 13: 231-256.

Bell, D. N. F., & Hart, R. A. 1999. Unpaid Work. ***Economica***, 66(262): 271-290.

Black, S. E., & Lynch, L. M. 2001. How to Compete: The Impact of Workplace Practices and Information Technology on Productivity. ***The Review of Economics and Statistics***, 83(3): 434-445.

Chesley, N. 2005. Blurring Boundaries? Linking Technology Use, Spillover, Individual Distress and Family Satisfaction. ***Journal of Marriage and the Family***, 67(December): 1237-1248.

Churchill, E. F., & Munro, A. J. 2001. Work/place: mobile technologies and arenas of activity. ***ACM SIGGROUP Bulletin***, 22(3): 3-9.

Clark, S. C. 2000. Work/Family Border Theory: A New Theory of Work/Life Balance. ***Human Relations***, 53(6): 747-770.

Edur, O. 2000. Converging Technologies. ***CMA Management***, 74(9): 18-22.

Greenhaus, J. H., Collins, K. M., & Shaw, J. D. 2003. The relation between work-family balance and quality of life. ***Journal of Vocational Behavior***, 63(3): 510-531.

Guest, D. E. 2002. Perspectives on the Study of Work-life Balance. ***Social Science Information***, 41(2): 255-279.

Gutek, B. A., Searle, S., & Klepa, L. 1991. Rational verses gender role explanations for work-family conflict. ***Journal of Applied Psychology***, 76(560-568).

Healy, E. 2000. The Shift to Long Working Hours: A Social and Political Crisis in the Making. ***People & Place***, 8(1): 38-51.

HRDC.2005.Addressing Work Life Balance in Canada. Accessed January 2006. http://www.hrsdc.gc.ca/en/lp/spila/wlb/awlbc/01table_of_contents.shtml

Jarvenpaa, S. L., & Lang, K. R. 2005. Managing the Paradoxes of Mobile Technology. ***Information Systems Management***, 22(4): 7- 23.

Johnson, K. 2005. Europe Picks Up 3G, As Phone Hopes Lift; Consumers Embrace Technology Converging Voice, Music, Video; U.S. Telecom Sector Falls Behind, ***Wall Street Journal***, Aug 25 Eastern ed.: C.1. New York.

McIntyre, S.2006.Blackberry addiction 'similar to drugs'. Daily Mail, UK. Accessed September 2006. http://www.dailymail.co.uk/pages/live/articles/news/news.html?in_article_id=401646&in_page_id=1770

Nath, R., & Chen, L. 2005. Nomadic Culture: Culture Support for Working Anytime, Anywhere. ***Information Systems Management***, 22: 56-64.

Orlikowski, W. J. 2000. Using Technology and Constituting Structures: A practice lens for studying technology in organizations. ***Organization Science***, 11: 404-428.

Parasuraman, S., & Simmers, C. A. 2001. Type of employment, work-family conflict and well-being: a comparative study. ***Journal of Organizational Behavior***, 22(5): 551-568.

Patel, D. 2002. Vacation? What vacation? ***HRMagazine***, 47(8): 144.

Perry, M., O'hara, K., Sellen, A., Brown, B., & Harper, R. 2001. Dealing with Mobility: Understanding Access Anytime, Anywhere. ***ACM Transactions on Computer-Human Interactions***, 8(4): 323-347.

Reuteres.2006.BlackBerry Users Addicted But Happy.PCMAG.COM. Accessed September 2006. http://www.pcmag.com/article2/0,1895,2008288,00.asp

Rothausen, T. 1999. 'Family' in Organizational Research: A Review and Comparison of Definitions and Measures. ***Journal of Organizational Behavior***, 20(6): 817-836.

Rothberg, D.2006.BlackBerry on the Beach: You call this a real vacation?eWeek. Com. Accessed September 2006. http://www.eweek.com/article2/0,1895,1974714,00.asp

Schlosser, F. K. 2002. So, how do people really use their handheld devices? An interactive study of wireless technology use. ***Journal of Organizational Behavior***, 23(4): 401-423.

Sparks, K., Cooper, C., Fried, Y., & Shirom, A. 1997. The Effects of Hours of Work on Health: A Meta Analytic Review. ***Journal of Occupational and Organizational Psychology***, 70(4): 391-408.

Staines, G. L. 1980. Spillover versus compensation: A review of the literature on the relationship between work and non work. ***Human Relations***, 33: 111-129.

US_Department_of_Labor.2006.FairPay Fact Sheet by Exemption Under the Fair Labor Standards Act (FLSA).U.S. Department of Labor. Accessed December 2006. http://www.dol.gov/esa/regs/compliance/whd/fairpay/fs17a_overview.htm

Venkatesh, A., Kruse, E., & Shih, E. C.-F. 2003. The networked home: an analysis of current developments and future trends. ***Cognition, Technology & Work***, 5(1): 23-32.

Wharton , A. S., & Blair-Loy, M. 2006. Long Work Hours and Family Life. ***Journal of Family Issues***, 27(3): 415-436.

Zedeck, S., & Mosier, K. 1990. Work in the Family and Employing Organization. ***American Psychologist***, 45: 240-251.

ENDNOTE

1. The group of technologies (the internet, email and portable communication devices) is referred to as the *"ICT cluster"*.
2. Initial participants introduced more participants for the study
3. Spillover Model, Compensation Model, Segmentation Model, Instrumental Mode, and Conflict model (Zedeck and Mosier (1990))

Assessing Web Designers' Perception of Web Accessibility

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ABSTRACT

People with disabilities continue to be at a disadvantage in terms of opportunities on the Web. Federal laws and state policies help govern website design for federal and state agencies, but their impact thus far is unclear. This paper addresses the issue of web accessibility. A survey was developed and administered to web designers to discover their knowledge, attitudes, and actions taken regarding making pages accessible. The results of these studies are presented in this paper.

INTRODUCTION

The World Wide Web is an integral part of the fabric of our society. Using the Internet has become a way of life for many people around the world, especially in the United States. Prior to being required by law, many buildings were not constructed with handicap access. Today, in the United States, architects must design buildings that are handicap accessible. Just like the buildings of old, most web sites have not been built with user accessibility in mind. Will laws and regulations be needed to force web designers to create accessible web pages? A website is accessible if "anyone using any kind of Web browsing technology is able to visit any site and get a full and complete understanding of the information contained there, as well as have the full and complete ability to interact with the site." (Letourneau, 2003)

According to the 2000 Census, the number of Americans (age five and over) with a disability is 49.7 million, a ratio of nearly one in five people (US Census, 2002). The Internet has had a powerful impact upon the disabled community. According to the National Organization on Disability, the following statement shows the effect the Internet has had on those with disabilities:

"While the Internet has significantly increased the opportunities for social participation for both people with and without disabilities, it has had a much more dramatic impact on quality of life for people with disabilities. 42% of Americans with disabilities online say the Internet has significantly increased their ability to reach out to people who have similar interests and/or experiences, compared to 30% of non-disabled online Americans. And 52% of Americans with disabilities online say the Internet has helped them to be better informed about the world around them, compared to 39% of non-disabled Americans online." (nod.org, 2002)

Anyone can become disabled. Most people experience some temporary or permanent disability -- a broken arm, stroke, hearing loss (to name a few), can render someone disabled. Furthermore, everyday circumstances can mimic a disability, forcing someone to rely on the same solutions used by those with disabilities. For example, if your mouse stops functioning, you must rely on your keyboard – the same way someone who is blind or quadriplegic might. Accessing a web page in a noisy environment increases the importance of audio transcripts or captions just as these transcripts or captions are important to someone with a hearing impairment.

This paper addresses the issue of web accessibility. A survey was developed and administered to web designers to discover their knowledge, attitudes, and actions taken regarding making pages accessible. The results of these studies are presented in this paper and compared against the following hypothesis.

HYPOTHESIS

This research will test the following hypothesis:

Null Hypothesis (H_0): Web designers will ensure their web pages follow the WCAG if there is a policy governing the accessibility of their pages.

Alternative Hypothesis (H_1): Web designers will not ensure their web pages follow the WCAG if there is a policy governing the accessibility of their pages.

Research in this field can lead to improved and more realistic policies and guidelines. This study on accessibility builds awareness and increases the understanding of the magnitude of this problem.

SURVEY OF WEB DESIGNERS

Web designers/developers were anonymously surveyed in April, 2006 to determine their knowledge of issues surrounding web accessibility, the degree to which their organization encourages the design of accessible web pages, and what metrics are in place to ensure that sites are accessible.

Research Methodology

A survey was developed consisting of twenty-two questions to determine perceptions of web accessibility for web designers/developers. The link to this online survey was sent to two mailing lists *(*highedweb-l@geneseo.edu and uwebd@listserver.itd.umich.edu*)* on April 17, 2006. The survey was also sent to a few web designers in Rochester, NY.

Results

There were a total of 161 responses to the survey; 53.42 percent were male, 45.34 percent were female, and 1.24 percent did not answer the gender question. The education level of the respondents was mostly college educated, with 93.79 percent being college graduates, and 32.3 percent of the total with graduate degrees. The age ranges are shown in Figure 1. The respondents were asked what percent of their job was devoted to design and development of web pages. Nearly 30 percent said that 96-100 percent of their job is web design/development. 18.63 percent said that it was 81-95 percent of their job. 16.15 percent responded that it was 61-80 percent of their job. 11.80 percent responded with 41-60 percent of their job, 13.66 percent said it was 21-40 percent of their job, and the remaining 10 percent said it was less than 20 percent of their job. Nearly thirty-seven percent of the respondents have had formal training specifically on web accessibility.

Because of the specific mailing lists that the survey was sent to, not surprisingly, 93.17 percent of the respondents were from educational institutions. When asked whether any websites they design are subject to a web accessibility policy, 49.07 percent responded "yes", 36.65 percent responded "no", 13.66 percent were "not sure" and 1 person did not answer the question. Unfortunately, data was not gathered to determine if the individuals were from public or private schools which would have been a better measure of whether they are subject to state policies on web accessibility, as public universities would be more likely to have to follow state policies.

When asked if their organization had a policy with respect to web accessibility, the responses are shown in Figure 2.

Figure 1. Age ranges of survey respondents

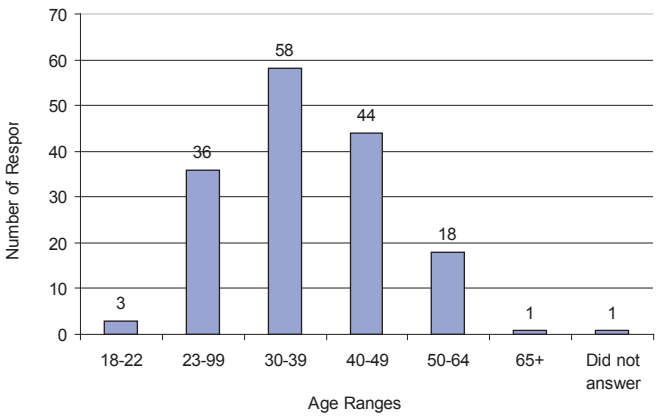
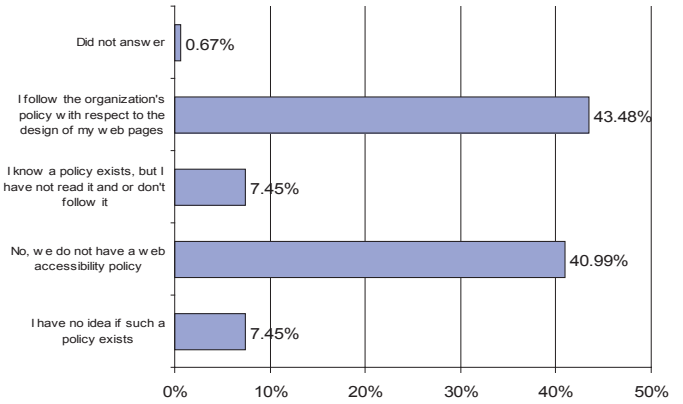


Figure 2. Does your organization have a policy?



An interesting analysis is comparing those who said their web sites are subject to a web accessibility policy (49.07 percent) with answers to questions related to the actual design of their pages and how important the guidelines are to them. When asked, "How familiar are you with the World Wide Web Consortium's (W3Cs) Web Content Accessibility Guidelines (WCAG)?" the answer choices and percentage of respondents are shown below:

How familiar are respondents with the W3Cs WCAG?

0.62% I've never heard of them
15.53% I have heard of them, but don't really know the particular details
11.18% I'm aware of the guideline specifics but don't use them to guide my website design
47.83% I use them regularly but not consistently to guide my website design
24.84% I always ensure my web pages adhere to the guidelines

In summary from the last two questions analyzed, around 49 percent of the designers/developers surveyed have a policy governing their web pages; yet, only 25 percent always ensure their pages adhere to the Web Content Accessibility Guidelines or their policy.

Respondents were asked which software they used to evaluate their pages for accessibility. The most popular answers were: 62% used Bobby, 51% used browser toolbars, 35% used Lynx, 30% used JAWS, and less than 18% used any other software.

Bobby and the web browser toolbars were by far the most widely used. The browser toolbars are free and easy to use. They give quick feedback to designers because they can be easily docked in the browser window. Bobby is well known and reputable. Nearly eight percent of respondents reported that they have not used any of the software that is available to check for accessibility. When asked *what percentage of their pages* they check with at least one of the programs listed in the previous question, their answers were that only 13.04 percent of respondents check 100 percent of their pages. Roughly 20 percent check between 76-99 percent of their pages. Nearly ten percent of the respondents do not check any of their pages. This number differs from the amount of people that have not used any of the accessibility software which was eight percent.

Questions were asked that do not directly correspond to checking for accessibility, but relate to the topic. These questions related to whether the designers/developers check their pages on multiple browsers, if they check their pages on multiple platforms, and if they use ALT tags with their images. Surprisingly, only 44.10 percent of respondents check 100 percent of their pages on two or more browsers. This might be a result of the volume of pages they are responsible for, or that multiple pages are built on the same basic template or design and/or coding. Almost 30 percent of respondents checked 76-99 percent of their pages with multiple browsers. When asked which browsers they routinely check their pages with, the two most common were Internet Explorer (99 percent of respondents) and Mozilla Firefox (96 percent of respondents). Thirty-two percent of respondents check 100 percent of their pages on multiple platforms (e.g., Windows and Macintosh).

With respect to including ALT tags for images, 47.2 percent use ALT tags with all of their images and nearly 40 percent responded that they use ALT tags with 76-99 percent of their images. As seen in the degradation process, this may be that they do not use ALT tags on images that are used for design only and do not include content.

Question 4 of the survey asked respondents if they had ever viewed any of their web pages using assistive technologies. The results are presented in Figure 3.

When asked what percentage of content of their web pages were displayed requiring browser plug-ins, such as Flash or Shockwave, less than 37 percent of the respondents used these technologies to display any of their content. Only one person responded that 100 percent of their content used these technologies, and one other person said that 76-99 percent of their content used plug-ins. In the same line of questioning, respondents were asked: "What percentage of your pages do you ensure are usable when scripts, applets, or other programmable objects are turned off or not supported?" Only 9.32 percent responded that they do not use these technologies. Twenty-two percent of the respondents checked all of their pages to ensure they are usable without these technologies.

Question 13 asked about their perceptions regarding the importance of ensuring their web pages are accessible according to the W3C's Web Content Accessibility Guidelines, 57.14 responded with the answer "I try to make my pages accessible, but don't always have the time." Full responses to this question are shown in Figure 4.

Figure 3. Assistive technologies used to view Web pages

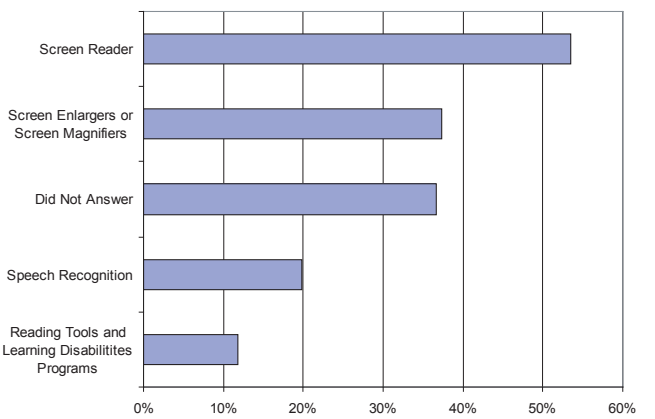
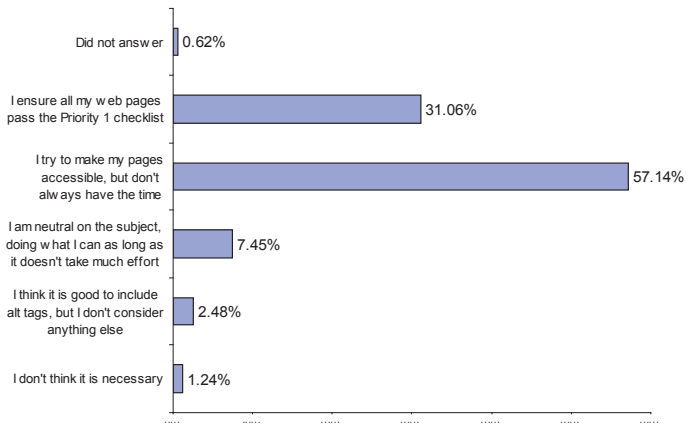


Figure 4. Perceptions about importance of accessible pages



Finally, an important open-ended question was asked: "If you currently don't ensure your web pages are accessible, what factors would influence you to make your web pages accessible?" This question provoked fifty-nine responses. Many people answered that *time* was a major factor influencing whether they make pages accessible or not. Some people pointed out that the checklists are not easy to figure out. One person stated, "Wading through W3C verbosity is a pain." Others stated that organization policies are not in place for this and that customers expect results quickly or they will go elsewhere. There needs to be "an increasing awareness of how important it is for our target audience." Some individuals stated that they have or are moving to a content management system where their template will be developed that is accessible and then the content developers will not have to worry about this issue because it will be built into the template.

Many responses pointed to the fact that there does not seem to be a great development tool that adheres to the standards. They point to, "ease of use, better tools, cheaper tools, ease of checking, better software, additional resources, WYSIWYG editors that build-in fool-proof accessibility," and more. Dreamweaver and other software solutions are moving to build many more accessible standards into the software, like automatically creating a cascading style sheet in the background when using different fonts and font styles. Many features still require users to take the initiative to use them. For example, when inserting a picture in Dreamweaver, there is a box for the developer to add an ALT tag. However, there is not a warning or any action that occurs to alert the user if they do not use one.

Lastly, many people stated that there is not a clear message about web accessibility from their supervisors. They stated that they would put more effort into it if their supervisors told them they had to. One person wrote, "Support from management for making accessibility a priority – having their support is the only way it could happen. Without it, my time will continue to be taken up maintaining the old, less-accessible design. I *want* all my pages to be accessible, but don't have the time."

Accepting/Rejecting the Null Hypothesis

The Null Hypothesis (H_0) was: Web designers will ensure their web pages follow the WCAG if there is a policy governing the accessibility of their pages. The Alternative Hypothesis (H_1) was: Web designers will not ensure their web pages follow the WCAG if there is a policy governing the accessibility of their pages. As stated in the results, almost 49 percent of the web designers surveyed have a policy governing their pages, but only around 25 percent of them always ensure their pages adhere to the guidelines. Therefore, the null hypothesis is rejected.

SUMMARY AND RECOMMENDATIONS

Evidence shows that web pages governed by an organizational or state policy are more likely to be accessible than those that are not. Standards and legislation are having a positive impact on accessibility. However, a policy in no way guarantees that the sites are accessible. Of the web designers surveyed, all of them had heard of the Web Content Accessibility Guidelines (WCAG), but responses varied as to the extent to which they follow them or try to make their pages accessible. Many still feel the tools are inadequate, and the time and resources are insufficient. Based on this research, the following recommendations are suggested for executives in any organization:

- Create a policy for web accessibility and strongly encourage and support designers/developers in making pages accessible
- Regularly assess usability and accessibility of company websites
- Devote adequate resources – time, training, and software tools
- Educate employees, clients, and other stakeholders about this topic

One goal when creating websites should be universal design and access. This will only be achieved through education and increased awareness about this very important issue. If brick-and-mortar companies had signs on their doors stating that only certain people were allowed to enter, this would be apparent to them that this was wrong. The same awareness and understanding needs to be considered on the web.

It is a myth, at best, to believe accessible pages have to be plain or boring. Almost all accessibility guidelines deal with adding to the page, not subtracting (e.g., if you have an image, add an ALT tag). Designers/developers should strive to develop high quality pages visually, with all content intact and usable when viewed in Lynx. In addition, search engines are like blind users. An accessible page may even help a company get to the top of the Google list! Just as we have seen with buildings that have been modified for accessibility, everyone has benefited from elevators, ramps, curb cuts, and other accommodations. There are so many more reasons to create accessible pages. It cannot be stated enough that by making the web more accessible, everyone wins.

REFERENCES

Letourneau, C. (2003) Accessible Web design - a definition. Retrieved November 2005 from http://www.starlingweb.com/webac.htm.

nod.org (May 15, 2002) What is the Technology Gap? Retrieved January 2006 from http://www.nod.org/index.cfm?fuseaction=page.viewPage&pageID=1430&nodeID=1&FeatureID=771&redirected=1&CFID=1881143&CFTOKEN=22827025.

US Census (2002). Retrieved January 2006 from http://www.census.gov/Press-Release/www/2002/cb02ff11.html.

W3.org (May 1999). Web Content Accessibility Guidelines 1.0 W3C Recommendation. Retrieved January 1, 2006 from http://www.w3.org/TR/WAI-WEBCONTENT/.

Guidelines for Developing Quality Use Case Descriptions

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ABSTRACT

A use case description (UCD) is used to document detailed behavior of a use case in order to communicate its functionalities to different stakeholders related to the use case. A UCD plays an important role throughout software project's lifecycle. But there is no standard or widely-accepted approach for developing UCDs. They are developed based on the personal preference; both UCD formats and contents vary largely among different documenters. In this paper we present the seven-step use case documentation method. Our method integrates two writing rule sets and the three-level hierarchical use case evaluation method. The two writing rule sets cover syntax style and step rules that guide how to write each step in UCDs. The three-level hierarchical use case evaluation method helps use case developers evaluate UCDs from the overview level, the use case element level, and the sentence level. The recommended techniques of our paper is a synthesis of a thorough comparison of various UCD contents and formats discussed in literatures and our own experiences developed through a graduate Systems Analysis and Design class for many years.

1. INTRODUCTION

A use case approach is widely used to model system functionalities. A use case is a collection of success and failure scenarios in achieving a goal of an actor. A use case model consists of a *use case diagram* and a *use case documentation* (UCD). A use case diagram succinctly summarizes system behaviors from the point of view of actors. A UCD describes use case behaviors and functions in a narrative structured text file [1]. The documentation could be supplemented by diagrams such as activity diagrams and sequence diagrams. These diagrams provide a visualized flow of system interactions. The textual document, however, is the most common and understandable approach for UCDs [7, 8, 15].

A UCD is a communication tool which helps different stakeholders to understand the use case and provides supplementary information for system specification. As a communication channel, readability and understandable is the primary goal for a good UCD. Also since UCDs serve for software system specification, there are extra requirements than the regular text documentation. UCDs should clearly and completely depict system requirements for the specification. Narrative descriptions, however, usually tend to be ambiguous and lack a structure. There must be a set of coherent guidelines to direct documenters in content and structure selection.

A UCD plays an important role throughout software project's lifecycle. But there is no standard or widely-accepted approach for developing UCDs. They are developed based on the personal preference; both UCD formats and contents vary largely among different documenters [1-8, 11, 13-16]. In spite of the important roles of UCDs throughout the project's lifecycle, there have been only few guidelines for producing good UCDs. The lack of accepted guidelines makes both writing and assessing UCDs difficult. It is very difficult to ensure the proper information to be conveyed to all related stakeholders.

In this paper, we present the seven-step method for developing high quality UCD for a given use case diagram. Our method integrates *two writing rule sets* and the *three-level hierarchical use case evaluation method*. The two writing rule sets cover syntax style and step rules that guide how to write each step in UCDs. The three-level hierarchical use case evaluation method helps use case developers evaluate UCDs from the overview level, the use case element level, and the sentence level. The recommended techniques of our paper is a synthesis of a thorough comparison of various UCD contents and formats discussed in fifteen literatures and our own experiences developed through a graduate Systems Analysis and Design class for many years.

The rest of the paper is organized as follows. Section 2 first synthesize the previous work on methodologies for developing UCDs and then give a literature review. Section 3 presents the seven-step UCD development method. Section 4 concludes our paper.

2. A REVIEW OF PRACTICES ON UCDS

Our review on UCDs shows that there is no consensus on the well-accepted methodology for writing UCDs. Based on our reviews on literature as well as our own experiences, we believe that there are two aspects in improving the merits of UCDs as a communication and a specification tool: 1) a need for more concrete writing guidelines for UCD documenters; 2) a need for a methodology for assessing the quality of UCDs and removing mistakes.

2.1 UCD Writing Guidelines

A UCD writing process is no easy task since different writing styles may affect the usability and readability of the UCD. The review of the literature results in only a few simple writing guidelines. One notable guideline is the CREWS (Co-operative Requirements Engineering with Scenarios) Use Case Authoring Guidelines [3]. CREWS consists of eight specific rules. It is believed to be the most complete guideline available till now. But even these rules are quite abstract and hard to remember [4]. To further enhance usability, Cox and Phalp simplified the CREWS to a four step guideline called CP rules [5]. A summary of CREWS and CP rules are shown in Table 1. We will discuss how to remedy the limitations of CREWS and CP rules in Section 3.5.2.

2.2 Literature Review on UCD Evaluation Approaches

UCDs need to be assessed before they are used for system design and implementation. Some experts [6, 2, 7] mentioned that precision and clarity are key

Table 1. A summary of CREWS and CP rules [3, 5]

CREWS rules	CP rules
Style 1: Each sentence in the description should be on a new, numbered line. Alternatives and exceptions should be described in a section below the main description and the sentence numbers should agree. Style 2: Avoid pronouns if there is more than one actor. Style 3: No adverbs or adjectives. Style 4: Avoid negatives. Style 5: Give explanations if necessary. Style 6: All verbs are in present tense format. Style 7: There should be logical coherence throughout the description. Style 8: When an action occurs there should be a meaningful response to that action.	Structure 1: Subject verb object. Structure 2: Subject verb object prepositional phrase. Structure 3: Subject passive. Structure 4: Underline other use case names.

factors for assessment. But they are quite subjective and hard to measure. Most researchers provide simple guidelines on how to write a description. But none of them addressed the issue of evaluating the whole UCDs. More comprehensive criteria are needed to solve this issue. Our review found two types of evaluation methods: *Factor approaches* that address important aspects that a good UCD must meet and C*hecklist approaches* that lists questions for assessing a UCD.

2.2.1 Factor Based Evaluation Approaches

Cox and Phalp [5] proposed a method called 4-independent factors - *Plausibility*, *Readability*, *Consistent structure*, and *Alternative flows*. Later, Cox, Phalp and Shepperd [8] came up with a more concrete 4-C use case heuristics which address the communicability of use cases. The concept of 4-C consists of Coverage, Coherence, Consistency, and Consideration of alternatives. Phalp and Vincent further specified the 4-C heuristics into a 7-C approach [4] based on the empirical study they conducted. In the 7-C heuristics, every criterion consists of several sub-criteria. The 7-C heuristics include:

1. **C**overage: the use case should contain required information in relevant details.
2. **C**ogent: the use case has to be complete, logical path follows the correct order.
3. **C**oherent: the written styles should be coherent to be understood.
4. **C**onsistent Abstraction: use case should follow a consistent level of abstraction.
5. **C**onsistent Structure: alternatives should be separated from the basic flow.
6. **C**onsistent Grammar: Using simple present tense and avoid adverbs, adjectives, pronouns, synonyms and negatives.
7. **C**onsideration of Alternatives: alternatives should contain all the possible paths.

2.2.2 Checklist Based Evaluation Approaches

Though the 7-C approach is quite comprehensive, it lacks the requirements of how much details should be included in the UCD. A checklist based approach assesses UCDs from various users' perspectives: customers, designers and testers [9]. Another checklist approach to address the different users' requirements is 3-C checklists proposed by Copeland [10]. The 3-C represents Complete, Correct and Consistent. This approach is to test 3-Cs of a use case from the point of view of syntax, domain, and traceability:

- Syntax testing is to verify that a UCD contains correct and proper information. Copeland claims that more than half of the use cases failed syntax test in a project he conducted.
- Domain expert testing is to check whether the description meets the domain knowledge requirements.
- The traceability testing is to ensure that all the functional requirements are represented in the UCD and can be traced back.

3. THE SEVEN-STEP USE CASE DOCUMENTATION METHOD

Our review showed that there are only few writing guidelines and inspection methods available. It is necessary to propose a comprehensive and understandable method to documenting and assessing UCDs. In this section, we propose our seven-step UCD method which synthesizes existing rule sets and our own rules. Note that our method focuses on UCDs, rather than use cases themselves. Therefore, our method begins from developed use case diagrams.

Table 2. The outline of our seven step guidelines

Step 1	Understand actors and their goals
Step 2	Write use case goals in one phrase
Step 3	Write an overview description in a few sentences
Step 4	Define the precondition and postcondition
Step 5	Write the sequences of interactions
Step 6	Document non-functional requirements and other optional information
Step 7	Evaluate use case descriptions

We propose the following seven-step use case documentation method. It is a set of coherent guidelines covering UCDs from the very beginning to the end. Especially, our focus is on the Writing Rules and Evaluation method of UCDs. Due to the space limit, we only outline the steps without detailed examples. The seven steps of UCD development guideline are summarized in the Table 2. We discuss them in further details below.

3.1 Understand Actors and Their Goals

The first step in writing a UCD is to understand the actors and their goals. Knowing who the actors are and what their goals are help developers write steps of a UCD. Goals of an actor are high level responsibilities of the actor in the system. A goal should represent "what" of a responsibility, not "how" of the responsibility.

3.2 Write a Use Case Goal in One Phrase for Each Use Case

In this step, a developer states the goal of a use case in one phrase using the format of Verb + Noun phrase. This simple phrase will define the specific goal at a high level term to distinguish one use case from another. For example, if we have a use case named "Process Rents" in a video rental system, the goal phrase could be "To capture rental items along with payment."

3.3 Write an Overview Description for Each Use Case

The next step is to write a short summary of the actor-system interaction [11] in a few sentences. The brief description states an overview of what you are trying to achieve and the scope of the use case. At this step, use only business terms without any technology-oriented terms. For example, the overview description of the above use case could be "A store employee checks out rental items for a customer by calculating due dates and correct charges. The use case also includes checking for any overdue items. The store employee accepts payments for the items and any late payments. A rental slip is issued and kept by the store employee."

3.4 Define the Precondition and Postcondition

Preconditions and postconditons could help developers set up the boundary of the use case. These conditions would limit the sequences of interaction into a clearly starting and ending situation [11]. A use case that was performed earlier could affect the preconditions of the others; some use case is included or extended from others. All these relations will affect the content in a UCD. Before start writing the detailed steps, the documenter must understand the use case suite well and know relationships among the use cases so that relationships among use cases are represented and managed correctly, consistently, and completely. A good precondition is the one set by another use case if one needs to be executed after another.

Postconditions are lists of the conditions that must be true after the use case successfully finishes. Larman suggests that postconditions be documented in a passive and past sentence to represent what already happened [15]. Larman also recommends the following three types of postconditions – (a) objects that need to be created/deleted (b) data that need to be changed, and (c) associations that need to be connected/disconnected.

3.5 Write the Sequences of Interactions

The sequences of interaction are the major part of a UCD. It carries the communication and system design function of the UCD. We will give more focus in this step. There are three types of interactions.

3.5.1 Write the Main Successful Scenario

We begin with the main successful scenario first. It represents the most common and successful path. To identify the main successful scenario, we need to start from the triggering event, proceed step by step till the use case reaches the postconditions depicted before.

3.5.2 Write the Other Successful Scenarios

We then write other successful scenarios that refer to alternative scenarios. They are less frequently executed than the main success scenarios, but still achieve the goal of the actor.

3.5.3 Write Unsuccessful Scenarios

We then write other unsuccessful scenarios that refer to those scenarios that stop before the use case goal is achieved

The Two Writing Rule Sets for Developing UCDs

CREWS and CP rules as we reviewed before focus on the syntactic aspect but miss the specific guidelines such as how to develop each step; what information to record in each step; and what information to avoid. To address these issues, we present synthesized rule sets for writing steps, integrating the ideas of CREWS and CP rules as well as our own experience. We present the guidelines in the form of two writing rule sets as shown in Table 3.

Rule set 1: The Syntax Rules - Describe steps in a precise and unambiguous way

- *Use specific nouns*: Avoid using vague terminology like information, data [11]. Specify the data to be created, deleted, changed or associated [1].
- *Avoid pronouns*: If there is more than one actor involved in the UCD, using pronouns will confuse users on which actor this pronoun is referring to [3].
- *No adverbs or adjectives*: A UCD is to depict the goal fulfillment endeavors, not to write a story. Don't use any adverbs or adjectives like appropriate, required, relevant or sufficient [3, 11]. Using these adjectives make the sentence ambiguous.
- *Use straightforward and specific verb*: Avoid using verbs that have overloaded meanings such as get, keep, have, or do. Try to use specific verbs or associate an overloaded verb with an object as in *find a customer name*.
- *Using present tense*: Write in "present tense" to describe what the system does, rather than what it will do or already done [11].
- *Avoid negatives*: Document use case in affirmative way, don't use "not or no" in the description [3].
- *Using active voice*: Using direct and declarative statements started by an actor or the system [11]. For example: document a step as in "the system validates the amount entered" instead of "the amount entered should be validated by the system".
- *Avoid compound sentences*: Using simpler grammar [13], [4, 6] is recommended to adapt "Subject verb object" or "Subject verb objects prepositional phrase" style when documenting the flow of events.

Rule set 2: The Step Rules - Each step should be only one logical step towards the use case goal

- *Each step must be a goal-driven movement*: Describing the user's step at user interface level is one of the most common mistakes in recording use case steps. For example: "system asks for name, user enters name, system ask for address, user enters address" could be replaced by "user enters name and address" [6].
- *Each action should have a system response*: Any action is users' request sent to the system. Thus it should not occur alone, there must be a system response associated to it [3].
- *Each step must represent only one logical step*: State one logical step at a time. Do not combine two different steps that require a system interaction in one step. For example: "Search products and select the item" are two steps and should be documented in two steps because the system needs to display the output before the second action. [16]
- *Describe your steps in a general tone rather a special case*: The description should be general enough for all the possible variations in this step. For example: "Request one-year subscription" is a special case when applying for a subscription; it should be written as "Select the number of years of subscription." [16].
- *Describe in a right logical order of execution*. Steps should be documented in a logically meaningful order of execution to show step-by-step procession. For example, adding a shipping charge during "Process payment" use case is logically in a wrong order [16].
- *Do not include steps stated in the preconditions*. [16].
- *Do not use ambiguous expressions*. For example, the following are ambiguous steps. "Subscriber enters in demographic information" and "Establish subscription data" [16].

Table 3. A summary of the rule sets

Rule 1: The Syntax Rules	Noun	Use specific nouns
	Verb	Use specific verb; Use present tense; Avoid negatives
	Adverbs	No adverbs
	Adjectives	No adjectives
	Pronouns	Avoid pronouns
	Sentences	Use simple sentences; Use active voice
Rule 2: The Step Rules	Each step must be a goal-driven movement	
	Each step must represent only one logical step	
	Each action should have a system response	
	Describe steps in general tone rather a special case	

3.6 Document Non-Functional Requirements and Other Optional Information

For future references and improving understandability, non-functional requirements can be appended at the end of a UCD. Those non-functional requirements include business rules, performance requirements (response time and throughput), reliability requirements, usability requirements, security requirements, volume and storage requirements, configuration, compatibility requirements, backup and recovery, and any training requirements.

3.7 Evaluation of UCDs

A UCD must be evaluated before actual releasing. The evaluation team should include all the possible stakeholders such as users and designers. We believe that the UCD evaluation process should be an iterative process in which each iteration evaluates different aspects. In this section, we present *the three-level hierarchical use case evaluation method – overall level, use case element level, and sentence level.* Evaluation should begin from the overall level to the use case element level and then to the sentence level.

3.7.1. Check from the Overall Level

This level is to assess the overall structure of a UCD. Issues judged at this level are whether the UCD contains an appropriate level of details and the structure of the use case templates are appropriate. A good UCD should convey all the required information but with no redundancy. There are two major factors that affect the levels of detail:

- Stakeholders' concerns: check if the UCD meets concerns of stakeholders such as end users, developers, and the testers [9].
- Different viewpoints: Depending on whether we adopt an external (black box) or internal (white box) view will affect how much details we need to add to the document and what kind of use case formats we select.

3.7.2. Check from the Use Case Elements Level

The next heuristic goes down to use case element level. It is to test whether the elements included in the UCD are content-wise appropriate and structurally sound. The testing could be conducted using the following 3-C rules [10]:

- Cogent: check the logical paths of the UCD and determine whether it follows a logically correct way.
- Complete: check whether the UCD provides a solution to the problem and check whether the entire possible alternatives are recorded.
- Consistent: check whether the UCD follow the same level of abstraction. The numbering in the main flow and alternatives should also be consistent.

3.7.3. Check from the Sentence Level

After checking the correctness of the use case elements, the next level heuristic goes down to the sentence level. Are the descriptions clear enough for users' to

Table 4. The three hierarchical heuristics of UCDs

Overall	Does the UCD satisfy stakeholders' concerns?
	Is an external or internal viewpoint applied?
Elements	Cogent: Are the logic paths correct?
	Complete: Are all alternative paths included?
	Consistent: Are the levels of abstraction and numbering consistent?
Sentence	Check the syntax rules
	Check the step rules

read and understand? Does each sentence make sense to the readers? The rules we proposed in Section 3.5 could be applied here for evaluation.

The three hierarchical heuristics provide us with a more structured approach which allows users to assess the UCDs from general to specific perspectives. The evaluation from a higher level iteration to a specific level gives assessors priorities in the evaluation process. This could potentially improve the evaluation results and improve the usability of the heuristics.

4. CONCLUSION

In this paper, we have presented guidelines for developing quality UCDs. We have presented the seven step method for writing UCDs for a given use case diagram. Our method incorporates two sets of rules for writing UCDs. Our first rule set, the syntax rules, describes the syntactic guidelines of sentences. Our second rule set, the step rules, shows the guidelines for writing each step specifically in UCDs. Our method also includes the three-level hierarchical use case evaluation approach– from the overview level, the use case element level, and the sentence level. The recommended techniques of our paper is a synthesis of a thorough comparison of various UCD contents and formats discussed in literatures and our own experiences developed through a graduate Systems Analysis and Design class for many years. We believe the methodology we proposed could serve as guidelines for UCD developers and help them to generate higher quality UCDs.

REFERENCES

1. Overgaard, G. and Palmkvist, K.: Use Cases: Patterns and Blueprints. Addison Wesley, (2005).
2. Adolph, S. and Bramble, P.: Patterns for Effective Use Cases. Addison Wesley, (2003).
3. Ben Achour, C., Rolland, C., Maiden, N., and Souveyet, C: Guiding use case authoring: Resultsof an empirical study. Proc. Fourth IEEE Int. Symposium on Requirements Engineering University of Limerick, Ireland, (1998). Retrieved 3/30/2006 from http://sunsite.informatik.rwth-aachen.de/CREWS/reports.htm. Report Number: 93-31.
4. Phalp, K.T., Vincent, J.V., and Cox, K.: Assessing the Quality of Use Case Descriptions, Accepted for the Software Quality Journal, February 2006, (2006) Retrieved 3/30/2006 from http://dec.bournemouth.ac.uk/ESERG/kphalp/
5. Cox, K. and Phalp, K.T.: Replicating the CREWS Use Case Authoring Guidelines Experiment, Empirical Software Engineering Journal, Vol. 5(3). (2000) 245-268.
6. Cockburn, A.: Writing Effective Use Cases. Addison Wesley, (2001).
7. Kulak, D. and Guinery, E.: Use Cases: Requirements in Context. 2nd ed. Addison.Wesley, (2003).
8. Cox, K., Phalp, K., and Shepperd, M.: Comparing Use Case writing guidelines. REFSQ'2001 - 7th International Workshop on Requirements Engineering: Foundation for Software Quality, Interlaken, Switzerland, 4th-5th June, (2001)
9. Rombach, H. D., Carbon, R., and Trapp, M. Software Engineering Processes and Measurement Research Group (AGSE), University of Kaiserslautern. (2003). Retrieved 3/20/2006 from: https://wwwagse.informatik.uni-kl.de/teaching/se1lab/ss2003/SysAnfBearbeiten/ChecklistenMitPerspektiven_Analyse.pdf
10. Copeland, L., Use cases and Testing, Testing UML Models, Part 1, Retrieved 3/30/2006 from: http://www.stickyminds.com/sitewide.asp?Function=edetail&ObjectType=ART&ObjectId=3428
11. Bittner, K. and Spence, I.: Use Case Modeling. Addison-Wesley,(2003).
12. Texel, PP. and Williams, C.B.: Use Cases combined with BOOCH OMT UML. Prentice Hall PTR, (1997)
13. Eriksson, H., Penker, M., Lyons, B.,and Fado, D.: UML 2 Toolkit. Wiley Publishing, int, (2004)
14. Leffingwell, D. and Widrig, D.: Managing Software Requirements. Second Edition. A Use Case Approach. Addison Wesley, (2003).
15. Larman, C. (2005). Applying UML and Patterns: An Introduction to Object-Oriented Analysis and Design and Iterative Development. Prentice Hall PTR.
16. Song, I.-Y.: Object-Oriented Analysis and Design Using UML: A Practical Guide. Pearson Publishing, Boston, MA (2004).

Temporal Categorization for Data Organization

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ABSTRACT

Temporal databases are designed to handle records that are time-oriented. While the additional dimension produces data that is rich in meaning, capturing this history results in large volumes of data that are rarely used. Previous research has found that the additional data can impair system performance when attempting to use temporal databases as operational systems. This paper presents work done in an area that the authors have termed, temporal categorization, which involves a method of data organization that groups records according to their unique temporal semantics. The initial testing on temporal categorization indicates the potential to effectively improve system performance as related to time-oriented data.

Keywords: Temporal Databases, Data Organization, Temporal Categorization, Database Performance

1. INTRODUCTION

While there are many ways of associating time with a fact, most temporal research only considers two time dimensions, valid times and transaction times, to be significant [1]. Valid times capture the history of a real-world object. Systems that handle this dimension of time are known as historical databases. Transaction times capture the history of a fact within the database itself and are handled by rollback databases [2]. Previous research has shown valid and transaction times to be orthogonal [3], but it has also been acknowledged that both of these dimensions are necessary to provide complete temporal functionality. Complete temporal systems are known as bitemporal databases due to their use of both time dimensions [4]. The following example illustrates a fictional, bitemporal employee database.

A company hires a new employee named Bob. He begins work on 1/1/2000 as an Engineer and is entered into the system on 12/30/1999, but is mistakenly listed as a Managing Engineer. This mistake is caught and corrected on 1/5/2000. Six months after being hired, Bob is promoted to the rank of Senior Engineer. Finally, Bob will be automatically promoted to the rank of Supervising Engineer one year after becoming a Senior Engineer.

Table 1 demonstrates how this data would be captured in a bitemporal database. Part A is the initial state of the system. Part B shows the table after Bob's title has been corrected. There are now two records in the system, the erroneous record that has been retired and the corrected record that is now active. Part C is the system after Bob's promotion to Senior Engineer. The Bob/Engineer record that was active in Part B has been retired and an updated version with a definitive Valid_To date inserted into the system. The predictive record of Bob's promotion to Supervising Engineer has also been inserted. It has the same Trans_From time

Table 1. Bitemporal employee database

Part A

Emp_Name	Title	Valid_From	Valid_To	Trans_From	Trans_To
Bob	Managing Engineer	1/1/2000	12/31/9999	12/30/1999	12/31/9999

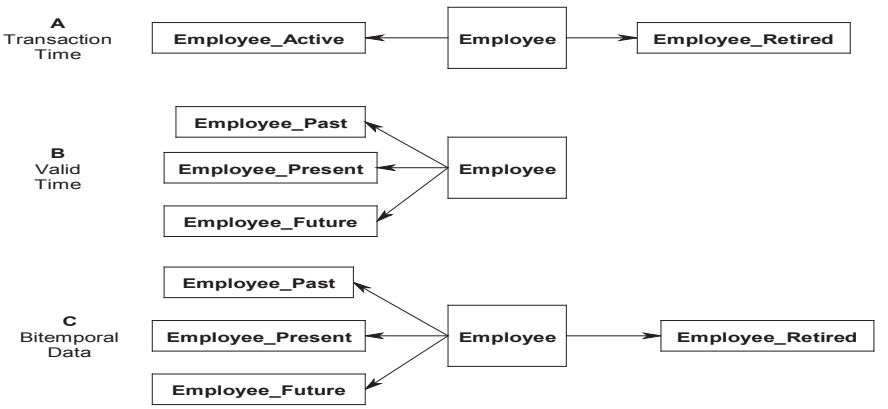
Part B

Emp_Name	Title	Valid_From	Valid_To	Trans_From	Trans_To
Bob	Managing Engineer	1/1/2000	12/31/9999	12/30/1999	1/4/2000
Bob	Engineer	1/1/2000	12/31/9999	1/5/2000	12/31/9999

Part C

Emp_Name	Title	Valid_From	Valid_To	Trans_From	Trans_To
Bob	Managing Engineer	1/1/2000	12/31/9999	12/30/1999	1/4/2000
Bob	Engineer	1/1/2000	12/31/9999	1/5/2000	6/30/2000
Bob	Engineer	1/1/2000	6/30/2000	6/30/2000	12/31/9999
Bob	Senior Engineer	7/1/2000	6/30/2001	7/1/2000	12/31/9999
Bob	Supervising Engineer	7/1/2001	12/31/9999	7/1/2000	12/31/9999

Figure 1. Temporal categorization



as the Bob/Senior Engineer record and both are considered active in the database even though the predictive record has not yet become valid.

The use of bitemporal data clearly adds semantic depth. A user is able to track when a record was entered into the system and when a record was updated or retired, as well as the history of the data in relation to the real world. Unfortunately, this depth comes at a price. The results of the large number of stored records have been shown to negatively impact data retrieval and insertions [5][6][7]. This is particularly true when the database user wishes to focus on records that are currently true in both the real world and the database.

Preceding approaches for dealing with the large number of stored records range from the use of external storage to the implementation of high-performance indexes. One of the first solutions identified the impact of mingling active and retired data in a single system**,** which is comprised of a two-level store to segregate active and retired data [5]. However, the work did not extend to bitemporal systems or to more complicated queries. Another approach focused on using external storage for retired data [8]. While this does allow for the maintenance of active and retired data, it does not permit queries against all data within a system and thus severely limits bitemporal functionality. The use of specialized temporal indexes has also been explored [6]. These high-performance data structures are tailored to the challenges of bitemporal systems, but they also require kernel level changes to the database and are unlikely to be used until they are incorporated into commercial database management systems.

This paper describes a proposed extension to the two-level store where the records are physically separated for categorization according to their temporal semantics by transaction time (active versus retired), valid time (past, present, and future), or a combination of both (sorting active records by valid time and keeping retired records separate from the active ones). The next two sections present an overview of the proposed temporal categorization and considerations related to the database and query processing requirements. Section 4 discusses the initial implementation findings followed by conclusions and recommendations for future work.

2. TEMPORAL CATEGORIZATION

Adding one or more dimensions of time to a database results in increased time for query processing [5][6][7]. This can be attributed to several factors, including the enforcement of temporal constraints and the additional volume of records produced by maintaining historical information in the database [9]. This research work proposes a method, referred to as temporal categorization, of organizing temporal data to alleviate the query processing issues resulting from numerous records. In temporal categorization, the records in a table are physically separated and grouped according to their temporal semantics. The technique involves the creation of separate tables (or storage spaces) for the temporal categories of active and retired in transaction time and valid time.

2.1 Transaction Time

Transaction times are the history of a record within the database. The time values define when a record was entered into the database and when the system stopped regarding it as being true. Therefore, only two semantic categories are defined by transaction times, records that are active and records that are retired. For example, the Employee from Table 1 would be separated into Employee_Active and Employee_Retired. The separation of the records is illustrated in Figure 1 A.

All records are considered true when they are first inserted into the system. This status changes only when a record is updated or deleted. In a transaction time system, a delete operation does not physically remove data from the system. Instead, it is logically deleted [2]. This means that the data remains within the system, but it is marked as inactive and no longer true. The system marks retired data by having a Trans_To value that is less than the current time. Updating a record results in its original form being retired while the newer version of the data becomes what is considered active by the database. An update can be considered to be a combination of a delete transaction and an insert transaction.

2.2 Valid Time

Valid time describes when a fact was true in the real world and creates three possible categories for a record. It was true in the past, it is true in the present, or it will be true in the future [2]. Categorizing records by these semantics is more complicated than using transaction times. This is due to the possibility of present and future records changing their categories. Present records may cease to be true and be moved to the past category. Future records may become true and be moved into the present category.

Figure 1 B presents the categorization of records according to valid times. The records are separated into past, present and future groups. While one cannot truly predict what the future state of an object will be, there are many instances where it is useful to store the predicted state of an object. The inclusion of predictive records is not a requirement for a valid time database, but they do represent a semantic possibility of this time dimension [10]. Therefore, they are included in the proposed valid time categorization.

What makes the valid time changes so challenging is the fact that these recategorizations are not due to user (or system) action alone. They can also result from the passage of time in the real world. The present is always moving and a record that is valid now might not be valid after a few minutes. A database that employed this scheme would need to regularly check future and present records to see if they require a change in category in addition to monitoring the effects of any user updates. There is also the possibility of not having enough records to justify the overhead of categorization. The use of this type of categorization would be decided by how many objects were modeled in the database, how much history (or future) each object had, and how many states were allowed for an object at any point in time.

2.3 Bitemporal Categorization

Figure 1 C presents a possible organization for bitemporal categorization. All active records would be categorized according to their valid time semantics (past, present, or future) and would keep any retired records in a separate group. Further categorization of a bitemporal table's retired records was considered, but it was decided that this might be ineffectual because many queries against a particular state of the database (other than current active data) would fall outside of easily defined temporal categories. Trying to presort the data for every possible temporal query would not be constructive.

3. CONSIDERATIONS FOR CATEGORIZATION

Categorization of temporal data has the potential to improve database performance as related to query processing time and to the complexity of temporal queries. The records in a bitemporal database system throughout time will change by update operations to retired and active records. Over time, the database collects a significant volume of retired records, making the overhead of the temporal categorization process worthwhile. Several possibilities for handling the time-based update and query retrieval have been contemplated.

3.1 Database Categorization

One possibility would be to poll the present and future records at the time of a user query similar to the standard SQL column, shown in Table 2. However, this could severely impact query performance because the system would have to check all of the records for the categorization condition based on the user=s request, particularly when the table grows with retired and valid record over a period of time.

A second possibility would be to maintain the time value of the next shift in categories, such as the earliest Valid_To time in the present group or the earliest Valid_From time in the future group. The system could then reclassify the affected records at the proper time. Unfortunately, any updates, insertions, or deletes would require the system to update its list of update times since these actions could render it inaccurate.

Another option would be for the database to poll the present and future groups at a given time interval, recategorizing as necessary. This approach is highly dependent on the granularity (or level of precision) of the valid time values. If the valid times are only precise to the day, the database could check the tables at the start of each new day. If the valid times were of microsecond granularity, the database would be doing nothing but polling the tables.

3.2 Query Categorization

In practice, if one table is used for holding active and retired data to provide a simple and more optimized query processing, a flag field can be set to mark the retired records. The flag field may be hidden from the users. It is activated and set to retired during the Update and Delete operations according to the semantics. The SQL data manipulation commands would use the flag to access only retired or active records in an optimized approach. To retrieve all the retired records from Employee table as in Table 1 C, a user may execute the following command.

SELECT * FROM Employee WHERE CATEGORY = RETIRED;

CATEGORY may use the options of [RETIRED | ACTIVE] for transaction time to select the correct category of the records from the table.

The active records in the table may be extended into past, present or future categories. In this case, a more comprehensive flag and temporal semantic comparison methodology can be used and the flag can be set to refer to different category domain of past, present or future. To access a particular category domain, the temporal SQL command uses the reserve word CATEGORY with any of the [PAST | PRESENT - CURRENT | FUTURE]. A command could be used to select particular domain as well as search for a conditional semantic value related to date or any other simple or compound condition. Table 2 shows several SQL categorization examples using the fictional Employee table in Table 1 with the query and the SQL that would produce the desired results in a standard system as well as a theoretical database using the proposed temporal categorization.

4. INITIAL IMPLEMENTATION OF TEMPORAL CATEGORIZATION

Physically separating current and historical records to improve system performance across a broad range of temporal queries would be a result of having multiple smaller tables for the system to query rather than one large table. Additionally, having the records separated by temporal semantics eliminates the need for evaluating each record=s timestamps in certain cases. Consider a system where records are categorized by transaction times. If a user wished to search only active records with a Trans_To time of 12/31/9999, the database would not need to test the Trans_To values of each record. It could just run the query against the active data set, ignoring the retired data completely.

To test the possible benefits of this categorization methodology, a simple experimental prototype system with separate tables to support retired and active records was constructed. As records were retired via Update or Delete actions, they were moved into the retired table. The data in these experiments consisted of a single key value coupled with valid and transaction times that tracked an object=s status through a period of time. While this cannot be considered representative of all bitemporal data, it does represent one of the more common applications of temporal databases. Each Insert represents a new state and requires an Update or Delete

Table 2. Comparison of queries across temporal systems

Results	SQL (standard)	SQL (categorized)
All data in the table	SELECT * FROM Employee	SELECT * FROM Employee
All active data in the table	SELECT * FROM Employee WHERE Trans_To = '12/31/9999'	SELECT * FROM Employee WHERE CATEGORY = ACTIVE
All current, active data in the table	SELECT * FROM Employee WHERE Trans_To = '12/31/9999' AND Valid_From < Current Time AND Valid_To > Current Time	SELECT * FROM Employee WHERE CATEGORY = CURRENT AND ACTIVE
All past, active data in the table (interchangeable with future)	Select * FROM Employee WHERE Trans_To = '12/31/9999' AND Valid_To < Current Time	SELECT * FROM Employee WHERE CATEGORY = PAST AND ACTIVE
All active data that was valid within a specified time period (valid for any part of interval)	Select * FROM Employee WHERE Trans_To = '12/31/9999' AND Valid_From < *Start Time* AND Valid_To > *End Time*	SELECT * FROM Employee WHERE CATEGORY = ACTIVE AND Valid_From < *Start Time* AND Valid_To > *End Time*
All data that was valid at a particular point in time for the database	Select * FROM Employee WHERE Trans_From < *Time* AND Trans_To > *Time* AND Valid_From < *Time* AND Valid_To > *Time*	Select * FROM Employee WHERE Trans_From < *Time* AND Trans_To > *Time* AND Valid_From < *Time* AND Valid_To > *Time*

of the current one. The design choice was made to monitor temporal constraint performance as well as query times.

To allow greater flexibility in searching the records, the actual values were also tested in addition to the keyword indicator, such as active or retired, as shown in Figure 1 and Table 2. This provided the capability to test records that were retired after a given date rather than only retired records. The system determines which tables to run against by examining the Trans_To value in the query. If the value matches the placeholder to signify activity, only the active table is searched. If the Trans_To value is something other than that placeholder, it means the record has been retired and only the retired table is used. A single evaluation is performed against the queries Trans_To value, in contrast to the standard system=s need to compare each record=s data against that of the query.

An experimental prototype system was designed to handle the transaction time with active and retired data in combined and separate tables. The performance analysis was focused on transaction time categorization due to its comparative simplicity of result and ease of implementation. Additionally, a combination of Insert/Update/Delete operations were implemented. These operators were built to test the insertion of new versions of real world data and the act of a record's current state becoming real world inactive. A control system was also implemented as the standard system. This system contained all of the functionality of the experimental system minus the categorization. Both systems were built from scratch in an effort to ensure more effective comparisons between systems. They were implemented using the Python programming language.

A collection of queries was designed and run against the standard and experimental systems. The performance data for the queries were collected and averaged. These queries were designed with various business rules and settings for different scenarios that are summarized in following cases. For each case, the queries for the data status involved three levels: all, active after a particular date and active between specified dates.

Case 1: Database records with active status
Case 2: Database records with active status after certain date
Case 3: Database records with active status between date intervals
Case 4: Database records with active and retired status

The performance and results of these queries for different numbers of records were collected and tabulated for both the standard and experimental system, and then averaged. The averaged comparison diagram is shown in Figure 2. It was observed that the categorized experimental system outperformed the standard system in every query category. Figure 2 shows a sample of the average system performance for all different queries used in cases 1-4. The data clearly shows the categorized system's performance to be significantly faster.

Figure 3 shows the insertion times required for various numbers of records in both the standard and experimental system records. The experimental system shows improved performance. It is suspected that this is due to not needing to test whether or not a record is active or retired before testing for any temporal constraints on a table.

Finally, in terms of data storage, there was a constant difference between the systems. The experimental systems showed a difference of approximately 30 additional bytes for any number of records, which appeared to be related entirely to the additional data structure used for holding retired data. The number of records stored did not affect the size difference.

Figure 2. Average query performance comparison

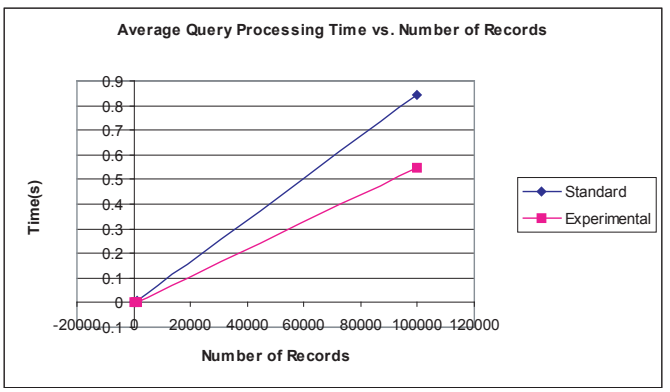


Figure 3. Comparison of record insertion times

5. CONCLUSIONS AND FUTURE WORK

This paper has presented an overview of the authors' current research work on temporal categorization, which was developed as a proposed solution to the problem of how to deal with the large volumes of data that are produced by adding one or more time dimensions to a database. While alternate methods have been suggested, these have typically involved using secondary storage and do not allow for immediate access to the data. By physically separating records according to their temporal semantics, temporal categorization may produce improved query performance due to the smaller volumes of data that must be searched as well as the reduced number of comparisons that must be made in order to find the desired data. This is especially true when dealing with those records that are active and defining the state of objects in the present.

The initial experimental system demonstrated promising performance gains in terms of data retrieval and insertion operations. Even those queries that were expected to show reduced performance were completed more quickly for the categorized system. Additionally, the improved query run times came at the cost of constant storage overhead, which the authors view as a minor cost in comparison to the benefits. In light of these initial findings, temporal categorization can be seen as a viable possibility for temporal data organization. The technique promises improved query processing times and faster data insertion / update transactions for a minor storage cost. The next steps will be to implement this technique in a more robust database system and to explore additional prototypes for temporal semantic categorization.

Future work will consist of evaluating the feasibility and performance of the temporal database categorizations for storage space requirements, insertion and update times, and data retrieval operations for different combinations of temporal criteria. The authors are also interested in seeing how this technique would compare to temporal indexing as a performance enhancement technique. Additionally, it would be worthwhile to examine a wide variety of temporal data sets to better understand how real-world users are storing time-associated records. Finally, the question of valid time categorization must be addressed. This topic will be examined in terms of implementation performance as well as which patterns of database usage will be best suited for these techniques.

6. REFERENCES

[1] Christian S. Jensen and Richard Thomas Snodgrass, "Temporal Data Management," IEEE Transactions on Knowledge and Data Engineering, Volume 11, Issue 1 (January 1999), pp. 36-44.

[2] Christian S. Jensen, "Introduction to Temporal Database Research," Temporal Database Management dr.techn.thesis (April 2000).

[3] Christian S. Jensen, Michael D. Soo, and Richard Thomas Snodgrass, "Unifying Temporal Data Models via a Conceptual One," *Information Systems*, Volume 19, Issue 7 (October 1994), pp 513-547.

[4] Niki Pissinou, Richard Thomas Snodgrass, Ramez Elmasri, Inderpal S. Mumick, Tamer Özsu, Barbara Pernici, Arie Segev, Babis Theodoulidis, and Umeshwar Dayal, "Towards an Infrastructure for Temporal Databases: Report of an Invitational ARPA/NSF Workshop," *ACM SIGMOD Record*, Volume 23, Issue 1, (March 1994), pp 35-51.

[5] Ilsoo Ahn and Richard Snodgrass, "Performance Evaluation of a Temporal Database Management System," *ACM SIGMOD Record*, Volume 15, Issue 2 (June 1986), pp 96-107.

[6] Rasa Bliujute, Christian S. Jensen, Simonas Altenis, and Giedrius Slivinskas, "Light-Weight Indexing of General Bitemporal Data," *Proceedings of the 12th International Conference on Scientific and Statistical Database Management*, (July 2000), pp. 125-138.

[7] Anil Kumar, Vassilis J. Tsotras, and Christos Faloutsos, "Designing Access Methods for Bitemporal Databases," *IEEE Transactions on Knowledge and Data Engineering*, Volume 10, Issue 1, (January 1998), pp 1-20.

[8] Betty Salzberg and Vassilis J. Tsotras, "Comparison of Access Methods for Time-evolving Data," *ACM Computing Survey*, Volume 31, Issue 2 (June 1999), pp. 158-221.

[9] C. J. Date, Hugh Darwen, and Nikos Lorentzos, *Temporal Data and the Relational Model*, Morgan Kaufmann, San Francisco, 2002.

[10] James Clifford, Curtis Dyreson, Tomás Isakowitz, Christian S. Jensen, and Richard Thomas Snodgrass, "On the Semantics of "Now" in Databases," *ACM Transactions on Database Systems,* Volume 22, Issue 2, (June 1997), pp 171-214.

Multimodal Language Processing Using NLP Approaches

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ABSTRACT

People usually communicate through multimodal dialogue. Multimodal interaction is in fact flexible and natural because it uses all five senses in parallel. For this reason we need to consider multimodal language definition and processing adopting the techniques and approaches used in Natural Language Processing (NLP). We describe the characteristics of a multimodal language by NLP, considering that the speech mode appears to be the most complete (it is considered the predominant mode). Users communicate and interact through reference to a set of key concepts. These can be expressed with different modes and/or by more than one mode simultaneously. When defining a multimodal language, these key concepts must be extracted. They are then processed using a natural language approach: any concept expressed in any mode can be "translated" into natural language. This implies that speech acts as a "ground layer" that all the modes refer to. We propose a tool to define multimodal languages, which allows the user to define the language in his/her own way to express concepts of a particular domain in the different modes.

Keywords: Multimodality, multimodal language, fusion, ambiguity.

1. INTRODUCTION

The purpose of this paper is to identify characteristics of multimodal languages in order to design a tool that enables the user to define them in some specific contexts. For instance, a possible case is the use of formal graphic models such as Unified Modelling Language (UML) and Entity-Relationship (E-R) diagrams during a project meeting. A second case is the use of tourist maps with which the user can interact to ask for information on restaurants, museums, theatre schedules, transport and so on through multimodal interaction on mobile devices.

A multimodal language is a language that allows people to communicate with a system synergistically through multiple modes (i.e. speech, sketch and writing).

In several contexts, such as those cited above, speech is the most complete (predominant) mode (users tend to explain everything orally, using other modes to support what they say). By predominant mode we mean the mode the system first refers to. It considers other modes only if it needs to solve any ambiguous or incomplete cases.

For this reason we need to consider the definition and processing of multimodal languages according to the techniques and approaches used in Natural Language Processing (NLP).

The study of a synergistic system cannot be separated from the study of the way a machine processes the natural language, i.e. Natural Language Processing (NLP). This presents many problems, the biggest of which is language ambiguity. Oviatt et al [1] explored whether a multimodal architecture can support *mutual disambiguation* (MD) of input signals. Mutual disambiguation enables recovery after unimodal recognition errors, leading to a more stable and robust performance, as it permits the strengths of each mode to overcome weaknesses in the others [2].

Oviatt [3] also highlighted the differences between unimodal and multimodal communication with respect to the structure of spoken language. Sharon Oviatt & Karen Kuhn showed that multimodal language differs from spoken language in its brevity, semantic content, syntactic complexity, word order, disfluency rate, degree of ambiguity, referring expressions, specification of determiners, anaphora, deixis and linguistic indirectness.

Qiaohui Zhang et al [4] handle ambiguity by using gaze information to integrate the user's speech input. If multiple objects are chosen simultaneously due to an ambiguous description, the one closest to the gaze fixation will be the multimodal result.

The ambiguity issue is addressed in [5] by designing a multimodal agent for route construction (MARCO).

This paper discusses both NL disambiguation and multimodal user interfaces. [6] presents studies on the combined use of different input modes. A component-based approach to specify and develop multimodal interfaces using a mode-independent fusion mechanism is described in [7].Michael Johnston [8] describes a multimodal language processing architecture in a unification-based grammar formalism.

Sections 2 and 3 summarise our approach to and problems related with fusion at the multimodal language level and the natural language processing approach in a multimodal environment. Sections 4 and 5 describe the system to define the multimodal language and in section 6 we draw some conclusions.

2. FUSION AT THE LANGUAGE LEVEL AND DEFINITION OF THE MULTIMODAL LANGUAGE

The synergic integration of the system's various input channels can be achieved in several ways. One possibility is to consider the input channels separately and then merge them [12]. An alternative approach is to carry out the integration during the definition of the multimodal language. This requires the capture of its characteristics using natural language and an understanding of the intrinsic nature of natural language; i.e. rebuilding of the language structure and consideration of how the same concept can be expressed by different input types and how implicit references (deictic expressions) can be solved. A deictic expression refers to the personal, temporal, or spatial aspect of an utterance; its meaning therefore depends on the context in which it is used. Examples of deictic expressions are "this", "that", "here" and "there".

When defining a multimodal language some key concepts for a particular domain are extracted. These can be then expressed in different modes, but are processed with a natural language approach. Any concept expressed in any mode can be "translated" into natural language. This implies that natural language acts as a "ground layer" that all the modes refer to, making speech the predominant mode and the key to the fusion of different modes.

Our study therefore involves NLP to understand how to obtain information from a text analysis and exploit it alongside other information conveyed by other modes, thus demonstrating the approach to solve such problems in a multimodal environment.

Through this approach, the definition of the multimodal language can be divided in two phases: the first is parsing-driven, the second oriented to tangible representations of linguistic experiences.

In the first phase some key concepts (expressed according to the various modes) are identified. They are encapsulated in structures (templates), which constitute their "frame" and define the language giving semantic value to what the user says or draws. A template is a syntactic structure consisting of concepts (expressed in the various modes) and syntactic categories, which are assigned with a given semantic value.

Each user action can match one or more templates. However, the multimodal language is not produced from a rules set but from a sentence analysis set - it is deduced from the spoken language. This helps to locate and eliminate syntactic ambiguity, as admissible syntactic structures (at the parsing level) that do not belong to the admitted structures set are not considered.

3. NATURAL LANGUAGE PROCESSING AND MULTIMODALITY

The first step we took was to discover how to pick up information produced by the user from the speech channel.

The study of NLP is important because we use natural language as the basis of our approach to fusion: the speech mode is predominant, while the others are used as a support when needed.

Most human communication is through speech, though in some cases the use of other modes makes it simpler to understand one another and convey concepts: this improves synthesis and precision, especially when relevant concepts need to be communicated.

NLP is thus the starting point for fusion. However, understanding a language involves - among other things - knowing what concepts a word or a sentence stands for and how they are related. The use of other modes therefore plays an important role in helping to solve problems that often arise in natural language comprehension.

In the following section the levels of NL understanding are discussed and some problems related to NLP are described from a multimodal point of view, i.e. with the help of other input channels.

3.1 Levels of Natural Language Understanding

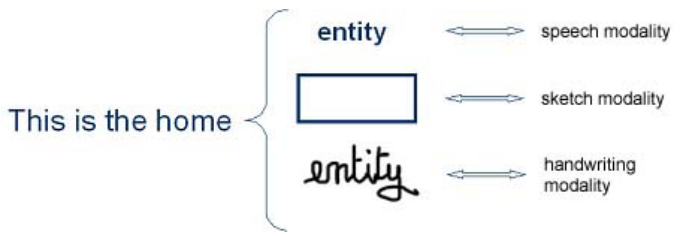
To process natural language a machine has to receive inputs from other modes and have a comprehension of natural language at different levels.

To determine what a user is saying, the system has to analyse an incoming audio signal and recover the exact sequence of words that the user used to produce that signal. This task requires knowledge of phonetics and phonology. The system also has to recognise word variations and contractions (morphology). Furthermore, a syntactic knowledge of the language is necessary to understand which word order makes sense. To this end, we used a statistical lexicalised parser that effectively solves the ambiguity problem. How this is done is explained below.

Understanding the nature of a request requires knowledge of the meaning of the words making up the sentence (lexical semantics) and the ways they can be combined to make a meaningful sentence (compositional semantics).

At this level, we used the information conveyed by the other modes: the key point is that the same concept can be expressed in a number of ways, which must be considered as semantically equivalent. This assigns a semantic value to the user's actions. The semantic side is therefore handled at different levels: first, at the level of each single mode, then at the multimodal level, when the modes are considered synergistically.

Figure 1. Example of the definition of an association in the E-R diagram scenario



The resulting multimodal language consists of these associations among different ways of expressing the same concept. This allows the problem dealt with at the fusion level to be solved at a language level. For example, in Figure 1, the sentence:

"this is the home entity"

has the same meaning as saying:

"this is the home" while drawing a rectangle,

once the entity concept and the rectangle shape have been associated.

A higher level of natural language understanding is founded on pragmatics, i.e. the knowledge of how words are used in everyday life to make conversation easier. This level is dealt with through deictic expression handling.

Some problems which arise in NLP are described below. We will see how the synergistic use of other modes supporting speech can help solve them.

Ambiguity is one of the biggest problems for NLP. First, it increases the range of possible interpretations of NL, and a computer has to find a way to deal with this. There are various types of ambiguity. These include category ambiguity, in which there are a number of grammatical terminal symbols for the same word; for instance, the word "time" can be both a noun and a verb. This can sometimes be resolved by syntactic analysis.

Another type of ambiguity is related to the meaning of a word, which may correspond to only one terminal but a number of different concepts. In fact, many words have more than one meaning; we have to select the meaning that makes the most sense in the context. Temporal observations are essential for this purpose: if a word (speech mode) appears to be ambiguous, it is possible to examine the other modes to rebuild the user's original intention.

A third type of ambiguity is structural, and consists of the existence of more than one parsing of the same sentence. For instance, the sentence "choose between A and B or C" has two possible interpretations:

1. [A] and [B or C]
2. [A and B] or [C]

Referential ambiguity arises when a language does not specify to which word an adjective refers. For instance, the sentence: "pretty little girls' school" can have various interpretations: the school is small, the girls are small, the girls are pretty, the school is pretty.

The use of more than one mode can help to resolve the syntactic and semantic ambiguity in the speech mode: considering speech as predominant, the other modes are called in to clarify the meaning of any ambiguous or incomplete sentences. Any ambiguity in the speech can be disambiguated by examining the information provided by the other modes to obtain the sense of the sentence.

Some types of ambiguity arise at the very moment that other modes are introduced. These are described below:

Ambiguity Caused by Deictic Expressions

Even if deictic expressions (and references in general) can help directly identify what the user is referring to, they can also be a source of ambiguity. When a user pronounces a deictic expression, it is not always clear if s/he is referring to something said previously or something that s/he has drawn or is drawing. The problem gets even more complex in the common situation that the user draws a figure while explaining what s/he is drawing using deictic expressions that do not refer to the figure directly. For instance, if the user says: "And this is the solution to this problem" while drawing a symbol matching a concept, the system has to understand that only the first deictic expression refers to the drawn object, while the second refers only to the discourse, without involving any modes other than speech.

The risk that deictic expressions will create ambiguity in a multimodal system is also related to another factor - their vagueness. In fact, people are not used to specify precisely what a deictic expression refers to, and so the system often has

insufficient information to understand what the user means. The use of temporal windows can be of help: if the user draws an object, the deictic expressions pronounced in a certain temporal interval refer to such object.

Structural Ambiguity

This arises when different multimodal inputs overlap, causing an incorrect interpretation of the user's action.

Let us consider the following example: a user pronounces the sentence "This is the home". Suppose that at this point, the system expects either the concept of entity or that of relation (expressed in any mode). The user may draw the object corresponding to the concept of entity (a rectangle) and at the same time carry on expressing the concept of relation in another mode:

This is the home, *the relation now has to be found.*

If the sketch of the rectangle temporally overlaps the pronunciation of the word "relation", it is not clear if "house" is a relation or an entity.

4. THE SYSTEM ARCHITECTURE

Starting from NLP approaches according to a set of concepts in an application domain, we have designed and implemented a software tool, which provides users with the functions to define a multimodal language.

The system consists of two environments: in the first, the user can define the language in his/her own way to express concepts in the different modes (in our case speech and sketch); in the second, s/he can use the language to interact with the multimodal interface.

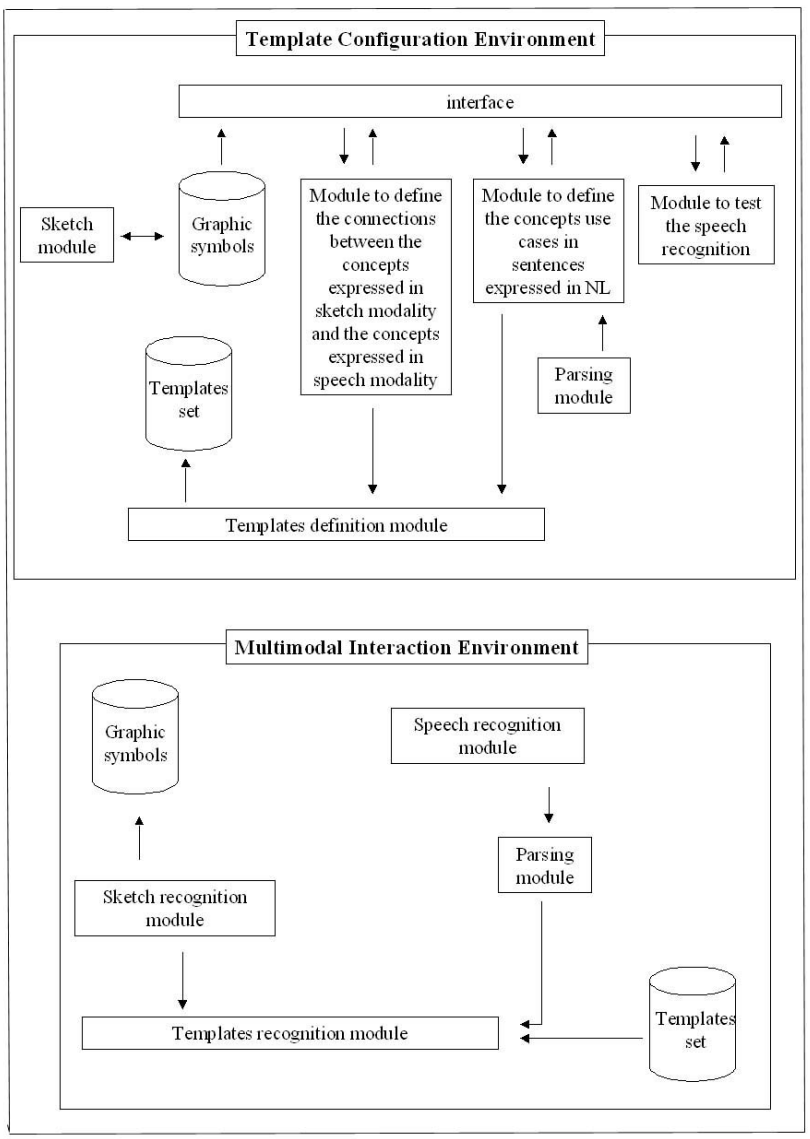
The definition environment is immersed in the fusion system, so that the user can switch from one environment to the other at any time.

The configuration environment has the aim of defining a set of structures - the templates - that enable the multimodal interaction to be processed.

Templates are defined through the following steps:

1. concept definition
   The user locates some concepts s/he thinks are relevant for his/her aim. For example in a E-R diagram definition, the user may locate the concept of entity.
2. correlation of concepts with "signs"
   Once the concepts have been defined, the user provides a sign to represent

Figure 2. The system architecture



these concepts in the speech and sketch modes. For example, the user may connect the concept of entity with the string "entity" (speech mode) and the rectangle (sketch mode).

3. correlation between signs
   The user is required to define a set of use cases (strategy "by example") for the relevant concepts in natural language. For example, the concept of entity is used to create a new entity, the user provides the example "this is the home entity".
4. template learning
   The system generalises the use cases provided in the previous step and builds the template set. It therefore:
   - assigns any deictic expression to the "deictic" category ,
   - replaces the concept with the related signs,
   - replaces any other word with its syntactic category.

In the example, the template obtained will be:

Deictic + VBZ + DT + NN + ("entity" or rectangle)

The template can thus be defined as the syntactic structure of an NL expression of a use case of the relevant concepts. It can then be used to interact with the multimodal system, in which the user can draw and speak at the same time.

A vocal recognition tool writes what the user says on a text editor, while a sketch recognition tool works on the user's drawing. The system makes the fusion between the two signals, recognising any matches between what the user said/drew and the template set. The two input streams are compared on temporally and according to the templates to see if they are complementary or redundant. For example, the multimodal dialogue may contain the following speech:

.....that, well, is now a new entity, the employer (rectangle)

The system architecture is summarised in figure 2: the configuration environment consists of an interface, which communicates with a graphical symbols set and with:

- the module to connect concepts with "signs",
- the module to provide use cases of the concept in NL,
- the module to test the template recognition algorithm.

These modules communicate with:

- the sketch module, which communicates with a graphic symbols library,
- the parsing module [13] which communicates with the module to define the use cases which define the template set,
- the module to define the templates, which communicates with the module to define the connections and the one to define the use cases. This module creates a set of generalisations of the use cases, i.e. a set of templates.

To define the template set, the use cases are provided as input to a natural language parser (in fact use cases are expressed in natural language).

Figure 3. The system

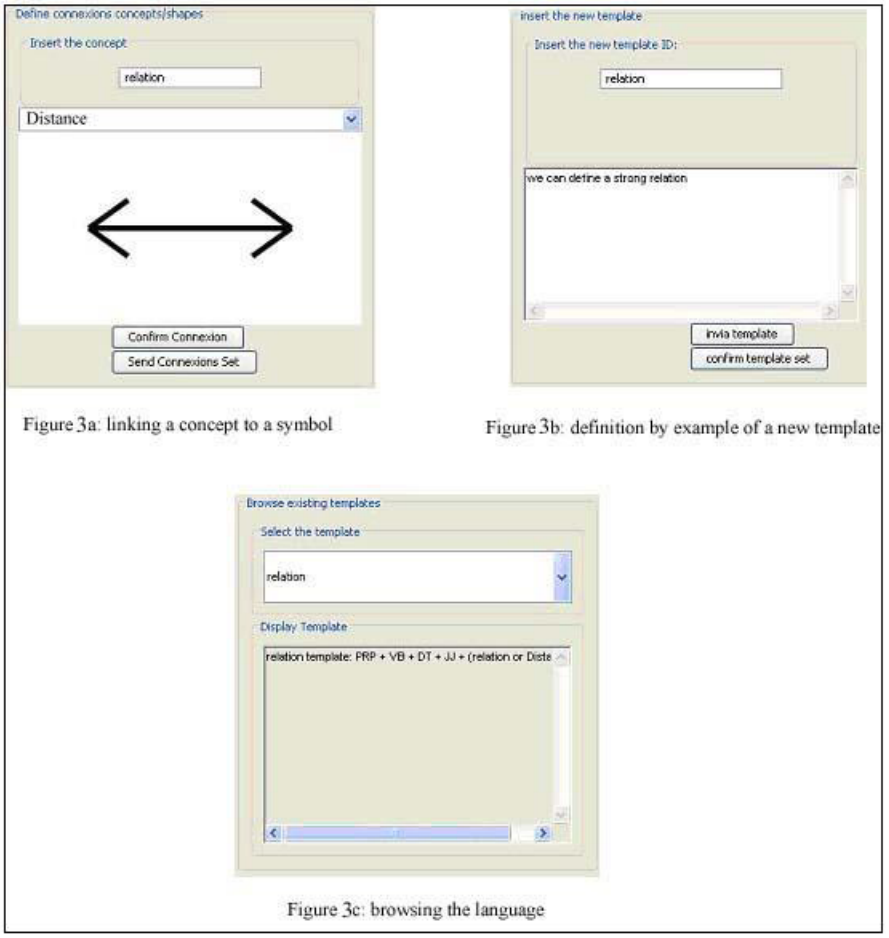


Figure 3a: linking a concept to a symbol

Figure 3b: definition by example of a new template

Figure 3c: browsing the language

The multimodal environment consists of the speech and sketch recognition modules. The sketch recognition module uses a set of graphic symbols, while the speech recognition module uses the parsing module to analyse the user's speech.

The first step in establishing the relationships between the multimodal user dialogue and the template set is the parsing of the user's speech (the parsing step in this environment is similar to the one seen in the configuration environment, except that the system parses the user's speech instead of a set of use cases).

The parser analysis constitutes the input of the template recognition module, which uses the set of templates defined in the configuration environment.

5. THE SYSTEM

The system was developed in Microsoft Windows XP environment, using Java 2 Platform Standard Ed. 5.0 as the programming language.

Figure 3 show the system's focal characteristics. As mentioned above, the language is defined by a set of templates containing a way in which a concept can be expressed.

Some key concepts can be expressed in both speech and sketch modes: the user can associate a word with a symbol (sketch mode) and a word expressed in the speech mode. This is demonstrated in Figure 3a: in this case, the user wants to relate the word "relation" and the symbol "distance" to the concept of relation.

Once the user has defined this relation s/he can define new templates as shown in Figure 3b: templates are defined "by example". That is, the user provides the system with the type of expression having a particular meaning through an example; the system picks the key concepts (in this example, the concept of relation) and lets the user express the rest by any words belonging to the same syntactic categories of the words in the example given. For instance, if s/he says, "we can define a weak relation" the template will be recognised.

Once the language has been defined, the user can browse the template set that makes up the language, as shown in Figure 3c.

Once the template set has been defined, the user can start multimodal communication with the system, thus speaking while drawing. After examining the text related to the user's speech and sketch, the system displays the matches it has found. Deictic expressions are solved by showing the object they point to.

6. CONCLUSIONS

This paper demonstrates the importance of natural language processing in the definition of multimodal languages. It addresses ambiguities by providing a tool for language definition. It shows that multimodal language is built from a template set that encapsulates a syntactic and conceptual structure, where concepts are expressed in the various modes and correspond to a precise semantic value.

The language is defined using a rule-oriented focus in constructing the templates, but is data-oriented in the definition of the overall language. This approach helps to reduce the problem of language ambiguity.

REFERENCES

[1] Oviatt, S.L. Mutual disambiguation of recognition errors in a multimodal architecture. In: Proceedings of CHI, pp. 576–583. ACM Press, New York (1999).

[2] Oviatt, S.L.: Taming recognition errors with a multimodal interface. CACM 43(9), 45–51 (2000).

[3] Oviatt, S.L. and Kuhn, K. Referential features and linguistic indirection, in multimodal language. In *Proceedings of the International Conference on Spoken Language Processing*. Sydney, ASSTA Inc., 2339–2342.

[4] Qiaohui Zhang, Atsumi Imamiya, Kentaro Go, Xiaoyang Mao: A Gaze and Speech Multimodal Interface. ICDCS Workshops 2004: 208-214.

[5] Henry Lieberman and Amy Chu, An Interface for Mutual Disambiguation of Recognition Errors in a Multimodal Navigational Assistant Multimedia Systems Journal, Special Issue on User-Centered Multimedia, Summer 2006.

[6] Sharon L. Oviatt, Antonella De Angeli, Karen Kuhn: Integration and Synchronization of Input Modes during Multimodal Human-Computer Interaction. CHI 1997: 415-422.

[7] J. Bouchet, L. Nigay, T. Ganille: The ICARE Component-Based Approach for Multimodal Input Interaction: Application to Real-Time Military Aircraft Cockpits. HCI International, 3rd International Conference on Universal Access in Human-Computer Interaction, Las Vegas, Nevada, USA, Juillet 2005.

[8] Michael Johnston. 1998. Unification-based multimodal parsing. In *Proceedings of COLING-ACL 1998*, pages 624–630.

[9] Roberto Navigli, Paola Velardi: **Structural Semantic Interconnections: A Knowledge-Based Approach to Word Sense Disambiguation, IEEE Transactions on Pattern Analysis and Machine Intelligence** Volume 27 , Issue 7 (July 2005) Pages: 1075 – 1086.

[10] WordNet 2.1: A lexical database for the English language; http://www.cogsci.princeton.edu/cgi-bin/webwn, 2005.

[11] Morris, J and Hirst, G (1991): Lexical cohesion computed by thesaural relations as an indicator of the structure of Text . *Computational Linguistics*, 17(1):21-42.

[12] Nigay, L.; Coutaz, J. 1993. A design space for multimodal interfaces: concurrent processing and data fusion. INTERCHI&#3993 Proceedings, Amsterdam, 172-178

[13] http://nlp.stanford.edu/software/lex-parser.shtml

An Optimized Service Oriented Middleware Design for RFID Enabled Solution

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ABSTRACT

Introduction of RFID at the Enterprise level has accelerated the automation of data interchange at various data points across the entire supply chain. The proliferation of RFID tags and readers will require dedicated middleware solutions that manage readers and process the vast amount of captured data. On the other hand, Service oriented architecture (SOA) represents a style of information systems architecture that enables the creation of applications, built by combining loosely coupled and interoperable services [1]. SOA Evolution promises a smooth integration and consolidation of large complex RFID implementation within large enterprise system architecture. The paper aims at the value propositions to the recent practices on such RFID middleware development using the SOA centric design approach and proposes model architecture along with the framework components for such optimization.

I. INTRODUCTION

The recent drift of innovation in an enterprise space is approaching towards two distinct spectrum of technological trends: turning massive amount of data into an operational intelligence by integrating Sensory /classical mobile devices at the edge of the enterprise network and on the other hand, building more adaptive and extensible application environment by addressing need based services with in an enterprise-wide heterogeneous Infrastructure. The essence of the "paradigm shifting" practices reveals that the collaboration of such emerging technology and a handshaking of conceptual abstracts would plot the road map for future solution offerings in an enterprise space. The widespread adoption of RFID requires not only low cost tags and readers, but also the appropriate networking infrastructure [2]. The constant effort of delivering solutions to such emerging areas has brought more focus into developing middleware and frameworks – that promises an application-agnostic offering for a diverse set of requirements. Functionally it manages readers, filters and aggregate captured RFID data and delivers these to the appropriate consumers. The platform also facilitates domain specific/independent integration, adaptation of a chosen set of RFID peripherals, combines the RFID data with application logic, and generates application-level events.

The main involvement of this paper is a middleware design approach delivering open standards along with the solution architecture of such middleware addressing new challenges of Automatic data collection using RFID and seamless integration over SOA platform. The governing idea of such system is primarily built on recent strategies on RFID enablement and extending service delivery approach demanding operational efficiencies within enterprise-wide "On Demand" space.

This paper is organized as follows: Section II focuses on the motivation that drives such design considerations. Section III depicts the principle of a scalable RFID middleware design and the value propositions. Section IV describes the proposed architecture of subsystems within the solution domain and integration methodology. Section V is a brief description of the reference implementation and Section VI illustrates how the service oriented approach addresses the recent challenges on solution design and integration. The paper concludes with a summary of the overall approach and discusses future directions in Section VII.

II. MOTIVATION

The recent pilots and rollouts of RFID implementations reveal that as adoption grows, the realization of benefits and scope of operational areas also grow. In industrial automation and supply chain management domains, RFID technology holds the promise to eliminate many existing business problems by bridging the economically costly gap between the virtual world of IT systems and the real world of products and logistical units [3] .The following points illustrate the objective of an extensible RFID middleware design suitable for wide range of implementations:

Leveraging opportunities provided by RFID to both private and public sectors involve understanding of the potential applications and the different business cases for the technology and its applications, along with their limitations and current challenges, to develop forward-looking policies [4]. Therefore the successful outcome of RFID enablement potentially depends on a set of technology advancement and smooth integration with the effective process change in an enterprise environment. The RFID implementation on top of the existing infrastructure would not highlight much on discrete business process issues and high impact on existing enterprise application architecture.

Item level tracking and asset management using RFID generate enormous amount of data which needs to processed, stored and transferred to an appropriate business system. Studies have been made to baseline the standard practices on data management and application component design to overcome technological challenges from passive RFID based solution. The current practices of solution development should also extend a mind-share on how RFID data can be interpreted in a given business context and turned into the corresponding application events for an optimized service offerings within entire enterprise application domain.

The solution providers have been working on standard set of applications /middleware design to cater most of the requirements evolved from the recent business practices. Such solutions could effectively accomplish the objective of integrating RFID with the operational environment but fails to anticipate the future business problems and collaborating on the solutions for a complex rollout.

SOA has emerged as one of the best alternative to turn the existing and new applications and data sources into an agile IT infrastructure that can help organizations meet changing business needs. This also facilitates reusability of components and services over time. I have tried to propose an architecture of the RFID middleware which extends the bandwidth of solution offerings over SOA centric design. Such optimization promises a wide spectrum of service delivery in a cross platform and cross domain automation where an extensible design not only targets to minimize the concerns as mentioned above but also try to eliminate technology specific constraints.

III. DESIGN RATIONALE AND OPTIMIZATION

Pilots carried out in various industry verticals have potentially extended the expected business values out off such automation. From the Architectural standpoint, an RFID middleware should not target to accomplish a specific goal or project requirements rather facilitate the scope of delivering anything beyond what is featured at the POC/ Pilot phase .

The recent practices and implementations have envisaged an ideal design approach of RFID middleware. The lessons are:

- Realization of early benefits would grow complexity in the incremental RFID enablement as the roll out would embrace more challenges beyond the traditional integration .Therefore a top-Down approach to design will not be well suited in the long run.

- The scalable design of such framework should be holistic to the entire enterprise and embed its capabilities in the overall system architecture.
- A device agonistic abstraction creates a common standard of data exchange protocol for the device service layers.
- Seamless integration of filter events, monitoring/logging and event routing should extend a common standard of event processing capabilities for processing streams of RFID and/or sensory inputs (Data/signals) into business events.
- A generic and scalable enterprise application framework in a multilayered architecture creating distinct service end points would serve data /information interchange and rule checking over the enterprise service bus (ESB).
- The solution framework would opt for a modular approach and well-defined separation of concern for the information interchange and smooth integration with the existing enterprise architecture.

The ongoing development of real-time asset tracking solution has widened the scope of distributed data aggregation and processing over an SOA layer to address the mentioned optimization sentinels.

IV. SOLUTION ARCHITECTURE-APPLICATION COMPONENTS AT VARIOUS LAYERS

The proposed architecture for the middleware design points to different challenges and the corresponding research approach in developing a RFID middleware to provide a seamless environment with in the enterprise network; moving data from the point of transaction to the enterprise systems. An Extensible Event broker model and robust messaging infrastructure constitute the backbone of the solution design. It encapsulates intelligent data processing and routing, interoperable solution components on top of business integration layer and standard communication protocol for data interchange. The multi layered architecture can be customized for specific operational need by configuring services and subsystems as per requirement. The basic design is intend to achieve a reasonable combination of core infrastructure and packaged application features, including device management, integration, data management, and generic business logic .The application layers are broadly structured as follows:

A. The Device Service Provider Domain

The sensory devices are controlled through the processing unit connected at the edge of the enterprise network. The service components primarily provide a device abstraction and logical filtering/aggregation services, supporting the analysis of volumes of data provided by the readers, applying local decision making and intelligence. The group of applications termed as Edgeware or Edgecontroller, are built on a standard framework which can be extended for specific service agent development. The contract between client or consumer and service is interface driven. Discovering and binding for the corresponding implementations are done through the framework layer. Agents are softly coupled and primarily rely on standard messaging protocol over an asynchronous public-subscribe model for information interchange. Thus the runtime components embrace an observer-observable pattern with in the processing environment. There is an external configuration /XML file which contains the declaration of service dependencies with in the runtime environment.

The functional features of the edgeware application environment are as follows:

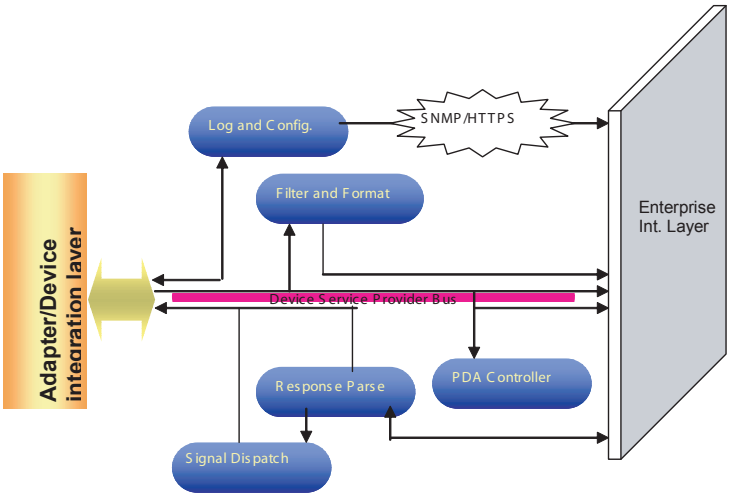
- The Device Integration Layer creates a façade for the transport and device protocol. This layer interprets the incoming signals/ data lists into a common XML format. The application components in this layer are also capable of translating standard commands into device specific instructions. A single interface contains a list of functions to transfer and execute standard read/write, I/O operations and device management command list. As the data/command formats are not yet standardized the implementation of the same adheres the dedicated supports from device/Vendor libraries and APIs in the heterogeneous reader landscape. This is a loosely coupled service agent which can be customized for various readers.[5].
- Depending upon the nature of implementation and volume of data, the notification latency should be configured on top of the data broadcasting layer. For a large scale implementation(i.e. Dock door receiving ,Real-time asset tracking using active tags ,Smart Shelves) a filtering and smoothing service is configured for minimizing the redundancy of the captured raw tag-reads and funneling the unique reads in a predefined format(Text/XML).The service agent additionally performs the checking of the Data format of the incoming raw tags considering either standard specifications(e.g. EPC SGTIN -96 , ISO 15693 , ISO/IEC18000-3) or proprietary data structure as per need .Such optional filter service at the local execution environment mitigates the risk of unwanted injection of bytes from the physical world. Similar filter service would be extended with respect to specific portal/Reader identifiers. Since a single Edge Controller is operational for multiple readers at a particular location , the service can be configured for a specific set of readers or logical grouping which would be considered for a specific application context[6]
- Each edge unit comprises of a Tag-Read- Handler Router -an agent broadcasts the formatted tag list to the centrally located Data aggregation service layers at the enterprise space. The performance of this service layer is optimized through a set of Latency parameters viz. 'paramPublish_Interval', 'param-Purging _Interval' at the enterprise space. On the other hand, relatively simpler application environments or solutions handling low volume of data but need to respond immediately to local interaction with the physical objects (i.e. Data collection using hand-held reader and PDA, WIP tracking, Security monitoring, vehicle tracking and fleet management etc) reduce the overhead of the filter service by eliminating the same within the runtime environment or consider a short notification latency that is comparable to the observation latency and receive immediate notification from the device layer[6].
- The edgeware establishes a common secure message subscription channels with the enterprise layer for data/signal event exchange asynchronously. The router agent publishes the XML messages contain the Event source /Destination ID, Timestamp along with Tag-data elements which are subscribed by the consumers at the enterprise layer to accomplish specific task.
- There is an SNMP [7] agent running on each Edge controller application environment. This service agent is exposed through a secure Web service for the device /infrastructure management. The centrally located Management Information Base with in the enterprise application layer queries for current performance statistics periodically in a systematic fashion using SNMP traps (Synchronous calls). Each Device Agent extends a worker thread which delegates the device/peripheral status to the SNMP agent The Agent persist the details in an XML format, which is forwarded upon request from the management station.
- The response parsing agent carry outs optional service management tasks locally when a notification is received from the other device agents and response/instruction received from the enterprise management base. The operations like Audio visual alarms for any failure, Sensing tagged physical objects in proximity and switch on the reader, maintaining a temporary persistence (using in-memory DB or XML) for the Tag reads if the network is down etc for immediate recovery and faster response at the local site.
- The mobile/handheld devices operational with in the edge domain use an additional GUI based controller (developed on top of standard GUI framework) for data collection trigger, formatting, Manipulation of the data elements and persisting/routing the same with in the application environment.

B. The Enterprise Integration Domain

The enterprise integration is the intermediary between enterprise applications and the Edge Domain. It compiles business sense of RFID read information and enables automatic decision making. The application infrastructure is built upon Service delivery framework defining so called plug-in to the real world. The application tier offers the following features:

- The Enterprise layer persist the configuration details and a logical mapping of the readers /sensory hubs within the business environment data points. The device infrastructure operational need to be registered with the system with respect to such predefined mapping. For an offline mode of operation the same details need to be validated prior to the data aggregation at the enterprise space.
- The Data interchange layer at the top of the enterprise space provides a common gateway for standard publish/subscribe mechanism (centrally Located) handing dataflow across the sensor hubs /handheld terminals and enterprise layer. The unidirectional communication channels are used for subscribing incoming tag lists and other operational inputs. There are standard set of XSDs to validate the data content and format of the incoming Tag-lists. For any non compliance, this service layer generates alert messages as a notification on

Figure 1. Functional components: Device service provider layer



the subscription feedback. The local application can subscribe to the same using the response handler agent to take immediate action (send message via alert console or switching on the Audio-visual alarms).

- The valid Data/Tag-lists subscribed over the enterprise gateway are processed by the data aggregation subsystem analyzing the source/content, are delegated to the respective event generation layer to process the same. The standard XML list contains sensor/RFID event specific inputs is processed as a generic message format and delivered in enterprise application infrastructure. The subscribers consume the message of its interest (RFID event specific to Dock door receiving, choke points, audit details or read counts etc.).Such subscription is structured through a management console considering the reader/sensory hub configuration/mapping and decentralized operations for a specific set of Data elements. A dynamic delegation pattern is incorporated in this layer to bind the message selectors with in the runtime environment. This service is a construct of the Application event emitter framework, which process the incoming messages and check the rules applicable for source of sensory events and specific problem domain.
- The implementation of a rule engine on top of this emitter layer extends an adaptive execution environment for the available service components. The predefined rules act on a set of subscribed data elements to generate Application level events. Such rules are derived from the custom process maps applicable for specific business context. The administrative consoles are available for add/modify the rules applicable at various service layer of the predefined event emitters. Hence the integration layer can be leveraged for numerous distinct process execution and service offerings and provide information directly to "line –of business" applications. The set of rules would be applicable for correlation, precedence checking and complex mapping of the data items from within the event repository. The service layer also facilitates a real-time state transition updation and deletion on the base events.
  The Application Level Events(ALE) generated by such event emitters are persisted in ESB for the consumers interested in specific business operation .The consumers can be any business service, pluggable subsystem which can access these data for raising notification /alert , update backend system and/or constitute an information hub for the business events in an organized report format.
- Reader devices which are part of a secured network are registered and go through a process of device authentication on an ongoing basis to prevent "reader spoofing" (e.g. unplugging a reader and plugging in a (e.g. unplugging a reader and plugging in a laptop which creates a false data stream which is meant to look like it comes from a reader) using a centrally located Administrative and monitoring service[8].The solution architecture is designed such a way that it can protect both stored data as well as data that is in transit. The system should also extend comprehensive management of the readers and other peripherals constitutes RFID enabled infrastructure. .The application component act as an SNMP management station analyzing SNMP traps send form the distributed device infrastructure.
- The centrally located management application service layer includes the product details lookup , rule management, Device infrastructure management , Log details and views ,analytics and other reports/enterprise content solutions

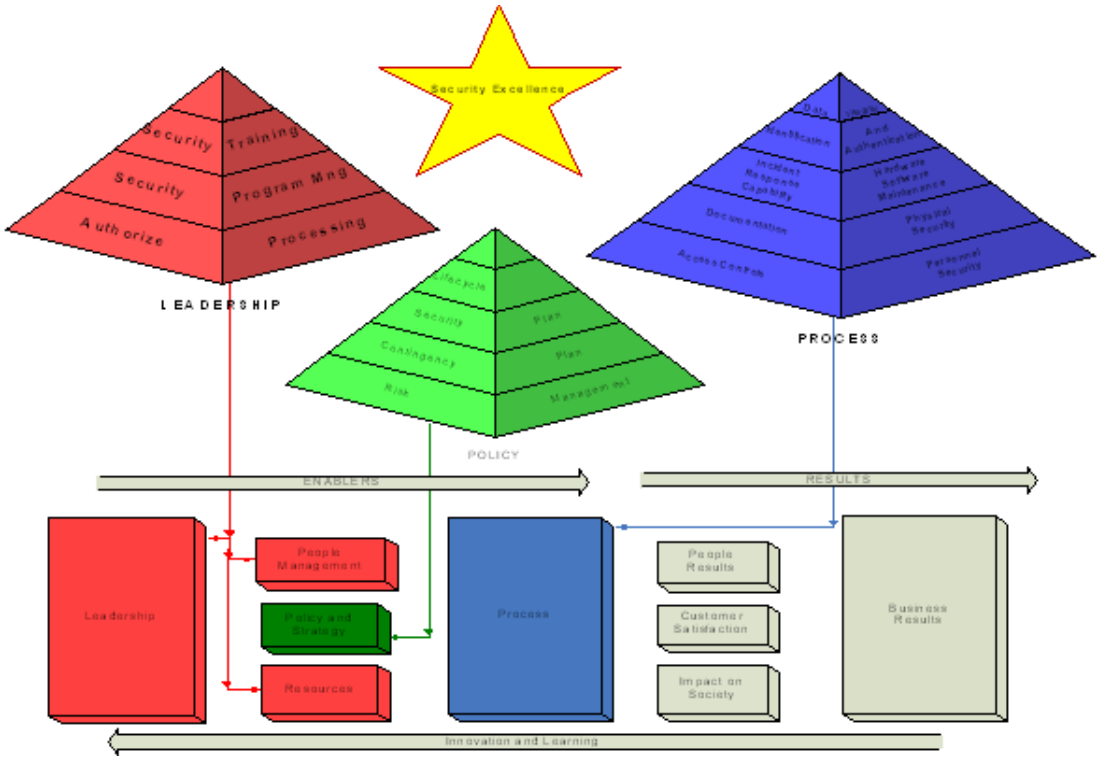
The Object Directory Domain associated with management application services running in the server and other handheld terminals is responsible for user authentication, authorization, and data encryption practices in accordance with a security and privacy management policy.

V. THE REFERANCE IMPLEMENTATION

The proposed design has been realized through an asset development activity in our lab. We have chosen OSGi application framework (SMF on top of IBM J9 environment) to build loosely coupled bundles of the solution .Each bundle exchange signal data over MQ Everyplace messaging infrastructure .The controller uses Message Queue Bridge for store/ forward signal/Data transfer over the network. In offline mode, DB2e is used for local persistence of the tag-lists. The SNMP client bundle updates the network status to the controller to route/persist tag reads. The basic SOA centric design promises a dynamic modularity for the edgeware application environment and accomplish following points of interest:

- The evolving standards/hardware and business requirements demands new generation of devices and sophisticated process automation .with in the enterprise space. The service components thus built on such framework can afford such enhancements following the evolutionary trend and helps to optimize the runtime environment by activating /deactivating services and configuring their service delivery behavior.
- The runtime environment should be integrated with large number of devices viz.; PC, Microcontrollers, OS embedded in the stationary readers, and micro

Figure 2. Functional components: Enterprise integration layer



environment of the handheld devices/PDAs. Therefore the framework components are built on J2ME runtime that supports diverse set of environments.

The server side components are built on WebSphere platform with DB2 as a backend. A service component is built on this platform to receive inbound messages as an MQe Gateway. The application module extends the Jeline event infrastructure and uses pub-sub broker on top of MQ series which exposes a Standard Event Infrastructure and management.

The application services builds on the J2EE layer .They are used for storing devices and other agent configuration along with configuring rules associated with the data aggregation, visualization and correlation. The asynchronous reads and other sensory inputs are parsed by the dedicated event emitter at the event processing layer based on such preconfigured rules and the same is persisted in the ESB layer as ALE.

A configurable supervisor service monitors the ALEs to update, Logs transitions and consumptions of the events in the back end database and sending notification to other systems using Response handler service components.

Some generic application service layers are built to subscribe the events and query the data objects and application level filter to look up the ESB contents for the specific needs.

There are other standard application services built for the health status check using secure SNMP trap, device /user authentication/registration and device agent configuration download over LDAP.

VI. SOA ENABLEMENT- THE VALUE PROPOSITIONS

In order to comply with the typical SOA centric middleware design the proposed framework focuses on three fold approaches:

- The sensory devices constitute the edges in enterprise infrastructure, should promise unique services deliver behavior that transcend the underlying technology for data collection using a common standard event model (XML based) over the network and visualized by enterprise application layer. Such event model is also adaptive to the connectivity of the sensory devices; logging performance is in an assorted device infrastructure and notification through audio/visual alarm and signals.
- The enterprise space extends a managed/scalable environment built on service oriented container/content model. Services comprise of standard event bus, complex calculations and analysis on composite business events using correlation technology and rules engine, which assure potential means of semantically rich communication between systems targeting various business operations. Apart from the data acquisition and translation of the business events, the enterprise application creates a centralized device management service and reduce the on site administration hassles.
- The integration layer relies on synchronization services with the legacy system .The dynamic event generation and logical data aggregation at the enterprise space is accessed through a Hub and spoke model on top of the Synchronization layer. The wrappers built for such synchronization services thus eliminates the hard coded point-to-point interfaces between the middleware layer and multi-platform heterogeneous enterprise IT infrastructure.

The architecture of such focuses beyond a point solution approach, reducing the overhead of replicating information between the Middleware infrastructure and other multitude enterprise systems .smoothen the transition of the events generated at the physical layer to the structured business events. It promises a readily available, reliable scope for real-time asynchronous Event propagation and state-based decision making.The mentioned design approach uses standards-based technologies on an extensible platform to ensure that it's well positioned for the future.

VII. CONCLUSION

Integration of RFID based data collection and automation is a cross functional exercise. Organizations need the freedom to implement RFID in increments and

the flexibility to re-engineer processes that are RFID-dependent. This should also minimize the cost and time to frame a new architecture. The proposed approach targets primarily on Service-oriented architecture (SOA) and features both services and events which could deliver the desired scalability and performance.

The proposed solution architecture is harvested from encouraging experience in designing and implementing RFID solutions for various industries. The optimized middleware design would promise an RFID- technology agnostic and holistic distributed platform for an enterprise wide integration and process automation. It targets to those requirements by exploiting the Service oriented application components, easy-to-use Event Infrastructure for Business process integration seamlessly with wide range of enterprise solutions.

The proposed solution demands continuous supports for integrating new breed of readers as the vendors don't adopt a standard protocol for device –to-application integration. However the recent researches in hardware and firmware development has evolved mature device specification which would have standard implementation for the communication protocol along with some of the built-in services of the device integration .With the advent of such maturity the Edgeware application would be upgraded to more slandered adapter with the evolution of mature specification in future and would be functional as proxy to the enterprise integration layer focusing more on local decision-making services.

At the enterprise space the custom service layers are developed to emit application level events with respect to the applicable rules for various business needs .The current research is targeted on using BPEL for service orchestration or process choreography to design much more flexible service layers and seamless integration.

Therefore considering the potential areas of improvement in the enterprise scale RFID implementation the loosely couple design can be optimized for applications of any size and can be leveraged with the realization of the multi-dimensional impact of the growing need for such automation.

VIII. REFERENCES

[1] Service oriented Architecture at: : http://en.wikipedia.org/wiki/Service-iented_architecture

[2] S. Sarma, D. L. Brock, and K. Ashton. The networked physical world – proposals for engineering the next generation of computing, commerce & automatic identification. Technical Report MITAUTOID- WH-001, MIT Auto-ID Center, 2000. Available at: http://www.autoidcenter.org/research/MIT-AUTOID-WH-001.pdf.

[3] E. Fleisch and M. Dierkes. Ubiquitous computing:Why auto-id is the logical next step in enterprise automation. Technical Report STG-AUTOIDWH-004, Auto-ID Center, 2003. Available at : http://www.autoidcenter.org/research/STG-AUTOID-WH-004.pdf.

[4] Organisation for Economic Co-operation and Development : Research abstract RADIO-FREQUENCY IDENTIFICATION (RFID): DRIVERS, CHALLENGES AND PUBLIC POLICY CONSIDERATIONS . Available at www.oecd.org

[5] P .Bhadra . RFREAD :The generic framework for RFID reader Adapter Publication at International conference EAIT 2006 , CSI .Page 357-360.

[6] RFID middleware design - addressing application requirements and RFID constraints Christian Floerkemeier and Matthias Lampe . Available at : www.vs.inf.ethz.ch/publ/papers/floerkem-rfidmi-2005.pdf

[7] Simple Network Management Protocol . Available at : http://www.cisco.com/univercd/cc/td/doc/cisintwk/ito_doc/snmp.pdf

[8] An Architecture Framework for RFID by Steffen Schaefer, IBM. Available at : http://www.lac2004.nl/docs/fvbg2hdsb83/Track9/S.%20Schaefer.pdf

Security Excellence: Fusing Security Metrics into a Business Excellence Model

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ABSTRACT

The European Foundation for Quality Management's Excellence Model is a highly recognized business framework that has been implemented in many European countries to achieve Business Excellence. It is a documented approach to determine the overall Total Quality Management (TQM) practices of an organization by assessing nine different criteria. Conversely, the US National Institute of Standards and Technology (NIST) has outlined a set of security metrics that are categorized into managerial, operational and technical controls that can be used to express the security posture of an organization. In this paper, we propose to integrate these two domains to produce a comprehensive security framework based on underlying TQM practices and principles. Hence, we have created security metrics that are more accurate in reflecting the holistic state of a business and all its important aspects including IT security aspects that were not formally considered before.

Keywords: TQM, EFQM, NIST controls, security metrics, business excellence

1. INTRODUCTION

According to the 2006 Computer Security Institute/Federal Bureau of Investigation (CSI/FBI) survey, a total estimated loss of US $52,494,290 was recorded for common types of security attacks. This is indicative of the vital role of security in an IT infrastructure when it comes to thwarting threats and attacks that can result in significant damage. IT security must also be addressed in order to comply with legal stipulations. For example, in the US, there must be compliance with HIPAA, FISMA and Sarbanes-Oxley while on the Canadian side, laws like PIPEDA must be abided by or stiff legal penalties could arise. There are also social and ethical obligations that have to be taken into consideration, surrounding privacy and confidentiality issues. If these considerations are overlooked then loss of reputation can result and a loyal customer base can also be destroyed (Calder, 2005).

A critical review on whether business productivity is facilitated by Information Technology (IT) investments in general has been performed by (Dedrick, Gurbaxani, & Kraemer, 2003), which established that there are indeed higher increases in productivity for both manufacturing and service sectors. Empirical results that were gathered in a production environment also support the claim that there is a payoff for investing in Information Technology (Gurbaxani, Melville, & Kraemer, 1998). In addition, (Martinez-Lorente, Sanchez-Rodriguez, & Dewhurst, 2004) performed an analysis of whether IT has an effect on TQM based on key elements from the European Quality Award- instituted by the European Foundation for Quality Management- and the Malcolm Baldrige Award, which reflect quality management and assurance principles. The analysis revealed that large industrial firms that actively support TQM do recognize that IT plays an important role in achieving the desired results of the TQM implementation.

It is therefore imperative that IT security be addressed as a paramount concern since it contributes to business productivity by ensuring that the IT investments and infrastructures are secure at a level that is acceptable to the business environment. By taking the security domain into account, we are a step closer to our synergistic model of Total Quality Management, which can be viewed as an integral approach for improving an existing framework of processes, where goods and services are delivered to customers based on their expectations and the societal impacts are also considered (Nasierowski, 1997).

IT security mitigates business risks by allowing the smooth functioning of daily activities, resulting in an increased possibility of productivity goals being achieved. It is however, primarily up to top-level management to decide the appropriate security levels for their environments (Michaelsen, Michie, & Boulanger, 1985). If this claim that management should determine the amount of emphasis to be placed on security is correct, then it is worthwhile to determine how much cost should be associated with these security investments.

There have been several proposals for measuring the associated costs which include a Cost Benefit Analysis or Return on Investments (ROI) approach which weighs the risks in relation to the value of assets to produce a quantitative measure (Mercuri, 2003) (Erkan, 2005). It is also a more suitable and relevant approach when it comes to clearly projecting business risks (Jorma & Reijo, 2005). Similarly, a scorecard can be used to model the Return on Investments in order to highlight the benefits of security investments when compared to potential business risks (Banker, Chang, Janakiraman, & Konstans, 2004). It has also been suggested that a Cost Benefit Analysis is an improvement over value-neutral models since it is more persuasive in convincing management that business productivity is facilitated by security investments (Michaelsen et al., 1985) . We agree with this claim and have, therefore, incorporated security metrics into an underlying business framework that already evaluates the return on business investments to determine if a business is successful or not.

By taking this one step further, the security posture of an IT infrastructure is investigated to determine the necessary adjustments that are made to steer the business on the path to excellence. Subsequently, we must have a convergence on what a metric or a measurement should entail: it is Specific, Measurable, Attainable, Repeatable, and Time-dependent (SMART). It is distinguished from a measurement- a single snapshot in time that reflects a certain state- by performing an analysis of the recorded data over time to an accepted baseline (Shirley, 2002). Metrics will be based on IT security goals and objectives and will be, "tools designed to facilitate decision-making and improve performance and accountability through collection, analysis and reporting of relevant performance-related data." (Swanson & Bartol, Nadya et al, 2003). This indicates that the performance-related data is dependent on the specific system and a different combination of the Confidentiality, Integrity and Availability principle will be a security requirement. For instance, governmental and military operations will be more inclined for a higher ratio of confidentiality measures while a commercial enterprise might be more interested in availability principles.

Developing security metrics that accurately produce quantitative results can be a disconcerting task with the level of subjectivity involved. Service Level Agreements had been investigated in the hopes of providing a more quantitative solution to this problem (Henning, 2000). Here, the authors presented different service levels which have distinct, associated cost metrics. In this context, security was investigated to deduce whether it can be represented as a Service Level Agreement by exploring four criteria for metrics: temporal (to be met within a specific time period), performance (tangible delivery of materials), functional (adjustments to systems for normal operations) and process-related (recurring tasks) metrics. However, while this approach to security metrics is important to note, it does not replace assurance methods but instead, defines a set of security-oriented practices for functional operations.

It was further proposed that security metrics should be based on a framework that is already in place or familiar to the organization in order to foster acceptance and widespread understanding of the new security paradigm (Shirley, 2002). As a result, our research aims to progress in this direction by relying on the foundations set, primarily by the European Framework for Quality Management and the US National Institute of Standards and Technology (NIST) in order to capture an

accurate security representation of the state of a business, relative to its existing strategy and goals. We believe that this approach also extends into a broader Total Quality Management solution since the security aspects of an IT infrastructure are also deemed to be important. The EFQM has been chosen based on its wide acceptance and holistic integration of all important business domains while the security controls have been selected based on the US's NIST documents that aim to deduce the security posture of a business.

2. EXISTING MODELS AND STANDARDS

There are numerous existing models that facilitate security evaluation and assurance. The Common Criteria (CC) comprises the ITSEC (*Information technology security evaluation criteria (ITSEC)*1991), TCSEC (Orange Book) and CTCPEC(*Canadian trusted computer product evaluation criteria*1993) while the SSECCM is another important model that can be used throughout the software product lifecycle (Jelen, 2001).

The Orange Book was developed for the Department of Defense in 1985 by the US to apply metrics that determine confidentiality levels of their security systems. On the contrary, the ITSEC was introduced by the UK where a Target of Evaluation has different evaluation levels where there are set security objectives that fit into these levels; the CTCPEC is the Canadian version which provides a guide to evaluate the assurance levels of objects that have certain rights and privileges (Bacic & Robison, 1993). The concerted culmination of these three models into the Common Criteria, focuses on preventing the insecure event from a technical level. In contrast, the Information Security Management System (ISMS) encompasses the BS7799 1995 as a specification and is deemed to be a management model suited for the real world(Brewer, 2005).The ISMS was modified into the ISO/IEC 17799:2000 and later updated as ISO/IEC 17799:2005 where requirements and prescribed roles and responsibilities are better explained. The framework is suited for risk assessment and building management controls (*ISMS standards overview.*2006). In fact, "A mix of aspects such as policies, standards, guidelines, codes-of-practice, technology, human issues, legal and ethical issues constitute an ISMS" (Eloff & Eloff, 2003).

The US National Institute of Standards and Technology is another authority that focuses on the development of security metrics. There are three control areas that are proposed- management, operational and technical controls that contain metrics that can be aggregated into other metric sets as deemed appropriate (Figure 1). This will further be discussed in the following sections. Questionnaires are provided for these critical elements which result in a quantitative measurement being assigned such as a percentage or an average number(Swanson, 2003) .Furthermore, the European Framework for Quality Management is a model that places emphasis on all aspects of a business framework by addressing the non-financial factors- for instance, recognizing the societal impact of its operations(Westlund, 2001) as well as ethical implications (Martín-Castilla, 2002) in the quest for business excellence.

By integrating security metrics into a TQM business model, a solution is created to address business strategy (corporate governance and policy), technology management (utilizing the accepted standards) as well as the management of legal and human-related issues (Eloff & Eloff, 2003). Similarly, Jorma & Reijo (2005) acknowledged the use of business models such as the Malcolm Baldrige model and the EFQM evaluation criteria to measure performance in these areas and noted that IT modeling should be present as well.

3. BUSINESS EXCELLENCE AND THE EFQM

In order for an organization to be a good corporate citizen, it must consider non-financial factors to deliver the required results to customers, the environment and society. In fact, this is increasingly achieved by using a TQM approach (Sciarelli, 2002). Business Excellence (BE) is a holistic concept, also representative of a TQM approach by considering all aspects that have non-financial and/or financial repercussions. Metrics for the non-financial aspects cater for domains that revolve around customers, society and employees. In contrast, financial metrics strive to measure the dollar earnings for the business relative to production goals (Westlund, 2001). On this note, we propose that security excellence is an extension of business excellence by blending the existing requirements of a business- whether being financial, legal or ethical domains- with the necessary security mechanisms to protect critical business information, resources and operations. It is not an add-on feature and should not be isolated from a business framework. Thus, with respect to its integration into the EFQM, there are proposed levels of fusion that can occur at the nine different domains of the EFQM model and these can be assessed or measured at periodic intervals. The **Enablers** in turn produce **Results** which are measured according to a set evaluation process (European Framework for Quality Management, 2003) (Figure 2). It should be noted that these assessments do not replace Risk assessments but instead include them as subset of the metric control sets that will be used in the evaluation process. Refer to the NIST controls which include Risk Assessments as a control set in Figure 1.

The EFQM is a highly recognized model that was formed in 1988 and has grown over the years with applications across a wide variety of sectors including health care (Perides, 2002) and educational settings (Saraiva, Rosa, & Orey, 2003). As a case in point, it was adopted by a University Medical Centre in the Netherlands after an initial implementation of an ISO 9000 system failed to meet their needs. Over time, the system was unable to cope with the integration of all aspects of the University setting in a holistic manner. As a result, the move was made to adopt the EFQM, one of the reasons being the inclusion of a continuous improvement process in its TQM principles (Geraedts, Montenarie, & van Rijk, 2001). As a result, the EFQM model has been chosen as a foundation for our Business Excellence extension because of its inherent feedback process that allows continuous innovation and improvements, which contribute to the business being sustainable and competitive over time. In addition, it encompasses a systemic integration of all business aspects that we also consider to be significant. It however, lacks a security component and this may be due to the period of time in which it was formed since security concerns were not a top priority in the business operations as compared to the shift in focus that they are currently experiencing. We firmly believe that security is an integral component that needs to be included and a security excellence paradigm is obtainable by transcending one step further to include this domain.

4. SECURITY EXCELLENCE

We will use the US National Institute of Standards and Technology's metric sets, which are used to evaluate the security of a business to perform an integrative assessment of the Business excellence aspects. As a result of the different EFQM domains that are present, the NIST metrics have been categorized under **Policy**, **Leadership** and **Process** metric sets to demonstrate their appropriate assessments and integration into the EFQM framework. The NIST metrics have been grouped into the appropriate categories based on their inherent characteristics and dominant factors. For instance, the **Risk management control** forms part

Figure 1. Puzzle of NIST controls hat can be aggregated into different metric sets

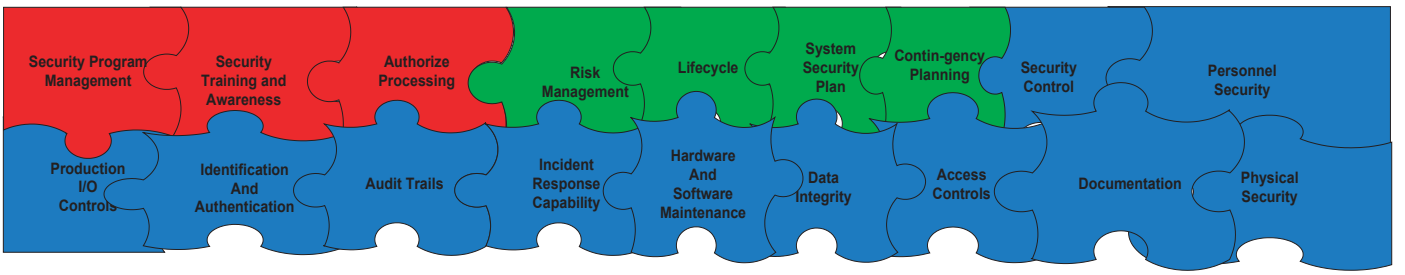
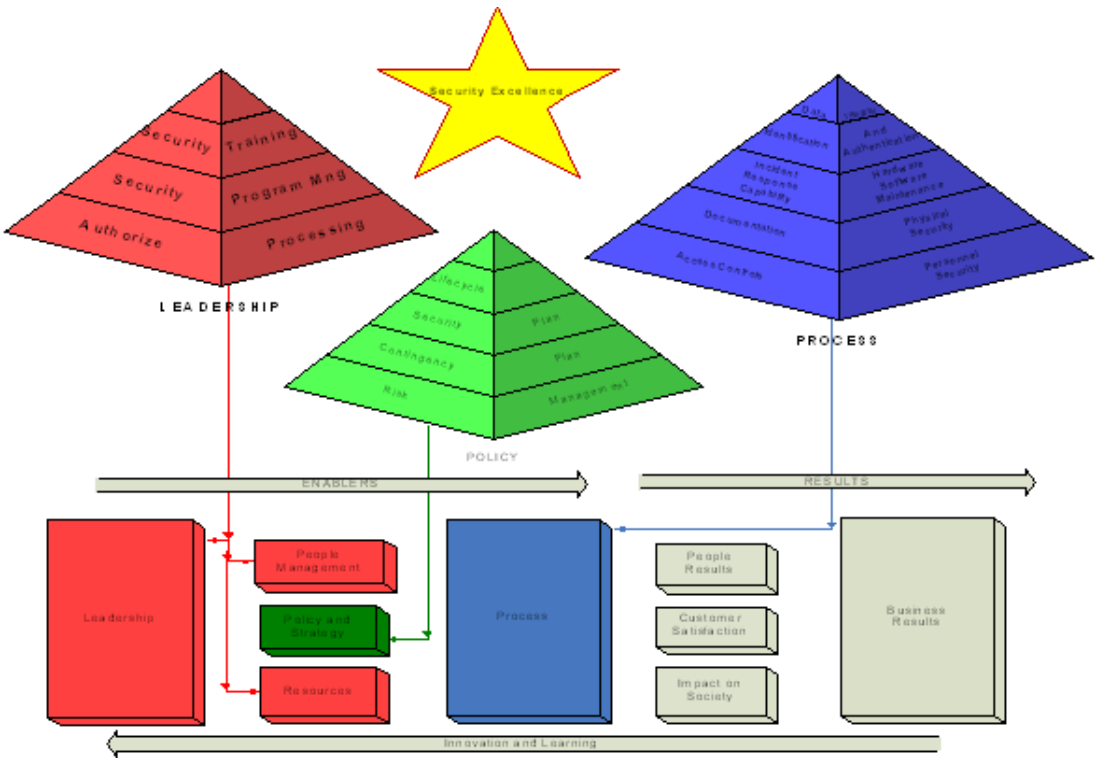


Figure 2. Integration of the NIST controls in the EFQM model



of the **Policy** metric set since it needs to be established firstly, in the Security Policy for it to flow across the remaining TQM structure (Figure 3). All of the remaining NIST controls will be further grouped into their appropriate categories in the following section.

Risk management, in the security context, is a process that encompasses identification and assessment of risks as well as mitigation, monitoring, reporting and prediction of security risks. After these phases have been completed satisfactorily to the expectations of the risk analysts, the appropriate procedures and guidelines are compiled into a Risk management document. The documented procedures will complement the Security Policy of the business which is integrated with the EFQM's corresponding **Strategy and Policy** domain; it represents a merger between both business and security policies. The top-down TQM structure becomes evident as the **Resources** are then tailored to deal with the results of the Risk management assessment as well as any contingency plans and guidelines in the Security/Business Policy. The **Leadership** criterion then comes into focus by communicating the contents of the Policy to all levels of the organizational structure. In addition, the Leadership skills must support and promote these Risk management assessments. **People** are then trained through aggressive security programs and awareness campaigns to carry out the guidelines of the Policy. Finally, the **Processes** are carried out as expected after having made the necessary changes that resulted from the security risk assessment.

The above is a description of how a specific control flows along the TQM structure and integrates with all the relevant business domains but it is however, performed from a security perspective. The obvious integration cannot be dismissed and as depicted in Figure 2, the synergy of these two domains is explicitly shown as the NIST metric sets are fused with their corresponding counterparts in the EFQM. Each specific control in each of the metric sets follows a similar TQM structure as explained above with the Risk management control (Figure 3). In essence, after the control is placed in the appropriate metric set by determining where it has a stronger impact, it is then related to all the other business domains in the EFQM. This relation or interaction of the metric sets produces a more integrated and accurate result for the individual security metric. This is due to the fact that there is an evident interaction of the security metric to the goals of the different business domains and the metric, thus, needs to be applied to all of the other EFQM criteria as well. This therefore, contributes to a more accurate result of the state of the business' performance level when it comes to that particular area or control, as defined by NIST.

As another example, the **Security Training control** can be considered as more of a driving force as part of the Leadership domain since it is an appropriate metric to determine how supportive management is toward training sessions. If management has the right approach and support for training sessions, then the **People** will be motivated to be security-conscious and will be educated on how to use the **Resources** effectively so that the **Processes** can then function as expected. This same sort of analysis has been performed for each metric to determine the category in which it is assigned to and a TQM approach is then followed to establish its relationships to the other domains, as explained above with the **Security Training** control.

After a control has been placed in either of the **Policy**, **Leadership** or **Process** categories (or pyramids), it is grouped along with other similar controls that collectively, will reflect the overall measurement or state of that category. We have therefore, classified similar controls in their respective categories which are depicted as pyramids in Figure 2. Each metric set has been represented as a pyramid due to the fact that all the stages of a pyramid converge to a common apex. The common apex is representative of precise goals and objectives that are shared by all the elements or controls of that metric set. For instance, all controls of the **Policy** pyramid should converge to the same security requirements that are reflected in the Security policy. If all layers have satisfactorily produced desirable results, then the pinnacle of the pyramid is reached in terms of there being an "excellent" Policy framework in place. The same is applicable to the other Process and Leadership pyramids or metric sets.

Furthermore, when the goals have been achieved in each pyramid, there is an alignment of their summits to the desired concept of **Security Excellence**. However, only if each pyramid has produced the required results then this can

Figure 3. Top-down TQM approach to formulating risk management security control

be achieved. Otherwise, it will not be a total security solution if one pyramid has been positioned correctly while its counterparts are dangling in a precarious or insecure position.Each metric set can now be immersed into their corresponding components in the EFQM framework. For instance, the **Policy** pyramid is fused with the evaluation criteria of the **Policy and Strategy** criterion of the EFQM. The same integration is also performed for the other pyramids as depicted in Figure 2. Tables 1 and 2 depict an integration of the **Policy** and **Leadership** security metrics into the EFQM's **Leadership and Policy** criteria.

4.1 NIST Pyramid for Policy Metric Set

The **Policy** metric set is representative of all the controls that measure the effectiveness of a Security Policy. They may be interlinked with each other at varying degrees and are as follows:

- **Lifecycle**- Deals with the implementation of security to any new process or even existing methodologies that have already been implemented.
- **Security Plan**- A plan should be implemented depending on the system requirements and defined roles to personnel should be allocated. The plan should be periodically assessed and should conform to an ISMS policy, such as ISO/IEC 17799.
- **Contingency Plan**- In the event of a catastrophe, a back up plan must be in place based on potential risks. Responsibilities and prescribed actions should be clearly outlined to avoid confusion and to restrict further damage.
- **Risk Management**- Risks should be eliminated or controlled to an acceptable level. The outcomes are mostly projected on an economic basis and can also be consequences that result from failing to comply with regulations. Even past experiences that have been recorded could be taken into account to provide a more comprehensive risk analysis. Also, linkages to other systems must be documented and those arising risks should be dealt with accordingly (Calder & Watkins, 2005).

Table 1. Integration of leadership metric

Enablers- Leadership				
1.1Leadership-10%(Inspire, Support, Promote)	Checklist Questions	Policy (Docs/records)	Process (actual procedure)	Tested and Improved (continual assessment)
"Visible demonstration of TQM"-Zink [30]	1.1.1 Do managers participate in regular meetings?			
	1.1.2 Do managers take initiative and train new employees?			
	1.1.3 Are they available to answer questions via email or other means?			
	1.1.4 Do they participate in training courses or make new courses available?			
	1.1.5 Do they share their knowledge that they may have learnt from training courses/conferences themselves?			
	1.1.6 Do they regularly remind and keep the security culture alive in meetings?			
	1.1.7 Are they present at all levels of meetings whether personally or by distributing memos?			
	1.1.8 Do they make use of other media such as bulletin boards, posters, letters, videos to communicate concepts?			
	1.1.9 Do they explicitly inform employees and stakeholders about the current state/level achieved in terms of security?			
	1.2.0 Do they effectively communicate the steps that need to be taken to reach the company's ideal security target or state?			
"Support of TQ through provision of appropriate resources and assistance"[30]	1.2.1Is management available when defining security issues in improvement activities?			
	1.2.2 Is there a security budget or emergency security fund?			
	1.2.3 Is there active support for moderating workshops or executing training activities?			
	1.2.4 Are resources made available for training sessions e.g. fully equipped room or releasing staff for training sessions?			
	1.2.5 Is support available for those actively taking improvement activities and suggestions taken into account?			
"Involvement with clients, external customers, external organizations" [30]	1.2.6 Are security links to other branches, divisions, conglomerates protected?			
	1.2.7 Are clients' privacy concerns ranked as a high priority and systems are in place to protect this?			
	1.2.8 Does the company software facilitate the adherence to legal and social implications?			
"Recognition and appreciation of the efforts and achievements of people"	1.2.9 Is there a system in place to provide recognition for departments or divisions that provide innovative security-related solutions?			
	1.3.0 Is there recognition and support for those teams/individuals that have effective security solutions?			
	1.3.1 Are the evaluations constructive in motivating persons to reflect on their strengths and weaknesses?			

Table 2. Integration of risk management metric

2. Enabler-Policy and Strategy	2.1.1 Is there a documented risk policy included in the security policy?
2.1 Risk Mgmt-NIST control	2.1.2 Is there current documentation available about the state of each system/entity?
	2.1.3 Are risks outlined regarding CIA principle?
	2.1.4 Are natural/manmade disasters taken into account as well as expected guidelines?
	2.1.5 Are other links to systems documented?
	2.1.6 Is there an acceptable level of risk defined and communicated throughout the organization?
2.2 "Policy based on info that is relevant and comprehensive" –{{391 Calder, Alan 2005; }}	2.2.1 Are social, political and legal scenarios covered?
	2.2.2 Do employees agree based on feedback that it is comprehensive?
	2.2.3 Compared to other best in class companies, are the security measures comparable or inferior to theirs?
	2.2.4 Is there an annual evaluation to address and update the security policy?
2.3 "How policy and strategy are developed" and " How the policy and strategy are regularly updated and improved"	2.3.1 Are the corporate goals fused with the security policy in the employee handbook?
	2.3.2 Are customer and other concerns updated in the policy as they occur?
	2.3.3 Are there regular internal and/or external assessments of the policy?
	2.3.4 Are the results incorporated into an annual strategy review and then adapted?
	2.3.5 Are less time-consuming, regular assessments done at least fortnightly?

4.2 Process Pyramid Metric Set

The **Process** metric set forms the core of the IT infrastructure and appropriate metrics that facilitate the smooth functioning of the Security

Policy is categorized here under the process-oriented view. The corresponding controls are:

- Data Integrity
- Identification and Authentication
- Incident Response Capability
- Documentation
- Access Controls
- Hardware and Software Maintenance
- Physical Security
- Personnel Security

4.3 The Leadership Pyramid Metric Set

The **Leadership** pyramid represents leadership skills that are applied in a more cutting-edge, integrative management style that is integrates best security practices. The metric set is dependent on the Policy being carefully crafted and being used in a way that is understood and engrained in those who are involved in the process. To achieve this aggressive security training and a security management program should be enforced. The metric set also evaluates how enthusiastic and supportive management is toward training sessions and if they themselves serve as reminders and enforcers of the Policy. In addition, management should make provisions to assign key roles and responsibilities to the right personnel.

The Leadership metrics measure:

- Security Training
- Security Program Management
- Authorize Processing

5. FUTURE WORK

The next stage of the project involves producing the actual quantitative security metrics that will represent the EFQM structure since the TQM relationships have been determined for the NIST metrics. The metrics will be applied to an environment that already utilizes a TQM approach in the form of a case study. We envision that a software prototype can then be built which encompasses a fusion of Security and Management principles and supports an evaluation process that encompasses both Business and Security Excellence.

6. CONCLUSION

TQM has been widely adopted because its value has been understood in supporting the corporation in its on-going efforts to satisfy its business objectives while at the same time paying attention to other non-financial aspects as well. IT Security, therefore, needs to be considered as a part of any Business Excellence effort. We presented an approach on how such an integration can be achieved by complementing an existing business excellence framework in order to maintain the competitive advantage and to be sustainable over time. In addition, the accompanying metrics to measure the effective merger of these two domains are not done in isolation since the security goals also support the business goals and therefore, can be measured in an integrated fashion.

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REFERENCES

Bacic, E. M., & Robison, A. (1993). The rationale behind the canadian criteria. 170-179.

Banker, R. D. (., Chang, H. (., Janakiraman, S. N. (., & Konstans, C. (. (2004). A balanced scorecard analysis of performance metrics. *European Journal of Operational Research, 154*(2), 423-436.

Brewer, D. (2005). Is the CC the only way? *International Common Criteria Conference,* Tokyo.

Calder, A. (2005). *A business guide to information security: How to protect your company's IT assets, reduce risks and understand the law*Kogan Page.

Calder, A., & Watkins, S. (2005). *IT governance: A manager's guide to data security and BS 7799/ISO 17799, 3rd edition* (3rd ed.) Kogan Page.

Canadian trusted computer product evaluation criteria(1993). No. Version 3)Canadian Systems Security Centre, Communications Security Establishment, Government of Canada.

Dedrick, J., Gurbaxani, V., & Kraemer, K. L. (2003). Information technology and economic performance: A critical review of the empirical evidence. *ACM Comput.Surv., 35*(1), 1-28.

Eloff, J. H. P., & Eloff, M. (2003). Information security management: A new paradigm. *SAICSIT '03: Proceedings of the 2003 Annual Research Conference of the South African Institute of Computer Scientists and Information Technologists on Enablement through Technology,* 130-136.

Erkan, K. (2005). *Evaluating IT security performance with quantifiable metrics.* Retrieved May 25, 2006, from

European Framework for Quality Management. (2003). *Introducing excellence.* Retrieved 8/26, 2006, from

Geraedts, H. P. A., Montenarie, R., & van Rijk, P. P. (2001). The benefits of total quality management. *Computerized Medical Imaging and Graphics, 25*(2), 217-220.

Gurbaxani, V., Melville, N., & Kraemer, K. (1998). Disaggregating the return on investment to IT capital. *ICIS '98: Proceedings of the International Conference on Information Systems,* Helsinki, Finland. 376-380.

Henning, R. R. (2000). Security service level agreements: Quantifiable security for the enterprise? *NSPW '99: Proceedings of the 1999 Workshop on New Security Paradigms,* Caledon Hills, Ontario, Canada. 54-60. from http://doi.acm.org.uproxy.library.dc-uoit.ca/10.1145/335169.335194

Information technology security evaluation criteria (ITSEC)(1991). No. Version 1.2)Office for Official Publications for the European Communities.

ISMS standards overview. (2006). Retrieved 06/14, 2006, from http://www.gammassl.co.uk/topics/hot1.html

Jelen, G. (2001). *SSE-CMM security metrics.*

Jorma, K., & Reijo, S. (2005). *Towards better information security management by understanding security metrics and measuring process.* Retrieved May 27, 2006, from

Martín-Castilla, J. I. (2002). Possible ethical implications in the deployment of the EFQM excellence model. *Journal of Business Ethics, 39*(1/2), 125-134.

Martinez-Lorente, A. R., Sanchez-Rodriguez, C., & Dewhurst, F. W. (2004). The effect of information technologies on TQM: An initial analysis. *International Journal of Production Economics, 89*(1), 77-93.

Mercuri, R. T. (2003). Analyzing security costs. *Communications of the ACM, 46*(6), 15-18.

Michaelsen, R. H., Michie, D., & Boulanger, A. (1985). He technology of expert sy- stems. *BYTE 10, No. 4,* , 303.

Nasierowski, W. (1997). Rethinking corporate restructuring: A comparison of the four central approaches. *Technology Analysis and Strategic Management, 9*(1), 75-84.

Perides, M. (2002). Aiming at excellence in healthcare- the european foundation for quality management excellence model. *Business Briefing: Global Healthcare,* (3), 56-59.

Saraiva, P., Rosa, M., & Orey, J. (2003). Applying an excellence model to schools. *Quality Progress,* , 46-51.

Sciarelli, S. (2002). Business quality and business ethics. *Total Quality Management, 13*(8), 1141.

Shirley, C. P. (2002). A guide to security metrics. Retrieved May 18, 2006, from

Swanson, M. (2003). *Security self-assessment guide for information technology systems* No. 800-26). USA: National Institute of Standards and Technology, US Department of Commerce.

Swanson, M., & Bartol, Nadya et al. (2003). *Security metrics guide for information technology systems* No. 800-55). USA: National Institute of Standards and Technology , US Department of Commerce.

Westlund, A. H. (2001). Measuring environmental impact on society in the EFQM system. *Total Quality Management, 12*(1), 125-135.

Practice-Oriented Implementation of Medical Guidelines

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ABSTRACT

A survey conducted to determine the information needs of physicians revealed that medical guidelines are regarded as a vital instrument of quality management. Since many physicians lack adequate guideline knowledge, we advocate a process-oriented approach towards the implementation of medical guidelines. We argue that a successful implementation requires the embedding of guideline content into medical and clinical information systems. Thereby, physicians would more likely consider guideline information since they were readily available as part of their familiar information systems. Furthermore, relevant data stored in information systems can be used to tailor the presentation of guideline content to the physicians' actual needs. Additionally, the proposed integration of guidelines within information systems facilitates a guideline-compliant medical documentation. This paper investigates and discusses various integration methods to recommend a holistic approach for the deployment of medical guidelines in clinical information systems.

1. INTRODUCTION

As quality management has become an urgent issue within the healthcare market, the demand for additional information is increasing. Subsequently, new sources of information have arisen from this need (e.g. professional journals, medical knowledge data bases, discussion forums, etc.). Physicians, who have to catch up on aspects of quality assurance and management, are facing a vast amount of information with different levels of usefulness, significance and quality. In addition to simply providing information, the challenge is to make this information available appropriately. Only then, information regarding the process of quality management will become useful and in turn be used by physicians.

During a survey we asked about 2500 German physicians about their information demands and their handling of information [1]. It turned out, that physicians are interested in medical guidelines, which are elaborated and detailed documents on quality issues. The Institute of Medicine defines guidelines as "systematically developed statements to assist practitioner and patients decisions about appropriate health care for specific clinical circumstances" [2]. Several studies [3-5] report that despite physicians regarding medical guidelines as important, they often lack adequate guideline knowledge that would enable them to improve the quality of treatment.

We conducted interviews with physicians in order to learn about their difficulties when trying to implement guidelines into their daily practice. Based on the results of our survey, on the analysis of international Web portals providing guideline information, on the examination of different solution approaches towards the implementation of guidelines and adapted from the statements of the interviewed physicians, we developed a concept and a prototype for a work-process oriented implementation of medical guidelines [6]. Although, the system meets the requirements of physicians with respect to their information needs, it is restricted to address issues of information supply and advanced training. It doesn't support, however, the documentation of a patient's treatment according to medical guidelines and it doesn't provide pro-active information supply without explicit request from the physician.

This paper reports on current approaches of computer-based implementations of medical guidelines. We stress the importance of identifying workable and effective paradigms for guideline use, before developing formal models and designing applications. This is followed by a brief introduction of our prototype of a work-process oriented application of medical guidelines. After that, we discuss several possibilities to integrate our solution within clinical information systems. Finally, we briefly expose our future work.

2. COMPUTER-BASED IMPLEMENTATION OF MEDICAL GUIDELINES

Having recognizing that physicians don't automatically familiarize themselves with written medical guidelines and apply them appropriately, the provision of guideline information at the point of care is of growing interest. Possible applications focus not only on precisely tailored information supply but also on clinical decision support and reminder functions.

A well-structured formal model is a precondition for guidelines to become machine-interpretable and to integrate them into information systems. In our review, we considered several existing approaches [7-8]. Some of them require the modelling of detailed workflows, others, e.g. the SAGE guideline model [9-10] provide decision support based on existing clinical workflows. In contrast to the other approaches, the SAGE guideline model takes infrastructural standards such as Health Level Seven's Version 3 (HL7 v3) Reference Information Model (RIM) [11] and part of the SNOMED Clinical Terms [12] into account. The Fraunhofer Institute for Applied Information Technology currently works on a similar approach that is based on the Guideline Interchange Format (GLIF) [13-14] and also supports HL7 messaging standards to communicate with the patient's record repository [15].

It will depend on the integration strategy whether a guideline model including its own workflow description or being based on existing workflows would be useful. If physicians would like to document treatment processes closely according to specific medical guidelines, a guideline model extended with control flow specifications should be chosen. Otherwise, many physicians and hospitals define their own workflows (e.g. by clinical protocols or pathways); that's why the guideline model should not control the host systems' workflow management. Therefore, the identification of settings and applications in which medical guidelines can be most helpful, least obtrusive and demanding to workflow constraints is essential for developing a guideline model. Actually, there is little agreement on the most effective applications for computer-based guidelines. Consequently, it is not clear which functional requirements, and thus what conceptual guideline models offer the most likely chances of success. This problem is reflected by the variety of modelling approaches. In [16], Wears and Berg criticize current technology-driven approaches towards advancing clinical decision support systems for not adequately addressing the needs of physicians. They claim that any solution will not be effective with respect to yielding high-quality care, if it isn't tailored to the actual users and their specific environment.

3. SOLUTION APPROACH TOWARDS THE IMPLEMENTATION OF MEDICAL GUIDELINES

Our Web-based approach towards the implementation of medical guidelines focuses on two main features. The first one helps physicians to select appropriate guidelines, whereas the second feature adjusts the content and the layout of guidelines to the current task of a physician.

1. Assistance when searching for relevant guidelines
   In response to physicians reporting difficulties in identifying the appropriate medical guideline, particularly before the exact diagnosis is known, our solution makes it possible to select guidelines regarding the patient's symptomatology. By specifying main symptoms, it is possible to confine the number of diagnoses related to indication-specific guidelines. Furthermore, physicians get an overview of the complete symptomatology that is characteristic of a specific disease according to the guideline.
2. Process-oriented supply of relevant guideline information
   Physicians use medical guidelines for different reasons: E.g. they need specific guideline information during a patient's examination or they would like to deepen their knowledge about the treatment of a particular disease. In order to meet these requirements we developed two solution alternatives to visualize guidelines:
   - Due to the fact, that physicians don't want to adapt their daily routine to medical guidelines, it is necessary, to determine the activities that are typically part of the treatment process. By this means, we developed a simple process model consisting of the activities "Anamnesis", "Diagnosis", "Make Diagnosis", and "Therapy" and adjusted structure and content of medical guidelines to these activities. Thus, it is possible to provide guideline information on a cross-guideline applicable level. Therefore, physicians can find relevant information more easily, independent of the particular guideline and without having to adapt general treatment processes. This model is intended to be used, e.g. during doctor-patient talks.
   - In order to assist physicians who would like to get known a medical guideline in more detail, we also provide an indication-specific process model. This model is not adapted to physicians' treatment processes but describes the course of treatment recommended by the medical guideline.

4. INTEGRATION OF MEDICAL GUIDELINES INTO INFORMATION SYSTEMS

Although the feedback received from primary care physicians who tested our stand-alone application has been very positive, we would have preferred our solution to be integrated within existing information systems for many reasons. Our current prototypical Web-based application offers low-level context oriented access, because only the current activity is taken into account. But there are other aspects, like e.g. the available amount of time, the physician's specialization, risk factors etc., which must be considered before it is possible to provide adequate guideline information. These context data could be made available by clinical information systems. Furthermore, our solution would be more valuable, if it's integrated in systems that physicians are accustomed to using, since they should not have to interrupt their current task to switch between different applications. Some physicians are also suspicious in terms of data protection and network security; that's why they don't like to access the internet from a computer on which patients' health records are stored. Besides, medical guidelines are supposed to gain importance as proof of quality assurance. Therefore, physicians would like to have documented evidence that patient's treatment conforms to guideline recommendations.

4.1 Objectives of Guideline Integration

Guideline integration seems to be a valuable improvement of our solution approach, because it provides the possibility of a tighter interconnection between guideline content and data stored in information systems. The objectives of guideline integration into information systems can be described as follows:

- Context-oriented information supply: Medical information systems contain data, e.g. patients' medical histories, that can be used to determine the current physician's needs in terms of guideline information. E.g., references to prophylactic measures should correspond to patients' health profiles and the comprehensiveness of the information supplied, should depend on the amount of time that a physician has available. Thus, it would be possible to regard a more extended set of context information instead of just the current activity.
- Continually education: By integrating medical guidelines into existing information systems, physicians constantly get in touch with guideline information. Such a "learning-by-doing"-strategy promotes the effective implementation of guidelines in everyday work life.
- Effective risk management: In the future, medical guidelines could gain importance in cases of legal disputes. If physicians can document patients' treatment according to guidelines, they are enabled to verify that healthcare was compliant to evidence-based medicine.
- Marketing instrument: The increasing competition in the healthcare market prompts hospitals to assure that their medical treatment meets high quality standards. Therefore, an effective integration of medical guidelines into physicians' daily practice could lead to a competitive advantage.

We identified several levels of guideline integration that differ from each other regarding the possibility of achieving the objectives mentioned above.

4.2 Web-based Information Supply

The easiest way of integrating guideline content within information systems is by providing access to Web applications resembling our prototype. The disadvantage of this approach is that the possibilities of information exchange between information system and web application are very restricted. It is possible to pass context parameters from the information system to the web-application. Thus, the guideline information that a physician is interested in, with respect to the current context, could be more precisely defined. Though, Web applications usually serve the purposes of information supply, due to data protection and limits regarding the interoperability with client systems, a comprehensive and integrated documentation of treatment processes is not possible. Furthermore, physicians have to use an additional tool; that could reduce acceptance and thus, the implementation success. Therefore, a full integration of medical guidelines requires more complex solution methods.

4.3 Assistance by Selecting Appropriate Guidelines

In order to prompt physicians to use medical guidelines, the system should indicate the existence of appropriate guideline information as soon as possible. Those hints can be made available automatically or on request. The system can identify potentially useful guidelines at two different points of time:

- The physician enters a diagnosis according to a well known classification standard, e.g. ICD-10 [17].
- The system compares the data, entered by the physician, with guideline information, e.g. typical symptoms, lab values etc. This requires the integration of comprehensive medical thesauri, e.g. SNOMED-CT [12].

Classification standards like ICD-10 are widely diffused and already integrated by most of the information systems. Therefore, it is only necessary to determine which medical guidelines correspond to which ICD-10 codes. The disadvantage of this approach is that most of the diagnostic measurements are already made. Therefore, physicians probably won't get guideline support during differential diagnostics. Furthermore, the amount of data that can be used to identify an appropriate guideline, like symptoms, risk factors, test results etc., is reduced to simple diagnosis codes. That's why this approach causes loss of data, that would be useful for purposes of information retrieval.

Standardized terminologies used for medical documentation and data exchange improve the semantic interoperability between different systems and applications. Physicians document clinical pictures and therapeutic procedures, which will be automatically enhanced with additional medical terms. Further on, these terms are used to improve the potential of information retrieval tools. Thus, the integration of medical thesauri is a promising way to identify relevant guidelines during the course of medical treatment.

4.4 Context-Oriented Information Supply

Since medical thesauri facilitate semantic interoperability, they could not only contribute to support the identification of appropriate guidelines, but also to provide guideline information regarding the context of treatment processes. As mentioned before, our prototypical Web application only considers the current activity of a physician to determine the required information. If the context of a treatment process is described by standardized medical terms in more detail, the filtering rules applied to guideline content will work more precisely.

Besides the current activity and a patient's symptomatology, there are other aspects that have an impact on what content is meaningful to be delivered. E.g. the

physicians' specialization, the available time slot, and patient information (age, sex, medication, etc.) are among these aspects.

In order to support context-oriented information supply, the parameters influencing the relevance of specific parts of guideline information must be defined. The resulting context model can be used in combination with knowledge tools, such as decision support systems. In this respect, the SAGE approach [9-10] describes a guideline model, that defines so called "context nodes". These context nodes correspond to preconditions whose fulfilment will trigger the presentation of specific guideline information, serving purposes of decision support.

4.5 Automatic Controlling of Guideline Compliance

Medical thesauri and context data could be used not only to select relevant guideline information but to implement control functions. These functions are aimed at assuring physicians that their treatment is guideline-compliant. Both, diagnostic measures and therapeutic procedures can be taken into account. The information system derives the activities, done by the physician, from the medical documentation or the underlying workflow management system. Thus, it is able to compare these activities with the recommendations of medical guidelines. Based on the results of the comparison it informs the physician about differences.

For instance, a patient is suspected of having early rheumatic arthritis. Therefore, the physician accomplishes the necessary laboratory tests and enters the resulting values into the system. Then, the activities of the physician are automatically compared with the guideline recommendations. After the data matching, it suggests to make an additional examination, e.g. the test for the rheumatoid factor is missing.

The advantage of this approach is that there is no need for changing user interfaces. Physicians can use their information systems as before. But now, they get the possibility to check if they provide healthcare according to medical guidelines. The control functions could be activated manually or automatically. In the latter case, the trigger events, e.g. the documentation of a diagnosis, that cause the execution of control functions must be specified.

The disadvantage is that the system doesn't actively support treatment processes. The compliance to the guideline is only determined after the treatment. Therefore, unnecessary examinations can't be avoided. As physicians treat patients as before and can only check the guideline compliance with hindsight, it is not possible to achieve the positive effects of a "learning-by-doing"-strategy.

4.6 Guideline-Compliant Documentation Based on Common Practices

If we succeed in making guidelines part of common documentation strategies of physicians, their implementation would be most effective. Therefore, the objective is to modify standard documentation processes as less as possible. E.g. existing documentation forms could be extended by adding a guideline information bar (see Figure 1). Physicians choose whether they use this bar or not. Since the forms don't change, the documentation process remains the same.

As illustrated in Figure 1, we integrated the bar into a documentation form for anamnestic examinations of an existing information system. By combining the bar with the functionality described in 4.3, the system presents relevant guidelines regarding the symptomatology. Additionally, the bar could contain more information, e.g. special notes with respect to drug dosages. Physicians can fill in the form as normal; after that, they can decide if they would like to access the next documentation form and proceed with the next treatment step as recommended by the guideline (by using the NEXT button). Therefore, forms must be connected to each other, according to the medical guideline. Only if the guideline describes activities that aren't covered by existing forms, new forms are necessary. Other functionalities might be included, e.g. physicians can access the relevant passage of the original medical guideline by using the INFO button.

Thus, it is possible to document the treatment process according to medical guidelines, based on common documentation practices. The advantages are, that physicians don't have to adapt their documentation strategy and suppliers of information systems don't have to adjust documentation forms completely, in order to support process-oriented guideline compliant medical documentation. But, as process orientation becomes more and more an important issue in healthcare (e.g. clinical pathways), the systems will have to support process-oriented documentation strategies anyway, in the future. However, this solution approach could contribute to smooth the transition from the current medical documentation, that mainly considers aspects of reimbursement, to a documentation strategy, that allows to follow the treatment process that led to specific medical decisions more easily. Additionally, a history function could be implemented, that stores the sequence, in which a physician filled in documentation forms. Thus, it is possible, to check the compliance of the treatment with guideline recommendations with hindsight, as described in chapter 4.5.

4.7 Process-Oriented Documentation According to Medical Guidelines

The objective of medical guidelines is to influence physicians' decisions and practices. For acceptance purposes, in 4.5 and 4.6 we described strategies that can assure a guideline-compliant treatment and documentation without fundamentally changing treatment processes. With respect to educational purposes, it should be possible to adjust treatment processes to guidelines. This requires developing a

Figure 1. Guideline information bar to support guideline compliant treatment

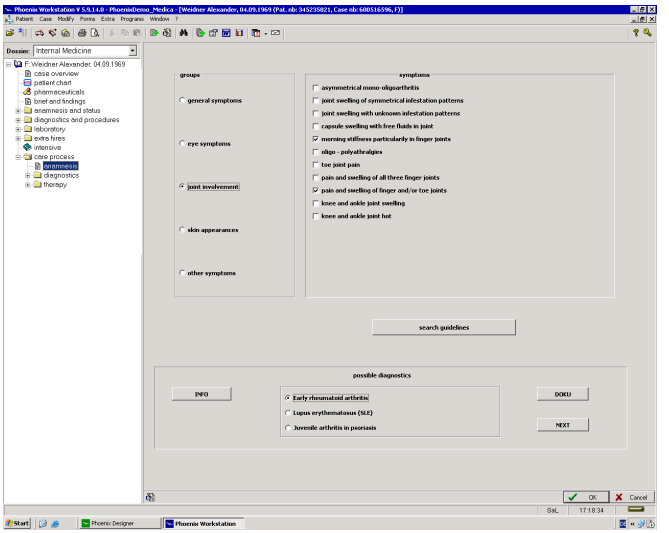
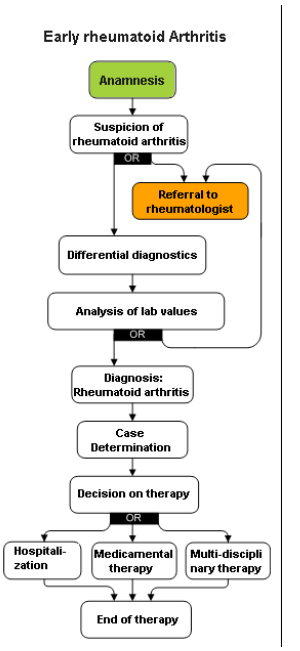


Figure 2. Process model of the medical guideline "Treatment of early rheumatic arthritis"



detailed process model of every guideline. Figure 2 shows an exemplary process model of a German medical guideline about the treatment of early rheumatic arthritis. We developed this model for our prototypical Web application.

The suppliers of information systems have to create documentation forms related to these process steps. E.g. if the physician confirms the activity "Referral to rheumatologist", the activity has to be registered as done and optionally a corresponding referral form should be issued automatically. Additionally, active decision support based on guideline information and patient's data, should be realized. If the physician confirmed the diagnosis and has to decide on therapy, the system could indicate which therapy appears to be most appropriate according to the patient's health status and medical preconditions. This requires the implementation of the functionality described in 4.4. Thus, this integration method would fulfil all the objectives mentioned in 4.1. The disadvantage of this approach is that treatment processes differ from guideline to guideline and therefore, physicians have to reconsider medical documentation depending on the current diagnosis.

5. CONCLUSIONS AND FUTURE WORK

Medical guidelines define recommended strategies for managing health care in order to improve quality, to reduce variations in practice and to help control costs. Since studies have shown that physicians lack adequate guideline knowledge, there is a growing interest in finding effective ways of integrating guidelines within information systems in order to deliver patient-specific recommendations at the point of care. Regarding the variety of formal guideline models and experiences with clinical decision support systems, it is essential to identify promising clinical settings and to determine the functional requirements in terms of practice-oriented guideline implementation.

Therefore, our fist step was a detailed analysis of the physicians' needs. After that, we developed a solution concept towards a process-oriented implementation of medical guidelines. Based on this concept, we developed approaches to directly implement guideline content into information systems. It turned out, that the full implementation of some features previously requires the implementation of other features. For example, in order to document treatment processes according to a specific guideline, first of all, the relevant guideline has to be identified. Furthermore, if systems should provide relevant guideline information in order to support physicians' decisions, it must be possible to determine the context parameters of the current treatment.

In cooperation with a number of German physicians and a commercial supplier of information systems, it is planned to develop a prototype that evaluates the integration options as described in chapter 4 with respect to a specific clinical setting. Thus, it will be possible to give recommendations on appropriate guideline modelling.

REFERENCES

[1] Koch O, Kaltenborn R, Wissensmanagement am Arbeitsplatz – Mehr Zeit für Patienten durch bessere Information, Deutsches Ärzteblatt online, www.aerzteblatt.de/aufsaetze/0506, 2005 (18-01-2006).

[2] Field MJ, Lohr KN, eds. Guidelines for Clinical Practice: From Development to Use. Washington, DC: National Academy Press, 1992.

[3] Heidrich J, Behrens T, Raspe F, Keil U, Knowledge and perception of guidelines and secondary prevention of coronary heart disease among general practitioners and internists. Results from a physician survey in Germany, European journal of cardiovascular prevention and rehabilitation, 2005 Dec;12(6):521-9.

[4] Backlund L, Skanér Y, Montgomery H, Bring J, Strender LE, The role of guidelines and the patient's life-style in GPs' management of hypercholesterolaemia, BMC Family Practice, 2004; 5: 3.

[5] Cranney M, Warren E, Barton S, Gardner K, Walley T, Why do GPs not implement evidence-based guidelines? A descriptive study, Familiy Practice 2001;18(4):353-5.

[6] Reuter C, Vollmer G, Koch O, Work Process-oriented Implementation of Medical Guidelines, Proceedings of the International Conference on Information Society (i-Society 2006)

[7] Peleg M, Tu SW, Bury J, Ciccarese P, Fox J, Greenes RA, et al. Comparing Models of Decision and Action for Guideline-Based Decision Support: a Case-Study Approach (Part 1 of 2), 2002.

[8] Wang D. Peleg M, Tu SW, Boxwala AA, Greenes RA, Patel VL, et al. Representation primitives, process models and patient data in computer-interpretable clinical practice guidelines. International Journal of Medical Informatics. 2002;68(1-3):59-70

[9] Tu SW, Campbell J, Musen MA. The SAGE guideline modelling: motivation and methodology. Stud Health Technol Inform. 2004;101:167-71.

[10] Ram P, Berg D, Tu S, Mansfield G, Ye Q, Abarbanel R, Beard N. Executing clinical practice guidelines using the SAGE execution engine. Medinfo 2004; 11(Pt 1):251-5

[11] Health Level 7, Hl 7 Reference Information Model. 2003: http://www.hl7.org/library/data-model/RIM/modelpage_non.htm

[12] Wang AY, Sable JH, Spackman KA. The SNOMED Clinical Terms development process: Refinement and analysis of content. Proc AMIA Symp. 2002; pp. 845-849

[13] Ohno-Machado L, Gennari JH, Murphy SN, Jain NL, Tu SW, Oliver DE, Pattison-Gordon E, Greenes RA, Shortliffe EH, Barnett GO. The Guideline Interchange Format: A Model for Representing Guidelines. J Am Med Inform Assoc. 1998; 5(4):357-372

[14] Peleg M, Boxwala AA, Ogunyemi O, Zeng Q, Tu SW, Lacson R, Bernstam E, Ash N, Mork P, Ohno-Machado L, Shortliffe EG, Greenes RA. GLIF3: The Evolution of a Guideline Representation Format. Proc AMIA Symp. 2000; 645-649

[15] Sedlmayr M, Rose T, Röhrig R, Meister M, Michel A, Ansatz zur Automatisierung klinischer Guidelines in GLIF mit Workflow Techniken. Proc gmds Symp. 2006

[16] Wears RL, Berg M: Computer Technology and Clinical Work – Still Waiting for Godot, JAMA. 2005; 293:1261.1263

[17] World Health Organisation (WHO), International Classification of Diseases. 2006: http://www3.who.int/icd/currentversion/fr-icd.htm

Web Science: Conceptualization of the Semantic Web

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INTRODUCTION

As the use of Web technologies has increased tremendously, the web business is getting attentions from business organizations. Originated from artificial intelligence (AI) tradition, the syllogism based Semantic Web has a great deal of hype. To introduce the semantic web, this paper is the initial effort to conceptualize the promises of the semantic web in the context of information and communication technologies. Especially, this paper emphasizes the science aspect of the semantic web, introducing theoretical approach on its meaning.

A promising and ambitious statement can be found from the inventor of Web technology and the director of W3 Consortium, Tim Berners-Lee (1998), that "One of the major obstacles to this has been the fact that most information on the Web is designed for human consumption…the Semantic Web approach instead develops languages for expressing information in a machine processable form." As we all can perceive, data on the Web is not in a processable form for any application. Thus, what the semantic web seeks is data in a reprocessable form from the the web. XML and web service have been in the same track of this idea. Even combined with XML and web services, the semantic web intends to serve more intelligently who use the web technologies.

Through the theoretical conceptualization in this paper, the merits of the semantic web are revisited in terms of web science.

THE SEMANTIC WEB

The semantic web is "a web of actionable information – information derived from data through a semantic theory for interpreting the symbols" (Shadbolt et al., 2006). The semantic theory explains "meaning" to which the logical connection of terms establishes interoperability between systems. The aim of the semantic web is to provide services based on the machine-understandable web resources so that the business integration through machine internetworking and communication is facilitated. To effectively communicate through the semantic web, there needs to be a common conceptualization, called *ontologies*. Ontology is defined as the science or study of being. In the artificial-intelligence and Web science, however, it refers to the specification of a conceptualization, which defines terms and their relationships in a formal manner (Hendler, 2001). That is, ontology in the web science is a document or file that formally defines the relations among terms including taxonomy and a set of inference rules (Berners-Lee et al., 2001).

Ontologies, the basis for the semantic web, consist of various forms of knowledge such as entity-relationship (ER) models, unifying modeling languages (UML), data warehouses, XML schemas and documents, and other metadata repositories (Frankel et al., 2004). ER diagram and UML, based on the theory of sets and relations, advocate standardization on conceptualization. On the contrary, there is no single ontology for the semantic web. The semantic web rather diversifies ontologies because of its flexibility in semantic expression.

IS VIEW OF THE SEMANTIC WEB

According to the proponents of the semantic web, the conventional web is ill suited for automated information processing due to the unavailabilty of semantics for machines to infer. Building semantics on the Web brings the meaning to the web data and its relations. Proponents of semantic web, therefore, propose "the use of markup language to annotate data with semantic labels so that machines can identify content meaning and use rules for manipulating semantic information appropriately" (Flake et al., 2003). To do this, the semantic web uses ontologies. Though there is no standard ontology elected, ontologies in the semantic web have deep and shallow structure (Shadbolt et al., 2001). Often discovered in science and engineering, deep ontologies involve building and developing conceptual specifications toclassify complex sets of properties of objects. Shallow ontologies, on the contrary, explain the basic relations in terms of geospatial information. Shallow ontologies consist of a relatively small number of unchanging terms that help organize a large amount of data. The examples include the terms like customer, account number, etc.

However, these two views of ontologies are not enough to understand all forms web business. This classification of the semantic web does not provide conceptual framework which can help to build the semantic web. Therefore, we introduce the theory of deep structure from the field of linguistics because it can append the meaning of the semantic web in information and communication aspects. This theory was pioneered by Noam Chomsky in linguistics, and was introduced in IS by Wand and Weber (1995). The theory of deep structure consists of three structures: deep, surface, and physical structures (Truex and Baskerville, 1998). Table 1 summaries the relationships between the terms of structure, definition, and meanings. In addition to this theory, we interpret three structures into core, concept, and framework (Table 1).

A core is a central and often foundational part usually distinct from the enveloping part by a difference in nature. Deep structure defines the intention of information systems to be modeled by real world systems. It implicitly means value, beliefs, and norms that are important to organization and IS. Thus, deep structure has rules that govern individual behavior and interactions. We will use the term 'core' in

Table 1. Conceptualizations of IS: Core, concept, and framework

Conceptualization	Structure	Definition	Meaning
Core	Deep Structure	Intention	Rules, Values, Beliefs, Norms
Concept	Surface Structure	Institution	Mind, Thought, Notion, Abstract
Framework	Physical Structure	Interaction	Categories, Terms, Practices

this study with the same meaning of deep structure to view IS. Second, a concept is something conceived in the mind, thought, notion, or an abstract or generic idea generalized from particular instances. Instantiation occurs from interactions between actors. In the context of IS, actors interact with IS. Thus, institutions built by actors through interactions can be formalized to concepts. The second structure, surface structure, explains this nature of concept. Surface structure can be explained as an interface between the IS and its users' organizational environments. Third, a framework is a basic conceptual structure (as of ideas) and a skeletal, openwork, or structural frame. The third structure, physical structure, belongs here. It refers to the technologies used to implement information systems. Thus, it determines the protocols that apply to the perceptions of social interaction as collectives by observers. Information system provides such categories and terms to be used in actual work places.

World Wide Web (W3) Consortium defines the semantic web as follows:

The Semantic Web provides a common framework that allows data to be shared and reused across application, enterprise, and community boundaries. It is a collaborative effort led by W3C with participation from a large number of researchers and industrial partners. It is based on the Resource Description Framework (RDF).

The core of the semantic web is well established as appeared in the W3 Consortium statement. This is a definition of semantic web in which semantics is represented in XML and Resource Description Framework (RDF) using URIs. Thus, URIs, XML, and RDF represent the deep structure of semantic web. There is less ambiguity in this structure because it is clearly defined in general terms. Framework, however, raises difficulties in a rationalization of actual data-sharing practice. It determines the physical structure of semantic web, interaction between the semantic webs in actual practice. In other words, ontologies, inferences, and logics of semantic web explain what physical structure of semantic web is about. Until now, the use of ontolgies is limited to the interested community meaning that there will be multiple ontologies of different fields of web businesses. The hardest conceptualization of semantic web is surface structure. What concepts can be drawn from semantic web? For core and framework in Table 2, it is relatively easy to picture what semantic web is and what it does. However, surface structure directly points institutions of semantic web. What institutions can we possible expect? Can different ontologies share same institutions? As we listed in Table 2, partial understanding explains the evolution of semantic web from large scale to medium scale systems while transformability applies to the situation from small scale to medium scale. Intertwingling basically pinpoints the concept of "self-organized web" (Flake et al, 2003). However, to develop the governing concept of the semantic web that describes different ontologeis in a big picture, we will envision the surface structure of semantic web more rigorously in the following section.

RECURSIVE SELF-ORGANIZING ARCHITECTURE

One of the anticipated benefits of the semantic web is that direct machine-to-machine communication can replace the human end-user interaction as with the current web applications, increasing the efficiency of systems. As the current web enables users to connect to applications, the web agent architecture enables applications to connect to other applications. The semantic web, therefore, is a key technology in enabling business models to move from B2B to more intelligent B2B.

Internet technology has evolved from a primitive information exchange to a complex information communication and even can be extended to knowledge management. Traditional client/server architecture, the backbone of the Internet technology, was mainly applied to exchange information through World Wide Web, connecting clients and servers. The Internet technology, however, has been limited to documents to documents based on hyper linkable relations. With the introduction of the semantic web, the processes of applications are combined in the self-organizing nature. The conventional web is based on the Internet as 'inter-networking'. The semantic web, however, view the Internet as 'meta-networking', where it is named as the recursive self-organizing architecture while the conventional web uses client/server architecture. The conventional client/server architecture consists of direct connections between client and server. However, the semantic web is emphasizing the logical structure using semantics, **recursive self-organizing architecture**. Recursive self-organizing architecture is a new design paradigm that explains there is no need for a direct relation between machines. Instead, a machine may establish a connection to the recursive self-organizing network. Thus, the recursive self-organizing architecture appends the collective inferences of all networks' processes, data, information, and knowledge on the semantic webs. In other words, institutions are structured in semantic web and can be hosted, as established on recursive self-organizing network. It is also recursive because of its inference engine.

As discussed earlier, the relation structure has a different meaning in the semantic web compared to the conventional web. In the conventional web, hyper links implicitly infer TCP/IP protocol that is shown to the users as logical addresses for the connection between client and server. The relation between the links is static as the link between web pages embedded in html files. In the semantic web, the relation between web pages is not explained by hyper links; rather it is abstracted as "instantiation" between machines. Not like hyper links, instantiation infer freedom of connection to any other ontologies.

Table 3 summarizes the design paradigms of the conventional web and the semantic web.

Table 2. Conceptualizations of the Semantic Web

Conceptualization	Structure	Definition	Examples
Core	Deep Structure	Intention	• URIs • XML • RDF
Concept	Surface Structure	Institution	• Partial understanding • Transformability • Intertwingling
Framework	Physical Structure	Interaction	• Ontologies • Inferences • Logic

Table 3. Design paradigms of the Web

	The Conventional Web	The Semantic Web
Logics	Inter-Networking	Meta-Networking
Relation Building Structure	Client/Server Architecture	Recursive Self-Organizing Archtecture
Information Orientation	Server-Centirc	Server-Decentric
Communication Mode	Static	Instant

Figure 1. Dynamics in enterprise integration

Structure View	Process Integration	Service Integration	Communication Integration
Relation View	Static	Dynamic	Instant

IMPLICATIONS

Back in the 1990's companies like SAP AG, Oracle, Baan, PeopleSoft and J. D. Edwards created a multi-billion dollar business with ERP technology that automated and connected what had once been disparate parts of corporations – human resources, manufacturing processes, inventory supply and financial planning. These companies rode the wave of the corporate BPR (business process re-engineering) trend that gained steam in the middle of the decade. Along the way, the ERP industry began to get saturated and view its growth struggle due to its focus on internalization. The main reasons for this were the Internet revolution and the surprising speed with which e-business began to change the way business was done, i.e., externalization of enterprise. Almost immediately, businesses have started to become Web centric.

In technical tradition, three solutions are accepted in current externalization efforts. First, process integration solutions have become commonplace in today's market, but the current vendor emphasis is on proprietary offerings, not standards. Process integration is critically important to the automation of both internal and enterprise systems, so both vendors and users will come under increasing pressure to standardize process models and protocols as relational database model became a de facto. The second important integration model is the "Web Services" framework model, promising a dynamic approach to application integration. The idea behind the autonomous distributed integration pattern is that integration can occur dynamically by combining Internet-accessible services at run-time according to a predefined pattern. Finally, an internet-based, hosted integration service is emerging as a cost-effective way for mid-market companies to participate in integration. These services join trading partners by employing integration hubs with transformation, routing and message management services. Lease/rental and per-transaction payment models provide an alternative to software purchase and enable smaller players to participate in value chains with much larger partners.

Although the integration market has been characterized by many small innovative start-ups, the essential e-business integration problem is an enterprise-level problem. Companies that started out adopting EAI technology to connect ERP systems with a few other systems, or synchronizing databases or a data warehouse, are quickly moving toward e-business solutions. E-Business infrastructures are complex, big-ticket items. Large organizations are more comfortable partnering with large vendors that can provide full solutions. IBM is considered a leader in this space, even though the components of its solution are not yet fully integrated. Other vendors making end-to-end integration include BEA, NEON (New Era of Networks), STC, TIBCO and Mercator.

To implement e-business technically means to determine how to implement in the three areas as discussed previously, integrations of processes, applications, and communications. To move this topic to the organization level, components of organizations must by re-visited and re-structured in the lights of modern IT-enabled organizations. Organizations have been collection of people with same goals and their relationships. With enterprise externalization of modern IT-enabled organizations equipped with advanced information and communications technologies, it adds one more values on integrations in processes, applications, and communications. E-business, in many cases, not just extends existing business practices but also include new perspective of how to integrate different levels of processes, services, and communications. Thus, the use of e-business imposes different roles in relations.

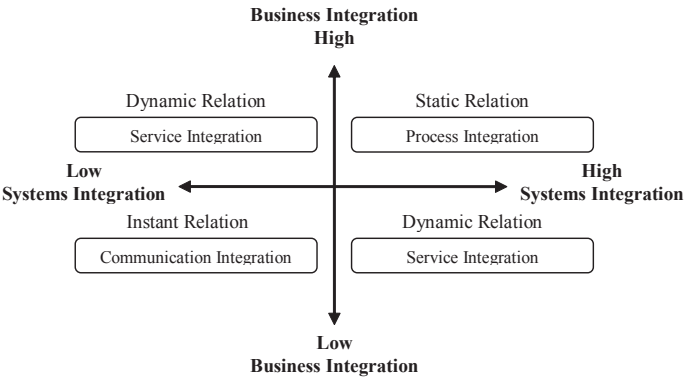
Now, it is possible that all organization contents can be stored, manipulated, and exchanged in any form of information systems. Examples are any relational database systems, ERP systems, and more recently web stores. Any part of organizational contents including business processes can be separated and digitized into information systems. Even, these systems can be related with other systems. These relationships, however, had been established only among humans. Thus, integrated processes are still static. Due to advance networking and the Internet, businesses information systems can be connected through communications networks. But, wait. What happened to the human members of organizations? In traditional settings, organizations used to be all about members and their relations. This at present is very tough to define due to the rapid changing environment but it alternately puts into two directions human roles in IT organizations. The first direction is rather negative effects on the importance of human roles. The traditional roles of humans are digitized into the IT systems. Thus, valuable assets, relations, which have an ontological meaning of members in their organizations are drastically diminished. Dramatic effects were many incidents of lay-offs in the late 1990s and early 2000s. This changes can reflected in dynamic relation in service integration structure. The second direction is now being gradually discovered in the field, establishing the new types of relations to systems instead of the ones using humans. Traditional strong cohesive bondage with other members is now shifting to information systems because organizational contents are abstracted into the systems and those can be communicated with others. This new trend builds new type of communication, communication instantiation (machine-to-machine instantiations).

Business integration in terms of processes, applications, and communications is touted to add considerable value to companies (Figure 1). In particular, recent development in e-business allows companies to enjoy the benefits of integration both by extending existing business practices and by adopting new perspective to the roles of business partners. The basic premise of the business integration through information technology is that any part of business including business processes and content can be digitized and embedded into information systems.

Figure 2 shows a graphical illustration of two different dimensions; business integration and systems integration. Business integration occurs when two parties coordinate their businesses while systems integration means the level of configuration to adjust systems. It also shows the nature of relation between systems; static, dynamic, and instant. Technically speaking, this shift has already begun from late 90's when eXtensible Markup Language (XML) gained popularity.

There are organizational impacts from business integration. Because the traditional human roles are digitized into the information systems, process integration, such

Figure 2. Business integration topology



as ERP or EAI, has been reflected in many incidents of lay-offs in the late 1990s and early 2000s. As a result, new relations built in process integration replace the traditional strong cohesive bondage between humans with the role-based modular integration. Toward service and communication integration, companies have hard time to find business implications till now. Service integration is promising but it has a drawback that it needs manual adjustment to coordinate run-time services. The proponents of the semantic web claim that communication integration can solve the problem of service integration.

CONCLUSION

The use of the Web is evolving, even it is self-evolved. Without semantic web, it is also possible to write a scenario that envisions Web algorithms which are intelligent enough to infer semantics from the current Web structure. However, it would also highly increase the complexity of Web business, making business integration heterogeneous. As shown in the enterprise externalization, communication instantiation movement shares the same idea, machine-to-machine instantiation, by the recursive self-organizing architecture. In other words, semantic web has strong business implications. For future study, the semantic web conceptual model we developed here can be mapped to the physical model, discussing recursive self-organizing architecture.

Web science is described as "a science that seeks to develop, deploy, and understand distributed information systems, systems of humans and machines, operating on a global scale" (Shadbolt et al., 2006). This paper discusses the conceptualization, dynamics, and topology of the semantic web in web business. This is an initial step to analyze the essence of practical technologies using the lens of science in business context.

REFERENCES

Berners-Lee, T. (1998). Semantic web road map. http://www.w3.org/DesignIssues/Semantic.html.

Berners-Lee, T., Hendler, J., and Lassila, O. (2001). The Semantic Web. Scientific America.com, May 17.

Flake, G. W., Pennock, D. M., and Fain, D. C. (2003). The self-organized web: the Yin to the semantic web's Yang. IEEE Intelligent Systems, July/Aug, pp. 72-86.

Frankel, D., Hayes, P., Kendall, E., and McGuinness, D. (2004) The model driven semantic web. 1st International Workshop on the Model-Driven Semantic Web (MDSW 2004), http://www.sandsoft.com/edoc2004/FHKM-MDSWOverview.pdf#search=%22semantic%20web%20paper%22

Glaser, B. G. and Strauss, A. L. The discovery of grounded theory: strategies for qualitative research, New York: Aldine Publishing Company, 1967.

Hendler, J. (2001). Agents and the semantic web. IEEE Intelligent Systems Journal, March/April.

Shadbolt, N., Hall, W., and Berners-Lee, T. (2006). The semantic web revisited. IEEE Intelligent Systems Journal, May/June.

Truex, D. P., and Baskerville, R. (1998). "Deep structure or emergence theory: contrasting theoretical foundations for information systems development", Information Systems Journal, 8, pp. 99-118.

Wand, Y. and Weber, R. (1995). "On the deep structure of information systems", Information Systems Journal, 5, 3, pp. 203-223.

CIO's Perspectives of Critical Issues in ERP Upgrade

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INTRODUCTION

Enterprise systems have spread rapidly among organizations. According to AMR research (2005), ERP market size was $47.88 Billion in 2004. Although ERP systems offer a great deal, implementation success is far from assured. Statistics show that more than 70% of ERP implementations fail to achieve their corporate goals (Standish Group, 2004) and the number of horror stories about failed or out-of-control projects is growing (Olson, 2004). To deeply understand ERP systems, many researchers are working on this topic and hundreds of ERP research was published in last eight years. However, recent review (Botta-Genoulaz et al., 2005) suggests that most existing ERP research focuses on selection and implementation, not on ERP's post-implementation impacts.

Selection and implementation are critical areas, and numerous valuable insights have been studied by many researchers (Quiescenti, et al., 2006; and Wang, et al., 2006). According to Staehr et al. (2002), the ultimate impacts of ERP on the organization – once the system has been implemented and has been "shaken down" – are not as thoroughly researched. Therefore, understanding post-implementation of ERP will help organizations succeed longer after the ERP implementation. ERP upgrade is one of the major activities in the post-implementation stage of ERP implementation (Nah et al. 2001). Every three years, a major ERP upgrade and several small upgrades are typically needed to keep the system running smoothly. Organizations will spend a significant amount of money on each ERP upgrade project. Without comprehensive understanding of ERP upgrade concepts in the organizational environment may lead to terrible nightmares, and even result in irretrievable disaster. Therefore, the aim of this research focuses on what factors are associated with ERP upgrade success.

There are several reasons why this study is important. First, each ERP upgrade project costs a significant amount of money. For example, a Midwest university spent over $2 million on a recent ERP upgrade project. While the initial ERP implementation happens only once, ERP upgrades will happen many times after the first ERP implementation (probably once every three years). Therefore, the cost of ERP upgrade is continuous along with the usage of the ERP system in the organization.

Second, according to our literature review through over forty IS top journals in last decade, relatively little research attention has been given to ERP software upgrade. One possible reason could be that upgrade is perceived a smaller project (compared to first time ERP implementation), and another reason could be that little theory has been developed regarding the topic of ERP upgrade. However, ERP upgrade is one of the important activities in the ERP software lifecycle, and an effective and efficient implementation of ERP upgrade has a tremendous impact on an organization's continuous business process improvement.

Third, little progress has been made in identifying relative importance of success factors in each ERP upgrade stage. Understanding the relative importance of success factors in each stage can help IT managers emphasize on dominant issues during the ERP upgrade projects. Especially when there are needs to make decisions about trade-offs among different upgrade activities, IT managers can focus on the most important factors other than less important factors in each upgrade stage.

ERP UPGRADE

ERP upgrades are mainly intended to take advantage of new technologies and business strategies to ensure that the organization keeps up with the latest business development trends. Therefore, the decision to upgrade ERP is usually not driven by code deterioration or anticipated reduction in maintenance costs alone, but by different purposes. According to an AMR study (Swanton, 2004), 55% of upgrades were voluntary business improvements triggered by the need for new functionality, expansion or consolidation of systems; 24% of upgrades were triggered by technology stack changes; 15% of upgrades were forced by de-support of the running version of software to avoid vendor support termination (Craig, 1999); and 6% of upgrades were triggered by bug fixes or statutory changes.

The cost of ERP upgrades is high (Montgomery, 2004). Swanton (2004) mentioned that the cost of each upgrade includes: 50% of the original software license fee and 20% of the original implementation cost per user, which means over 6 million dollars for a 5,000-user system. Typically, each ERP upgrade requires eight to nine months of effort with a team the equivalent of one full-time employee per 35 business users. The ERP-adopting organization does not have to develop and re-write the ERP system itself but rather it replaces (or upgrades) the old version with a readily available new version from the ERP vendor. However, a lack of experience may cause the costs and length of the upgrade project to approach or even exceed those of the original ERP implementation effort. Collins (1999) listed some general benefits for organizations from ERP upgrades:

- Eligibility for Help Desk Support: Most of ERP software vendors stop providing technical support 12 to 18 months after the next version becomes available. Therefore, keeping upgrade with the pace of ERP vendors will guarantee the support for the system from the vendors.
- Solutions for Outstanding "Bugs" or Design Weaknesses: It is impossible to guarantee spotless and error-free ERP systems after the implementations even though vendors will conduct many different testing processes to eliminate the happenings of errors in the system before the leasing time. "The majority of software bugs are resolved and delivered either fix-by-fix, or all-at-once as part of the next release version of the ERP package." In this case, upgrades will be beneficial to the organizations in problem solving.
- New, Expanded, or Improved Features: ERP software provides organizations with the knowledge and strength (i.e. best practices) from the vendors. ERP upgrades provide organizations future enhancement from the vendors to give the organizations better opportunities to catch up the current business development, improve their processes and build more efficient business models with new functions, new features and new processing styles provided in the upgraded ERP versions.

This study seeks to provide a comprehensive understanding of ERP upgrade by interviewing CIOs in different organizations according to their experiences from their organizations' ERP upgrade projects.

METHOD AND ANALYSIS

This study uses an in-depth semi-structured interview technique to examine the success factors in ERP upgrade. This method allows a more spontaneous, informal and broader examination into the specific experiences of the interviewees in relation to the topic, which can be useful in identifying factors of influence that previously have not been examined (Taylor and Bogdan, 1984).

To ensure better results, we used only those companies who reported that their organization's ERP upgrade was completed the previous year or this year. By excluding organizations who completed ERP upgrade over two years, 15 CIOs were interviewed. A wide variety of industries were represented in the responses. Characteristics of the organizations are shown in Table 1. The purpose of this study is to gain an initial understanding of key factors in ERP upgrades.

Semi-structured interviews were audio-taped and later transcribed verbatim in preparation for analysis. In analyzing the data, Miles and Huberman's (1994)

Table 1. Sample demographics

Organization	Industry Sector	Annual Gross Revenue	Number of employees	ERP Vendor
A	Industrial Manufacturing	9 Billion	60,000	JD Edwards
B	Public Sector	1 Billion	3,000	JD Edwards
C	Consumer Products	3 Billion	6,500	Oracle
D	High Technology	1.1 Billion	2,000	Oracle
E	Agriculture	100 Million	200	Oracle
F	Education	500 Million	6,000	PeopleSoft
G	Healthcare	850 Million	6,000	PeopleSoft
H	Education	800 Million	11,000	SAP
I	Industrial Manufacturing	2.6 Billion	24,400	SAP
J	Industrial Manufacturing	19 Billion	84,000	SAP
K	High Technology	200 Million	200	SAP
L	Utilities	200 Million	1,100	SAP
M	Bank	1 Billion	86,000	SAP
N	Distillery	2.7 Billion	3,400	SAP
O	Industrial Manufacturing	100 Million	100	Syspro

method was followed. That is, two researchers coded data independently. In the first phase, each coder read the transcripts to identify the key factors using qualitative classification. In the second phase, subcategories were identified to further the understanding of the layers of factors within each category. In the last phase, each factor was weighed by counting the number of respondents who provided the same or similar answers or emphasized similar themes.

Several strategies were used to ensure the reliability and validity of the analyses. The use of two independent coders ensured convergence in interpretation. Member checks as proposed by Maxwell (1996) were used by sending research findings to all participants. All of the participants concurred with the interpretation of the data gathered from their own interview.

RESULTS

Eight themes emerged from the coding and analysis of the qualitative interview data: Business vision, communications, consultants, customization, project management, top management support, training and education, and user involvement.

Business Vision

It is important that the organization has a clear sense of whom and what it is before implementing an ERP project (Cotteleer & Bendoly, 2006). Business vision concerns project goals clarification and their congruence with the organizational mission, business objectives and management expectations of the IT project. All the CIOs believe that "ERP upgrade should have a clearly defined business vision/mission to serve as a blueprint for organizations' success." It is a common knowledge that the first phase of an IT project starts with a conceptualization of goals (Mandal & Gunasekaran, 2003). Further more, the CIO from organization A mentioned that "careful deliberation of success measurement as well as management of expectation by the project manager of IT projects is important factor influencing the success of the project."

ERP projects could suffer a huge disaster without a clear business direction (Cotteleer & Bendoly, 2006). This can be approved by past ERP project failures resulted by inadequately defined business visions (Ehie & Madsen, 2005). A clear business vision remains important through all stages of the implementation life cycle (Loh & Koh, 2004). The vision should provide a direction and general objective, and no details are required (Al-Mudimigh et al. 2001).

Communication

One major purpose of communication is to inform every level in the organization about the expectations or goals of the change (Huang et al., 2004). Communication involves messages about why change was needed, what the "to be" environment will look like, and what will happen if change does not occur. All the CIOs described positive perspectives about communications. The CIO from organization F emphasized that "Building a complete and convenient communication system for employees was found to be the best way to avoid various communication failures in the organization." Researchers have identified communication as a critical success factor influencing organizational projects (Holsapple & Sena, 2005). Poor communication among reengineering team members and outside organizational members could cause a failure result of project implementations (Belout & Gauvreau, 2004).

Communication should not occur only within a small group of project team members. Frequent interlocking discussions between different functional teams should also be scheduled (Tsai et al., 2005). Given an example, the CIO from organization J mentioned that "We offered employees a good e-mail system, and also created many telephone and face-to-face opportunities for all employees to gain information about ERP changes. So users can share and exchange their education, knowledge, and information quickly and conveniently."

Consultants

Due to the complexities of ERP projects, most organizations will hire consultants. Consultants may have experience in specific industries, comprehensive knowledge about certain ERP packages or modules, and may be able to help organizations make best decisions in different situation during the implementation of ERP projects (Ehie & Madsen, 2005).

Most of the CIOs mentioned that the cost of hiring consultants can consume more than 30 percent of the overall budget for their ERP upgrade projects. The CIO from organization B displayed a positive perspective on consultants, "I think the success of an ERP upgrade project depends on the capabilities of consultants based on their knowledge of the ERP system. We delayed our upgrade project for 4 months because of the consultants. We replaced our consults three times and that's a nightmare for us during the ERP upgrade." Therefore, organizations should manage and monitor it very carefully by determining the number, how and where to use external consultants appropriate to the ERP projects needs (Botta-Genoulaz et al., 2005).

Customization

Even with today's state of the art technology, organizations find that not all their requirements are provided by the ERP systems they adopt. One of the major challenge an adopting organization faces while configuring an ERP system is that software does not fit all their demands (Kumar et al., 2003).

In ERP projects, customization includes two types of activities: configuration and modification. Configuration is a customization that organizations make decisions on all the functional choices designed by ERP vendors in the ERP packages. Modification is a customization that organizations try to modify the ERP vendors' code to build new functions in the ERP packages.

Since customizations are usually associated with increased information systems costs, longer implementation time, and the inability to benefit from vendor software maintenance and upgrades (Loh & Koh, 2004), customization should only be requested when essential or when the competitive advantage derived from using non-standard processing can be clearly demonstrated (Light, 2005). The CIO from organization C declared that "Organizations should try to adopt the processes and options built into the ERP, rather than seek to modify the ERP to fit the particular business practices."

Project Management

Project management is a key to the success of any large project (Kumar et al., 2003). 15 CIOs mentioned project management 37 times during the interviews. Proper management of scope is critical to avoid schedule delays and cost overruns (Tsai et al., 2005).

The vast combination of hardware and software and the myriad of organizational, human and political issues make many ERP projects huge and inherently complex, requiring new project management skills (Ryan, 1999). According to the CIO from organization D, "a better project management can ensure a better upgrade plan and lead you to the right direction in the next couples of months during the upgrade. One of the reasons we delayed our ERP upgrade for two and half months and spent a half more millions dollars is because we underestimated the importance of project management."

Top Management Support

The commitment of top management to the diffusion of innovations throughout an organization has been well documented (Mabert et al., 2003). In particular, early in a project's life, no single factor is as predictive of its success as the support of top management (Sun et al., 2005). The support of the top management will help focus efforts toward the realization of organizational benefits and lend credibility to functional managers responsible for its implementation and use (Tsai et al., 2005).

All the CIOs emphasized that top management support is critical. The CIO from organization H stated that "it empowered IT team to be flexible in upgrading." Research on project failures also shows that project cancellations occur when senior management delegates progress monitoring and decisions at critical junctures of the project to technical experts (Tchokogue et al., 2005).

Training & Education

The lack of user training and education has been one of the significant determinants of many ERP systems failure (Gupta, 2000). End users will become frustrated and refuse to use the system if they do not know exactly what happens in the processes (Tsai et al., 2005). To describe the problems his team faced during the ERP upgrade, the CIO from organization M mentioned that "training was a problem. It was a logistic problem in terms of getting enough classroom space and balancing the number of instructors and classroom space versus when we were going to take the system live. Some of the earlier classes had empty seats and some of the late classes had demand that exceeded our capacity. In a perfect world we would have had more training, especially when we went live, or perhaps even try to break up the go live."

ERP implementation requires a critical mass of knowledge to enable people to solve problems within the framework of the system. If the employees do not understand how a system works, they will invent their own processes using those parts of the system they are able to manipulate (Al-Mashari et al., 2003; Mabert et al., 2003; Dowlatshahi, 2005).

User Involvement

User involvement refers to participation in the system development and implementation processes by representatives of the target user groups. System implementation represents a threat to users' perceptions of control over their work and a period of transition during which users must cope with differences between old and new work systems (Wu & Wang, 2006). According to the CIO from organization I, "user involvement is effective because it restores or enhances perceived control trough participating the whole project plan. The organization should have an implementation process that strives for a high level of user acceptance early on through the use of constant presumptive end user consultations."

CONCLUSIONS

ERP upgrade projects have grown in importance, as vendors are seeking to generate revenue through improved systems. The reticence of vendors to support old systems was noted by multiple organizations in this study. (The value of improved functionality was also noted.) Upgrade projects seem to be much more controllable than initial ERP installation projects. This should be expected due to the experience organizations gain with their original systems.

This study aims to improve understanding of ERP upgrade. 15 CIOs from a wide variety of industries were interviewed. Qualitative data were analyzed and themes were developed from the data. In essence, the paper recognizes a series of critical issues that must be carefully considered to ensure successful implementation of an ERP upgrade project. These factors, business vision, communication, customization, external support, project management, top management support, training and education, and user involvement, are teamed together to build a complete picture of ERP upgrade. This picture makes a worthwhile contribution since it has clearly identified factors that are influencing ERP upgrade and gives important implications to those CIOs and IT manager who are implementing or will implement ERP upgrade projects. With knowledge of these eight factors, CIOs and IT managers can avoid underestimating or overestimating some factors during their ERP upgrade.

Further more, adhering to the various levels of application of ERP systems will ensure that organizations can derive maximum benefits from ERP systems after upgrading, and that the decision-making process and the flow of information happen in a seamless, corporate-wide perspective.

Since this research is a qualitative study, it is recommended that future studies apply quantitative methods to evaluate the results from this study.

REFERENCES

Al-Mashari, M., Al-Mudimigh, A. & Zairi, M. (2003). Enterprise resource planning: a taxonomy of critical factors, *European journal of operational research*, 146, 352-364.

Al-Mudimigh, A., Zairi, M. & Al-Mashari, M. (2001). ERP software implementation: an integrative framework, *European Journal of Information Systems*, 10, 216-226.

AMR (2005). AMR report, available at: www.amrresearch.com.

Belout, A. & Gauvreau, C. (2004). Factors influencing project success: the impact of human resource management, *International Journal of Project Management*, 22, 1-11.

Botta-Genoulaz V., Millet P.-A. and Grabot B. (2005) A survey on the recent research literature
on ERP systems. Computers in Industry (56) pp. 510-522

Collins, K. (1999). Strategy and execution of ERP upgrades, *Government Finance Review*, 15(4), 43-47.

Cotteleer, M. & Bendoly, E. (2006). Order lead-time improvement following enterprise information technology implementation: an empirical study, MIS Quarterly, 30(3), 643-660.

Craig, R., (1999). Laurier enterprise system upgrade, *International Conference of Information Systems*, Charlotte, USA.

Dowlatshahi, S. (2005). Strategic success factors in enterprise resource planning design and implementation: a case study approach, *International Journal of Production Research*, 43(18), 3745-3771

Ehie, I. & Madsen, M. (2005). Identifying critical issues in enterprise resource planning (ERP) implementation, *Computers in Industry*, 56, 545-557.

Gupta, A. (2000). Enterprise resource planning: the emerging organizational value systems, *Industrial Management & Data Systems*, 100(3), 114-118.

Holsapple, C. & Sena, M. (2005). ERP plans and decision-support benefits, *Decision Support Systems*, 38, 575-590.

Huang, S., Chen, H., Hung, Y. & Ku, C. (2004). Transplanting the best practice for implementation of an ERP system: a structured inductive study of an international company, *Journal of Computer Information Systems*, Summer, 101-110.

Kumar, V., Maheshwari, B. & Kumar, U. (2003). An investigation of critical management issues in ERP implementation: empirical evidence from Canadian organizations, *Technovation*, 23, 793-807.

Light, B. (2005). Going beyond 'misfit' as a reason for ERP package customization, *Computers in Industry*, 56, 609-619.

Loh, T. & Koh, S. (2004). Critical elements for a successful enterprise resource planning implementation in small and medium-sized enterprises, *International Journal of Production Research*, 42(17), 3433-3455.

Mabert, V., Soni, A. & Venkataramanan, M. (2003). The impact of organization size on enterprise resource planning (ERP) implementations in the US manufacturing sector, *Omega*, 31(3), 235-246.

Mandal, P. & Gunasekaran, A. (2003). Issues in implementing ERP: A case study, *European Journal of Operational Research,* 146, 274-283.

Maxwell, J. (1996) *Qualitative Research Design: An Interactive Approach*, Thousand Oaks, CA: Sage.

Miles, R. and Huberman, A. (1994). *Qualitative Data Analysis*, Beverly Hills, CA: Sage.

Montgomery, N. (2004). Build your business case for upgrades by adding functionality, *Computer Weekly*, 2/10/2004, 16-16.

Nah, F., Faja, S., & Cata, T. (2001). Characteristics of ERP software maintenance: a multiple case study, *Journal of Software Maintenance and Evolution: Research and Practice*, 13, 399-414.

Olson, D. (2004). *Managerial Issues of Enterprise Resource Planning Systems.* New York: McGraw-Hill Companies.

Quiescenti, M., Bruccoleri, M., La Commare, U., Noto La Diega, S. & Perrone, G. (2006). Business process-oriented design of Enterprise Resource Planning (ERP) systems for small and medium enterprises, *International Journal of Production Research*, 44(18/19), 3797-3811.

Ryan, H. (1999). Managing development in the era of large complex systems, *Information Systems Management*, 16(2), 89-91.

Staehr, L., Shanks, G., and Seddon, P. (2002) Understanding the Business Benefits of Enterprise Resource Planning Systems, in Proceedings of the 8th Americas Conference on Information Systems, R. Ramsower and J. Windsor (Eds.), Dallas, TX, 899-905.

Standish Group. (2004). Third Quarter Research Report. Available at: http://www.standishgroup.com/index.php, accessed May 2005.

Sun, A., Yazdani, A. & Overend, J. (2005). Achievement assessment for enterprise resource planning (ERP) system implementations based on critical success factors (CSFs), *International Journal of Production Economics*, 98, 189-203.

Swanton, B. (2004). Build ERP upgrade costs into the business change program – not the IT budget, *Computer Weekly*, 9/21/2004, 28-28.

Taylor, S. and Bogdan, R. (1984) *Introduction to Qualitative Research Methods*, New York: John Wiley and Sons.

Tchokogue, A., Bareil, C. & Duguay, C. (2005). Key lessons from the implementation of an ERP at Pratt & Whitney Canada, *International Journal of Production Economics*, 95(2), 151-163.

Tsai, W., Chien, S., Hsu, P. & Leu, J. (2005). Identification of critical failure factors in the implementation of enterprise resource planning (ERP) system in Taiwan's industries, *International Journal of Management and Enterprise Development*, 2(2), 219-239.

Wang, E., Klein, G. & Jiang, J. (2006). ERP Misfit: country of origin and organizational factors, *Journal of Management Information Systems*, 23(1), 263-292.

Wu, J. & Wang, Y. (2006). Measuring ERP success: the ultimate users' view, International Journal of Operations & Production Management, 26(8), 882-903.

The Impact of Transactional E-Commerce on CPAs' Perception of Audit Risk: Preliminary Results

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ABSTRACT

In this paper, we report results from a preliminary study designed to understand 1) the level, if any, at which transactional e-commerce systems are viewed as sufficiently substantive to have a material impact on audit risk, and 2) how the presence of a material transactional e-commerce system impacts auditors' perceptions of audit risk. The results provide motivation for a more extensive and detailed study that investigates how a material e-commerce presence impacts the individual components of audit risk specified in SAS 55 (AICPA, 1988).

INTRODUCTION

It is well understood that the development of computerized information systems has long spawned challenges for accounting professionals charged with auditing financial statements. In particular, numerous authors and texts have discussed the problem of "auditing around the computer." The problem, in essence, occurs when information systems are either sufficiently complex or opaque as to render it impossible for auditors to efficiently and effectively conduct an audit. In these situations, there may be an increase in audit risk.

Audit risk is the risk that the auditor will fail to detect one or more material errors in the financial statements. Audit risk is espoused to have thee components: Inherent Risk, Control Risk, and Detection Risk. The basic audit risk model framed in *Statement on Auditing Standards 55* (SAS 55) is as follows:

Audit Risk = Inherent Risk * Control Risk * Detection Risk

Inherent Risk is the risk that an assertion made in a financial statement contains a material misstatement, assuming the absence of controls that might detect the misstatement. Inherent risk varies by financial statement assertion, type of business, and complexity of the business environment. *Control Risk* is the likelihood that controls established by a business fail to prevent, detect, and correct a misstatement. Inherent and control risk are assessed by the auditor, but are not directly under their control (although the auditor might make recommendations that will influence future levels of control risk). *Detection Risk* is the risk that an auditor fails to detect a material misstatement in the financial statements that has evaded detection by internal controls. Detection risk is controllable by the auditor and is a function of nature, timing, and extent of audit procedures applied.

As information technology has become more complex and ubiquitous, the challenge facing auditors has grown correspondingly. The accounting profession has responded with more guidance to auditors (embedded in professional standards), automated auditing software, better educated and more technically savvy audit professionals, and the use of information technology specialist on audit teams. However, despite the responsiveness of the accounting profession, the exponential growth in the scope and sophistication of new information systems technologies threatens to outpace and overwhelm the responses of the auditing profession, almost like a fire that is growing faster than firefighters can extinguish it.

While the information technology (IT) environment continues to challenge auditors' ability to effectively and efficiently test information systems controls or verify the integrity of transactions, recent changes in regulations and professional standards, most notably the Sarbanes-Oxley act of 2002 (henceforth SOX) (SEC, 2002) and SAS 94 (AICPA, 2001), compel auditors to be more aggressive, thorough, and efficient in this regard. The overarching consequence of SAS 94 and SOX is that managers and auditors can no longer simply assess control risk at its maximum level and assert that the effectiveness of IT controls can not be assessed. They are now compelled to develop a detailed understanding of the controls and the associated control risk.

Specifically, section 404 of the Sarbanes-Oxley act (SOX) requires the senior management of publicly traded companies to establish and maintain adequate internal controls for financial reporting as well as annually assess the effectiveness of said controls. The law also establishes attestation requirements auditors to assess management's certification of the effectiveness of its internal controls over financial reporting. Section 404 went into effect in November 2004; see Geiger and Taylor (2003) for a review of section 404.

SAS 94, *The Effect of Information Technology on the Auditor's Consideration of Internal Control in a Financial Statement Audit* requires the auditor to test the automated IT controls embedded in computer programs by using computer-assisted audit techniques. Auditors are obliged to respond in this fashion when the IT environment is complex and it is not practical to reduce detection risk to acceptable levels through the use of substantive tests alone. Further, SAS 94 requires tests of both the design and operation of controls in order to reduce the assessed level of control risk. While SAS 94 focuses on the control risk component of audit risk, threats to inherent risk are implied as well. SAS 94 identifies various IT-related threats that render certain asset classes inherently more risky. These include reliance on systems that incorrectly process data, the processing of inaccurate data, unauthorized access to data, destruction or modification of data resulting from unauthorized access, recording of unauthorized or nonexistent transactions, unauthorized changes to systems and programs, and unauthorized manual intervention. A number of authors have discussed the correlation between control and inherent risk; see for example Cushings and Loebbeck (1983) and Waller (1993).

The issues addressed in SAS 94 are not entirely new to auditors, as SAS 94 amends on guidance provided earlier in other professional standards, including SAS 47 (Audit Risk and Materiality), SAS 55 (Internal Control in a Financial Statement Audit), SAS 73 (Using the Work of a Specialist) SAS 78 (Internal Control: An Amendment to SAS 55), SAS 80 (Electronic Evidence). SAS 94 does not, however, change the basic audit risk model described above and specified in SAS 55.

RESEARCH QUESTIONS AND FOCUS

SAS 94 and SOX both compel auditors to pursue enhanced vigilance in the face of existing and emerging IT environments. Two general questions for researchers are:

1. To what degree, if any, do auditors perceive that various IT environments and technologies change audit risk and, therefore, audit practice?
2. At what scope of adoption do various IT environments become a material concern in the assessment of audit risk?

While these questions can be asked for many of the exciting IT technologies embraced by business in recent years, our focus in this paper will be transactional e-commerce. We define transactional e-commerce as *the process of conducting*

transactions, including buying, selling, purchasing, and payment using the internet or other computer networks connecting two or more organizations. Transactional e-commerce (TEC) has had a profound impact on business practice and the degree to which TEC has become ubiquitous suggests that its impact on audit risk is relevant to many in the audit profession. Further, transactions are perhaps the most fundamental inputs to the financial reporting process and are therefore key to the consideration of how technology impacts audit risk.

A priori, it is difficult to predict how a material transactional e-commerce presence impacts audit risk. Traditionally, transactional e-commerce has taken the form of highly structured electronic data interchange (EDI) transactions supported (and recorded) by a third party value added network (VAN) using dedicated, private, and secure communications links. EDI has evolved into a highly structured and mature technology, benefiting from international standards such as EDIFACT and ANSI X12 (see, for example, OECD, 1995). It can be argued, for example, that traditional EDI systems lend themselves to perpetual auditing approaches and would therefore result in a corresponding reduction in audit risk; see, for example, Helms (2002) and Write (2002). Because there are substantial costs involved, EDI has been adopted primarily by large organizations that often have highly trained IT staff and internal audit staff, also suggesting reduced audit risk.

Compared to traditional EDI, web-based TEC is much less mature as a technology and much less standardized. Consider, for example, that web-based TEC has grown from virtually zero in 1995, in terms of number of companies impacted and volume of sales, to billions of dollars in sales and thousands of companies involved. Traditional EDI is rapidly being replaced or augmented by internet-based solutions that are often less secure, standardized, and robust in their designs than traditional EDI implementations. Adopters of web-based transactional e-commerce include smaller firms with more modest IT and internal audit staffs. In this new environment, we might expect audit risk to increase.

Consider also that e-commerce technologies have facilitated accelerated fracturing of the business value chain. As companies outsource nearly everything except their core competencies, it becomes more and more difficult for auditors to confirm the existence of management and software application controls; it is not unusual for those controls to reside with other companies. As paper trails, legacy systems, and programming staff are replaced with vendor-based and outsourced IT solutions, institutional knowledge of the details underlying software controls becomes increasingly scarce. See Pathak and Lind (2003) for a good discussion of possible ways that IT might impact audit risk.

This paper represents the initial stages of inquiry regarding the relationship between a transactional e-commerce presence and audit risk. Our long-term goal is to develop a detailed understanding of whether changes in perceived overall audit risk, related to the IT environment, are directly related to changes in the auditor's perception of inherent, control, and detection risk as suggested by the SAS 55 audit risk model. However, we first begin by determining whether audit professionals can even respond to questions concerning the impact that transactional e-commerce has on audit risk. As such, our immediate goal in this study is to explore the following questions:

1. From an auditor's point of view, what is a material e-commerce presence? That is, at what point does a transactional e-commerce presence become enough of an issue as to impact perception of audit risk and, therefore, the conduct of an audit?
2. How does a material e-commerce presence impact audit risk and, consequently, audit costs?
3. Are the components of audit risk (inherent, control, and detection risk) impacted by a material e-commerce presence?
4. Does the amount of experience of the auditor, in the e-commerce environment, impact perceptions of changes in audit risk?

While some, most notably Pathak and Lind (2003), have discussed the relationship between audit risk, audit practice, and IT, we are unaware of any research that seeks to solicit the perception of auditors on these issues.

SURVEY INSTRUMENT AND RESULTS

This inquiry is based on analysis of responses of fifty CPAs who agreed to complete a brief survey. The fifty participants, identified from the American Institute of Certified Public Accountants (AICPA) database, worked for large firms and indicated auditing as an area of interest. We hoped to identify individuals who had experience auditing in a TEC environment as well as individuals who had little or no experience, in order to understand how perceptions between the two groups differed.

Prior to administration of the survey to the target population, a pilot survey was administered to 12 local CPAs for the purpose of investigating clarity in the wording of survey instructions and questions. Survey questions are prefaced by instructions, to participants, that include a brief description of the audit risk model and the definitions of inherent, control, and detection risk. A definition of the phrase *transactional e-commerce* is also provided.

Results - Question 1: What is a material transactional e-commerce presence? Participants were asked to define a material transactional e-commerce presence in terms of percent of total sales and percent of total purchases. Results appear in Exhibit 1.

Exhibit 1. Material transactional e-commerce presence defined in terms of sales and purchases

A material transactional e-commerce presence is defined as….			
Sales		**Purchases**	
Response	**% of Respondents**	**Response**	**% of Respondents**
Sales exceed 10%	34%	Purchases Exceed 10%	24%
Sales exceed 20%	52%	Purchases Exceed 20%	70%
Sales Exceed 30%	14%	Purchases Exceed 30%	6%
More than 40%	0%	More than 40%	0%

Exhibit 2. Impact of material transactional e-commerce on audit risk and costs

A material transactional e-commerce presence results in….		
Response	**Impact on Audit Risk**	**Impact on Audit Cost**
Increases significantly	46%	22%
Increases, but not significantly	54%	62%
Does not increase/decrease	0%	16%
Decreases, but not significantly	0%	0%
Decreases significantly	0	0

Exhibit 3. Impact of material transactional e-commerce on audit risk components

What is the impact of a material e-commerce presence on…			
	Inherent Risk	Control Risk	Detection Risk
Significant Decrease	0%	0%	0%
Moderate Decrease	0%	4%	0%
No Meaningful Impact	12%	22%	14%
Moderate Increase	74%	40%	70%
Significant Increase	14%	34%	16%

The results suggest that a fairly modest e-commerce presence is considered to be material with regard to audit planning and risk.

Results - Question 2: How does a material transactional e-commerce presence impact audit risk and, consequently audit costs. Responses appear in Exhibit 2.

The auditors uniformly perceived an increase in overall audit risk, with about one-half perceiving a significant increase in risk. Interestingly, only about twenty-five percent thought that the increased risk would result in significant increases in audit costs while the remainder predicted little or no impact on costs. Ninety-four percent believed that increased costs would *not* be passed along to the client.

Results - Question 3: Are the components of audit risk (inherent, control, and detection risk) impacted by a material e-commerce presence? We asked auditors to provide "overall and general[1]" perceptions concerning the impact of a material e-commerce presence on inherent risk, control risk, and detection risk. Results appear in Exhibit 3 below.

Only two of the fifty participants suggested a decrease in any of the risk components (control risk). Auditors are most concerned with significant increases in control risk, consistent with the focus of SAS 94.

The results suggest that the perceived change in overall audit risk, shown in Exhibit 2, is associated with changes in the components of the SAS 55 model. However, since we measured the changes in a qualitative rather than quantitative fashion, the exact nature of the relationship AR = IR * CR * DR cannot be explored. In future research, we will determine whether CPAs are able to articulate percentage increases/decreases so that the relationship can be explored more completely.

Results - Question 4: Lastly, we were interested in whether the amount of experience one has in auditing in an e-commerce environment would influence perceptions of changes in audit risk. Of the fifty participants, thirty-two percent claimed "substantial" experience auditing in an e-commerce environment, thirty-six percent claimed "moderate" experience, twenty-six percent claimed "little" experience and six percent claimed "none". We organized our subjects into two groups, whose experience was "substantial or moderate" and "little or none". Utilizing the categories shown in Exhibits 2 above, a chi-squared test of independence revealed no statistically significant difference (α=.05) in the responses of the two groups with regard to perception of changes in audit risk. As such, we conclude that perception is independent of level of experience.

SUMMARY AND CONCLUSIONS

Our goal was to begin an investigation of how an important type of information technology, specifically transactional e-commerce, is perceived by CPAs to impact audit risk and practice. A survey was used to determine whether auditors have salient opinions that can be expressed concerning the relationship between transactional e-commerce and audit risk. Not only were auditors able to express opinions on the relationship, the opinions were uniform in suggesting an increase in overall audit risk and in the individual components of risk. The results motivate further detailed study to see if the relationship between the components of audit risk, as specified in the SAS 55 model, can be substantiated, perhaps by asking auditors to express perceived changes in risk in numeric terms and at the account and management assertion level. A larger sample will facilitate the inclusion and analysis of additional control variables. For example, the differences in responses pertaining to traditional EDI systems and non-EDI web-based systems might be explored.

A majority of auditors suggested that some increase in audit costs would occur, suggesting (as anticipated) a change in audit practice. A more detailed analysis of changes in audit practice, resulting from the perceived increase in audit risk, could be pursued. This includes understanding whether increased costs are due to changes in procedures, changes in scope, changes in timing of procedures, or some combination.

REFERENCES

AICPA, Statement on Auditing Standards No. 55, "Consideration of Internal Control in A Financial Statement Audit," New York, (April 1988).

AICPA, Statement on Auditing Standards No. 94, "The Effect of Information Technology on the Auditor's Consideration of Internal Control in a Financial Statement Audit", New York, (May 2001).

Cushings, B. E. and Loebbecke, J. K. "Analytic Approaches to Audit Risk: A Survey and Analysis," *Auditing: A Journal of Practice and Theory*, 3(), (Fall 1983), pp. 23-41.

Helms, Glen L. "Traditional and Emerging Methods of Electronic Assurance," *The CPA Journal*, 72(3) (2002), pp. 26-31.

OECD (Organization for Economic Cooperation and Development), "The development of ANSI X12 and EDIFACT," *The OECD Observer*, (Oct/Nov 1995).

Geiger, M. and Taylor, P. "CEO and CFO Certifications of Financial Information," *Accounting Horizons*, 17(4) (2003) pp. 357-368.

Pathak, J. and Lind, M. R., "Audit Risk, Complex Technology, & Auditing Processes" (March 2003). Available at Social Science Research Network: http://ssrn.com/abstract=397321

Securities and Exchange Commission, Public Company Accounting Reform and Investor Protection Act of 2002 (commonly known as Sarbanes-Oxley Act of 2002), Pub. L. No. 107-204, 166 Stat. 245.

Waller, W. S. "Auditor's Assessment of Inherent and Control Risk in Field Settings," *The Accounting Review*, 68(4), (October 1993), pp. 783-803.

Write, A. "Forum on Continuous Auditing and Assurance," *Auditing, a Journal of Practice and Theory and Practice*," 21(1), (2002), pp. 123.

ENDNOTE

[1] The qualifier "overall and general" is required because these risk factors should be assessed for each account classification (e.g. accounts receivable) on the financial statements and for each management assertion made for the account. Under SAS 55, the assertions are completeness, existence, ownership, valuation, and disclosure.

Examining Data Cleansing Software Tools for Engineering Asset Management

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ABSTRACT

To be more cost effective and efficient, organizations are relying on improved operations and maintenance strategies for their engineering assets. Even after having done huge investment in operations and maintenance systems, they are not able to reap proportional benefits. It is mainly attributed to the quality of data present in these systems and lack of integration between diverse systems used in the organizations. The paper presents uniqueness of data encountered in engineering asset management (EAM) setup and the quality problems in such data. It reviews the suitability of commercially available data cleansing software tools for EAM environment, provides a comparative evaluation of features of tools and points to the areas that need improvement to effectively handle EAM data.

Keywords: Engineering asset management, data cleansing, data quality, data cleansing tools.

1. INTRODUCTION

Striving for success in today's global economy has put manufacturing and utilities organizations under intensive pressure. They are trying to achieve this through increasing production efficiency, reducing inventory carrying costs through just-in-time strategies, while ensuring that their products meet customer satisfaction. Unfortunately, organizations have not done equally well on the asset management front. To achieve maximum possible up-time for their assets, organizations are now trying to turn towards asset management as an optimization strategy to improve their process efficiency, reduce maintenance cost, and improve their returns over time on assets (Eerens, 2003). The objective of effective engineering asset management (EAM) is to reduce total cost of ownership of assets, ensure the optimum level of reliable and uninterrupted delivery of quality service, minimize the need for new assets, and continuously align assets with organizational needs (IPWEA, 2002).

Engineering asset management involves acquiring, maintaining, and disposing of assets and is a serious business. Staggering investments are made in engineering assets. The cost of maintenance and replacement of these assets represents a major share of their operating costs. According to a study conducted by ARC Advisory Group (Snitkin, 2003), nearly 40 percent of manufacturing revenues are budgeted for maintenance. The potential for savings from proper management of assets is immense. Obviously, a little improvement can result into significant savings through reduction in maintenance cost. Enhancing quality of data stored in various information systems supporting EAM through data cleansing can reduce the operational and maintenance cost in organizations and contribute significantly to their bottom line.

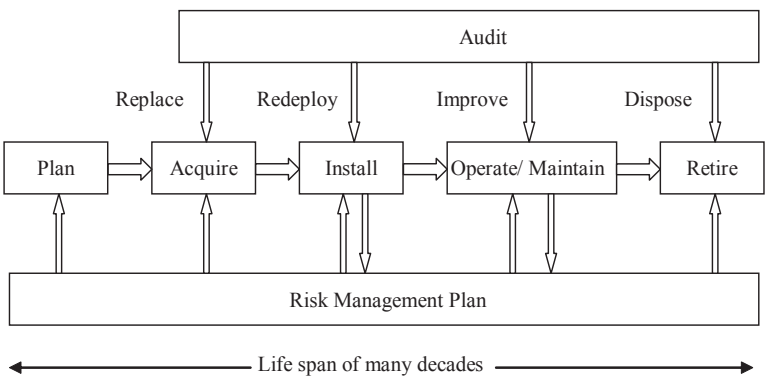
In this paper, the authors discuss the results of a study done to evaluate commercially available data cleansing software tools for EAM environment. The paper is organized as follows. Section 2 discusses how data encountered in EAM is different from data found in business applications. Section 3 defines the concept of data quality and highlights the quality problems in such data. Section 4 then provides a solution to improve data quality through data cleansing. Section 5 provides a list of commercially available data cleansing tools that were investigated and also provides a comparative evaluation of features of these tools and points to the areas that need improvement to effectively handle EAM data.

2. EAM ENVIRONMENT

Engineering asset management deals with the effective management of broad range of physical assets like machinery, production equipment, and fleets belonging to engineering organizations. Engineering assets exhibit unique characteristics in many ways. They are generally complex, expensive and operate for continuous periods of time. They need care so that they can provide service without failure for an extended useful lifetime. They need to be managed through best practice methodologies and business processes for getting maximum benefit from them (Blanchard, 2006). The process of asset management is sophisticated and involves the whole asset lifecycle that generally spans over many decades as shown in Figure 1.

Maintenance strategies for engineering assets, once *run-to-failure* now are becoming *condition-based*. Condition-based maintenance used in strategies like Reliability

Figure 1. Engineering asset lifecycle stages



Centered Maintenance (RCM) constantly monitor the health of assets and collect lots of data pertaining to asset conditions. In addition to this, data related to asset operations are also collected. The analysis of collected data provides knowledge about the current and future condition of assets and helps to schedule and plan future maintenance activities.

Data typical of asset management environment can be both structured and unstructured. The structured data could be related to physical characteristics of assets like its type, size, ratings, specifications, bill of materials (BOM) of parts and spares etc. The unstructured data could in the form of notes, inspection reports, sketches, work instructions, safety data sheets etc. Data can be captured both automatically through sensors and field devices, and manually through human operators and technicians in a variety of formats. The automatically captured data can be periodic or continuous process-centric streaming real-time data. Data could also be sourced from a variety of databases and disparate operation and maintenance systems.

Data types can typically include: inventory data, condition data, performance data, criticality data, lifecycle data, financial data, risk data, reliability data, technical data, physical data, GPS data, etc. EAM environment contains many information systems used at various life cycle stages and these systems store data in their propriety formats. Some of the systems used in typical EAM environment are:

- CAD: Computer Aided Design
- CMMS: Computerized Maintenance Management System
- DMS: Document Management System
- ERP: Enterprise Resource Planning
- GIS: Geographic Information System
- LIMS: Laboratory Information Management System
- PAM: Plant Asset Management
- PDM: Product Data Management
- PLM: Product Life Cycle Management
- SCADA: Supervisory Control and Data Acquisition
- SRM: Supplier Relationship Management
- WMS: Warehouse Management System

3. DATA QUALITY ISSUES

Data quality has become an important topic of investigation in research and industry however, so far there is no single agreed definition of data quality (Maletic and Marcus, 2000). We define high-quality data as data that are *fit for use* by data consumers—a widely adopted criteria (Strong et al, 1997). Data quality is regarded as multidimensional concept in the literature and there is no general agreement on a firm set of data quality dimensions (Wand and Wang, 1996; Wang et al, 1995). Frequently mentioned dimensions are:

(i) accuracy (degree of correctness and precision with which real world data of interest to an application domain are represented in a system),
(ii) completeness (degree to which all data relevant to an application domain have been recorded in a system),
(iii) consistency (degree to which the data managed in an information system satisfy specified constraints and business rules), and
(iv) timeliness (degree to which the recorded data are up-to-date).

Data used in EAM organizations can have a wide range of errors, inaccuracies and inconsistencies, such as wrong data, missing data, inconsistent use of abbreviations, misspellings during data entry, outdated or invalid data etc. in single or multiple data sources. Also EAM organizations generally have a significant portion of their data stored in legacy systems that constitutes lots of unstructured data. These organizations face many problems in mapping field names while migrating from legacy systems to enterprise asset management applications.

As discussed in the last section, EAM organizations use plethora of information systems that deal with asset data. Data in these information systems have great diversity in formats and semantics (Friedman, 2006). These organizations cannot deliver attractive return on investment unless they are underpinned by clean and consistent data. As systems grow in complexity and the volume of data increases, the level of data quality becomes more critical to success. The effectiveness of decision-making is limited to the quality of the data. A number of organizations worldwide have suffered large financial losses due to inaccurate, incomplete or wrong data in their data repositories (English, 1999).

4. DATA CLEANSING

Data cleansing deals with detecting and removing errors and inconsistencies from data in order to improve their quality (Muller and Freitag, 2003; Rahm and Do, 2000). Data cleansing also called data cleaning or scrubbing has caught on in a big way as a crucial first step in organizations dealing with applications like data warehousing, data mining and knowledge discovery where data forms their core asset.

As mentioned in section 2, asset management is characterized by a range of diverse data sources most often from multiple vendors and at times with some proprietary data formats. Data cleaning becomes especially important in such situations when multiple data sources need to be integrated. On the lower end of the problem, it could be a case of simple redundant data that can be handled easily. On the other end, semantically same data having different representations in heterogeneous sources will result into redundant data. In order to have a single view and access to accurate and consistent data, consolidation of different data representations and elimination of duplicate information becomes very necessary. This problem has been referred to in literature as merge/purge problem (Hernandez and Stolfo, 1998).

While most practitioners of data quality are aware of the problems with their data quality issues, only recently there has been an emphasis on the systematic detection and removal of data quality problems (Dasu and Johnson, 2003). A data cleansing approach detects and then removes all major errors and inconsistencies both in individual data sources and when multiple data sources are integrated. Therefore, data cleansing should not be performed in isolation but together with schema-related data transformations based on comprehensive metadata.

5. DATA CLEANSING TOOLS

5.1 Commercially Available Data Cleansing Tools

In recent years there has been a significant growth of data quality tools in the market. This is the result of organizations realizing the importance of good quality data and the harm poor quality data can do to their effectiveness. The organizations are considering data quality as a strategic issue and are actively seeking solutions for its improvement. They are relying on technology for improving data quality which has led to a strong interest in data quality tool market. Although data quality tools market is still modest in size compared to many other software markets, there is a likelihood of it growing in future. This is evident by the tumultuous movement in the market and the interest it has evoked in small and large vendors. There have been mergers and high profile acquisitions by large vendors like Business Objects, IBM and Pitney Bowes.

The authors investigated the suitability of some commercially available data cleansing software tools in the market for the cleansing of asset management data. Our analysis is based on our appraisal of the available literature found on vendor's homepages, their product specifications, and independent industry survey reports from consulting firms. The limitation of this research at this stage is that the comparison of the cleansing tool is not based on any testing of installed software with real data. The reason for not doing this is that the cleansing software tools are very expensive and hence it was not practically possible and financially feasible to investigate all software installations. In future research activities we plan to interview the vendors so that we can get information that is not freely available. Later on, with the identification of industry partners of our University who have used these software tools, we plan to have even more in-depth viewpoint and feedback about the respective advantages and features of these tools. Although every attempt was made to include major vendors in this study, it is possible to have missed some major vendor in this area and/ or not adequately covered some specification of their tools that they might support.

Following is the list (in alphabetical order) of commercially available tools that we reviewed:

- Athanor - Similarity Software (IMC, 2006)
- DataSight - Group 1 Software - Pitney Bowes (G1S, 2006)
- dfPower Studio - DataFlux SAS (DFC, 2006)
- i/Lytics - Innovative Systems Inc (ISI, 2006)
- Information Quality Suite - First Logic - Business Objects (FLI, 2006)
- PowerCenter - Informatica (IMC, 2006)
- Trillium Software System - Harte-Hanks Trillium Software (HTS, 2006)
- WebSphere QualityStage - Enterprise Edition IBM (IBM, 2006)

Table 1. Comparison of data cleansing software tools

Features	Athanor 3.0	DataSight	dfPowerStudio	i/Lytics	IQ8	PowerCentre	Trillium Software System	WebSphere QualityStage
Vendor	Similarity Systems (Informatica)	Group1 Software (Pitney Bowes)	DataFlux SAS	Innovative Systems	First Logic (Business Objects)	Informatica	Harte-Hanks Trillium Software	IBM
Sub systems	Athanor Designer Athanor Server Athanor Runtime Athanor RealtimeSDK	CODE 1 Plus Suite Universal coder Merge/Purge Plus	dfPower Profile dfPower Quality dfPower Customise	i/Lytics Data Profiler i/Lytics Data Quality i/Lytics GLOBAL i/Lytics SECURE			TS Discovery TS Quality	DataStage QualityStage ProfileStage
Data profiling	Basic	Basic	Very good	Basic	Good	Good	Very good	Very good
Data parsing/ correction	Good	Very good	Very good	Good	Very good	Very good	Very good	Very good
Matching/ de-duplicate	Good	Very good	Very good	Good	Very good	Very good	Good	Very good
Enrichment		Very good	Very good		Very good		Very good	
Integration	Good	Good	Basic		Good	Very good	Basic	
Data monitoring			Good					
Data types	Customer Financial Inventory Materials data	Mutiple –mainly customer	Customer and product related data	Customer and non-customer	Customer and non-customer	Multiple	Multiple	Name and address; and non-name data
Real time support		Good	Good	Very good	Good	Good	Very good	Good
Database support		Good	Good	Basic	Very good	Good	Very good	Good
Enterprise Transactional Systems		Good	Very good				Very good	
Support for SOA	Basic		Good		Very good		Good	Very good
Integrated repository of rules and reference data	Basic				Very good	Good	Very good	
Define new rules							Basis	
Support for Metadata			Good			Good		Good
Geocoding		Very good		Good			Good	
Support for Unicode	Basic	Very good	Basic		Good		Good	
Client Server platform	Good	Basic	Good		Good		Very good	
User Interface		Intuitive	Graphical workflow GUI		Intuitive	Effective		Easy to use
Scalable		Good			Very good		Good	

In addition to the above mentioned data cleansing tools, we also investigated some more commercially available tools as well as tools developed as an outcome of academic research, like: AJAX (INRIA, France), Arktos (National Technical University, Athens), DataLever Enterprise Suite (DataLever Corporation), dn: Clean (Datanomic), Intelliclean (National University of Singapore), Porter's Wheel (University of California, Berkeley), and WinPure (WinPure Inc). These tools are not included in the comparison shown in Table 1, as they did not offer an exhaustive range of data cleansing features.

5.2 Comparison of Data Cleansing Tools

The data cleansing software tool vendors are offering a wide range of data quality functionality like data profiling, data parsing/ correction, data matching/ de-duplication, enrichment, integration, and data monitoring (Howard, 2004). They are either offering various data quality components as a separate product, with some degree of integration between them or a suite of functions covering full spectrum of capabilities. It becomes convenient for organizations to deploy a single-vendor solution for enterprise-wide data quality requirement. Table 1 provides a comparison of eight major data cleansing tools we investigated in detail. The three levels of rating: 'basic', 'good' and 'very good' are assigned based on the degree of support for a feature by the vendor. Cells in a column are left blank where sufficient information about the respective features is not available from the vendor.

5.3 Analysis of Data Cleansing Tools

The initial impetus to commercial data quality tools was given by customer data management problem. The customer data (i.e. the name and address of customers) that support Customer Relationship Management (CRM) related activities is the most volatile field in corporate databases. The quality of this type of data quickly degenerates over time. Therefore, most of the pioneering data quality tools focused initially on cleaning up customer data only; even today majority of data quality functionality is aimed at this type of data. But at the same time the present day data quality tools have expanded well beyond such capabilities and the vendors are including other data domains like product data and financial data to their list. Master data management (MDM) initiatives are driving the product data whereas financial data is being driven by corporate accountability and regulatory pressures from governance initiatives like Sarbanes-Oxley, and HIPAA compliance.

Lots of applications are driven by today's powerful database technologies. The data cleansing tools are offering fast access to and from relational databases like: Oracle, SQL Server, DB2 and others. They are also supporting Windows ODBC connectivity, and traditional delimited files. In addition to conventional data quality functions, the tools provide a scope for connectivity to databases, integration with enterprise systems like Enterprise Resource Planning (ERP) and data warehousing tools like Extract transform Load (ETL).

Text processing systems worldwide are increasingly supporting Unicode to have a consistent way of encoding multilingual text and to exchange text files internationally. As enterprises expand their reach to global locales and clients, more and more companies are moving their business data to Unicode. Majority of vendors we reviewed are providing support for Unicode framework, allowing users to read and write data from a wide variety of Unicode and non-Unicode pages. Some vendors are supporting Geocoding and are able to enrich data by adding value to the captured data. This feature is very importance for assets that are installed in remote areas and for those assets that are in transit.

Adoption of Web services and service-oriented architecture (SOA) for achieving agility and ease of adapting to changing business requirement by organizations is at an increase. This is very well matched by the data cleansing tool vendors who are providing support for SOA. They are supporting industry Web Services standards like SOAP, XML, WSDL, UDDI, and HTTP through the SOA framework. SOA is an ideal implementation methodology for centralizing data quality processing across the enterprise and is quick to implement and easy to maintain. The tools should reach out with Web Services integration for popular IBM WebSphere, BEA WebLogic, and Microsoft .NET platforms.

6. MORE NEEDS TO BE DONE TO SUPPORT EAM DATA

The functionality of commercially available data cleansing software tools has improved over the years. The tools can adequately address the data quality problems of transaction based data that usually reside in tables of relational databases. But more needs to be done towards the improvement of specifications and feature of these tools enabling them to cater for the peculiar and unique data that are typical of asset management environment.

Some asset data may not be available in structured tables; it may reside on flat files. Though data cleansing tools have started to broaden their range by adding more data types like non-name product data and financial data under the structured data category, they are far from handling typical asset data that might include parts list and condition monitoring data under structured data types, and specifications, inspection reports, instructions etc. under unstructured data types.

The earlier versions of data cleansing tools worked on flat files in batch mode. The present data cleansing tools are supporting hybrid client/server architectures that allow validation, standardization, and matching done in real-time across a LAN or WAN (Lee et al, 1999). Support for real-time functions is very important in an asset management setting where control and monitoring data can be in real-time and streaming and it is expected to cleanse data before it is saved onto a database or data repository, or used for triggering or actuating some action linked to the status of data.

In asset management environment, annotations are often done by engineers and technicians during regular installation, operation and maintenance of assets and while carrying out modifications and improvements to the existing process or assets. This generates a lot of very useful metadata that calls for adequate handling. The future tools need to enhance their capabilities from syntactical to semantic. They not only need to merely recognise the structure of data but also understand the meaning of data through extensive use of metadata. The tools based on metadata-driven design will enable enterprises to move beyond defect inspection to solving data defects through root-cause analysis and building in data quality from the outset as a core function of any application design. The vendors like Trillium Software and Firstlogic have developed tools that make use of some data matching and cleansing business rules (Galhardas, 2001) but tools need to have centralised set of common business rules that can drive all the various data quality components like profiling, matching, cleansing, validation, standardization and enrichment.

7. CONCLUSIONS

By having an effective asset management in place, EAM organization can reduce total cost of ownership of their assets, get the most out of their assets, minimize the need for new assets, and continuously align capital assets with organizational needs. The organizations rely on a number of disparate information systems to improve operations and maintenance strategies for their engineering assets. Through these systems, they collect structured and unstructured data in various formats. Bad quality data in data repositories and lack of integration between diverse systems does not allow the organization to have a comprehensive view of all the data they own and severely impacts the quality of their decision making process.

Data cleansing software tools can provide help in improving data quality. But sadly, as shown above, data cleansing tools that are commercially available from vendors fall short of cleansing some nuances of engineering asset data. The vendors need to enhance their features to cater for the burgeoning need for cleansing asset management data.

This paper discusses how data cleansing tools can improve the quality of dirty data; though it should not be considered as the only way to improve the quality of data. Moreover data cleansing through tools should not be seen as a standalone activity. The real and more effective solution lies in establishing a well defined data quality methodology that controls the business process and does not allow the bad data to enter information systems in the first place.

8. ACKNOWLEDGMENTS

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9. REFERENCES

Blanchard, B.S. (2006). System Engineering Management, 4th edition, New Jersey: John Wiley and Sons.

Dasu, T & Johnson, T. (2003). Exploratory Data Mining and Data Quality. New Jersey: John Wiley and Sons.

DFC (2006). SAS DataFlux Corporation Home page, URL www.dataflux.com/, Accessed 2 Apr 2006.

English, L.P. (1999). Improving Data Warehouse and Business Information Quality: Methods for reducing costs and increasing Profits, Willey & Sons.

Eerens, E. (2003). Business Driven Asset Management for Industrial & Infrastructure Assets. Le Clochard: Melbourne.

FLI (2006). FirstLogic Inc. Home page, URL www.firstlogic.com/, Accessed 3 Apr 2006.

Friedman, T. & Bitterer, A. (2006). Magic Quadrant for Data Quality Tools, Gartner Research Report.

G1S (2006). Group1 Software Home page, URL www.g1.com/, Accessed 5 Apr 2006.

Galhardas, H., Florescu, D., Shasha, D., Simon, E. & Saita, C.-A. (2001). Declarative data cleaning: Language, model, and algorithms. Proceedings of the 27th VLDB Conference, Roma, Italy.

Hernandez, M. A. & Stolfo, S. J. (1998). Real-world data is dirty: Data Cleansing and the Merge/Purge problem, Journal of Data Mining and Knowledge Discovery, 2(1), 9-37.

Howard, P. (2004). Data Quality Products: an evaluation and comparison, Bloor Research Report, Bloor Research, Milton Keynes, United Kingdom.

HTS (2006). Harte-Hanks Trillium Software Home page, URL http://www.trilliumsoftware.com/site/content/products/tss/index.asp, Accessed 2 Apr 2006.

IBM (2006). IBM Corporation Home page, URL http://www-306.ibm.com/software/data/integration/qualitystage/, Accessed 2 Apr 2006.

IMC (2006). Informatica Corporation Home page, URL http://www.informatica.com/solutions/data_quality/default.htm, Accessed 7 Apr 2006.

IPWEA. (2002). International Infrastructure Management Manual. Australia/New Zealand Edition. The Institute of Public Works Engineering Australia.

ISI (2006). Innovative Systems Inc. Home page, URL http://www.innovativesystems.com/, Accessed 6 Apr 2006.

Lee, M.L., Lu, H, Ling, T. W. & Ko, Y. T. (1999). Cleansing data for mining and warehousing. Proceedings of the 10th International Conference on Database and Expert Systems Applications, Florence, Italy.

Maletic, J.I. and Marcus, A. (2000). Data Cleansing: Beyond Integrity Analysis. Proceedings of the International Conference on Information Quality, MIT, Boston, USA.

Muller, H., Freitag, J., (2003). Problems, Methods, and Challenges in Comprehensive Data Cleansing, Technical Report HUB-IB-164, Humboldt University, Berlin, Germany.

Rahm, E & Do, H.H. (2000). Data Cleaning: Problems and Current Approaches, IEEE Data Engineering Bulletin 23 (4).

Snitkin, S. (2003). Collaborative Asset Lifecycle Management Vision and Strategies. Research Report. ARC Advisory Group.

Strong, D.M., Lee, Y.W., and Wang, R.Y. (1997). Data Quality In Context. Communications of the ACM, 40(5), 103-110.

Wand, Y. and Wang, R.Y. (1996). Anchoring Data Quality Dimensions in Ontological Foundations. Communications of the ACM, 39(11), 86-95.

Wang, R.Y., Storey, V.C. and Firth, C.P. (1995). A framework for analysis of data quality research. IEEE Transactions on Knowledge and Data Engineering, 7(4), 623–640.

Low Budget E-Commerce Solution for a Dental Supply Company

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ABSTRACT

This case presents an overview of an e-commerce solution for a dental supply company that provides dentists with over 16,000 different dental products from alloys, to dental instruments to x-ray products. Using the e-commerce solution of ENG Dental Supply, dental offices are able to order products online. This is a more efficient approach to the traditional catalog order method where dentists would call in or fax their orders. The process and challenges of implementing this low budget e-commerce solution are discussed.

INTRODUCTION

ENG Dental Supply is a family owned and operated dental supply company serving the community of dentists of Southern California. The company was founded in the 1940's and currently serves approximately 1,000 clients and offers over 16,000 different products from over 200 manufacturers. ENG Dental Supply was a labor-intensive company where traditional methods were still used for most of the company's operations. ENG was relying on the fax machine and most processes were completed manually. Management did not have the vision to keep up with technology. Management did not consider the importance of technological solutions that other firms have implemented to increase efficiency and cut costs. The company's processes were considered to be so straight forward by the management that little attention was paid to changing the way business was conducted. A decision to modernize came as revenues started falling and existing clients started ordering dental supplies from competitors.

The organization consists of the following units:

- The executive team oversees the organization, maintains relationships with key clients, and with top suppliers.
- The accounting department is responsible for accounts receivable and accounts payable, as well as financial reporting.
- The warehouse operations department receives products from over 200 manufacturers of dental products and equipment. Employees unpack merchandise, arrange merchandise on shelves in the warehouse, and enter incoming inventory into the computer system. They also collect merchandise from shelves and pack into boxes for shipment to dentist offices, and load on trucks for daily delivery.
- The purchasing department monitors inventory levels, and purchases the appropriate merchandise ensuring sufficient levels exist in the warehouse.
- Customer services department employees answer client phone calls to take orders, and provide product information / prices. They record orders in the computer system. They also process faxed orders sent by sales people or clients.
- Sales Department employees visit client dental offices to provide product information, and take orders. They then fax these orders to the customer service department for entry into the computer system and fulfillment. They also visit prospective clients, and work to convert them to clients.

THE DENTAL SUPPLY INDUSTRY

The North American market size in 2005 was estimated to be $5.6 billion (Patterson D.S., 2006). Two main players in the market are Patterson with 32% and Sullivan-Schein with 30% market share. Market growth is estimated to be 7-9% annually. Consumables growth is estimated to be 5%-7%, whereas equipment growth is estimated to be 10%-12%.

Benco (Benco, 2006) and Pearson Dental Supplies (Pearson, 2006) are two mid sized companies. The other players in the Dental Supply Industry include but are not limited to AccuBite Dental Supply, Atlanta Dental, Applied Dental, Burkhart Dental, Conger Dental Supply Company, Darby Dental Supply, Discus Dental, and Eastern Dental Supply.

The North American dental market consists of about 156,000 U.S dentists and around 18,000 Canadian dentists (Pearson D.S., 2006). 65%-70% are sole practitioners. There are over135,000 dental practices. The average revenue per dentists stands on $550,000 per annum. Dentists spend $0.05 – $0.07 revenue per dollar on consumables supplies, which means $25,000 to $35,000 of revenues per annum.

STAYING COMPETITIVE WITH E-COMMERCE (EC)

The Internet, the World Wide Web and other developments of the information revolution will redefine patient care, referral relationships, practice management, quality, professional organizations and competition (Bauer, J.C., Brown, W.T., 2001). The Web offers the advantages of both centralization of information and coordination (Marks, R.G. (2004). To survive, ENG needed to increase revenues, reduce operating costs by automating business processes through the implementation of their website and e-commerce solution, and build on the ENG Dental Supply brand name. By achieving these goals ENG will then provide customers with information online, allow them to place orders online, and reach out to their prospects using the internet. ENG will become more accessible to their clients and prospects.

ENG will use their website to further inform its customers of new dental supplies and sell dental supplies to its customers. The ENG website will ultimately consist of four systems:

- Product system: will include product search and an online catalog system
- Customer system: will include a customer accounts systems, authentication system and links to order and product systems
- Order system: will include customer orders and delivery systems
- Supplier system: will tie the products and inventory levels to suppliers for automated reordering

The website was designed to integrate the first three areas of commerce. The systems mentioned above were implemented using web technologies. Databases, web servers, web applications and other computer technology were used to get the website up and running.

After performing some preliminary research on websites of major dental supply companies an effort was undertaken to implement some of their strategies for success in our own website. The goal is to deliver a complete set of services for our customers that is easy to use and navigate. These services include:

- Customer accounts systems: customers will be issued a personal account, which will include past purchases and current purchases. They will also be able to customize their home page for easy shopping, by defining their preferences.
- Online catalog systems: customers will have access to an organized list of products where he or she can browse and click through to the product detail level.
- Products search systems: customers will have the convenience of a product search engine whereby a keyword is entered to retrieve a "like" product.
- Order/order tracking systems: customers will be able to track their purchases from the time they place an order until it arrives at their offices.
- Inventory and procurement system: inventory levels will be updated daily for customers convenience

The implementation would be based on expanding our website capabilities. Ways that the company can utilize to sell its products to customers were determined. This information was conceptualized on how the website would look compared to accessibility of the content.

EC Planning Phase

In creating the E-commerce solution for ENG Dental Supply, the Systems Development Life Cycle process was utilized. It consists of seven phases. The planning phase covered project scope and budget.

Determine Project Scope - ENG needed to catch up with their competitors almost immediately if they wanted to remain a viable dental supply company. In order to do so, ENG needed to provide its customers with an online product catalog that would have electronic commerce capabilities so the customers could compare products and place orders.

Determine Budget - The client allocated $45,000 for the initial implementation, and so the question facing the team was how to implement the maximum possible for the tight budget. To achieve that, the activities were prioritized and implemented selectivity.

EC Analysis Phase

The e-commerce site needed to be easy to use and maintain. An analysis study of the company's business processes was performed in order to identify ENG's requirements. Information about employees and their duties was collected, and a course of actions was formulated based on the analysis of the findings.

Research Competition - Portals differed in many characteristics, such as the number of services, product pricing, discussion forum activity, navigability, reaction time in response to questions and site responsiveness (Schleyer T, Spallek H., 2002). The online presence of the dental supply competitors including their e-commerce capabilities was analyzed. These companies included: Patterson Dental Company, Sullivan-Schein Company, Burkhart Dental, Inc., Darby Dental Supply and Benco Dental, Inc.

Analyze Employees and Client Requirements – Meetings with management covered the employee and client requirements. The customer service department, and the outside sales people, were then utilized to determine their requirements for such a system. They were asked to review competitors systems, and recommend ways in which the ENG System could be designed to achieve their needs and be better then the competition.

Research ISP's - The information of the company's Internet Service Provider was gathered. The company hosting the website relied on older technology and the ISP features did not allow for the usage of dynamic information. Several ISP's were studied for reliability, connectivity and service to support the new website. A company by the name of 1and1 met all the requirements for the solution.

Research E-Commerce - Several e-commerce packages were tested before making a final purchasing decision. X-cart Gold was selected to drive the new e-commerce site. The price was also very competitive compared to other vendors. The main reasons why this package was chosen are listed in Table 1.

EC Design Phase

The design phase consisted of designing an e-commerce site look and functionality, creation of the process to update prices, creation of the process to add/remove/modify products and the planning for marketing campaigns.

Design E-Commerce Site Look/Functionality - Two main actions were taken with respect to ENG's website, to improve its performance and usability:

- **Minimize** dynamic content; with careful performance analysis, it was determined that the usage of dynamic content on the site would decrease server performance. Budget constraints impeded the company to afford a high-end dedicated hosting server. Therefore, in order to improve performance on the website, dynamic content use would be minimized as much as possible.
- **Increase** the appeal of ENG's website. The main page of every website is critical in capturing the visitor's attention. Generally only five seconds are required to captivate the audience's attention. If the content does not convey the right message, the potential customer may be lost. The company's original website did not attract visitors.

The site was not sophisticated enough and e-commerce was non-existent. A survey of 250 clients was performed in order to determine what needed to be changed. The results were very clear. The recipients agreed that the website needed to be thoroughly revised. Hence, the website was redesigned, to maximize its appeal and functionality.

Create Process to Update Prices - Product prices were updated daily on the existing DMS environment. This was a manual process based on market prices of products offered by the competition. A new e-commerce solution meant that prices would need to be updated twice, creating possible inconsistencies between online and offline ordering prices due to human data entry errors. To resolve this, a batch process would be created to copy all price changes from the DMS to a Microsoft Access document twice each month. This document would be manually imported into the new e-commerce environment, then updating the prices quickly and consistently.

Create Process to Add/Remove/Modify Products - A list of products added, removed or modified would be downloaded from the DMS environment twice per month. The changes to product descriptions, added products or removal records would then need to be manually recorded into the system by an operator.

Plan Marketing Campaigns - A plan and a schedule were created outlining the traditional and online marketing efforts that would take place to promote the e-commerce website. Some activities were planned for the pre-launch period, others for the initial operational period and for ongoing activities.

EC Build Phase

E-commerce software was purchased, customized and tested.

Purchase/Configure Test Computer - A dedicated computer was purchased in order to perform testing of the website by the company's staff. The computer was setup as a dedicated machine to perform intensive tests and identify any

Table 1

Free customer support for X-cart customers. Whereas most vendors provide technical support for their products at a cost, X-cart has free customer support with the purchase of the software.	Personal order history log gives ENG' customers the ability to view how much and what they have ordered in the past.
Ability to print transactions.	Clients can search products by title, description and category.
The option to use discount coupon codes and gift certificates.	Full inventory control.
"Out of Stock" notifications.	Quantity discounts.
Retail and wholesale pricing.	Allow customers to choose delivery methods.
Ability to process credit cards using different known transaction companies.	Export sales and customer data for use in a spreadsheet.
Printable shipping labels.	Personalized greetings of regular customers.
Real-time order tracking for registered customers.	Encryption protection for secure transaction and customer data transmission.

Figure 1. Screenshot of ENG's homepage

Figure 2. Screenshot of ENG e-commerce storefront page

possible design errors. The investment of this system was a few hundred dollars.

Purchase E-Commerce Package - The software package chosen for the design and implementation of the e-commerce site is called X-cart Gold and was purchased from X-cart solutions (X-Cart). The basic package offered system capabilities such as querying, ordering and processing.

Create E-Commerce Website - The graphical user interface was customized for a more aesthetically appealing look. Features such as product search and thumbnail display were added (see Figure 1 and Figure 2).

Test E-Commerce Website - A limited data set of product records and clients was entered into the system. Testing was performed to ensure online ordering, transaction recording, and reporting of other key functions worked flawlessly.

Data Build Phase

The current database contained in the DMS was updated with detailed product descriptions and placed into a hierarchy in accordance with industry norms.

Extract Product Data from DMS - A script to extract all DMS data was created, tested and executed. Data was extracted into an MS Access file.

Figure 3. Screenshot of ENG's product categories

Identify Products to List Online - The organization's purchasing manager reviewed each product item in the Microsoft Access file. Over 5,000 products were identified as being discontinued or no longer sold by the company. Records were uploaded into the e-commerce package and tested to ensure the system reflected the appropriate values.

Product Data Cleanup - Focus was placed into making sure that all products had full description including prices and tags. The data was extracted into Microsoft Excel.

Classify Products - The DMS environment used only by ENG staff did not classify products in categories. Dental offices would require these to facilitate a more user friendly search. A list of ENG product categories was created by analyzing the categories of products available on competitor's websites (see Figure 3). These categories were subdivided into 638 subcategories to allow users to further refine their search of dental products.

Load Data - The e-commerce website uses MySQL to store the extracted records provided by the vendor in charge of retrieving the mainframe's information. The MS Access data was exported into a common separated value (CSV) file that would be recognized by the e-commerce package. These records were then carefully imported into MySQL to ensure data integrity (see Figure 4).

Collect Product Images – The image collection process caused major time delays due to difficulties entailed in obtaining the images from product supplier and manufacturers. ENG's suppliers and manufacturers were contacted in order

Figure 4. Screenshot of ENG's product listings

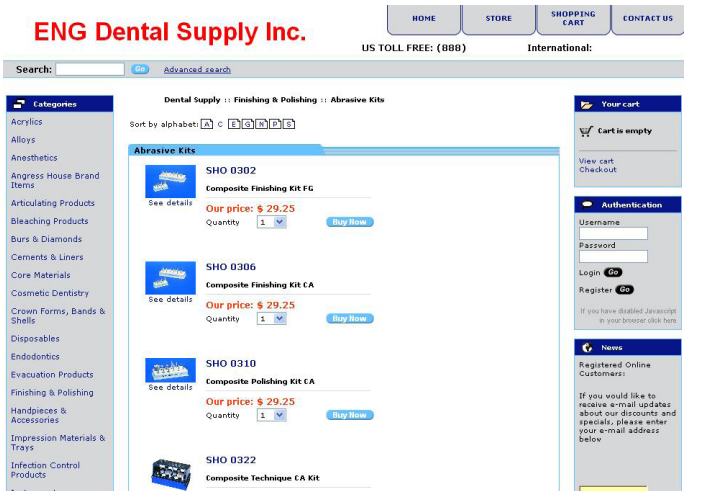
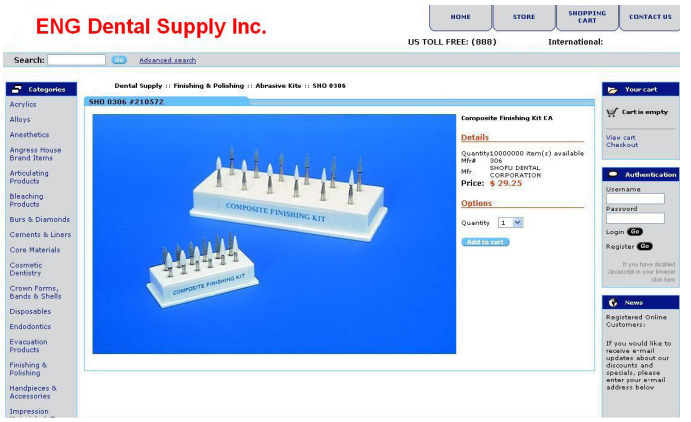


Figure 5. Screenshot of a dental product image



to provide their images for the e-commerce environment. Manufacturers provided diskettes or CDs with the product data. These images were converted to low-resolution format using Advanced JPEG compression version 4.8 software. The images were named according to the ENG product codes. Images are in the JPG format, which is a standard format supported by the X-cart package.

Populate Images into E-Commerce Website - This manual process involved importing one image for the directory of images into the corresponding data record in the e-commerce environment (see Figure 5).

Test E-Commerce Website/Data Focus - Testing was performed for a period of one week. All departments of the organization were involved in the thorough testing of the new site. Feedback was provided for minor adjustments of the e-commerce environment. A full time person was assigned to search for the most popular products to ensure their descriptions would help locating them online. A second week of testing involved ten ENG clients. They were provided with written instructions and telephone support to help them register, and use the system to purchase dental products online.

EC Deployment Phase

Deployment consisted of creating training materials, training employees, moving the website to the production environment, and then training ENG's customers.

Create Training Materials - Two training programs were offered to ENG: one for its employees and another for its clients. Separate training materials were prepared to train customer service staff and employees supporting the system. The documentation included:

- A document specifying the system's different features and capabilities; product search features, registering to the website, etc.
- A document containing an overview of the architecture of the system, instructions of how to maintain and add basic features to the system.
- A document containing a site map and information regarding product so as to assist customer service staff in supporting customers remotely.

Train Employees - The ENG customer service and sales department employees were trained on registering to the system, searching for products, reviewing transactions and extracting transactions from the DMS environment for order fulfillment.

Move site from Test to Production Environment - The new website had to be uploaded and promoted from testing to production once the required tests were performed.

Train Clients Online - Two main options for client training support were offered:

- Phone support by the customer service department staff for those clients encountering difficulties ordering or searching products through the system.
- Personal visit by sales representatives - in extreme cases where phone support didn't resolve the clients' problems or for VIP customers.

Customers were trained to register online, to search for products, to order products, to change orders and to review the order history.

EC Operations Phase

Ongoing operations of the e-commerce environment include price updates, adding, removing or modifying product information, marketing the e-commerce website, and supporting the site and the data.

Update Prices - The customer service support department employees were trained in the process outlined earlier. The ongoing was then implemented.

Add/Remove/Modify Products - The customer support department employees were trained in the process to add, remove and modify product information as outlined earlier. The ongoing process was then implemented.

Market E-Commerce Website - Both online and traditional marketing materials were created to maximize the exposure of the new program. ENG was provided with creative solutions to help increase its website exposure through website optimization, search engines and cross linking to dental websites frequented by prospective customers. The website was developed and optimized to attract search engine spiders. Online Marketing has been an ongoing activity since outside forces (such as updated content of other websites and other organizations' online presence) impact ENG' position in the major search engines such as Google, Yahoo, AOL and MSN. Search engines assist leading interested visitors to any page in the updated website.

The online marketing campaign was marketed directly to:

- Existing clients not currently buying online.
- As clients started purchasing online, clients were targeted to purchase more.
- Existing clients online that should be buying more.
- Lost clients – in order to regain their business by offering purchasing in a more convenient environment.
- New clients:
  - Established dental offices
  - Newly graduated from dental school

The following are examples of the online marketing activities that ENG had to adopt after the implementation of their e-commerce site:

- Setting up website cross linking with other organizations. Cross-linking was done with organizations in the same sector and related areas to increase traffic.
- Publishing articles in other dental organizations' online newsletters, announcing the launch of ENG' website as a way to increase exposure.
- Promoting ENG site on search engines to increase traffic to the website. The primary engines were Google, Yahoo, MSN, AOL Search, and AskJeeves.
- Creating a store on E-bay to expand the sale of the goods through other means. The reasons for recommending this approach were:
  - To sell products
  - To channel more traffic from e-bay to the e-commerce website.
  - To enhance the ENG brand.
- Linking to portals (vertical portals of the dental industry)

Targeted traditional marketing of new capabilities was accomplished as follows:

- Sales persons contacted selected clients to inform them of the new capabilities of the system. These clients were invited to a special launch event where the new system was presented. In order to provide incentives, discounts were offered for those clients ordering products using the new system.
- Other existing clients of ENG were contacted by sales persons to inform them of the new capabilities and its advantages.
- Flyers were distributed in major dentistry schools in California in order to expose ENG' products to recent dental school graduates.
- Stickers were placed on dental shipments showcasing the new e-commerce website URL.
- Letters were mailed with each client's invoice, informing them of the benefits of the searching for and ordering products online.

The key to this e-commerce implementation solution is to measure our website's functionality. To ensure a successful implementation the following activities will take place:

- Monitor number of membership forms submitted through the company website.
- Measure how many potential clients sign up for the company newsletters through the website.
- Monitor the number of reported emails and requests.
- Monitor the increase of business as the website is enhanced.
- Create online surveys on our website and partner website to gather information about customer service satisfaction levels and customer suggestions.
- Collect customer feedback and customer complaints to measure the satisfaction levels and identify our weaknesses.

Support E-Commerce Website - The ENG customer service department would be responsible for fielding client calls about the usage of the new e-commerce environment, about recommendations for changes or enhancements to the environment, as well as product search assistance to clients that cannot find the products they need. A list of proposed enhancements would be created to be incorporated into the planning on the next release of the site. Any data errors identified would be resolved within one business day.

SUMMARY

A decision was made to implement a shopping portal for dental practitioners that serves as a gateway for accessing over 16,000 products offered by ENG over the web. The objective of the portal was to: (1) Lower the cost of operations for ENG, (2) Improve efficiency, (3) Increase revenues. The ability to capture demographic information, shopping habits and other vital information was also implemented. Several kinds of reports were created through data mining to perform effective target marketing.

The dental portal currently allows visitors to access all the products offered by ENG through a single-secured sign in.

The number of customers quadrupled and revenues more than tripled over a two-year period since the installation of the system.

REFERENCES

Bauer, J.C., Brown, W.T. (2001), The digital transformation of oral health care - Teledentistry and electronic commerce. *Journal of the American Dental Association*, Vol 132, No 2, 204-209.

Benco, Retrieved June 1006: http://www.benco.com

Hirschinger R. (2001). Digital dentistry: information technology for today's (and tomorrow's) dental practice. *Journal of the California Dental Association*, Mar;29(3):215-21, 223-5.

Marks, R.G. (2004). The Future of Web-based Clinical Research in Dentistry. *Journal of Dental Research*. 83: C25-28C.

Palmer, D. (2002). Organizational Adoption of a New E-commerce Innovation: A Controlled Field Experiment within the Market Channel. *Proquest Information and Learning Company*. 1-22

Patterson Dental Supply, Patterson Companies Investor Relations, Retrieved June 15, 2006: http://equitymarketpartners.com/PDCO

Pearson, Retrieved June 2006: http://www.pearson-dental.com

Schleyer T.K., Spallek H, Bartling WC, Corby P. (2003). The technologically well-equipped dental office. *Journal of the American Dental Association*. Jan;134(1):30-41.

Schleyer T.K., Spallek H. (2002). An evaluation of five dental Internet portals. *Journal of the American Dental Association*, Vol 133, No 2, 204-212.

Schleyer T.K., Spallek H, Torres-Urquidy MH. (1998). A profile of current Internet users in dentistry. *Journal of the American Dental Association*. Dec;129(12):1748-53.

Sullivan-Schein, Retrieved June 15, 2006: http://www.henryschein.com

US Department of Commerce. (2000). The U.S Industry and Trade Outlook - Medical and Dental Instruments and Supplies. *The McGraw-Hill Company*. 1-10

X-Cart Software Solutions Retrieved July 3, 2006: http://www.x-cart.com/

Towards a Design Theory of Autopoietic Knowledge Management Support Systems

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ABSTRACT

The theory of autopoiesis, as a system-grounded way of thinking with biological foundations together with its extension into social domain, is used as a kernel theory for developing a design theory for knowledge management support systems. The "design product" aspects, meta-requirements and meta-design, are defined. Design methods are also suggested.

INTRODUCTION

As the awareness of the importance of managing organizational knowledge grows, the issue of how to build information and communication technology (ICT)-based systems to support knowledge management activities has been raised. However, as argued by Malhotra (Malhotra 2002), the underlying premises guiding the development of ICT-based knowledge management support systems (KMSS) increase the possibility of their failure. In fact, knowledge and its manipulating activities, by their very nature, are socio-technical phenomena in which social and technical factors interweave the ways in which people work (Alavi et al. 1999; Nidumolu et al. 2001; Pan et al. 1999). Therefore, a new "design theory" is needed to address the salient features of KMSS (Hahn et al. 2000). A "design theory", as explicated by Walls et al. (Walls et al. 1992a), must have two aspects - one dealing with the system (design product) and the other dealing with the procedures of designing the system (design process). In addition, these two aspects have to be grounded on theories from natural or social sciences, i.e., kernel theories.

The search for kernel theories requires a closer look at the system theories that go beyond the traditional system theory that is based, among other things, on Cartesian dualism, i.e., mind/body or cognition/action, and on a model of cognition as the processing of representational information (Mingers 2001). One of the candidate theories is the theory of autopoiesis, which can be best viewed as a system-grounded way of thinking with biological foundations, together with its extension into social domain.

To this end the objective of this work is to explore the potential of theory of autopoiesis as one of the kernel theories for dealing with both "product" and "process" aspects of autopoietic KMSS (AKMSS) design theory.

The remainder of this paper is organized as follows. In the next section, the issue of why a new approach for designing KMSS is need will be addressed. In the following sections the autopoiesis theory and autopoietic view of organizational knowledge are discussed. Then the autopoiesis theory will be used to derive a design theory for knowledge management support systems. The paper concludes by discussing the implications of the proposed approach.

WHY A NEW APPROACH IS NEEDED

In order to develop a design theory for KMSSs, the work to be supported by them has first to be described. This work can generally be described in terms of the characteristics of three elements: *organizational knowledge*, *the knowledge manipulating processes to be supported*, and *users and their work context* (Markus et al. 2002). The first element, *organizational knowledge*, has the following distinctive features:

- *Action-orientation*: According to Collins (Collins 1974), knowledge is a capability and thus creates the capacity to do something. Therefore, organizational knowledge is always anchored to business things toward which thought or action is directed or is communicated by the members of the firm (Hislop et al. 2000) and is constantly produced and re-produced through its business application (Augier et al. 1999) in order to create business value. One of the implications of the action-orientedness is its *indeterminacy*: As the business environment is in the state of continuous change and as organizational knowledge whatever its type is engrained in business activities, it is difficult to determine a-priori what knowledge will be requested, who will request it, who will supply it, and when and how the knowledge will be used (Abou-Zeid 2002; Markus et al. 2002).
- *Distributedness:* Organizational knowledge is spatially and temporally distributed as it is generated, owned and used by *autonomous* members of the organization, e.g., individuals and groups, and mobilized among them (Boland et al. 1996; Bonifacio et al. 2002). Moreover, the actions of organization members and their interpretation of symbolic representation of knowledge (explicit knowledge or information) are grounded in their *collective* tacit knowledge which has been formed in the course of past socialization and has become basic assumptions (Polanyi 1983; Tsoukas 1996).
- *Situatedness*: Knowledge cannot be disembodied from the people who carry it or from the situations in which they engage (Sierhuis et al. 1997). Therefore, using knowledge depends on the situation and people involved rather than on absolute truth or hard facts. Even the effective re-use of knowledge representations requires its re-creation to suit the local conditions (Boland et al. 1995; Collins 1993; von Krogh et al. 2000).

The aforementioned distinctive features of organizational knowledge require that *K- manipulating processes*, the second element, to be *social* and *contingent*. First, since organizational knowledge is distributed and context-dependent, most K- manipulating processes involve social interactions among organization members. Moreover, knowing and learning are inherently situated and distributed phenomena, residing in a series of non-localizable associations between social and material elements (Araujo 1998; Nidumolu et al. 2001). Second, as organizational knowledge is action-oriented and situated the type of its manipulating processes and the patterns of their execution are contingent upon these factors.

These characteristics of organizational knowledge and its manipulating processes call for re-conceptualizing *users of KMSS*, the third element, as *active social actors*. First, the use of knowledge and the interpretation/re-interpretation of explicit knowledge (or symbolic knowledge representations) cannot be disembodied from the user. Therefore, *the users of KMSS have to be considered as constituents of such systems who play specific roles in their operations*. Second, because of the distributed nature of organizational knowledge and the sociality of its manipulating processes, i.e., involve social interactions among organization members, the concept of the KMSS user is best described as a social actor - defined as "an organizational entity whose interactions are simultaneously enabled and constrained by the socio-technical affiliations and environments of the firm, its members, and its industry" (Lamb et al. 2003), p. 218) .

The distinctive features of organizational knowledge and its manipulating processes, together with the concept of active social actor suggest that the dominant capture/codify/store approaches (Hildreth et al. 2002) for developing KMSS are ineffective (Malhotra 2002; Swan et al. 2000). First, these approaches are based on the conceptualization of an ICT-based system as a representation of another pre-given "real world" system that enables its users, through its processing functions, to obtain information about a certain domain without having to observe it (Wand et al. 1995). Central to this conceptualization is the notion of "representability", i.e., the capability of representing the knowledge about the pre-given and objective things that exist in the real world using static structures such as entities and objects. Underlying this notion is the assumption that knowledge exists independently of human knowers (Hirschheim et al. 1995) and consequently

can be publicly owned by the organization (Wasko 1999). However, knowledge representations, which are static and context-independent structures, cannot be equated with knowledge, which is dynamic and context dependent (Malhotra 2002). Second, these approaches treat the user as an atomic individual capable of articulating her/his knowledge requirements well (Hahn et al. 2000; Lamb et al. 2003). Moreover, they consider users as external entities who have no major role in manipulating knowledge, i.e., *disembodiment assumption*.

OVERVIEW OF THEORY OF AUTOPOIESIS

In order to conceive of living systems in terms of the processes that realized them, rather in terms of their relationships with an environment, Maturana and Varela (Maturana et al. 1980) coined the word *autopoiesis* (αυτοσ = self, ποιενιν = creation, production) to denote the central feature of their organization, which is "autonomy". The meaning of this word coveys the very nature of living systems as systems that maintain their *identity* through their own operations of continuous self-renewal. Moreover, these systems could only be characterized with *reference to themselve*s and whatever takes place in them, takes place as necessarily and constitutively determined in relation to themselves, i.e., *self-referentiality*.

One of the key concepts of autopoiesis is the distinction between *organization* and *structure*. On one hand, *organization* is the capability of a system to re-produce its identity by referring constantly to itself, through the alternate re-production of its components together with the component-producing processes, i.e., the capability of a recursive self-reproduction. On the other hand, *structure* is the realization of a system's organization through the presence and interplay of its components in a specific realization space. While *organization* is necessary to establish system unity and identity, *structure* is necessary because different spaces of its actualization impose different constraints on system's components (Maturana et al. 1980). By rough analogy, an algorithm for solving certain problem can be viewed as a description of the system's organization whereas the corresponding computer program can be viewed as the realization of this organization (structure) in a certain space (programming language).

Autopoietic Systems

An autopoietic system is defined by Maturana and Varela as "a network of processes of production, transformation and destruction of components. These components constitute the system as a distinct unity in the space of its actualization and they continuously regenerate and realize, through their interactions and transformations, the network of processes that produce them." (Maturana et al. 1980), p.135)

Among the distinct characteristics of the autopoietic systems, the most relevant ones are:

- **The simultaneous openness and closure.** Autopoietic systems are *open* with respect to structural interaction with the environment, i.e. *structural openness*, which is unavoidable consequence of the fact that system elements must satisfy the particular requirements of the physical domain in which they occur, while they are *closed* with respect to their own organization, i.e. *organizational closure*. The recognition of *the simultaneous openness and closure* of autopoietic systems is in opposition to the tradition for which a system is one or the other but not both. This interpretation is possible only because of the clear distinction between organization and structure (Bednarz 1988).
- **Structural determination**. The state transition a system undergoes in response to environmental perturbations is entirely determined by its structure at that time. Moreover, a system specifies which environmental perturbations may trigger which structural changes. In other words, the environmental perturbations could trigger the system's structural changes but can never determine or direct these changes. Moreover, a system specifies which environmental perturbations may trigger which structural changes. Over time, through ongoing interactions with the environment, an autopoietic system will experience what Maturana and Varela (Maturana et al. 1992) describe as a *structural drift*, or a gradual change to their structure. The nature of this change is determined by previous system's history of structural changes, i.e., its *ontogeny.*

Higher-Order Autopoietic Systems

Two (or more) lower-order autopoietic systems can be "structurally coupled" to form higher-order autopoietic system. S*tructural coupling* is the ongoing process of the congruent structural changes between two (or more) systems that results from recurrent interactions between (among) them. Therefore, structural coupling has connotations of coordination and co-evolution. Moreover, following structural determination principle, two structurally coupled systems means that each of them selects from its possible structural changes those which are compatible with those in the other system and, at the same time, are suitable for the maintenance of its identity.

Social systems, such as enterprises, are constituted through the process of third-order structural coupling, or *social coupling*, the one that occurs between (or among) two (or more) second-order autopoietic systems. However, the unique feature of any human social system, such as an enterprise, is that the social coupling among its constituents occurs through "*language in the network of conservations which language generates and which, through their closure, constitute the unity of a particular human society*" (Maturana et al. 1992), p. 196). From this perspective, language is viewed as an example of social structural coupling that generates the self and creates *meaning* through interactions with others. Moreover, language represents what Maturana and Varela would describe as a *consensual domain*, which is defined as "the domain of interlocked conducts that results from ontogenetic structural coupling between structurally plastic organisms" (Mingers 1995), p. 78). Within a consensual domain, two autopoietic systems would be able to observe the attribution of meaning to common events and undertake coordinated actions.

THE AUTOPOIETIC PERSPECTIVE OF ORGANIZATIONAL KNOWLEDGE

The underlying premise of the dominant perspective on cognition is that effective action is explainable in terms of manipulating formal and static representations of the objective and pre-given reality (Mingers 2001). In contrast, according to theory of autopoiesis, perception is neither objectivist nor purely constructivist (Varela 1992), p. 254). Rather, it is co-determined by the linking of the structure of the perceiver and the local situations in which it has to act to maintain its identity. This is the basis of *enactive (embodied) cognition* which implies that the autopoietic system's activities condition *what can be perceived* in an environment, and these perceptions, in turn, condition future actions. In this view, "A cognitive system is a system whose organization defines a domain of interactions in which it can act with relevance to the maintenance of itself, and the process of cognition is the actual (inductive) acting or behaving in this domain." (Maturana et al. 1980), p. 13). In addition, cognitive domain of an autopoietic system is defined as the domain of all the interactions in which it can enter without loss of identity (Maturana et al. 1980), p. 119). Therefore, knowledge is not an object that may be captured, packaged, processed and distributed. Rather, it is an embodied notion.

Moreover, the concepts of structural coupling and consensual domains provide the bridge between the cognition of the individual and the patterned behaviors that are often described as 'organizational knowledge' (Kay et al. 2005)..

As discussed in the previous section language is viewed as an example of social structural coupling that generates the self and creates *meaning* through interactions with others. According to theory of autopoiesis "it is by languaging that the act of knowing, in the behavioral coordination which is language, [which] brings forth a world" (Maturana et al. 1992)(p. 234). In other words, meaning arises as pattern of relationships among the linguistic distinctions done by firm's members through the process of languaging.

In this context "languaging" refers to "the process in which language is not only maintained but is constantly being developed based on previous language" (von Krogh et al. 1994), p. 61). Organizational languaging, therefore, means *word choice in usage*, the process by which meaning emerges as a relationship between and among the various linguistic descriptions (distinctions) that actually used by members of the organization during their interaction with themselves or with external entities. Moreover, organizational languaging covers two domains: writing and conversations (von Krogh et al. 1995).

A PRELIMINARLY DESIGN THEORY FOR AUTOPOIETIC KMSS (AKMSS)

Table (1) summarizes the components of an information system design theory (ISDT).

AKMSS Meta-Requirements

One of the implications of theory of autopoiesis is that organizational knowledge

Table 1. Components of an information system design theory (ISDT) (Walls et al. 1992b)

Design Product	
1. Meta-requirements	*Describes the class of goals to which the theory applies.*
2. Meta-design	*Describes a class of artifacts hypothesized to meet the meta requirements.*
3. Kernel theories	*Theories from natural or social sciences governing design requirements.*
4. Testable design product hypotheses	*Used to test whether the meta-design satisfies the meta-requirements hypotheses.*
Design Process	
1. Design method	*A description of procedure(s) for artifact construction.*
2. Kernel theories	*Theories from natural or social sciences governing design process itself.*
3. Testable design process	*Used to verify whether the design method results in an artifact which hypotheses is consistent with the meta-design.*

is an embodied (enactive) notion and it cannot be treated as an object. Furthermore, it indicates the crucial role played by languaging in creating and sharing new knowledge. This perspective implies that KMSS can be best conceptualized as "an additional medium through which interlocking behaviors may converge and the congruities of context, that give rise to consensual domains" (Kay et al. 2005). Therefore, the meta-requirements of autopoietic KMSS can be stated as follows:

- An AKMSS should support organizational knowledge evolution and sharing through organizational languaging.
- An AKMSS should support the two aspects of organizational languaging: writing and conversations.

AKMSS Meta-Design

One of the implications of autopoietic "structural determination" principle is that the same environmental stimuli are perceived differently by different firm's members. Therefore, each member develops a repository of tacit personalized knowledge that allows him/her to make sense of reality. Such personalized knowledge can be *partially* described in terms of a "personal ontology". According to Gruber (Gruber 1993) an ontology is *an explicit specification of a conceptualization of a domain*. Therefore, changes to any of the three elements in the definition can cause changes in an ontology: (1) changes in the domain, (2) changes in conceptualization, or (3) changes in the explicit specification (Noy et al. 2002). Furthermore, such changes (ontology evolution) frequently occur in a distributed environment through interactions among different firm's members over different contexts (Bouquet et al. 2003). Therefore, the class of artifacts that meet the meta- requirements of AKMSS is:

- A set of firm's members (stakeholders) evolving personal ontologies.

AKMSS Design Method

Beside the evolution of firm's members (stakeholders) personal ontologies caused by their interactions, these interactions can result in merging or aligned personal ontologies. In merging, a single ontology that is a merged version of the original ontologies is created. Often, the original ontologies cover similar or overlapping domains. In alignment, the two original ontologies persist, with links established between them.1 Alignment usually is performed when the ontologies cover domains that are complementary to each other (Noy et al. 1999). Therefore, the design methods of AKMSS are:

- Personal ontologies creation, evolution, merging and alignments methods.

CONCLUSIONS

We contend that the theory of autopoiesis, as a system-grounded way of thinking with biological foundations, can be useful as one of the kernel theories for both of "design product" and "design process" aspects of KMSS's design theory. There are several implications for the KMSS development process deriving from our theoretical orientation. First, organizational knowledge is an embodied (enactive) notion and it cannot be treated as an object which can be captured, packaged and processed. From this perspective, organizational knowledge is nothing but a "purposeful coordination of action" while what is called explicit knowledge (symbolic knowledge representations or information) is the symbolic description of action (Zeleny 2005). Second, the role of "languaging" in creating new knowledge is emphasized. Third, the conceptualization of KMSS as the medium in which the organizational languaging can be realized is introduced.

REFERENCES

Abou-Zeid, E. "A Knowledge Management Reference Model," *Journal of Knowledge Management* (6:5) 2002, pp 486-499.

Alavi, M., and Leidner, D. "Knowledge Management Systems: Issues, Challenges, and Benefits," *Communication of the AIS* (1:7) 1999, pp http://cais.isworld.org/articles/1-7/.

Araujo, L. "Knowing and Learning as Networking," *Management Learning* (29:3) 1998, pp 317-336.

Augier, M., and Vendela, M. "Networks, Cognition and Management of Tacit Knowledge," *Journal of Knowledge Management* (3:4) 1999, pp 252-261.

Bednarz, J. "Autopoiesis: the Organizational Closure of Social Systems," *System Research* (5:1) 1988, pp 57-64.

Boland, R., and Tenkasi, R. "Perspective Making and Perspective Taking in Communities of Knowing," *Organizational Science* (6:4) 1995, pp 350-372.

Boland, R., Tenkasi, R., and Te'Eni, D. "Designing Information Technology to Support Distributed Cognition," in: *Cognition Within and Between Organizations,* J. Meindl, C. Stubbart and J. Porac (eds.), Sage Publications, 1996, pp. 245-280.

Bonifacio, M., Bouquet, P., and Traverso, P. "Enabling Distributed Knowledge Management: Managerial and Technological Implications," *UPGRADE* (III:1) 2002, pp 24-30.

Bouquet, P., van Harmelen, F., Giunchiglia, F., Serafini, L., and Stuckenschmidt, H. "C-OWL: Contextualizing Ontologies," 2nd International Semantic Web Conference, Sanibel Island, Florida, (USA), 2003, pp. 164-179.

Collins, H. "The TEA Set: Tacit Knowledge and Scientific Networks," *Social Studies* (4) 1974, pp 165–186.

Collins, H. "The Structure of Knowledge," *Social Research* (60:1) 1993, pp 95-116.

Gruber, T. "A Translation Approach to Portable Ontology Specification," *Knowledge Acquisition* (5) 1993, pp 199-220.

Hahn, J., and Subramani, M. "A Framework of Knowledge Management Systems: Issues and Challenges for Theory and Practice," 21st International Conference on Information Systems, Brisbane, Australia, 2000, pp. 302-312.

Hildreth, P.J., and Kimble, C. "The Duality of Knowledge," *Information Research* (8:1) 2002, pp Available at http://InformationR.net/ir/8-1/paper142.html.

Hirschheim, R., Klein, H., and Lyytinen, K. *Information Systems Development and Data Modeling: Conceptual and Philosophical Foundations* Cambridge University Press, 1995.

Hislop, D., Newell, S., Scarbrough, H., and Swan, J. "Innovation Processes and the Management of Knowledge," BPRC Conference on 'Knowledge Management: Concepts and Controversies', University of Warwick, Coventry, United Kingdom, 2000, p. http://bprc.warwick.ac.uk/km003.pdf.

Kay, R., and Cecez-Kecmanovic, D. "Organizational Knowledge & Autopoiesis: Implications for Knowledge Management," Systems Thinking and Complexity

Science: Insights for Action, 11th Annual ANZSYS Conference/Managing the Complex V, Christchurch, New Zealand, 2005, pp. http://www.isce.edu/ISCE_Group_Site/web-content/ISCE%20Events/Christchurch_2005/Papers/Kay_Goldspink.pdf.

Lamb, R., and Kling, R. "Reconceptualizing Users as Social Actors in Information Systems Research," *MIS Quarterly* (27:2) 2003, pp 197-235.

Malhotra, Y. "Why Knowledge Do Management Systems Fail? Enablers and Constraints of Knowledge Management in Human Enterprises," in: *Handbook on Knowledge Management 1: Knowledge Matters,* C.W. Holsapple (ed.), Springer-Verlag, Heidelberg, Germany, 2002, pp. 577-599.

Markus, M., Majchrzak, A., and Gasser, L. "A Design Theory for Systems that Support Emergent Knowledge Processes," *MIS Quarterly* (26:3) 2002, pp 179-212.

Maturana, H., and Varela, F. *Autopoiesis and Cognition* Reidel, Dordrecht, 1980.

Maturana, H., and Varela, F. *The Tree of Knowledge: The Biological Roots of Human Understanding (Revised Edition)* Shambhala, Boston, 1992.

Mingers, J. "Information and Meaning: Foundations for an Intersubjective Account," *Information Systems Journal* (5) 1995, pp 285-306.

Mingers, J. "Embodying Information Systems: The Contribution of Phenomenology," *Information and Organization* (11:2) 2001, pp 103–128.

Nidumolu, S., Subramani, M., and Aldrich, A. "Situated Learning and the Situated Knowledge Web: Exploring the Ground Beneath Knowledge Management," *Journal of Management Information Systems* (18:1) 2001, pp 115-150.

Noy, N., and Klein, M. "Ontology Evolution: Not The Same As Schema Evolution," SMI-2002-0926, Stanford Medical Informatics.

Noy, N., and Musen, M. "An Algorithm for Merging and Aligning Ontologies: Automation and Tool Support," Proceedings of Sixteenth National Conference on Artificial Intelligence (AAAI-99), Workshop on Ontology Management, AAAI Press, Orlando, FL, 1999, pp. 17-27.

Pan, S., and Scarbrough, H. "Knowledge Management in Practice: An Exploratory Case Study," *Technology Analysis & Strategic Management* (11:3) 1999, pp 359-374.

Polanyi, M. *The Tacit Dimension* Peter Smith, Gloucester, Massachusetts, 1983.

Sierhuis, M., and Clancey, W. "Knowledge, Practice, Activities and People," AAAI Spring Symposium on Artificial Intelligence in Knowledge Management, Stanford University, 1997, pp. 142-148.

Swan, J., Newell, S., and Robertson, M. "Limits of IT-driven Knowledge Management Initiatives for Interactive Innovation Processes: Towards a Community-Based Approach," HICSS-33, IEEE Press, Maui, Hawaii, 2000.

Tsoukas, H. "The Firm as a Distributed Knowledge System: A Constructionist Approach," *Strategic Management Journal* (17:(Winter Special Issue)) 1996, pp 11-25.

Varela, F. "Whence Perceptual Meaning? A Cartography of Current Ideas," in: *Understanding Origins: Contemporary Views on the Origin of Life, Mind and Society,* F. Varela and J. Dupuy (eds.), Kluwer Academic, Dordrecht, 1992, pp. 235-263.

von Krogh, G., Ichijo, K., and Nonaka, I. *Enabling Knowledge Creation: How to Unlock the Mystery of Tacit Knowledge and Release the Power of Innovation* Oxford University Press., 2000.

von Krogh, G., and Roos, J. *Organizational Epistemology* St. Martin's Press, New York, 1995.

von Krogh, G., Ross, J., and Slocum, K. "An Essay on Corporate Epistemology," *Strategic Management Journal* (15) 1994, pp 53-71.

Walls, J., Widmeyer, G., and El-Sawy, O. "Building an Information System Design Theory for Vigilant EIS," *Information Systems Research* (3:1) 1992a, pp 36-59.

Walls, J.G., Widmeyer, G.R., and El Sawy, O.A. "Building an Information System Design Theory for Vigilant EIS," *Information Systems Research* (3:1) 1992b, pp 36-59.

Wand, Y., Monarchi, D., Parsons, J., and Woo, C. "Theoretical Foundations for Conceptual Modelling in Information Systems Development," *Decision Support Systems* (15:4) 1995, pp 285-304.

Wasko, M. "How are Knowledge Management Systems Different from Information Systems, and Who Cares?," The Americas Conference of Information Systems, Milwaukee, WI, 1999, pp. 486-488.

Zeleny, M. "Knowledge-Information Circulation Through the Enterprise: Forward to the Roots of Knowledge Management," *Lecture Notes in Computer Science* (3327) 2005, pp 22-33.

Metacognition and Its Role in the Development of Team Competencies

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ABSTRACT

When graduates now enter the professional workplace, their ability to work as effective team members will contribute much to their immediate levels of productivity. Various types of group work are already being incorporated into higher education pedagogies with the stated intention of preparing students for modern workplace environments. Yet preparing for such an important vocational skill is not always so enthusiastically embraced by students. Many students openly state that they do not like working in groups because they believe that they can achieve better outcomes on their own. We investigate in this paper the metacognitive processes that students might engage in to help explain why group activities in an academic environment may be so unpopular.

Keywords: Team work, metacognition, pedagogy, team-learning

INTRODUCTION

There has never been a greater need for mastering team learning in organizations, as team learning will be a critical step in building learning organizations:

"Team learning is vital because teams, not individuals are the fundamental learning unit in modern organizations", (Senge, 1992, p10*).*

Within institutes of higher education, the incorporation of various types of group work into pedagogies is already widespread, yet many examples fail to embrace a rationale for, or the potential benefits of, multiple contributor environments essential in a knowledge intensive society. While perhaps being an ideal candidate to capitalise on the benefits of knowledge sharing behaviours, higher education has generally not realised its potential. The teaching of team learning extends beyond commonly used approaches merely requiring students to produce a report in which they can adopt a jig-saw approach (Biggs 2003) where each individual places their piece in the final task or puzzle.

One high performing post-graduate student recently summarised the apparent view of many when he commented in an email on 3 October 2006:

"My honest opinion is that the way in which we as students are encouraged to work in teams has little or no relevance to the 'real world' (whatever that is) that this university is preparing us for."

It would appear that collaborative learning as a group approach, as distinct from cooperative learning, continues to monopolise the intention of teaching students to learn to work with others, a goal synonymous with team learning. The emergence of newer online learning approaches such as 'intergroup collaboration' still emphasises knowledge access as distinct from knowledge sharing (Palloff & Pratt 1999), dependant on the co-production of knowledge, which itself is dependant on particular contexts or environments in which learning is socially situated (Brown, Collins, & Duguid 1989).

Group work does have a place in learning as one strategy which develops particular skills such as communication, and providing avenues to practise small and discrete skills. In contrast, however, team learning is a significant approach to knowledge sharing which harnesses the synergy of collective knowledge.

Data collected recently from students undertaking various IT degree courses indicated that they were aware of individual qualities that might contribute to team competencies, ably nominating several (Jewels & Ford 2006). However, their ability to apply those qualities was questionable, with many claiming they did not really understand how to be a successful contributor to sustain a team outcome, and particularly how to function in a high performance team. This not only applies to students, it reflects the real world as noted by Katzenbach & Smith (1993).

Knowing what students know about themselves when functioning in the social-cognitive context of teams, and how they monitor this, provides insight into the development of a theory of team learning and a significant contribution to taxonomy of team competencies.

A better understanding of how individuals function in teams, and how teams can learn together would appear to have some important practical benefits.

"Until we have some theory of what happens when teams learn (as opposed to individuals in teams learning) ... Until there are reliable methods for building teams that can learn together, its occurrence will remain a product of happenstance", (Senge, 1992, p238).

While others have described ideal team practices and how team building can be encouraged, as yet no-one has developed a theory. To advance the teaching of team learning and its inherent shared knowledge, a conceptual framework is required; one that will embrace the synergy and energy created when individuals aspire to excellence and are intrinsically motivated to accept challenge in dealing with conflict, in order to arrive at new knowledge.

Extending on previous works by Jewels & Albon (2006, 2007), this paper specifically examines the contribution of metacognition in identifying the basis for a theory of acquiring team competencies, beginning with the identification of the metacognitive processes students employ to function either in working groups or higher performing teams. The authors believe that information provided to the following question will assist to advance a theory: What metacognitive strategies do students use to know how to work competently in teams?

Senge (1992) describes the types of teams that we are discussing:

"...where new and expansive patterns of thinking are nurtured, where collective aspiration is set free, and where people are continually learning how to learn together", (p3).

Working in a team for students may be seen merely as working in a group, a situation in which they use familiar habits of doing things at the expense of being metacognitive about functioning differently. It may be that because the context involves planning and committing effort to receive a mark and eventually a grade for the unit/subject, in difference to the real world of projects, that theories of motivation are also needed in developing a theory of team learning.

There are many examples of group work currently being conducted within institutes of higher education that appears not to reflect team work at all, but is only characteristic of the poorest of the five levels of group/team performances that is described by Katzenbach & Smith (1993), where effective knowledge management practices are unlikely to occur. A taxonomy, synthesising works

Table 1. Taxonomy for the assessment of team competency maturity (Jewels & Albon, 2006)

Levels of Group/ Team Maturity	Examples of Competency		
	Individual	Team	Organisational
Working Groups	Individuals are only nominally a group coming together to report on individual progress.	Members help each other at a peripheral level in the belief that each member can best perform for the group by working individually.	The organisation only expects group members to provide individual inputs. Tendency to reward individual not group performance.
Pseudo Teams	Psychologically members know they must contribute to team output but cannot see beyond their own view & perspective.	Members know their contribution must interact in the final product and so are prepared to assist each other. Effort is made to listen to and respond to each other.	Explicit acknowledgement of value of teams but no resources or incentives given for team output.
Potential Teams	Members recognise their individual responsibilities but yet to recognise team responsibility.	Members recognize personal skills and those of others; are aware how these can contribute to the success of the team project; have nominated strategies but lack collective accountability.	Support given for overall team performance but lack of acknowledgement of the individual's team responsibilities.
Real Teams	Prepared to up-skill and do additional work as part of accountability to team.	Members hold themselves mutually accountable for the projects direction, development and outcome.	Support and resources given to teams and the individuals in them for current work.
High Performance Teams	Members recognise each others strengths and weaknesses and how the final project can be shaped by these factors.	Members all deeply committed to each others personal growth and success. Contribute so member's contributions are optimised for the collective good.	Support provided to teams and individuals for personal growth that is focussed towards current and future work.

from Katzenbach and Smith, Barnett, and Frame, developed by Jewels & Albon (2006), (Table 1) enables group or team work to be defined and in turn enables educators to set criteria for assessments in accordance with the expectations of each team description or level.

METACOGNITION

Metacognition, a term originally associated with John Flavell (1979), is often referred to as '*thinking about thinking*'.

"Metacognition refers to one's knowledge concerning one's own cognitive processes or anything related to them, e.g., the learning-relevant properties of information or data", (Flavell, 1979, p232).

Metacognition and its inherent internal monitoring of thinking, 'cognitive processes, knowledge, cognitive and affective states, and the ability to consciously and deliberately monitor and regulate' (McCaslin 2004, p279), has a significant role to play in the development of team competencies and their successful application in challenging and complex assessments in higher education contexts.

Most of the research on metacognition has focussed on cognitive factors with little to no studies conducted on social influences on learning (McCaslin, 2004). Flavell (1971) recognised that knowledge of others influenced an individual's thought processes and behaviour. He identified that one monitors one's behaviour in response to differing social contexts. A clear example is the control of people's language in differing social groups or situations: with mates, with the Vice Chancellor, parents or the court room.

Levine, Resnick, & Higgins (1993) have called for more research in understanding cognition in the real world in which *'emotions, social meanings, social intentions and social residues'*, (p64) are inter-related with cognitive activity. Functioning successfully in teams is one such activity which demands we teach students how to understand and monitor themselves, if they are to participate productively in the future world of work, either through implicit structures and behaviours or through direct instruction. Being better informed about what students understand about team performance and its inherent competencies, and also how students might adapt to working in teams, will contribute to enhancing the taxonomy of team competencies originated by Jewels & Albon (2006, 2007).

In contrast to the typical metacognitive instruction used by learners to help them monitor and control effectiveness in learning and problem solving behaviour, this research extrapolates ideas and principles from Lin, Schwartz, & Hatano (2005) and their adaptive metacognition (AM) developed for teachers. AM *'involves both the adaptation of oneself and one's environment in response to a wide range of [classroom] variability'*, (p245). In a similar way to the action of teaching, in which new and novel problems and situations present themselves, interacting successfully in teams as an integral member also requires individuals to move beyond habit and routine and take on adaptive behaviour. This is in contrast to existing and usual research which has focussed only on individualistic approaches to metacognitive thinking, where problems or needs are clearly defined, environments are stable, and learners are responsive. AM posits that the teaching environment and therefore this current research on the individuals who make up teams that *'problems are ill-defined, and involve a variety of values that may not be in complete harmony'*, (p247). The team member handles *'many interacting factors simultaneously that often cannot be neatly decomposed and treated one at a time',* Lin et al. (2005, p248), and *'reflects on their values and the consistency between their own values and those of other members…to guide them towards an acceptable solution'*, (p248).

CONTRIBUTION FROM MOTIVATIONAL THEORIES

Self-determination theory (Reeve, Deci & Ryan 2004) raises the issue of the sociocultural forces that support autonomy, competence, and relatedness. Do students perceive the learning environments of universities to value collectivist ideas and solutions? Team allegiance and team cohesion is fundamental to high performance teams but what is the thinking related to achieving this outcome by students? What is the baseline of thinking and behaviour from whence change

will come? Student's behaviour in a team will be affected by the way they think they are expected to behave, or need to perform as a team member. Students perceive themselves to have a defined role – that of the student as established by institutions. When placed in teams, this familiar role is challenged, leaving them unsure how to behave so as to maximize outcomes for the team and develop an 'egoless' team (Weinberg 1971). To realise the potential of teams, academics need to articulate and maintain a strong performance ethic within the university context, such as providing for flexible learning, being available for consultation through various means, providing flexible consultation perhaps through online programs, reviewing timetables, providing meeting rooms or spaces and facilities as well as developing a mind set of teams (Figure 1).

McClelland (1961) cited in Maehr & McInerney (2004) suggested that achievement behaviour was comprised of four distinct but related elements:

- competition with a standard of excellence,
- affective concern for goal attainment,
- an evaluation of performance, and
- some standard for the attainment of a long-term goal.

It is assumed these same four elements also apply to teams, because it is the team who is now motivated to function and work as one. Functioning in this way would also appear to challenge notions of the self, and the self as student who aspires to passing the unit/course. It is further assumed, as noted by Katzenbach & Smith (1993), that if companies with strong performance standards spawned real teams (Table 1), then team members must think about standards, leading to the following questions:

- How do students determine themselves to be self-competent and valuable contributors in team work assessments?
- What is their criteria, and how do they measure and monitor their personal performance?
- Do students think about their behaviour and its impact on the success or failure of the group to achieve shared goals? If so, what questions or attributions do they make?

When we know more about students' thinking, we can take positive steps to assist them acquire self-competence. Davidson, Jaccard, Triandis, Morales, & Diaz-Guerrero (1976), with their etic-emic personal investment model, cited in McInerney & Van Etten (2004), highlighted the conflict an individual has between behaving through habit (adaptive behaviour) and behaving through conscious intent. Teams take the risks associated with conflict and team members deal with the conflict – but how? Intent is affected by larger macro-environment of the institution, lecturer expectations, team member expectations and perceived value of these to the behaviour. The student's normative beliefs affect their intent to behave in the group environment, but again, how are these applied and when?

Goal theory (Schunk 2000), identifies why students want to be successful and translates to why and how students intend to be successful in team work. Identifying metacognitive strategies associated with ability orientations, task orientations or social orientations will assist in developing a taxonomy of competencies for each of the team levels (Table 1). That is, if students metacognitive thoughts focus on gaining social approval, respect or recognition from their team peers, then they are making an effort to conform with social norms. Alternatively a lack of effort may be felt by disapproval and rejection from other team members. Identification of these normed behaviours and how they are established will assist in focusssing teaching on students' acquisition of team competencies associated with group dynamics and successful interaction behaviour. In contrast, if students' metacognition reflects attention to demonstrating competence in the team, this may be at the expense of contributing quality work to achieve team outcomes, further contributing to the competences required for each level of the taxonomy. This is also supported by the self-worth theory of Covington (2004) and human motivation theory of Maslow (1954), cited in Schunk (2000), which state the need and focus on approval and acceptance by others is dependent on how competent one is perceived in the eyes of others.

The sociocultural framework of motivation espoused by McCaslin (2004), provides insight into investigating and interpreting the metacognitive thoughts by students engaged in tasks reflecting the levels of team performance. McCaslin contends that, as tasks become more difficult (higher team levels), they *'require and challenge the integration and enhancement of the affective and the intellectual in the mediation of goal-directed behaviour'*, (p9). Further, *'a focus on peers, shifts attention from the social origins of emergent identity…to a notion of continuous coregulation of activity and consciousness'*, (p9). Obtaining metacognitive thinking about how team member's function in groups or teams should provide insight into understanding the nature of the skills or competencies that concern students.

PEDAGOGICAL IMPLICATIONS

In addition to motivational theories, a teaching model which enables learning in teams, should be selected. Maker & Nielson's (1995) teaching model appears philosophically aligned with the principle of team competencies described by Gilson, Pratt, Roberts, & Weymes 2000; Katzenbach & Smith, 1993; Senge, 1992, providing the initial structure for acknowledging the implicit and intangible features of teams. This model is characterised by four broad non-mutually exclusive categories:

- content,
- learning environment,
- product, and
- process.

The model has numerous specific features, such as complexity, abstractness, mobility, openness and variety which suggest that learning opportunities should be created by centering on complex and abstract content so as to deepen students' understanding of ideas/concepts. This lends itself readily to the management of knowledge where learning is continuous, knowledge is generated and the tolerance and encouragement of initiative is considered significant in students' development of team competency skills. The development of a team-centred approach through this model has the potential to mobilise the efforts of each member to share knowledge, develop shared goals and operate as an effective team.

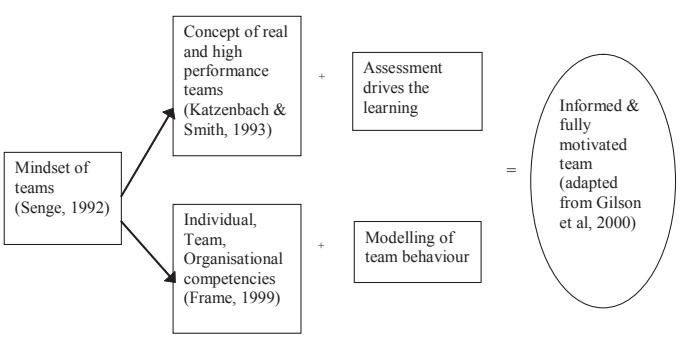
The model also highlights the impact of an open rather than closed approach to learning, necessary when teams search for solutions to problems. The use of acceptance and evaluation in preference to judgement alone further aligns this model to one suitable for the development of team competencies where responding to ideas critically and constructively is essential. The diversity and differences of team members are accepted as the team sharpens its focus on shared purposeful activities, and opportunities for students to learn with non-traditional classroom pedagogies and spaces is nothing short of essential to the development of team competencies for future managers of knowledge. An emphasis on real-audience and real product is central to the new propounded team-centred approach as this culminates the team's synergy, shared knowledge and aspirations for success.

It appears that Maker & Nielson's teaching model complements both the teaching of team competencies and team competency values. We offer it as a framework for educators to create opportunities to teach team competencies within specific curriculum.

A model proposed by Jewels & Albon (2007), (Table 1) highlights three key factors:

- Mindset of teams – real and high performance teams & individual, team and organisation competency,
- Modelling of team behaviour,
- Assessment drives the learning: complex, challenging assessment tasks.

Figure 1. Multi dimensional team competency teaching model



Optimal function of the taxonomy, that is, its eventual use in teaching team competencies at each of the identified levels, is dependent on its expansion, which we argue is obtained through an investigation using metacognition. An analysis of skills will enable categories to be identified and aligned with each level of team.

Although the authors are cognisant of explicit teaching, they value implicit and powerful approaches such as modelling. Following the identification of the social and interpersonal cues, and interpersonal effectiveness to make effective team interactions academics can assist in sensitising all members to achieving and contributing to high performance teams. Of note is the need for students to see the team as accountable for success and equally, failure. It is no longer relevant to be accountable as individuals, but at the same time individuals cannot be loafers. Identifying, through an analysis of student's metacognition, how students monitor their own and others behaviour to arrive at their behaviour in team accountability is important in the development of the team competency taxonomy.

SUMMARY

Traditionally, higher education has predominantly focused at the individual level, even though inroads have been made into student-centred learning and its related group approach. We propose that in order to align more with real-world environments it is also necessary to take into account team competencies in which those individuals operate and to explicitly teach how these team competencies can be realised.

By employing deliberate strategies and making students aware of their conscious behaviour and intent, team competencies may be more readily and consistently acquired. The concept of subordination of the individual goal to that of the team encapsulates the ethos which must underpin the teaching of teams in the higher education contexts, aptly termed team-centred learning as distinguished from teacher-directed or student-centred learning.

University students require more than being physically placed into teams to complete team assessments; they need to learn how to share knowledge. Complex, rich and meaningful assessments force students to draw on the knowledge, attitudes, beliefs of each of its members, and in turn, engage them in the process of learning to be team members and acquire specific team competencies. Performance is the primary objective and the team becomes the means to the end (Katzenbach & Smith, 1993). The discomfort students might feel when they recognise they do not work well in groups is described by Takeuchi & Nonaka (2004):

"New knowledge can also pose a threat to self-image. In order to accommodate new knowledge, people must make changes in themselves – existential changes (Polanyi, 1958) ..... He or she may have to accommodate new routines and technical requirements associated with another line of work. For most of us such a change in work and profession involves a major shift in who we are. Indeed, what we know – and how that affects what we do – is often at the root of personal identity. Because knowledge is so intimately tied to self-image, people often resist anything new. Breaking away from known habits can feel very risky", (p129).

Katzenbach & Smith (1993) state that, *'A demanding performance challenge tends to create a team',* (p3). They note that the drive and need to perform and take up this challenge outweighs other rewards and incentives, and that often potential teams fail to become a team due to the lack of challenge. Academics should therefore set a complex and challenging task beyond the ability of one person to complete if the value of working in teams is to be truly recognised by students.

There are compelling reasons why students need to be equipped to be multi-contributors in the kind of teams required in the future world of work. The research supporting the increased performance when students are explicitly taught how to think using comparisons and reflections paves the way for teaching team competencies in order for students to aspire to and become high performance teams. It is anticipated that problem solving and decision making behaviour would become transparent in addition to instilling a degree of confidence in students. Understanding the metacognitive strategies students use when in any role, particularly those identified by Belbin (1981) will further the development of the competencies for the taxonomy and lay the foundations for a theory on team learning.

REFERENCES

Belbin, R. (1981). *Management Teams: Why They Succeed or Fail*. Oxford U.K.: Butterworth-Heinemann.

Biggs, J. (2003). *Teaching for Quality Learning at University 2nd edition*. Buckingham: Society for Research into Higher Education and Open University Press.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated Cognition and the Culture of Learning. *Educational Researcher, 18*(1), 32-42.

Covington, M. V. (2004). Self-Worth Theory Goes to College: Or Do Our Motivation Theories Motivate?,. In D. M. McInerney & S. Van Etten (Eds.), *Big Theories Revisited. Vol 4 Research on Sociocultural Influences on Motivation and Learning*.. USA: Information Age Publishing.

Davidson, A. R., Jaccard, J. J., Triandis, H. C., Morales, M. L., & Diaz-Guerrero, R. (1976). Cross cultural model testing: toward a solution of the etic-emic dilemma. *International Journal of Psychology, 11*, 1-3.

Flavell, J. H. (1971). First discussant's comments: What is memory development the development of? *Human Development, 14*, 272-278.

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry. *American Psychologist, 34*, 906-911.

Frame, J. D. (1999). *Project Management Competence*. San Francisco, CA: Jossey-Bass.

Gilson, C., Pratt, M., Roberts, K., & Weymes, E. (2000). *Peak Performance: Business Lessons from the World's Top Sports Organizations*. Netley, South Australia: Harper Collins Business.

Jewels, T., & Albon, R. (2006). Teaching Team Competencies. In A. Cartelli (Ed.), *Teaching in the Knowledge Society: New Skills and Instruments for Teachers*. Hershey PA: Idea-Group.

Jewels, T., & Albon, R. (2007). Supporting Arguments for Including the Teaching of Team Competency Principles in Higher Education. *International Journal of Information and Communication Technology Education, 3*(1), 58-69.

Jewels, T., & Ford, M. (2006). The Development of a Taxonomy of Desired Personal Qualities for IT Project Team Members and Its Use in an Educational Setting. *Journal of Information Technology Education, 5*, 285-298.

Katzenbach, J., & Smith, D. (1993). *The Wisdom of Teams*. Boston, MA: Harvard Business School Press.

Levine, J., Resnick, L. B., & Higgins, E. T. (1993). Social foundations of cognition. *Annual Review of Psychology, 44*, 585-612.

Lin, X., Schwartz, D., & Hatano, G. (2005). Toward Teachers' Adaptive Metacognition. *Educational Psychologist, 40*(4), 245-255.

Maehr, L., & McInerney, D. M. (2004). Motivation as personal investment. In D. M. McInerney & S. Van Etten (Eds.), *Big Theories Revisited Vol 4: Research on Sociocultural Influences on Motivation and Learning*. USA: Information Age Publishing.

Maker, C. J., & Nielson, A. B. (1995). *Teaching Models in Education of the Gifted 2nd edition*. Austin TX: Pro-ed.

Maslow, A. (1954). *Motivation and Personality*. New York: Harper.

McCaslin, M. (2004). Coregulation of opportunity, activity, identity in student motivation: Elaboration on Vygotskian themes: In D. M. McInerney & S. Van Etten (Eds.), *Big Theories Revisited. Vol 4 Research on Sociocultural Influences on Motivation and Learning*. USA: Information Age Publishing.

McClelland, D. C. (1961). *The Achieving Society*. Princeton, NJ: Van Nostrand.

McInerney, D. M., & Van Etten, S. (Eds.). (2004). *Big Theories Revisited. Vol 4:Research on Sociocultural Influences on Motivation and Learning*. USA: Information Age Publishing.

Palloff, R. M., & Pratt, K. (1999). *Building Learning Communities in Cyberspace: Effective Strategies for the Online Classroom*. San Francisco, CA: Jossey-Bass.

Polanyi, M. (1958). *Personal Knowledge: towards a post-critical philosophy*. Chicago I.L.: University of Chicago Press.

Reeve, J., Deci, E., & Ryan, R. (2004). Self-determination theory: A dialectical Framework for understanding sociocultural influences on student motivation. In D. M. McInerney & S. Van Etten (Eds.), *Big Theories Revisited. Vol 4: Research on Sociocultural Influences on Motivation and Learning*. USA: Information Age Publishing.

Schunk, D. (2000). *Learning theories: An educational perspective*. Ohio: Merrill.

Senge, P. M. (1992). *The Fifth Discipline: The Art and Practice of the Learning Organization*. Adelaide, Australia: Random House Australia.

Takeuchi, H., & Nonaka, I. (2004). *Hitotsubashi on Knowledge Management*. Singapore: John Wiley & Sons.
Weinberg, G. (1971). *The Psychology of Computer Programming*. New York NY: Van Rostrand Reinhold.

The Power of Informal Networks: A Perspective of Two Studies

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INTRODUCTION

The terms 'dissemination of information', 'information needs', 'information seeking', and 'information sharing' are usually connected with library science. However, these concepts go beyond the field of librarianship. These concepts are now considered elements of 'information behaviour'. Information behaviour has been defined as "the totality of human behaviour in relation to sources and channels of information, including both active and passive information seeking, and information use. Thus, it includes face-to-face communication with others, as well as the passive reception of information" (Wilson 2000: 49). Many organizations provide value for customers by facilitating the dissemination of information. They do so by strategically utilising their knowledge about customers' information seeking and needs, and information and communication technology in support of networks of self-organizing employee teams.

During the 1990s, a number of companies attained dramatic competitive advantage by creating comprehensive, complex communication and information networks. The increasing efficiencies and speed of information and communication technology (ICT) enabled these companies to remain flexible and adaptable to change, and also to make accurate predictions and minimise risk. Tucker, Meyer, and Westerman (1996) explain that the impact of technology on such business organizations has resulted in them being referred to by various names such as "modular", "cluster", "perpetual matrix" or "network" organizations.

In the military, Network Centric Warfare (NCW) is an attempt to translate this business concept of the 1990s into military practice. The NCW has emerged as the umbrella under which the implications of information and communication technologies and the connectivity they enable for military operations and organization, are argued and assessed (Army, 2003). One of the tenets of NCW is that a robustly networked force leads to increased information sharing (Directorate of Future Warfighting 2004). In this paradigm, the focus seems to be on hardware, bandwidth, and electronics, and yet the human, and his or her behaviour within the networked environment, is a crucial element. An important, yet often overlooked aspect, of NCW-related behaviour is information seeking.

The sharing of information lies at the core of NCW[1] — shared information leads to improved quality of information, which in turn leads to enhanced shared situational understanding[2]. The role of information behaviour in NCW is, therefore, paramount. Atkinson and Moffat (2005) state that the sharing of information is based on trust developed through social interaction, and shared values and beliefs. In line with Wilson's (2000) definition of information behaviour, the human, not technology, is the node in such interactions, and this node is more than just a link; it is a bond between the players that has developed from mutual trust. Therefore, a significant component of a person's information environment is the relationships he or she can tap into for various informational needs.

This paper focuses on how people gather and share information in environments characterised by high levels of uncertainty and high tempo. It will draw on the research outcomes of two separate, yet interrelated, studies that highlight the role of informal networks as a crucial source of information. In this sense, the paper looks at information behaviour in the context of the military organization. The understanding of factors impacting on human information behaviour is of particular importance to the military where the speed and quality of decision making in operational situations determines mission effectiveness.

The first study, which investigated Social Learning within the Australian Defence Organisation (ADO), was conducted during 1999 through to 2002 by a research team of the Defence Science and Technology Organisation (DSTO) in Australia. The immediate aim of that research was to understand the issues inherent in building learning, adaptive, and sustainable organizations. The long-term objective, however, was to develop frameworks that would support the development of information systems to guide and enhance organizational learning and facilitate knowledge management. In the context of that study, social learning was defined as learning occurring within a group, an organization, or any cultural cluster and it includes:

- the procedures that facilitate generative learning – learning that enhances the enterprise's ability to adjust to dynamic and unexpected situations and to react creatively to them; and
- the processes and procedures by which knowledge and practice are transmitted across posting cycles, across different work situations and across time (Warne, Ali, and Pascoe 2003).

This paper will refer specifically to the processes and procedures by which knowledge and practice are transmitted as they directly relate to human information behaviour.

The second research project conducted by this same DSTO research team[3], during 2003 through to 2006, focused on the human dimension of future warfighting (HDoFW) and examined broad psychosocial issues that need to be considered to fully exploit NCW and other future operating concepts. Interviews were conducted with one hundred Australian Defence Force (ADF) personnel returned from deployment to the Middle Eastern Area of Operation (MEAO)[4] (HDoFW Research Team 2006).

In both studies predominantly qualitative research methods (semi structured interviews) were used to collect data. In the social learning study, the interviews and ethnographic observations were supplemented by a quantitative survey to collect data and to validate qualitative findings (for full details of the research methodology see Warne, Ali, and Pascoe 2003; HDoFW Research Team 2006). The data was analysed using qualitative software NVivo and Leximancer.

In drawing out the outcomes of these two research projects, this paper focuses on a predominant theme that emerged from our data—that people continue to use social sources as a primary means of gathering and sharing information in high uncertainty and high tempo environments.

INFORMATION SEEKING AND SHARING: FINDINGS OF THE TWO STUDIES

Given the role of information in military organizations and military operations, it is interesting to note that very little research appears to have been conducted on information behaviour in the military[5]. A quick Google search[6] of various terms highlights this point:

Search terms	Results
"Information systems" and "military operations"	5,030, 000
"Information use" and "military operations"	78 600
"Information seeking" and "military operations"	41,400
"Information behaviour" and "Information behavior" and "military operations"	32

These results are especially interesting in light of what information behaviour actually is: "the totality of human behaviour in relation to sources and channels of information" (Wilson 2000: 49).

Given the lure of technology and the current fervour about what it can achieve, a noteworthy point was made by Kruse and Adkins (2005:1) that almost every worthwhile achievement or development is the result of group effort because, after all, humans are born collaborators and social animals. Furthermore, despite the opportunities provided by technology, key elements for innovation and advancement are the sharing of information and knowledge and the willingness to cooperate. In this respect, warfare is no different from other endeavours.

The findings from both of our research studies clearly point to relationships playing a key role in people's behaviours, and it is the quality of their networks of interconnected relationships that determines opportunities for sharing information, or places constraints on information seeking. There are numerous factors that underpin these relationships and, in turn, underpin people's information-seeking and information-sharing behaviours. There are three factors that repeatedly emerged from the research findings: trust, informal networks, and the development of common identity, as shaping human information behaviour. This paper will focus on these factors.

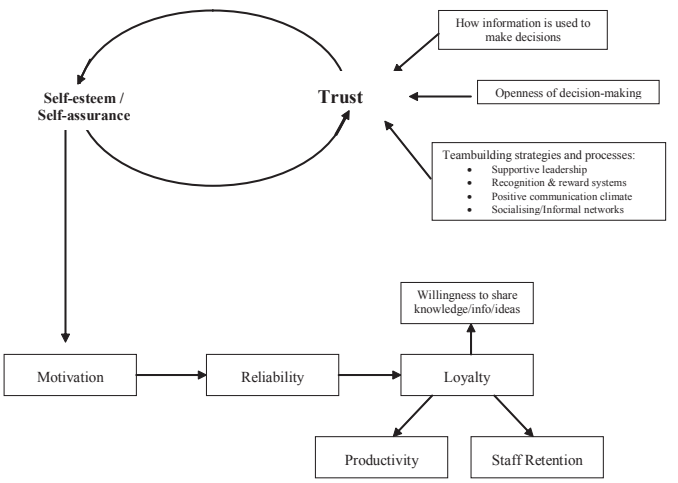
TRUST

Effective and efficient exchange of information underpins the success of military activities because accomplishing military goals, particularly in operational contexts, requires collective action and cooperation. However, in the warfighting context, where information can be highly sensitive and when the potential recipient is largely unknown, individuals are not always willing to provide requested information, or to volunteer information. As might be expected, therefore, trust building was seen by most study participants, in both of our research projects, as an essential activity for information sharing.

The term 'trust' generally refers to positive expectations held by one party (individual or group) about the actions or intent of another when there is some degree of risk involved. For example, Mayer, Davis, and Schoorman (1995:712) define trust as "the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party".

In other words, we trust another person to the extent that we believe they will act beneficially (or at least not detrimentally) towards us if we choose to engage them in some form of cooperation and when cooperating involves some degree of risk (see Gambetta 1988; Mayer, Mollering, Bachmann, and Lee 2004). Thus, trust is especially relevant when there is uncertainty or ignorance as to the motives and actions of others. When these can be predicted with absolute certainty, trust is not required. When they cannot, as in most 'real world' circumstances, a degree of trust is necessary to make human action and interaction possible (Simmel 1964; Costigan, Ilter, and Berman 1998; see also Ali et al 2004).

Figure 1. The role of trust in organizations



In both of research studies, our participants identified trust as critical to Australian-US/coalition cooperation and jointness within the ADF. In fact, trust was one of the most frequently mentioned factors in the HDoFW study. People spoke about trust as the glue that kept human networks and interconnections aligned and it was also seen as an underlying foundation for collaboration:

... if you can build up a rapport very quickly and get to know them and they get to trust you and you trust them, it becomes a lot easier...

The findings of our research into social learning revealed that employees who were feeling assured about themselves and their value to the organization were more likely to be motivated, reliable, and to have loyalty to the organization. Of importance here is that our interviews and observations clearly highlighted that the willingness to share information, knowledge and ideas with others is precipitated from this loyalty (as is higher productivity and higher staff retention). These relationships are depicted in Figure 1 below (Ali et. al, 2002).

COMMON IDENTITY

Studies into the impact of information sharing on various aspects of organizational life suggest that information sharing promotes common identity and mutual trust (eg, Schein 1993 and Phillips 1997). Interestingly, our study findings into social learning in military organizations (Ali et al. 2002; Warne, et al. 2003) indicate that it is common identity and trust that foster willingness to seek and share information. In line with systems thinking (Senge, 1992), common identity requires a shift from seeing ourselves as separate to seeing ourselves as connected to, and part of, an organization or its sub-units.

For NCW, developing common identity is an important issue because the core effort of NCW is to develop and distribute superior situational awareness, common understanding of the commander's intent, and common identity to synchronise operations and activities (Ahvenainen 2003). In the HDoFW study the extent to which developing a common identity impacted on information sharing was well illustrated by looking at the role of embedded, liaison or exchange officers (HDoFW Research Team 2006). Our interviewees frequently spoke of the critical role played by liaison, exchange, or embedded personnel. Whilst the presence of these personnel was vital in many ways, most important was their role in the provision of information and the development of situational awareness. For example, many of our interviewees spoke of how ADF personnel embedded in US Headquarters became critical nodes in the ADF's understanding of US plans and activities.

Likewise, having US personnel embedded in ADF Headquarters paid similar dividends in terms of information behaviour and, in turn, interoperability. The following account of the value added of having an American officer embedded within a RAAF unit illustrates this point:

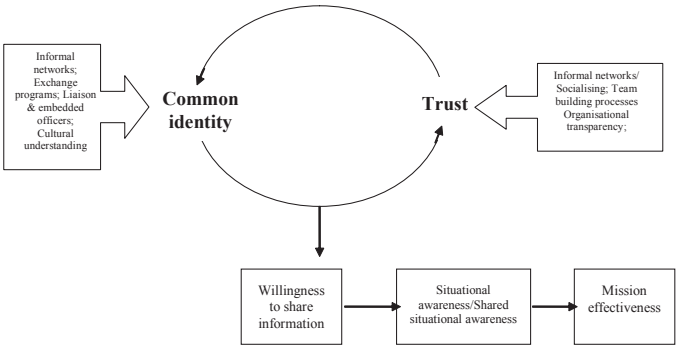
He knew our system. He knew what we didn't know about working with an American wing in combat. So he was kind of critical to helping the guys through the labyrinth of what's different...the exchange positions are absolutely critical to your interoperability.

As common identity grew, through fostering of informal networks by exchange or embedded personnel, the access to information and other resources became more available:

...our American officer ... was working hand in hand with us all day, every day, and he literally became part of the Australian team – [these] personal relationships that allowed us to get pretty much what we needed.

Specifically, achieving 'seamless' interoperability necessitated a more sophisticated form of interaction. In describing this, one of the interviewed officers drew a sharp distinction between 'liaison' and 'embedded' personnel:

Figure 2. The role of trust and common identity for mission effectiveness



…the value of having not liaison officers, but embedded staff officers in an international headquarters…[is that they] develop an intimate knowledge of the American and British planning processes, the way they execute an operation. And having that knowledge meant that we could integrate directly into their team…as opposed to being someone who sat in the back of the office and answered questions.

These examples clearly show that developing common identity, relationships, and trust paves the way for information and other resource sharing. This is particularly important in operational or disaster situations where information is critical to decision making and actions that follow.

Figure 2 provides a diagrammatic representation on the relationship between trust and common identity (which our data suggests is a recursive one), and the impact on willingness to share information via the development of common understanding. Figure 2 also depicts that information and knowledge sharing enhances shared situational awareness, which in turn impacts on decision making and ultimately on mission effectiveness.

INFORMAL NETWORKS

The HDoFW interview data clearly indicates that in addition to the formal networks provided by exchange or embedded officers programs, the informal networks that people established were crucial in the development of trust and common identity. They also provided a further set of conduits for information seeking and sharing (HDoFW Research Team 2006).

i. The Role of Socialising in Building Informal Networks

In both our studies, almost all the interviewees said that establishing a personal connection was crucial for a productive working relationship and for trust building. Scholars use the term *social capital* to refer to human relationships that make organzations work effectively. They explain that healthy social relationships in organizations build trust, make people learn faster and be more productive and creative (Prusak et al 2001; Ehin 2004). Of importance here is that our interviewees reported that the sharing of information was sometimes impeded by a lack of trust arising from barriers associated with rank, position, service or force affiliation, and the perceived expectations that go with those barriers. Therefore, discovering non-work related commonalities allowed them to relate to each other on more than an instrumental basis. Socialising was perceived as a vehicle for developing wider networks, and therefore it enabled people to get to know each other.

...even with the little bit of rapport that we had, the results were astounding … The socialisation did contribute a lot to the success of our mission.

In the social learning study, the majority of respondents indicated that work-related social activities lead to a greater sense of team spirit and thereby positively contributed to the willingness of information exchange. These social activities were not seen as frivolous functions but as core activities that are ultimately task-oriented. As one of the respondents put it:

…it is important and we do, we have time out where we go for coffee and to chat, it's team building and getting to know each other, and I think that's really important because you need to get to know the personalities on your team….We talk about work things when we're having coffee, but it's joking and fun.

Informal social gatherings were seen by both studies' participants as an opportunity to get to know each other, build trust and stronger relationships and, more importantly, share knowledge. Many interviewees told us that during such informal social gatherings they learn more about what is happening in other areas of the organization than though formal channels, and they increase their matrix of informal connections, as illustrated by the following quote:

…social gatherings are necessary because they provide an opportunity for face-to-face talking and to find out what are the important issues on people's minds at the moment….If you didn't have those social gatherings, you would just see the range of issues that they were dealing with, but you wouldn't really know what was important to them or what they were particularly worried about…

The participants in both of our studies pointed out that developing these connections and networks paid dividends in promoting interpersonal trust and paved the way for subsequent information and resource sharing:

So I'd go up and have a chat with them and then I'd find out more of what they did. So when the boss would come up and say, "Look, you know, we need to know about this and this",[so I'd say]"Yeah, I know this guy …

ii. The Role of Informal Networks in Managing Handovers

In the military, frequent changes in postings and job rotation are natural occurrences. How quickly and effectively a new person assimilates into a new job is, to a large degree, determined by the quality of the handover. Our interviewees said that during handovers they were not after 'procedural things' as these are fairly standard; instead they were after

…getting to know and getting to feel what the organisation is, who the personalities are, and really getting a feel for the culture in the organisation…

When personnel were asked what they look for during a handover, the frequent answer was a list of contacts that one officer can pass to another. This 'invisible college' provided a trusted source of information for things which do not appear in organizational charts or in formal policies and procedures. These informal networks cut through formal reporting procedures and could jump start many initiatives. Additionally, they were seen as essential for day-to-day business and for information and knowledge sharing. Those who did not get the chance for a handover relied heavily on informal networks and contacts for pre-deployment information gathering and to find out as much as possible about their posting and what might lie ahead.

…from an informal process. A friend of mine - I was taking over from a friend of mine, who was already there, so I rang him over there to find out exactly what was going on…

The results of both our studies clearly indicate that tasks were accomplished more efficiently as a result of the informal networks of relationships that were formed across functional groups, multinational forces and agencies. Furthermore, these informal networks enhanced the quality and timelines of shared information which, in turn, contributed to overall mission effectiveness.

CONCLUSIONS

Military operational environments and emergency management require that critical and timely information comes from known and trusted sources. Information seeking, therefore, is a prominent and crucial activity in any military operation and more so in a NCW environment because of the reliance on timely and relevant

information for individual and team situational awareness. Although technical developments in information and communication technology facilitate speedier and wider sharing of information, they do not reflect the information seeking behaviour that people engage in.

The results of our studies demonstrate that information sharing and people's willingness to disclose information is shaped by the building of trust and the development of common identity that occurs through informal networks and relationships. This research points to the informal networks being a precursor for development of trust and common identity. In addition, analysis of numerous disasters that occurred in the last few years demonstrate that quality of response depends not so much on quality of planning or even equipment, but on the quality of human networks that are formed to provide relief (Denning 2006).

The effectiveness of military operations, or for that matter management of any emergency situation, requires collaboration between many players. A shift from co-existence to cooperation cannot occur without informal networks since it is through these networks that trust and common identity are cultivated. And the result is not only more coordinated planning, but also a greater pool of knowledge to draw upon. Therefore, the power behind informal networks and the significance of human interaction for information sharing and gathering must be taken in account in the planning of communication strategies in military settings. More research into this area is still needed to fully understand why typical 'command-and-control' approaches and technological solutions do not always provide the desired result.

Although the research subjects and settings are military, the study findings have much wider applications. Organizations that need to quickly respond to a changing environment need to harness the knowledge of many diverse players and in doing so must not underestimate the power of informal networks for information and other resource sharing. There is a need to better understand what gives rise to such networks and how to facilitate their functioning without sabotaging formal plans and decisions. Furthermore, the implications of this research for any organization are that it is essential to understand human information behaviour first and how people use technology before investing into technological solutions.

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REFERENCES

Ahvenainen, S. (2003). "Backgrounds and Principles of Network-Centric Warfare", Course of Network-Centric Warfare for Post-Graduate Students, National Defence College.

Ali, I., Pascoe, C., Warne, L. (2002) "Yet Another Role for Team Building and Work Motivation - Enabler of Knowledge Creation and Knowledge Sharing", In proceedings of the 7th International Command and Control Research and Technology Symposium, Québec City, 16th to 20th September, 2002, Tracks/pdf/119.PDF, http://www.dodccrp.org/Activities/Symposia/7thICCRTS/

Ali, I., Warne, L., Bopping, D., Hart, D., & Pascoe, C. (2004). "Organisational Paradigms and Network Centric Organisations", *Journal of Issues in Informing Science and Science and Information Technology, 1,* 1089-1096

Army, Department of Defence. (2003). *Network Centric Warfare - The Army Approach* DRAFT. Canberra, Army. Dept. of Defence

Atkinson, S., & Moffat, J. (2005). *The Agile Organization*. Washington, DC: CCRP Publication Series.

Costigan, R. D., Ilter, S. S., Berman, J. J. (1998) "A Multi-Dimensional Study of Trust in Organizations". *Journal of Managerial Issues,* 10**,** 303-317.

Cross, R., & Parker, A. (2004). *The hidden power of social networks.* Boston: Harvard Business School Publishing Corporation.

Daft, R. L. and A. Y. Lewin. (1993). "Where are the theories for the 'new' organizational forms? An editorial essay", *Organization Science* **4**(i-vi).

Denning, Peter (2006) "Hastily formed networks", *Communications of the ACM*, 49(4).

Directorate of Future Warfighting (2004), *Enabling Future Warfare: Network Centric Warfare*, ADDP-D.3.1. Canberra, Australia. (March) ISBN: 0-642-50184-X.

Ehin, C (2004) "Hidden Assets: harnessing the power of informal networks", Springer Science Business Media Inc, NY.

Gambetta, D. (1988). "Can we Trust Trust? *Trust: Making and breaking cooperative relationships"*, D. Gambetta, Oxford: Blackwell.**:** 213-237.

Human Dimension of Future Warfighting (HDoFW) Research Team (2006), "The Transition from Network-Centric Warfare to Networker-Centric Warfare: Outcomes of the Human Dimension of Future Warfighting Task". DRAFT DSTO Client Report, December 2005, Canberra.

Kruse, J. & Adkins, M. (2005). "The Technology Trap". *PROCEEDINGS*, August 2005, 59-62

Mayer, R., Davis, J., & Schoorman, E. (1995). "An integrative model of organisational trust". *Academy of Management Journal*, 20(3), 709-734.

Mollering, G., Bachmann, R., Lee, S. H. (2004) "Understanding Organizational Trust - Foundations, Constellations, and Issues of Operationalisation". *Journal of Managerial Psychology,* 19**,** 556-570.

Phillips, R. A. (1997). "A Stakeholder Theory and Principle of Fairness", *Business Ethics Journal* 7(1): 51 to 66.

Prusak, L. et al (2001) "How to Invest in Social Capital". *Harvard Business Review* 2001; June: 86 - 93.

Sarma, A. and A. van der Hoek. (2004). "A Needs Hierarchy for Teams." ISR Technical Report: UCI-ISR-04-9, Department of Informatics, Donald Bren School of Information and Computer Sciences, University of California Irvine

Schein, E. H. (1993). "On Dialogue, Culture, and Organizational Learning." *Organizational Dynamics* 22(2): 40-51.

Senge, P. M. (1992). *The fifth discipline: the art and practice of the learning organisation* Sydney: Random House.

Simmel, G. (1964) *The Sociology of Georg Simmel* (K.H. Wolff, Trans.) New York, NY: Free Press

Tucker, M. L., Meyer, G. D., Westerman, J. E. (1996). "Organizational Communication: Development of Internal Strategic Competitive Advantage." *Journal of Business Communication* 33(1): 51-69.

Warne, L. Ali, I. Pascoe, C (2003) "Team Building as a Foundation for Knowledge Management: Findings from Research into Social Learning in the Australian Defence Organisation", *Journal of Information & Knowledge Management*, Vol. 2(2): 93-106.

Warne, L., Ali, I., Bopping, D., Hart, D., Pascoe, C. (2004). "The network centric warrior: The human dimension of network centric warfare", *DSTO Report CR-0373,* Defence Systems Analysis Division, ISL, Defence Science and Technology Organisation, Department of Defence, Edinburgh, S.A. (Approved for Public Release).

Wilson, T. D. (1999). "Models in information behaviour research." *Journal of Documentation, 55* (3), 249-270.

ENDNOTES

1. For an overview of the current literature on the role of information sharing in NCW see Warne et al 2004
2. Also known as Network Enabled Operations (NEO) and a number of other variations on this theme.
3. This team, formerly of the Joint Systems Branch, is now a part of the Integrated Capabilities Systems Branch of DSTO.
4. This area is that region bordered by Iraq, Pakistan, and Afghanistan.
5. Two notable studies that do address information behaviour in the military are Prekop, P. (2002). "A qualitative study of collaborative information seeking", *Journal of Documentation*, *58*,(5), 533-547, and Sonnenwald, Diane H., & Pierce, Linda, G. (2000). "Information behaviour in dynamic workgroup contexts: interwoven situational awareness, dense social and contested collaboration in command and control". *Information Processing and Management, 36*, 461-479.
6. Conducted on 3 October 2006

Mobile Image Communication Using JPEG2000

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ABSTRACT

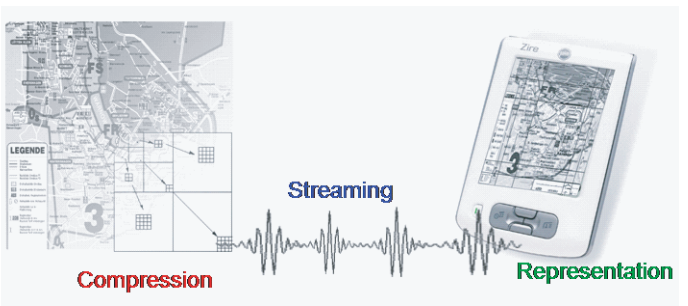
Imagery must be adequately processed and adapted to be used in mobile environments. This contribution shows that this can be reached by a rigorous combination of all stages of the image communication pipeline to a single task-aligned system. To achieve this, the modern imaging standard JPEG2000 serves as a foundation for image compression and streaming. Founded on the concept of Regions of Interest and Levels of Detail to describe current demands at client side, powerful generic strategies for the content handling are proposed. The pre-defined task is represented by one of 3 common problems in mobile environments – image browsing, viewer guidance, and content exchange. Beside new ideas to accomplish these tasks on application level, in focus is the strong decrease in the demands for device capabilities by an appropriate image handling. The achieved results show that many resources are saved by an appropriate image communication using JPEG2000.

1. INTRODUCTION

The enthusiasm for mobile computing is still unbroken. With the ability to access information every time and everywhere, the mobile freedom allows for completely new commercial applications. Due to its form factors and the application environment, however, mobile devices are still restricted by *low computing power* and *bandwidth*. As imagery is one of the most important but also most demanding information carriers it must be adequately processed and adapted to be used in such environments (Rosenbaum et al., 2006). How to achieve this by efficient image communication strategies designed to solve a task at hand is shown in this publication. Thereby, the focus is on the achieved results rather than the technological background. However, the required basic technology is briefly explained.

A meaningful image communication strategy consists of the stages *compression, streaming*, and *visual representation* (cf. Figure 1). Although numerous different techniques for each stage have been proposed, an arbitrary combination does usually not lead to an appropriate result. A high performing system can only be guarantied if all stages of the whole communication pipeline are tightly coupled (Rosenbaum & Schumann, 2005). Founded on an appropriate visual representation at the mobile client, this basically means that *only data contributing to the current representation is processed and transmitted*. Although, similar ideas have already been proposed, they are either based on proprietary solutions (Owen et al., 2001) or discuss a specific task only (Deshpande & Zeng, 2001; Ortiz et al., 2004). The ideas proposed in this publication are fully compliant to the international standard JPEG2000 (ISO, 2002), which allows an easy migration of the introduced strategies into existing systems, and due to the generic description of the current demands by Regions of Interest (RoI) and Levels of Detail (LoD) for a broad applicability. To avoid the redundant data transfer in case these demands change during interaction, the principle of a progressive refinement is adopted.

Figure 1. The image communication pipeline



Although the applicability of the proposed JPEG2000-based compression and streaming technology extends far beyond the discussed tasks, this publication focuses on 3 common problems in mobile environments: *Image browsing, Viewer guidance,* and *Content exchange*. Beside the proposal of new ideas for appropriate visual representations and the underlying data handling, of main interest within this publication is their coupling to an appropriate communication system.

This contribution gives an overview about the proposed ideas and achieved results for each single communication stage. Section 2 reviews the idea of RoIs and LoDs and introduces different options for their flexible access within an JPEG2000-compressed image. Section 3 is concerned with a demand-driven streaming of the data based on dynamic RoIs. Section 4 is dedicated to introduce new ideas for the visual representation of the image data depending on the previously mentioned tasks and shows the results of an appropriate image communication. The publication closes with conclusions in Section 5.

2. FLEXIBLE COMPRESSION WITH JPEG2000

Image compression is the foundation for an effective and efficient data handling. Although there are numerous approaches, the JPEG2000 standard represents the current state-of-art and combines a superb compression performance with numerous features. The main important properties regarding a flexible image communication are the modular structure of the data and the ability to support dynamic RoIs.

An RoI is basically a closed pixel area within the image. To determine the current interest, to every RoI is assigned an LoD. Although, there are many approaches to support RoIs within JPEG2000, they usually lack of flexibility to change RoI position or LoD during a running transmission. To achieve this, the concept of dynamic RoIs has been introduced and modeled for JPEG2000 (Rosenbaum & Schumann, 2002). It is based on the encapsulation of the encoded data in independent data containers and supports beside the general options to de- and refine RoIs dynamically, many LoD levels (e.g. gradual resolution, quality, and color). To increase the applicability and performance, different additional concepts, e.g. Limited Spatial Access (LSA) on the data-streams, may be applied (Rosenbaum & Schumann, 2004).

Although JPEG2000 is more complex than its predecessor JPEG, it has been revealed that the strong reduction in the amount of data by the RoI feature heavily decreases this drawback. This can be ensured by producing highly flexible data-streams during encoding.

Result: The result of the compression stage is an appropriately partitioned JPEG2000 image consisting of *modular data containers* able to support the independent reconstruction of single RoIs at the desired LoD. The RoI feature can heavily *decrease the need for computing power and bandwidth*.

3. IMAGE STREAMING WITH DYNAMIC ROIS

Progressive data streaming is an indivisible part of modern image communication. It handles the transfer of the data to the mobile device and basically consists of 3

stages*: Calculation, Sequencing,* and *Signalization* of the compressed data. The following sections discuss the different options for each of these points.

3.1 Calculation

Contrary to pixel domain, the calculation of data parts belonging to a RoI is more complex. As during compression the image is transferred into a scalable representation (ISO, 2002), the content of a pixel region is usually included in multiple data containers. Different approaches to accomplish their calculation have been proposed (Deshpande & Zeng, 2001; Ortiz et al., 2004). However, usually only the spatial dimension of the RoI and less its reconstruction at a reduced LoD is considered. Due to the known structure of the encoded image, this criterion can be fulfilled by a successive selection of RoI containers for each LoD dimension up to the desired LoD (Rosenbaum & Schumann, 2002; Rosenbaum, 2006). By reducing the number of transmitted containers, further bandwidth is saved.

3.2 Sequencing

The goal of sequencing is an interest ordered data transfer by changing the position of data containers within the transmission sequence. This can be achieved by either *global* or *local prioritization*. The global strategy is based on the prioritization between RoIs and thus, allows for a much more flexible adaptability of the streaming process. The basic idea is the assignment of a prioritization value to each RoI (Rauschenbach, 1999). RoIs with values n have an advantage of $(n\text{-}m)$ transmission steps before data of a RoI with prioritization value m $(n>m)$ is included in the sequence. If data from multiple RoIs is to be transmitted, it is interleaved.

The local R-D optimized strategy prioritizes containers belonging to a single RoI. As each element contributes to a pixel region, there might be elements which are truncated at the borders of the RoI. Thus, they do not contribute in the same extent to the refinement of the RoI as fully covered elements. Dependent on the respective overlap, to these elements is internally assigned a smaller priority (Taubman & Rosenbaum, 2003) to achieve a faster quality refinement at client side (cf. Figure 2).

Figure 2. Visual comparison of the reconstruction of a RoI at 6.4kB from the original (left) and R-D optimized sequencing (right).

3.3 Signalization

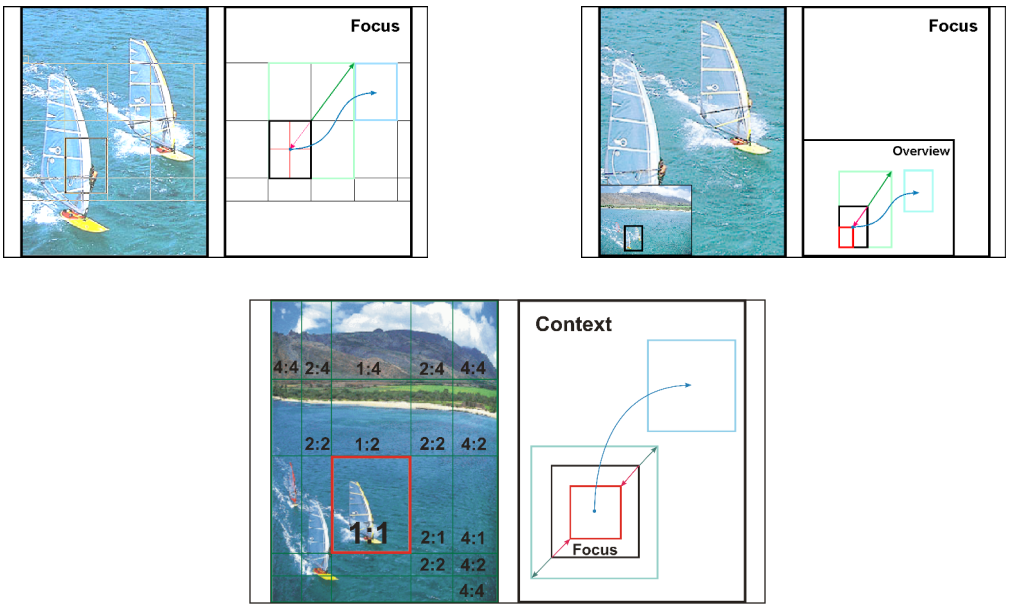
The goal of an appropriate signalization strategy is the proper identification of the transferred data at client side. Due to the reason within *external signalization* to each data chunk is assigned a unique ID, the required bandwidth might significantly increase (cf. to ISO, 2004). Contrary *inherent signalization* identifies each received data element from a predefined progression order. Although inherent in the JPEG2000 codec, the principle must be enhanced to deal with arbitrary container orders as outcome of the sequencing stage. Rosenbaum & Schumann (2002) accomplish this by the un-complex inclusion of new containers within the resulting data-stream. As this also increases the amount of data a strategy for *synchronized signalization* has been proposed by Rosenbaum (2006). Due to the reason server and client running synchronously during transmission, no additional data must be included into the transferred data and much bandwidth can be saved.

Result: A successful streaming of the image delivers the data containers provided by the compression stage in the currently most *appropriate order* to the mobile client. Thereby, the client is able to recognize each container and to process the included information. No more containers than required to reconstruct each RoI at its currently assigned LoD are transferred leading to the effect that much *less processing power and bandwidth* are required.

4. VISUAL REPRESENTATION

Before shown to the user, the received data is usually processed and converted to an appropriate visual representation. This process strongly depends on the respective task and the users needs. The creation of representations used by the 3 interactive tasks: *Mobile image browsing, Viewer guidance*, and *Content exchange*, however,

Figure 3. The image represented by different browsing techniques: Grid-based Zoom&Pan (top/left), largeDetail-View (top/right), and the rectangular FishEye-View with selected RoI scaling values (bottom). Each technique provides different means for interaction (blue: panning, red: zoom in, green: zoom out).



requires strong computing power. In the following, it is shown that the beneficial features of JPEG2000 can be exploited to significantly reduce these needs.

4.1 Mobile Image Browsing

The small screen space of mobile devices imposes a significant usability problem if large imagery is to be displayed. The aim of image browsing is to ease the comprehension of the content by an appropriate representation and means for interaction. Although there are different approaches to achieve this, especially for the strongly limited mobile clients new developments are required. In the next sections, a sophisticated browsing technique for each of the approaches – *Zoom&Pan (ZP)*, *Detail&Overview (DO)*, and *Focus&Context (FC)* – is reviewed and its resource requirements within an image communication system using the introduced streaming technology are discussed. The general approach for any representation is to partition the image in RoIs and to assign well-defined LoD and prioritization values. RoIs which are interesting are assigned a high LoD, RoIs which are not shown the lowest LoD. The prioritization strongly depends on the respective technique and expected behavior. A general taxonomy for image browsing techniques in conjunction with guidelines for their appropriate streaming can be found in (Rosenbaum & Schumann, 2005).

4.1.1 Grid-Based Zoom&Pan (GbZP)

The main disadvantage of many ZP-based techniques is that no context to the shown image part is provided. This is overcome within GbZP by a navigation grid showing information to the currently displayed region and the whole image (cf. Figure 3). This grid also serves as a means for interaction - another drawback of ZP-based techniques. The traditional slider paradigm and menu-based zooming is replaced by intuitive grid interaction. Each grid cell represents a different image region and corresponds in its dimensions to the displayed region. The grid outline represents the whole image. The information seeking mantra of Shneiderman (1996) -*Overview first, zoom and filter, then details-on-demand*- can be accomplished by 3 fast interactions only. More details to GbZP and the design of the belonging image communication system can be found in (Rosenbaum & Schumann, 2005).

Results: As only a certain image region is shown, creating a GbZP representation is *un-complex*. Furthermore, only data for the currently shown region is transferred. Consequentially, bandwidth requirements strongly correlate with the ratio between this region and the whole image. The *save of bandwidth* for a representation requiring 10% of the space consumed by the full-detail image is *approximately 90%.*

4.1.2 The largeDetail-View (lDV)

To display relevant micro and macro information at the same time, the large-Detail-View provides in additional overview to the whole image (cf. Figure 3). Although, the DO principle is well-known in the area of Information Visualization, it can also be applied for image browsing (Karstens et al., 2004; Rosenbaum, 2006). Within the overview, a viewfinder shows the currently displayed region with regard to the whole image. To concentrate the means for interaction to a particular structure, all browsing tasks are accomplished by a modification of the viewfinder. Though, the effective exploration requires many cognitive switches between the two views, the permanently shown overview eases the orientation within the image significantly. To explore contents covered by the overview, it may be displaced or hidden. An image communication system tailored to the lDV is described by Rosenbaum (2006).

Results: Due to the additional scaling operations needed to create the additional overview, the lDV requires *slightly more computing power* than ZP-based techniques. The same applies for the transmitted data. Due to the very low detailed overview, however, the *additional amount of data is little* and might be even negligible if content covered by the overview is omitted during transmission.

4.1.3 The rectangular FishEye-View (rFEV)

The rectangular FishEye-View has been introduced by Rauschenbach (1999). It is founded on the lens metaphor, and as shown by Karstens et al. (2004) allows for an intuitive user interaction . The consistent embedding of the focus is achieved by a complex belt partition of the background (cf. Figure 3). Belts close to the focus are less scaled than belts at the image borders. Thereby, a single belt is formed by many RoIs with different scaling values. Such a configuration is high-demanding for an appropriate image communication, but can still be handled by the introduced technology. More details to the design of the belonging communication system can be found (Taubman & Rosenbaum, 2003).

Results: The rFEV is very intuitive, but also *much more complex* during the creation of the belonging visual representation than other techniques. Much scaling operations are required to smoothly embed the focus. Regarding the requirements for bandwidth *more resources are required* as for GbZP or lDV. However, there is still much data which can be omitted during data transfer. If the ratio between the image dimensions and the available screen space is 4:1, approximately 70% of the data is negligible.

4.2 Viewer Guidance for Raster Imagery

To quickly extract relevant information from large images is difficult. The aim of viewer guidance is to intuitively direct the attention of the viewer to this information. Contrary to image browsing the image is represented in its full dimensions, but usually enriched with additional contents as frames or annotations. Due to the fact, these structures are usually permanently combined with the content, however, this has the significant drawback that the highlighted region may not be changed. To overcome this, two paradigms from Information Visualization - *Depth of Field* and *Tool glasses* - have been adopted to raster imagery.

4.2.1 Depth of Field

The effect aroused by embedding a highly detailed focus region into a blurred background is called Depth of Field (DoF) (cf. Figure 4/left). As humans do

Figure 4. The depth of field effect (left) and tool glass approach (right) applied to still imagery by blurring the background or removing texture from the current focus

not like to look at blurred objects, it is a very effective means of guiding the attention of the user to the focus. However, the demands of DoF representations often exceed the abilities of a mobile device. Due to this, new ideas for their creation and transmission have been introduced by the authors (2006). They are mainly based on the Discrete Wavelet Transform (DWT) as integral part of the JPEG2000 codec. As the DWT inherently separates detail and approximation of the image, the later can be used for blurring. Thereby, the modular structure of the data-stream allows the removal of the details without to decode the image. This also applies for an additional decrease in the quality of the reconstructed signal to advance the blurring effect. Even such complex image processing operations can be supported by an appropriate image handling (Rosenbaum & Schumann, 2006; Rosenbaum, 2006).

Results: All operations required to create a DoF representation of the content are accomplished in compression domain. Thus, the implementation is more than *5 times faster* compared to traditional pixel based processing. As the blurring of the large background regions is accomplished by removing data containers, the coupling with the proposed streaming technology leads to a *tremendous save of bandwidth*,. In case the focus covers 1/10th of the image, almost *90% of all available data can be skipped* during transmission.

4.2.2 Tool Glasses

The main idea of tool glasses is to reduce the content shown within the focus. Due to the resulting inconsistencies, the embedded focus immediately attracts attention. The reduction of presented information within edge or detail glasses, however, is also a great means for content exploration. In any event, the extraction of details requires much computing power. To extent the application area for such tools to mobile environments, new ideas are required. To achieve this, Rosenbaum & Schumann (2006) again take advantage of properties of the DWT. To all contents belonging to the focus, the approximation of the image is removed and replaced by more suitable data without to decode the image. This leads to a representation as shown in Figure 4/right, and is an proceeding can be fully supported by an appropriate communication system (see also (Rosenbaum, 2006)).

Results: Working in compression domain is *un-complex*. The proposed texture removal strategy is up to *20 times faster* compared to pixel-based techniques, and thus, is rather appropriate for mobile devices. During interactive exploration, the *modification* of the new focus region can be achieved *in real-time* on current mobile hardware. Due to the fact, the large background regions are shown in full detail, the *save of bandwidth is little.*

4.3 Content Exchange Between Imagery

The exchange of content between two or multiple images in consequence of modifications is a frequent task in mobile environments. Especially the often changing data in commercial information systems requires efficient mechanisms for remote content updates as achieved by non-interactive image editing functionality. As moving imagery also helps creative, editorial and business professionals to create powerful communications, the relevance of Motion-JPEG2000 for commercial applications is similar. However, data exchange is easy to accomplish in pixel domain, but requires much resources if the content is only be available in compressed representation. To overcome this, the content might directly be processed in this form. Rosenbaum & Taubman (2003) and Rosenbaum (2006) present a scheme for an exchange of JPEG2000-compressed content. After briefly describing the underlying idea, two of its main applications are explained in more detail.

4.3.1 Content Exchange in JPEG2000 Domain

Content exchange in compression domain requires the access of all encoded data contributing to the reconstruction of a closed image region directly on the data-stream. The crucial challenge here is the multi-resolution representation of the content. This is considered by the introduced Limited Spatial Access (cf. Section 2) leading to an appropriate partition of the image during compression. If this principle is applied to a source and a destination image, corresponding data containers can simply be exchanged without to violate the compliance of the resulting data-stream (cf. Figure 5/left). By taking advantage of the multi-resolution property, it is even possible to reduce the source contents in their spatial dimensions (cf. Figure 5/right). The decoding of the modified data-stream leads to a reconstructed image with contents from both images. If a remote scenario with frequent content changes at server side is considered, this idea can easily be applied for an efficient data streaming. Instead of transferring the whole modified image, only data belonging to the altered regions is transmitted and merged at client side with static contents.

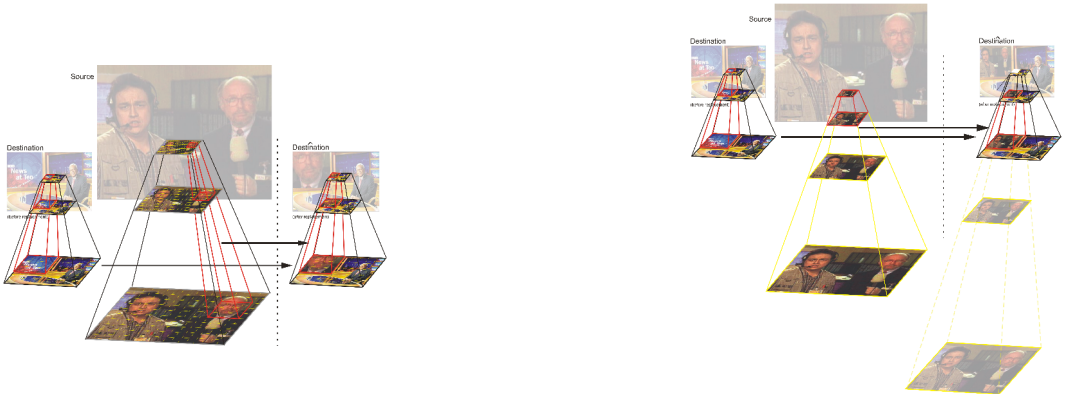
Results: Working in JPEG2000 domain *strongly decreases the complexity* of the exchange task for encoded imagery. As no decoding is required, the proposed strategy is *9 times faster* than pixel based processing. The performance gain even increases if the result has to be in encoded form for transmission or storage. The save of bandwidth strongly correlates with the ratio between the modified region and the whole image. If it covers a 1/10th of the image, 90% of all available data may be neglected.

4.3.2 An Image Editing Framework

Although content exchange in JPEG2000 domain is un-complex, all data containers involved in the exchange procedure must exactly fit to their respective counterparts. This is not always granted and limits the applicability of the approach. To overcome this, an editing framework has been proposed by Rosenbaum (2006). It is shown that the probability of a perfect fit increases with a subsequent un-do of the encoding procedure, and the recursive application of the exchange procedure based on different container types always leads to the desired result.

Results: The evaluation of the proposed framework has revealed that its performance is never slower than a full pixel-based exchange, but *in average much faster*. This means that by a universal applicability, *much less computing power* is required for content exchange at client side. As approximately the same amount of data is transferred in both cases, there is no significant difference in the use of bandwidth compared to the general exchange scheme.

Figure 5. The basic scheme for content exchange in JPEG2000-domain (left) can also be enhanced to inherently reduce the spatial dimensions of the included image region (right)



4.3.3 Motion-JPEG2000

Although Motion-JPEG2000 offers a number of very desirable features for digital video processing, its compression performance is not as high compared to other codecs. This is mostly due to the neglect of interframe redundancies. This is considered by a strategy designed to advance the compression performance of Motion-JPEG2000 video (Rosenbaum, 2006). By detecting and omitting data belonging to regions which are static with regard to two subsequent frames, much data is removed from the original data-stream. The original frame can easily be reconstructed by re-including this data from the previous frame whenever required. Due to the fact that each single frame within a compliant Motion-JPEG2000-video is encoded with JPEG2000, the proposed ideas for static or remote context exchange in JPEG2000 domain can be applied without limitations.

Results: Due to the foundation on the described basic scheme, detection, removal and reconstruction are *little demanding regarding computing power*. All stages are accomplished on encoded data and no decoding is required. Thereby, this procedure is also applicable to video streaming. By transmitting only the dynamic parts of each frame and reconstructing the whole frame at client side usually *much bandwidth is saved*.

5. CONCLUSIONS

By focusing on the results achieved by the design of appropriate communication systems, this publication has shown the potential of image communication using JPEG2000. To reduce the impact of *limited computing power* and *bandwidth* in mobile environments, all stages of the image communication pipeline have been tightly coupled. Based on the generic concepts for a *demand-driven streaming* based on *dynamic RoIs and JPEG2000*, the three major tasks in mobile environments – *Image browsing, Viewer guidance* and *Content exchange* could been implemented very efficiently. The respective communication systems *significantly reduce the need for computing power* (DoF-80%, content exchange-89%, Tool glasses-95%) *and bandwidth* (often 90%). Overall, the achieved results confirm the authors' assertion that such a system can *greatly increase the performance* in mobile environments. The rigorous compliance of the proposed technology allows for an easy migration in existing systems.

REFERENCES

S. Deshpande & W. Zeng (2001). Scalable streaming of JPEG2000 images using hypertext transfer protocol, *Proceedings of the 9th ACM international conference on Multimedia*

ISO/IEC JTC1/SC29/WG1 N2678 (2002). JPEG2000 image coding system, Part 1, FPD

ISO/IEC JTC1/SC29/WG1 N3052R (2004), JPEG2000 image coding system, Part 9, FDIS

B. Karstens, R. Rosenbaum, & H. Schumann (2004). Information presentation on handheld devices,Idea Group Publishing, *E-Commerce and M-Commerce Technologies*

J.P. Ortiz, V.G. Ruiz, & I. Garcia (2004). Remote Browsing of JPEG 2000 Images on the Web: Evaluation of Existing Techniques and a New Proposal, *Proceedings of VIIP*

M. J. Owen, A. K. Lui, E. H. S. Lo, & M. W. Grigg (2001). The design and implementation of a progressive on-demand image dissemination system for very large images, *Proceedings of the 24th Australasian conference on Computer science*

U. Rauschenbach (1999). The rectangular FishEye View as an efficient method for the transmission and display of large images, *Proceedings of IEEE ICIP*

R. Rosenbaum, & H. Schumann (2002). Flexible, dynamic and compliant region of interest coding in JPEG2000. In *Proceedings of IEEE ICIP*

R. Rosenbaum, & D. S. Taubman (2003). Merging images in the jpeg2000 domain. *Proceedings of VIIP*

R. Rosenbaum, & D. S. Taubman (2003). Remote display of large raster images using jpeg2000 and the rectangular fisheye-view. *Journal of WSCG*

R. Rosenbaum, & H. Schumann (2004). Limited spatial access in jpeg2000 for remote image editing. *Proceedings of VIIP*

R. Rosenbaum, & H. Schumann (2005). Grid-based interaction for effective image browsing on mobile devices, *Proceedings of Electronic Imaging - Multimedia on mobile devices*

R. Rosenbaum, & H. Schumann (2005). Jpeg2000-based image communication for modern browsing techniques. *Proceedings of Electronic Imaging - Image and Video Communications and Processing*.

R. Rosenbaum (2006). Mobile image communication using JPEG2000, *PhD-thesis*, University of Rostock

R. Rosenbaum, & H. Schumann (2006). Jpeg2000-based viewer guidance for mobile image browsing. *Proceedings of IEEE MultiMedia-Modeling*

R. Rosenbaum, Ch. Tominski, & H. Schumann (2006). Graphical Content on Mobile Devices, Idea Group Publishing, *Encyclopaedia of e-commerce, e-government and mobile commerce*

B. Shneiderman (1996). The Eyes Have It: A Task by Data Type Taxonomy for Information Visualizations, *Proceedings of the IEEE Symposium on Visual Languages*

D. S. Taubman, & R. Rosenbaum (2003). Rate-distortion optimized interactive browsing of jpeg2000 images. *Proceedings of IEEE ICIP*

Application of Delphi Technique for Development of E-Readiness Assessment Model: A Study on Small and Medium Enterprises of Iran

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ABSTRACT

The current dynamic and turbulent business environment has forced companies that are competing in global markets to change their traditional methods of conducting business. Recent developments in applying Information Technology (IT) offer the most exciting business opportunities in the marketplace. Organizations must re-evaluate every aspect of their strategies and quickly move to a working mode where the electronic commerce is essential for their success. One of tools that can be used for measuring the diffusion rate of IT is e-readiness assessment. Small and Medium Enterprises (SMEs) are critical to the economies of all countries, including developing ones. They cannot be left behind and many are already demonstrating their entrepreneurship strength by grasping opportunities offered by IT. The concept of e-readiness assessment for SMEs has received limited attention in the literature. This paper first studies e-readiness assessment models proposed for countries and then develops a model for measuring the e-readiness of SMEs (ESME) by an exploratory study using Delphi technique.

Keywords: E-readiness Assessment, Small and Medium Enterprise, Information Technology, Delphi technique, Iran.

INTRODUCTION

E-readiness can mean different things to different people, in different contexts, and for different purposes [1]. Thus, it is important to define e-readiness in the context of this paper. E-readiness of a Small and Medium Enterprise(SME) is defined here as the ability of an SME to successfully adopt, use and benefit from information technologies (IT) such as e-commerce.

Information technology (IT) is a term that generally covers the harnessing of electronic technology for the information needs of a business at all levels. It utilizes computer-based systems as well as telecommunication technologies for the storage, processing and communication [2,3]. While an information system (IS) is a group of formal processes that together collect, retrieve, process, store and disseminate information for the purpose of facilitating, planning, control, coordination and decision-making in organizations, IT on the other hand provides the technical solutions identified in the IS, including the networks, hardware and software [4]. IT today is basically electronics and is based on integrated circuits or silicon chips. Hanson and Narula further identified two major forms of IT as Telematics (meaning 'big media') and Ethnotronic (meaning 'small media'). Telematics are to be identified with such technologies as computers, telephone, satellites, television, radio, video and those that rely on large-scale infrastructure. Ethnotronics include technologies such as typewriters, audio cassette recorders, fax machines, paper copiers, calculators, digital watches and other more personal types of technology [5].

While providing insight into the overall e-readiness of countries on the macro level, few studies have attempted to evaluate e-readiness from a micro perspective. In particular, a small number of studies have undertaken as assessment of the adoption e-commerce in small and medium enterprises (SMEs) in the United States, Australia, some European and Asian countries [24]. The objective of the research is to present a model that assesses the e-readiness of SMEs, particularly their preparedness for adoption of electronic commerce.

E-READINESS MODELS AND CONCEPTS

Over the last years, a number of models for e-readiness assessment of countries on the macro level have been developed by different organizations. On the surface, each model gauges how ready a society or economy is to benefit from information technology and electronic commerce. On closer examination, the models use widely varying definitions for e-readiness and different methods for measurement. These models mainly are in four categories as follows:

1. Ready-to-use tools: There are few ready-to-use tools freely available on the web.
2. Case studies: There are numerous case studies assessing specific countries' e-readiness, and many of these could be used as bases for e-readiness tools.
3. Third party surveys and reports: These reports aim to rank and rate countries on various measures held to indicate e-readiness.
4. Other e-readiness assessment models: In addition to the formal tools and surveys described above, there is a range of other frameworks such as digital divide reports and position papers that can be similarly used for e-readiness assessment.

The above mentioned models can be divided into two main categories, first those that focus on basic infrastructure or a nation's readiness for business or economic growth, which are e-economy models and second, those that focus on the ability of the overall society to benefit from IT which are "e-society" models. These two categories of models also have different assessment methodologies such as questionnaires, Statistical methods, best practices, historical analyses [27,28]. Table 1 shows detail of some important e-readiness assessment models.

There are several definitions for e-readiness. The CSPP model defines an 'e-ready' community as one that has high-speed access in a competitive market; with constant access and application of ICTs in schools, government offices, businesses, healthcare facilities and homes; user privacy and online security; and government policies which are favorable to promoting connectedness and use of the network [26]. The Asian Pacific Economic Cooperation (APEC) group defines a country as e-ready that is 'ready' for e-commerce, has free trade, industry self-regulation, ease of exports, and compliance with international standards and trade agreements [6]. McConnell International defines e-readiness as the capacity of nations to participate in the digital economy[7] and finally, the Center for International Development at Harvard University the most acclaimed institution in e-readiness research defines an 'e-ready' society is one that has the necessary physical infrastructure (high bandwidth, reliability, and affordable prices); integrated current

Table 1. Some of important e-readiness assessment models

Model Name	Author	Reference	Focus
Apec	The Asian Pacific Economic Cooperation (APEC) Electronic Commerce Steering Group	[6]	E-Commerce Readiness
CSPP	Computer Systems Policy Project	[26]	Existing Infrastructure
CID's	The Center for International Development at Harvard and IBM.	[8,9]	Society
McConnell International	McConnell International prepared this report in collaboration with World Information Technology and Services Alliance (WITSA)	[7]	Infrastructure, Digital Economy, Education and Government
MQ	Mosaic Group	[10, 11]	Internet
CIDCM's	University of Maryland, Center for International Development and Conflict Management	[12]	Qualitative Assessment based on past performance and current internet pervasiveness
EIU	The Economist Intelligence Unit	[13]	E-Business Readiness
IDC	World Times / IDC's Information Society Index	[14]	Infrastructure
KAM	World Bank, Knowledge Assessment Matrix	[15]	K-Economy
NRI	Center for International Development (CID) at Harvard and the World Economic Forum	[16]	Infrastructure, E-Society, Policies, Digital Economy, Education and Government
ITU	International Telecommunications Union's Internet Country Case Studies	[17]	Telecommunications
Sida	Swedish International Development Cooperation Agency (Sida)	[18,19]	Mainly SWOT analysis of a Nation
USAID	U.S. Agency for International Development	[20,21]	Access, Government, People

ICTs throughout businesses (e-commerce, local ICT sector), communities (local content, many organizations online, ICTs used in everyday life, ICTs taught in schools), and the government (e-government); strong telecommunications competition; independent regulation with a commitment to universal access; and no limits on trade or foreign investment[8,9].

While the above mentioned tools focus on assessing readiness of countries, governments and policies for adopting information technologies, some others e.g. IQ Net Readiness Scorecard [22] assess the readiness to adopt other different concepts. IQ Net Readiness Scorecard was developed by CISCO and is a Web-based application that assesses an organization's ability to migrate to an Internet Business model. It is based on the book Net Ready [43], which gauges the readiness of IT service providers.

E-READINESS OF SMALL AND MEDIUM ENTERPRISES

There are a number of definitions of what constitutes a small to medium enterprise (SME). Some of these definitions are based on quantitative measures such as staffing levels, turnover or assets, while others employ a qualitative approach [23]. Some researchers suggests that any description or definition must include a quantitative component that takes into account staff levels, turnover, assets together with financial and non-financial measurements, but the description must also include a qualitative component that reflects how the business is organized and how it operates[23].

In our view, SMEs' e-readiness is the ability of an SME to successfully adopt, use and benefit from information technologies (IT) such as e-commerce. It is related to the level of IT acquisition or adoption (especially e-commerce) by them. Many other studies have attempted to describe the factors influencing IT adoption in SMEs. For example, Iacovou et al. [44] studied factors influencing the adoption of electronic data interchange (EDI) by seven SMEs in different industries, they included perceived benefits, organizational readiness, and external pressure. To measure perceived benefits they used awareness of both direct and indirect benefits. Variables measuring organizational readiness were the financial and technological resources. In order to measure external pressure, they considered competitive pressure and its imposition by partners. The results suggested that a major reason that small firms become EDI-capable is due to external pressure (trading partners). The adoption of the internet was also studied by Mehrtens et al.[45].

Other studies have shown that many of the barriers reported in the late 1990's by Lawrence and Hadjimanolis are still current in today's SMEs. Tambini (1999)[29] and Eid et al (2002) [30] found that SME managers are still not convinced that e-commerce fits the products or services that their businesses offer. Studies by Bakos and Brynjolfsson (2000) [31], Sawhney and Zabin (2002) [32], and Merhtens et al (2001)[33] have found that there is still a reluctance for SME managers to adjust their businesses to the requirements and demands placed on it by e-commerce participation. Some of these barriers are summarized in table 2.

E-readiness of SMEs (ESME) is related to the level of IT acquisition or adoption especially e-commerce by them. SMEs for achieving to a good level of e-readiness must remove the above mentioned barriers and also pay attention to the factors influencing IT adoption. Therefore, assessment model of ESME should be determined with regarding these barriers and also the factors affect IT adoption in SMEs. We consider the mentioned barriers and the factors influencing IT adoption in SMEs in seven groups which are, Telecommunication and technical infrastructure, Legal environment, Competitive pressure, Human resources and cultural infrastructure, Management and organizational policy, Communication with environment and finally, Information technology security.

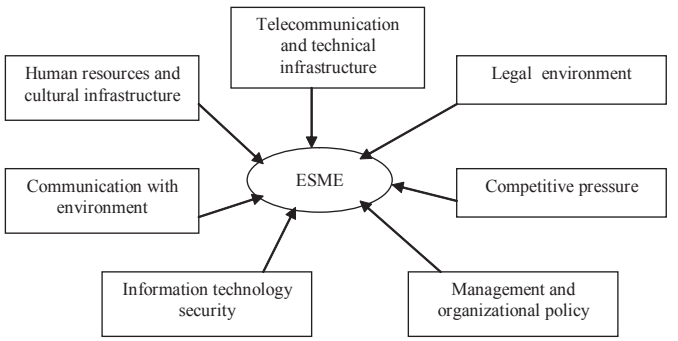
In this paper, we propose an assessment preliminary model of ESME with regarding the seven mentioned dimensions which are as follows (as shown in figure 1):

a. Telecommunication and technical infrastructure which determines the status of telecommunication and technical infrastructure in SMEs.
b. Legal environment which determines the required legal conditions for IT adoption in SMEs.

Table 2. Some barriers to e-commerce adoption in SMEs

Barriers	Ref.
E-commerce doesn't fit with products/services	Eid et al [30] , Kendall et al [34] Tambini [29], Hadjimanolis [27]
E-commerce doesn't fit with the way we do business	Sawhney & Zabin [32],Mehrtens et al [33] Bakos & Brynjolfsson [31], Farhoomand et al [35],Poon & Swatman [36]
E-commerce doesn't fit the way our customers work	Bakos & Brynjolfsson [31],Hadjimanolis [27]
We don't see the advantages of using E-commerce	Lee & Runge [39],Chau & Hui [40] Purao & Campbell [38],Lawrence [28] Hadjimanolis [27]
Lack of technical know how	Mirchandani & Motwani [43], Hadjimanolis [27] Farhoomand et al [35], Purao & Campbell [38]
Security risks	Oxley & Yeung [42], Reimenschneider & McKinney [37] Purao & Campbell [38], Hadjimanolis [27]
Cost too high	Reimenschneider & McKinney [37] Ratnasingam [41] , Hadjimanolis [27] Purao & Campbell [38],Lawrence [28]
Not sure what hardware/software to choose	Farhoomand et al [35], Hadjimanolis [27]

Figure 1. Proposed model for assessment of ESME



c. Human resources and cultural infrastructure that is related to the quality and quantity of IT workers and cultural circumstance for IT adoption in SMEs.
d. Management and organizational policy which determines status of organizational plans and management commitment for IT adoption in SMEs.
e. Communication with environment which determines the status of electronic communications with SME's stackholders.
f. Information technology security which determines the status of IT security in SMEs.
g. Competitive pressure which influencing IT adoption in SMEs.

RESEARCH METHODOLOGY

In the previous sections, the concept of e-readiness and its assessment models for countries on the macro level was introduced. In addition, we proposed an e-readiness assessment model for SMEs based on study of barriers and factors influencing IT adoption in SMEs.

In this research for validating the model, we use an exploratory Delphi study. The Delphi technique, which was developed by the Rand Corporation in the 1950s, is a data collection approach that is designed to structure group opinion [50]. A two-round Delphi technique was used to implement this research. Delphi panel members were selected amongst researchers and academics with experience in the use of IT and e-commerce applications within SMEs. A total of 100 members were identified as eligible for panel membership, and were mailed electronically invitation letter soliciting their participation in the research. A total 45 members volunteered to participate in two data collection rounds.

We use a Likert-type scale for analyzing the questions, where 1=strongly unimportant, 2=unimportant, 3= neutral, 4=important, 5= strongly important. In addition, for calculating weight of the indicators in comparison with each other, Eigenvector algorithm is used [51]. Figure 2 shows the frame structure of this research.

The rating used to assess each dimension or indicator (item) is ranked according to the table 3. Also, one sample t-test is performed to test the value of population mean (μ) for determining rating of each dimension or indicator as follows:

a. First, all of items are tested with "$\mu \geq 4$". According to the table 3, accepted items receive strong rating (+++).
b. We will perform two tests " $3 \leq \mu$ "and "$\mu < 4$" on unaccepted items in part a, the passed items receive medium rating (++).
c. Finally, remained unaccepted items in part b, will be tested with "$\mu < 3$". Accepted items receive weak rating (+). All items are tested at alpha = 0.05.

Table 3. Rating used to assess dimensions or indicators

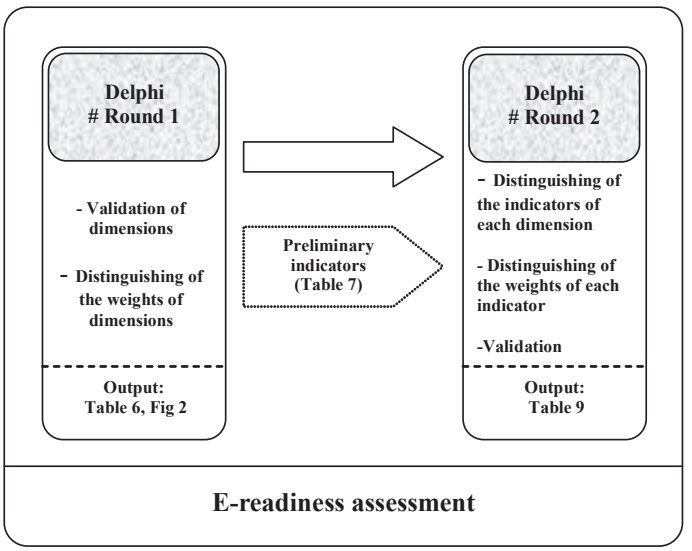
	Criteria	Assigned Rating
1	If the amount of the population mean is greater than or equal to 4, dimension or indicator has a strong effect.	+++
2	If the amount of the population mean is greater than or equal to 3 and less than 4, (3≤ mean <4) dimension or indicator has a medium effect	++
3	If the amount of the population mean is less than 3, dimension or indicator has a weak effect.	+

The dimensions or indicators that receive strong or medium rating are accepted as effective factors for assessment of ESME.(To analyze data the statistic package Minitab for Windows Software is used.)

RESEARCH RESULTS

As indicated in Table 4, the average of importance assessment (mean) for the seven proposed dimensions ranged from 2.77 to 4.31. This table also shows that six dimensions receive strong or medium rating (mean ≥ 3) and one dimension receives weak rating. Therefore, the accepted dimensions include: Telecommunication and technical infrastructure, Legal environment, Human resources and cultural infrastructure, Management and organizational policy, Communication with environment and finally, Information technology security. Validated model for assessment of ESME will be according to figure 3.

Figure 2. Research structure



As before mentioned, most of e-readiness assessment models are in national level and they mainly assess a country readiness for participation in the digital world. Some dimensions of the validated model have been considered for e-readiness assessment in macro level models according to table 5.

Table 6, shows another result of Round 1 that is related to calculating weight for dimensions of the validated model with using eigenvector algorithm. First, we make preference matrix. It is a reciprocal matrix which is made based on pairwise comparisons between pair of dimensions. Each element of the matrix is in the form $\frac{n_{ij}}{n_{ji}}$, n_{ij} is the number of experts that believe dimension ith is more important than dimension jth, and n_{ji} is the number of experts that believe dimension jth is more important than dimension i_{th}. The weight of dimensions is calculated by eigenvector of the matrix [76]. (The sum of weights is equal to one)

On the other hand, the main objective of the Round 2 was to identify validated indicators for the validated dimensions of the model. Table 7, shows the proposed preliminary indicators for assessing the validated dimensions. In this table, T1 to T9 are preliminary indicators for assessing telecommunication and technical infrastructure, L1 and L2 are preliminary indicators for assessing legal environment, C1 to C11 are preliminary indicators for assessing communication with environment, HC1 to HC4 are preliminary indicators for assessing human resources and cultural infrastructure, MO1 to MO5 are preliminary indicators for assessing management and organizational policy, and finally, I1 and I2 are preliminary indicators for assessing information technology security.

As indicated in Table 8, the average of importance assessment (mean) for the proposed indicators ranged from 2.2 to 4.91. This table also shows that seven indicators receive weak rating (+) include C1, C9, T2, T4, MO1, HC3, HC4 and the others that are validated indicators, receive strong or medium rating. Table 9, shows another result of Round 2, is related to calculating weight for validated indicators of the dimensions with using eigenvector algorithm that explained before.

The model can be used for the assessment and comparison of e-readiness of the considered SMEs with measurement of the indicators (qualitative or quantitative) and applying their weights and also dimensions' weights. For achieving more exact results, it must be further examined especially for different categories of SMEs.

Table 4. Validation findings for dimensions of the proposed model (n=45)

Dimensions of the proposed model	mean	stdev	p.value	rating
Telecommunication and technical infrastructure	4.31	1.30634	.069	+++
Legal environment	3.77	0.76541	1, 0.971	++
Human resources and cultural Infrastructure	4.20	1.33463	0.173	+++
Management and organizational policy	4.20	1.28793	0.141	+++
Communication with environment	3.75	0.98062	1, 0.949	++
Information technology security	3.88	0.76739	1, 0.849	++
Competitive pressure	2.77	1.16496	0.086	+

Table 5. The relation between the validated model and macro level models

Dimensions of the proposed model	E-readiness assessment models for countries (macro level models)
Telecommunication and technical infrastructure	APEC, CID, CSPP, EIU, NRI, UNDP, USAID, SIBIS, SIDA, MI, IDC, Mosaic
Legal environment	CID, APEC, ITU, USAID, SIDA, MI, CIDCM, EIU, NRI
Human resources and cultural infrastructure	CID, APEC, USAID, SIDA, MI, EIU, KAM, NRI
Management and organizational policy	CIDCM, EIU, NRI
Communication with environment	ITU, MI, CIDCM, EIU, NRI
Information technology security	CSPP, USAID, MI, EIU, SIBIS, NRI

Table 6. Calculating the weight for dimensions of the validated model (n=45)

Accepted Dimensions of the Model	Preference matrix						weight
Telecommunication and technical infrastructure	1.00	21.50	0.21	2.00	2.10	15.00	0.2846
Legal environment	0.05	1.00	0.11	0.11	8.00	0.17	0.0591
Human resources and cultural infrastructure	4.76	9.50	1.00	3.20	0.41	4.10	0.2607
Management and organizational policy	0.50	9.50	0.31	1.00	14.00	8.00	0.2229
Communication with environment	0.48	0.13	2.44	0.07	1.00	0.11	0.0723
Information technology security	0.07	6.00	0.24	0.13	9.50	1.00	0.1004

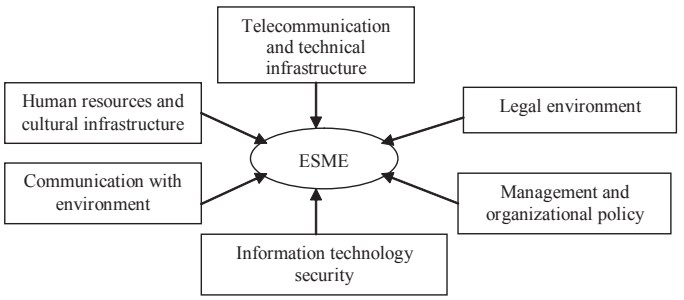
Table 7. Preliminary indicators for assessing the validated dimensions

Indicator	Indicator Description
T1	Percentage of organizational parts that connected to the computer network
T2	Bandwidth of access to the local network
T3	Bandwidth of access to the internet
T4	Number of phone lines
T5	Number of computers
T6	Number of computers that connected to the internet
T7	The quality of supporting telecommunication and technical services
T8	The quality of hardware equipment of the network such as servers, modems, etc
T9	The reliability in access to computer services
L1	The adherence rate to the laws related to information technology such as: copyright law, intellectual property right, e-commerce act, etc.
L2	The adherence rate to the ethical issues in using computer services
C1	Percentage of electronic customers of enterprise
C2	Percentage of electronic communication with customers
C3	The quality of electronic communication with customers
C4	The quality of electronic communication with partners
C5	Percentage of electronic communication with partners
C6	The quality of electronic communication with suppliers
C7	Percentage of electronic communication with suppliers
C8	The rate of communication with the IT developer organizations(consultants, developers of websites, etc)
C9	Percent of organizational revenue which related to the electronic customers
C10	Possibility of electronic communication with outside organizations (the whole of business process such as negotiation, order, deliver, etc.)
C11	The quality of information systems and electronic information exchange in the organization (e-government of the organization)
HC1	The level of information literacy of managers (level of computer skills)
HC2	The level of information literacy of employees (level of computer skills)
HC3	The level of information technology skilled literacy of employees such as percentage of employees that have high degrees in information technology related courses
HC4	The level of IT pubic acceptance (organizational environment)
MO1	Existence of organizational unit that is liable for IT development
MO2	Amount of investment by organization related to the IT development
MO3	Commitment and seriousness of management related to the IT development
MO4	Existence of strategy for IT development in the organization
MO5	Existence of clear plan and policy for IT development
I1	Existence of hardware and software infrastructure of information security in the organization such as firewall system, VPN, etc.
I2	Using of security mechanisms in the organization such as authentication, integrity, privacy, access control, etc.

Table 8. Validation findings for preliminary indicators (n=45)

Indicator	mean	Stdev	p.value	Rating
C1	2.9556	0.36739	0.650	+
C2	4.2444	0.90843	0.961	+++
C3	3.7778	0.76541	1.000، 0.971	++
C4	3.7556	0.98062	1.000، 0.949	++
C5	3.8889	0.76739	1.000، 0.849	++
C6	3.8667	0.86865	1.000، 0.846	++
C7	3.9333	1.11600	1.000، 0.691	++
C8	3.9778	1.07638	1.000، 0.890	++
C9	2.9333	0.81600	0.691	+
C10	3.9556	0.76739	1.000, 0.118	++
C11	4.0222	1.01105	0.883	+++
T1	4.3111	1.30634	0.929	+++
T2	2.2000	0.58793	0.141	+
T3	4.2000	1.33463	0.173	+++
T4	2.8222	0.62803	0.272	+
T5	4.2000	1.28793	0.141	+++
T6	3.9556	1.15370	1.000، 0.700	++
T7	3.7778	1.16496	1.000، 0.086	++
T8	4.1111	1.24540	0.390	+++
T9	4.0444	1.30634	0.761	+++
L1	4.2000	0.89443	0.141	+++
L2	4.1333	0.86865	0.309	+++
MO1	2.5111	0.32603	0.029	+
MO2	4.3111	0.59628	0.901	+++
MO3	4.4444	0.62361	0.127	+++
MO4	4.4000	0.61791	0.284	+++
MO5	4.0000	0.52223	0.900	++
I1	4.9189	0.27672	0.549	+++
I2	4.7568	0.43496	0.680	+++
HC1	4.4444	0.69267	0.669	+++
HC2	4.5111	0.69486	0.289	+++
HC3	2.3111	0.56343	0.669	+
HC4	2.5111	0.39267	0.289	+

Figure 3. Validated model for assessment of ESME



CONCLUSION

E-readiness of a small and medium enterprises is defined here as the ability of an SME to successfully adopt, use and benefit from information technologies (IT) such as e-commerce. In this paper, we proposed an assessment preliminary model of ESME with regarding to study of barriers and factors influencing IT adoption in SMEs and used an exploratory Delphi study for validating it. The study findings, showed the major six dimensions for assessing of ESME consequently are telecommunication and technical infrastructure, human resources and cultural infrastructure, management and organizational policy, information technology security, communication with environment and finally, legal environment.

The validated model can be used for the assessment and comparison of e-readiness of the considered SMEs with measurement of the validated indicators and applying their weights and also dimensions' weights.

REFERENCES

[1] T. Peters, Comparison of readiness assessment models, [online] Available at: http://www.bridges.org/ereadiness/report.html, 2001.

[2] R.G. Anderson, Data processing, vol. 2: Information Systems and Technology, Pitman Publishing, London, 1990.

[3] V. Claus, A. Schwill, Encyclopedia of information technology, Ellis Horwood Limited, England,1992.

[4] N. Grainger-Smith, C. Oppenheim, The role of information system and technology in investment banks, Journal of Information Science, 5, 20, 1994.

[5] J. Hanson, U. Narula, New communication technologies in developing countries, Lawrence Erlbaum Association Inc., New Jersey, 1990.

[6] [online] available at: http://www.ecommerce.gov/apec/docs/readiness_guide_files/ readiness_guide_5.pdf, 2005.

[7] [online] available at: http://www.mcconnellinternational.com/ereadiness/default.cfm, 2005.

[8] [online] available at: http://www.readinessguide.org, 2005.

[9] [online] available at: http://www.cid.harvard.edu/ciditg/research/library, 2005.

[10] [online] available at: http://som.csudh.edu/fac/lpress/gdiff, 2005.

[11] [online] available at: http://mosaic.unomaha.edu/gdi.html, 2005.

[12] [online] available at: http://www.bsos.umd.edu/cidcm/projects/leland.htm, 2005.

[13] [online] available at: http://www.ebusinessforum.com/index.asp,2005.

[14] [online] available at: http://www.worldpaper.com/2001/jan01/ISI/2001%20Information %20Society%20Ranking.html, 2005.

[15] [online] available at: http://www1.worldbank.org/gdln/kam.htm, 2005.

[16] [online] available at: http://www.cid.harvard.edu/cr/gitrr_030202.html,2005.

[17] [online] available at: http://www.itu.int/ITU-D/ict/cs, 2005.

[18] [online] available at: http://www.sida.se, 2005.

[19] [online] available at: http://www.sida.se/Sida/jsp/Crosslink.jsp?d=321&a=9481,2005.

[20] [online] available at: http://www.usaid.gov/regions/europe_eurasia/eeresources.html#IT, 2005.

[21] [online] available at: http://www.usaid.gov/regions, 2005.

[22] Cisco systems, Internet business solutions–IQ expertise, IQ Net Readiness Scorecard, [online]Available at: http://www.cisco.com/warp/public/779/ibs/netreadiness/20question.html, 2004.

[23] R. MacGregor, L. Vrazalic, Electronic commerce adoption in Small to Medium Enterprises (SMEs), A Comparative study of SMEs in Wollongong (Australia) and Karlstad (Sweden), University of Wollongong, May 2004.

[24] Comparison of E-Readiness assessment models, Final draft, v. 2.13, [online] available at: www.bridges.org,14 March 2001.

[25] E-readiness assessment tools comparison, [online] available at: www.brigges.org, 28 February 2005.

[26] [online] available at: www.cspp.org, 2005.

[27] A. Hadjimanolis, Barriers to innovation for SMEs in a small less developed country (Cyprus), Technovation, vol 19, no. 9, 1999, pp 561 – 570.

[28] K.L. Lawrence, Factors inhibiting the utilisation of electronic commerce facilities in tasmanian small-to-medium sized enterprises, 8th Australasian Conference on Information Systems, 1997, pp 587 – 597.

[29] A.M. Tambini, E-Shoppers demand e-Service, Discount Store News, vol 11, no. 38, 1999.

[30] R. Eid, M. Trueman and A.M. Ahmed, A cross-industry review of B2B critical success factors, Internet Research: Electronic Networking Applications and Policy, vol 12, no. 2, 2002, pp 110 – 123.

[31] Y. Bakos, E. Brynjolfsson, Bundling and competition on the internet, Marketing Science vol 19, no. 1, 2000, pp 63 – 82.

[32] M. Sawhney, J. Zabib, Managing and measuring relational equity in the network economy, Journal of the Academy of Marketing Science, vol 30, no. 4, 2002, pp 313 – 332.

[33] J. Mehrtens, P.B. Cragg and A.M. Mills, A model of internet adoption by SMEs, Information and Management, vol 39, 2001, pp 165 – 176.

[34] J.E. Kendall, K.E. Kendall, A paradoxically peaceful coexistence between commerce and ecommerce, Journal of Information Technology, Theory and Application, vol 3, no. 4, 2001, pp 1 – 6.

[35] A.F. Farhoomand, V.K. Tuunainen and L.W. Yee, Barriers to global electronic commerce: a cross-country study of Hong Kong and Finland, Journal of Organisational Computing and Electronic Commerce, vol 10, no. 1, 2000, pp 23 – 48.

[36] S. Poon, P. Swatman, The internet for small businesses: an enabling infrastructure, Fifth Internet Society Conference, 1997, pp 221 – 231.

[37] C.K. Reimenschneider, V.R. McKinney, Assessing beliefs in small business adopters and non-Adopters of web-based e-commerce, Journal of Computer Information Systems, vol 42, no. 2, 2001, pp 101 – 107.

[38] S. Purao, B. Campbell, Critical concerns for small business electronic commerce: some reflections based on interviews of small business owners, Proceedings of the Association for Information Systems Americas Conference Baltimore, MD, 14 – 16 August 1998, pp 325 – 327.

[39] J. Lee, J. Runge, Adoption of information technology in small business: testing drivers of adoption for entrepreneurs, Journal of Computer Information Systems, vol 42, no. 1, 2001, pp 44 – 57.

[40] P.Y.K. Chau, K.L Hui, Determinants of small business EDI adoption: an empirical investigation, Journal of Organisational Computing and Electronic Commerce, vol 11, no. 4, 2001, pp229 – 252.

[41] P. Ratnasingam, The influence of power on trading partners in electronic commerce, Internet Research, vol 10, no. 1, 2000, pp 56 – 62.

[42] J.E. Oxley, B.Yeung, E-Commerce readiness: institutional environment and international competitiveness, Journal of International Business Studies, vol 32, no. 4, 2001, pp 705 – 723.

[43] A. Hartman, J. Sifonis and J. Kador, Net ready: strategies for success in the economy, McGraw-Hill, NY, USA, ISBN: 0071352422, 2000.

[44] A.L. Iacovou, I. Benbasat and A.Dexter, Electronic data interchange and small organizations: adoption and impact of technology, MIS Quarterly, December 1995, pp.465–485.

[45] J. Mehrtens, P.B.Cragg and A.M.Mills, A model of internet adoption by SMEs, Information and Management, 39,2001, pp.165–176.

[46]S. Basu and P. Deshpande,Wipro's People Processes:A Framework for Excellence, White paper, [online] Available at: http://www.wipro.com/insights/wipropeopleprocesses.htm, 2004 .

[47] C.Goolsby, Integrated people+processes+tools=best-of-breed service delivery, Getronics White Paper, [online] Available at: http://itpapers.news.com ,2001.

[48] IBM, Arriving at the upside of uptime: how people processes and technology work together to build high availability computing solutions for e-business, White paper, [online] Available at: http://www.dmreview.com/whitepaper/ebizc.pdf, 1999.

[49] H. Kern, R. Johnson, S.Galup and D.Horgan, Building the new enterprise: people, processes and technology, Prentice Hall, 1998.

[50] C.M.Goodman, The Delphi technique:a critique, J.Adv.Nurs,12(6),1987,pp 729–734.

[51] C.L. Hwang, M.J. Lin, Group decision making under multiple criteria, Springer–Verlag, 1987.

MIS Textbook Selection Using Analytic Hierarchy Process

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ABSTRACT

Many business schools and individual faculty members are faced with decisions regarding the evaluation and selection of a MIS textbook for their courses due to the availability of many choices on the market. This evaluation and selection requires a multiple criteria decision-making method. The purpose of this paper is to apply the Analytic Hierarchy Process (AHP), a well-known multiple criteria decision making method, designed for decisions that require the integration of quantitative and qualitative data, to evaluating and selecting a MIS textbook.

1. INTRODUCTION

In today's classroom, textbooks serve as a tool, tutor, guidebook, and gauge (Association for Supervision and Curriculum Development, 1997). Teachers throughout the world base approximately 50 percent of their weekly teaching time on textbooks (Schmidt, McKnight, & Raizen, 1996). Therefore, selecting a proper textbook for a course has been one of the most important tasks for faculty. In order to help teachers select the proper textbooks, much research has been done to evaluate different textbooks at grade schools (Cohen, 2005; Dove, 1998). However, very little research is devoted to evaluating the textbooks used at the college level. Thus, it is no surprise that there is not much research done in regards to the evaluation and selection of textbooks for courses in the MIS field. While there is no indication of patterns of how MIS instructors select textbooks and the exact role the textbooks play in the classroom, which needs further study, at least one thing is certain— a majority of the instructors teaching MIS courses would like to have a textbook that would best meet their students' needs and become a good resource for other class activities such as case study analysis and discussion. A study of nearly eighty syllabi posted on the World Wide Web reveals that the majority of MIS instructors depend heavily on a textbook as a teaching tool in their courses. The proliferation of syllabi on the Web presents for the first time the possibility of gaining a comprehensive picture of how MIS survey courses are taught and how textbooks are used in them.

2. DETERMINING STUDY PARTICIPANTS

Textbooks may not be able to be rewritten or revised periodically, but the selection of textbooks can be done on a periodical basis. Therefore, instructors of MIS courses should evaluate available MIS textbooks frequently and select a textbook that meets their course objectives and incorporates the "voices" of all involved parties into consideration.

There are many factors that enter into the textbook evaluation and selection process and we will not attempt to be exhaustive in listing several general factors that may be involved. In the following sections, we will identify the parties that will either directly (faculty and students) or indirectly (employers) be affected by the choice of a textbook.

2.1 Instructors' Input

Decisions regarding textbook selection can only be made in the context of the particular learning situation in which they will be used and are influenced by a variety of factors. Besides the personal preference of an instructor, the evaluation and selection decision may be affected by factors such as content, availability of assessment tools and ancillary materials, a Web site, and price. As we mentioned earlier, this is not a complete list of factors that influence the choice of a textbook. However, we choose these factors to demonstrate our selection methodology.

2.2. Students' Input

Some of the students, whose needs are not met by a textbook, will lose interest and complain that they spent too much money on the textbook(s). Modern constructivist theories therefore believe that learning really takes place when the student can construct the new information into his/her original cognitive system (Jarvinen, 2001). In other words, students' needs have to be met in order to reach the goal of meaningful learning. Therefore, it is sensible to incorporate students' desires when considering the selection of textbook(s) in order to meet their needs.

To solicit students' inputs we conducted a survey in four sections of a 300-level Information Systems course, Information Technology Management, consisting of 106 students, as the sample for this study. This course is required for accounting and management majors in the AACSB accredited Business School, since it provides a comprehensive overview of the field of information technology management. The survey solicited students' feedback regarding various aspects of the textbook that was use during the course.

2.3. Employers' Input

Besides instructors' and students' needs, there is another equally important consideration for the selection of a MIS textbook. Since the information technology field is ever changing, teaching MIS courses requires instructors to equip themselves with the most up-to-date knowledge and technology. Therefore, one of the qualities of MIS textbooks that teachers should be looking for is adaptability. The textbook should not only be adaptable to new organizational developments, but also to the needs of local employers, based on the fact that most MIS graduates find jobs locally. However, most MIS textbooks are written in the view of being used nationwide. Therefore, they may not necessarily parallel the needs of local employers. Consequently, identifying local employers' needs and incorporating them into the process of selecting MIS textbooks is also important.

2.3.1 Employer Participant Selection

In order to select local employers to participate in this study, we asked the College's Career Services to identify the top 20 local employers of our accounting and management majors for the past five years. Following the approach used by and (Watson, 2000) each employer was initially contacted to identify the individual(s) in charge of hiring new graduates. Then each individual was asked about his or her willingness to participate in the study and twelve were selected. An important objective of the participant selection process was to solicit a diverse and well-informed viewpoints.

2.3.2. Data Collection

Telephone interviews were conducted to gather employers' feedback. The interviews were 20-30 minutes in length, including the introduction, and were comprised of the five questions. These questions were selected based on the review of AACSB requirements and 10 appropriate and current MIS textbooks on the market. At the end of the interviews the participants received a transcript of the telephone interview and were asked to review it for accuracy and add comments where appropriate.

3. METHODOLOGY

To incorporate all the voices, it is necessary to find a helpful methodology which provides for inclusion of quantitative as well as qualitative data. Analytical

Hierarchy Process (AHP) is an extremely useful methodology in this case. AHP has been known as a very useful multi-criteria decision making methodology to help decision makers select the best alternative among several available choices (Al-Subhi & Kamal, 2001; Bayazit, 2005; Lari, 2004).

Therefore, this paper attempts to demonstrate how AHP can help instructors to evaluate and select an appropriate MIS textbook for their courses with the inclusion of quantitative and qualitative factors from instructors, students and future employers, in the decision process.

4. AN OVERVIEW OF ANALYTIC HIERARCHY PROCESS

Saaty's Analytic Hierarchy Process (Saaty, 1995) has three major components:

1. Problem structuring – the formation of levels in a hierarchy,
2. Preference Assessment –prioritization, and
3. Synthesis

The AHP is unique in that it allows the quantification of intangibles through the construction of the problem in a visual hierarchical manner. This permits relationships between the ultimate goal, the criteria of choice and the alternatives to be clearly delineated in the decision-making process. This in turn functions as an aid to breaking the communication barrier that may exist between decision makers due to their different backgrounds, training and motivation. The hierarchy serves to create priority structures relevant to a specific decision problem. In deriving these priorities a distinction is made between local priorities that reflect the importance of an element at a lower level, those at a level higher in the hierarchy, and global priorities that reflect the importance of a criteria element with in relation to the focus of the problem. The basic AHP procedure consists of the comparison of pairs of factors within a set of reciprocal matrices.

The values in the matrix so formed indicate the strength by which one element dominates over another with respect to specific criterion by which they are being compared. Such a matrix is of the type:

$$A = \begin{Bmatrix} W_1 & w_1/w_2 & w_1/w_3 \ldots\ldots\ldots\ldots\ldots\ldots w_1/w_n \\ W_2/w_1 & & \\ \ldots\ldots & & \\ w_n/w_1 & & w_n/w_n \end{Bmatrix}$$

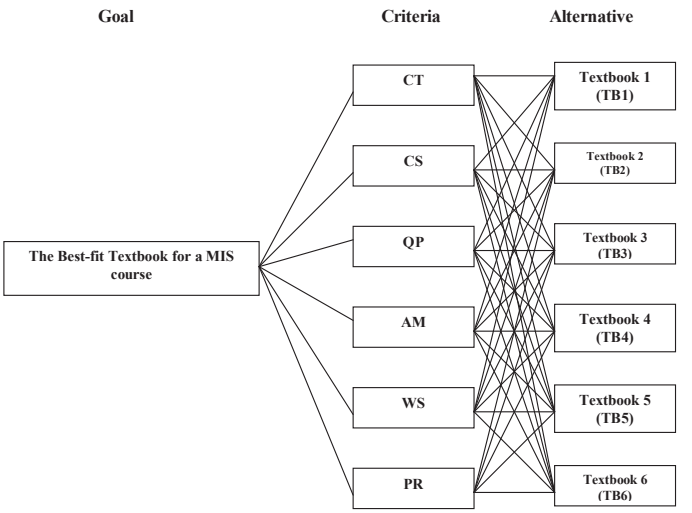
where every element wi/wj is representative of the a_{ij} comparison. Obviously if the i^{th} element is compared to the j^{th}, a comparison is also being made of the j^{th} with the i^{th} element (w_i/w_j, a_{ji}) causing the matrix to be a reciprocal matrix satisfying the criterion

$$a_{ij} = 1/a_{ji}$$

Since the comparisons may be qualitative, a scale capable of eliciting judgments from people in a consistent manner is needed, which also presents the flexibility to make judgments based on experience and personal expertise rather than on an absolute numerical value. Saaty uses a scale 1-9 based on the finding that an individual is incapable of simultaneously comparing more than seven alternatives (plus or minus two) (Miller, 1956, Saaty, 1977).

In this study we used scale 1 for equal importance (two factors contribute equally to objective), scale 3 for weak importance of one over another (experience and judgment slightly favor one factor over other), scale 5 essential or strong importance (experience and judgment strongly favor one factor over other), scale 7 for demonstrated importance (one factor is strongly favored and its dominance is demonstrated in practice), scale 9 for absolute importance (the evidence favoring one factor over another is of the highest possible order), and scales 2,4,6,8 as intermediate values. If factor i has one of the above non-zero numbers assigned to it when compared with factor j, then factor j has the reciprocal value when compared with i.

Figure 1. Decision hierarchy



5. USING AHP TO EVALUATE AND SELECT A MIS TEXTBOOK

5.1. Problem Structuring

In this study, a small group of evaluators comprised of three faculty members in charge of teaching MIS courses in an undergraduate accounting and management program discussed and brainstormed to generate evaluation criteria and identify alternatives. After initial deliberation, members of the evaluation team prepared a short survey to solicit inputs from students as well as several potential employers. After analyzing the results of these surveys, the evaluation team identified the following six evaluation criteria and six widely used MIS textbooks currently available in the market as the selection alternatives. These evaluation criteria were:

1. Content (**CT**)
2. Real World Case Studies (**CS**)
3. End of Chapter Questions and Problems (**QP**)
4. Ancillary Materials (**AM**)
5. Web Site (**WS**)
6. Price (**PR**)

Figure 1 shows the decision hierarchy.

5.2. Weighting the Criteria

After construction of the decision hierarchy, the second step was to assess the relative importance of criteria. An AHP evaluation is based on the decision maker's judgments about the relative importance of each criterion in terms of its contribution to the overall goal as well as preferences for the alternatives relative to each criterion. Therefore, in this example the evaluation team needs to specify their judgments about the relative importance of each of the six criteria.

Establishing priorities among criteria was based on pair-wise comparisons. A meeting with members of the evaluation team was scheduled to make pair-wise comparisons among criteria and available textbooks.

Table 1 shows the comparison matrix, which indicated the results when evaluating the relative importance of the criteria in a pair-wise fashion. The entries in the matrix consist of one's on the main diagonal and reciprocals of the ratings in the cells below the diagonal. The assignment of one's to the main diagonal is based upon the fact that when we compare any criterion against itself, the judgment must be that they equally preferred. The elements below the diagonal are reciprocals of those above because if, for example, content (CT) is eight times more preferred than case studies (CS), then (CS) must be one-eighth as preferable as (CT).

Table 1. Criteria comparison matrix

Criteria	CT	CS	QP	AM	WS	PR	Average
CT	1	8	5	8	8	9	.496
CS	1/8	1	1/3	4	5	5	.129
QP	1/5	3	1	7	7	7	.225
WS	1/8	1/4	1/7	1	1/3	1/5	.029
AM	1/8	1/5	1/7	3	1	1/3	.046
PR	1/9	1/5	1/7	5	3	1	.076

Table 2. Pair-wise comparison of how the selected textbooks address the content criterion

	TB1	TB2	TB3	TB4	TB5	TB6	
TB1	1	1/3	1/2	1/2	3	3	.124
TB2	3	1	3	3	5	5	.376
TB3	2	1/3	1	3	5	5	.247
TB4	2	1/3	1/3	1	3	3	.148
TB5	1/3	1/5	1/5	1/3	1	1	.052
TB6	1/3	1/5	1/5	1/3	1	1	.052

5.2.1. Calculating the Relative Weights(Priorities) of Criteria

While the AHP is an easy-to-understand methodology, the mathematical calculations required to derive priorities from pair-wise comparisons involve what are known as *eigenvalues* and *eigenvectors* and may turn out to be difficult and time consuming without a computer program. Although the Expert Choice software (http://www.ExpertChoice.com) easily performs these calculations, however these calculations can be carried out using a spreadsheet software, to obtain an approximation of the priorities.

The row averages of .496, .129, .225, .029, .046, and .076 in Table 1 provide an approximation to the priorities of the evaluation and selection criteria. Based on these priorities, content (CT) is the most important (preferred) criterion followed in importance by end of chapter questions and problems (QP), real world case studies(CS), price(PR), ancillary materials (AM), and Web site(WS).

5.2.2. Pair-wise Comparisons of Textbooks with Respect to Each Criterion

Tables 2 show the comparison matrix indicating the pair-wise evaluation on how the selected textbooks address Content (CT) criterion.

Similar tables should be constructed for CS, QP, WS, AM, and PR criteria.

Table 3 provides the relative importance of the textbooks by criterion type. For example, using the textbook comparison matrix for the content criteria (CT), the normalized eigenvector is calculated; it is shown in the CT column. Larger values of the eigenvector indicate a greater importance of textbook with respect to the criterion. Thus, TB2 best addresses the content criterion, followed in decreasing order by TB3, TB4, TB1, TB5, and TB6. This process of calculating the normalized eigenvector is repeated using the textbook comparison matrices for content (CT), case studies (CS), end of chapter questions and problems (QP), ancillary materials (AM), Web site (WS) and price (PR). Results of these calculations are provided under their respective columns. The results indicate that TB2 is the best-fit textbook alternative when considering the content criteria, TB3 is the best textbook when examining the Web site criteria, and TB2 is the best alternative when considering real world case study criteria.

The normalized eigenvector of the criteria comparison matrix is also shown in Table 3. It indicates the relative importance of the criteria based on the evaluation team members' data. The computational results yield the following: content(CT) is the most important, followed in importance by end of chapter questions/ problems(QP), real world case studies(CS), price(PR), ancillary materials(AM), and Web site(WS).

Table 3. Relative importance (normalized Eigenvectors)

	CT	CS	QP	WS	AM	PR
Criteria Relative Priority	.496	.129	.225	.029	.046	.075
TB1	.124	.030	.029	.104	.054	.130
TB2	.376	.446	.466	.278	.202	.150
TB3	.247	.268	.287	.278	.299	.308
TB4	.148	.032	.052	.156	.178	.114
TB5	.052	.078	.083	.156	.178	.237
TB6	.052	.145	.083	.027	.089	.060

Table 4. Composite prioritization

	CT	CS	QP	WS	AM	PR	
TB1	.496*.124 +	.129*.030 +	.225*.029 +	.029*.104 +	.046*.054 +	.075*.130 =	.087
TB2	.496*.376 +	.129*.446 +	.225*.446 +	.029*.278 +	.046*.202 +	.075*.150 =	.378
TB3	.496*.247 +	.129*.268 +	.225*.287 +	.029*.278 +	.046*.299 +	.075*.308 =	.267
TB4	.496*.148 +	.129*.032 +	.225*.052 +	.029*.156 +	.046*.178 +	.075*.114 =	.111
TB5	.496*.052 +	.129*.078 +	.225*.083 +	.029*.156 +	.046*.178 +	.075*.237 =	.085
TB6	.496*.052 +	.129*.145 +	.225*.083 +	.029*.027 +	.046*.089 +	.075*.060 =	.073

Table 4 illustrates the final overall prioritization of the six textbook alternatives. From this, the order of prioritization would be TB2, TB3, TB4, TB1, TB5, and TB6.

6. CONCLUSIONS

The purpose of this paper is to present a structured and systematic methodology, the Analytical Hierarchy Process (AHP), for the evaluation and selection of a MIS textbook. The methodology performs multiple criteria evaluation through a pair-wise weighting process for all criteria. This methodology allows a decision maker to incorporate qualitative as well as quantitative data in the decision process and offers a rigorous model on which a complex decision problem can be dealt with effectively. The evaluator does not have to reach an overall judgment in a single phase. Instead, the evaluator can (1) determine the relative significance (or importance) of the criteria through a relatively simple pair-wise comparison of two criteria, one at a time, then (2) evaluate textbooks under each criterion through a pair-wise comparison of each two textbooks one at a time, and (3) the AHP model will automatically present the solutions in terms of the evaluation of each textbook based on all criteria as well as on each single criterion.

In this paper six MIS textbooks were evaluated based on content, real world case studies, end of chapter questions and problems, ancillary materials, Web site, and price as the decision criteria. While the application described in this paper was carried out using a spreadsheet, an interactive commercial computer program (Expert Choice) is available that computes the priority vectors. Major conclusions from similar applications of the AHP were that it was found to be valid, flexible, and easy to apply and did not overlook any significant factor.

REFERENCES

Al-Subhi Al-Harbi, Kamal M. (2001), "Application of the AHP in project management," International Journal of Project Management, Vol.19(1), PP. 19.

Al-Tabtabai, Hashem M ; Varghese P, Thomas (2004), "Negotiation and resolution of conflict using AHP: an application to project management," Engineering,Construction and Architectural Management, Vol.11(2), PP. 90.

Association for Supervision and Curriculum Development, (1997), "Education Update," Vol. 39(1), 1997.

Bahurmoz, Asma M. A. (2003), "The Analytic Hierarchy Process at Dar Al-Hekma, Saudi Arabia," Vol. 33(4), PP. 70-78.

Bayazit, O. (2005), "Use of AHP in decision-making for flexible manufacturing systems," Journal of Manufacturing Technology Management, 16(7), PP. 808-819.

Cohen, D. J., (2005), "By the Book: Assessing the Place of Textbooks in U.S. Survey Courses", The Journal of American History, Vol. 91(4), pp. 1405-1416.

Dove M. K., (1998), "The Textbook in Education", The Delta, Kappa, Gamma Bulletin, Vol. 64(3), pp. 24-30.

Jårvinen, E-M. (2001), "Education about and thorough Technology. In search of More Appropriate Pedagogical Approaches to Technology Education", Acta Universitates Ouluensis, E 50, Oulun yliopisto,Oulu.

Lari, Alireza, (2004), "Application of AHP model for selection of technology licensor," International Journal of Technology Transfer & Commercialization. Vol.3(4), pp. 353.

Miller, G. A., (1956), "The Magical Number Seven Plus or Minus two: Some Limits on Our Capacity for Processing Information," The Psychological review, Vol. 63, pp.83-97.

Saaty, T. L., (1980), The Analytic Hierarchy Process, McGraw-Hill, New York.

Saaty, T. L. (1977), "A Scaling Method for Priorities in Hieraachical Structures," Journal of Mathematical Psychology, Vol. 3, pp.234-281.

Saaty, T. L., (1995), Decision Making for Leaders: The Analytic Hierarchy Process for Decision in a Complex World, RWS Publications, University of Pittsburgh, Pittsburgh, PA.

Schmidt, W. H., McKnight, C., and Raizen, S. (1997), "A Splintered Vision: An Investigation of U.S. Science and mathematics Education," Dordrecht, Netherlands, Kluwer.

Watson, H.J., G. Higgins, C. Kadlec, M. Meeks, and K.P. Taylor (1999) "Leaders Assess the Current State of the IS Academic Discipline", Communications of the Association for Information Systems, Vol.2(2).

Watson, H.J., R. D. Sousa and Junglas, I. (2000), "Business School Deans Access the Current State of the IS Academic Field" Communications of the Association for Information Systems Vol. 4(4).

Multi-Level Delegation for Flexible Business Process Modeling

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ABSTRACT

In this paper we address issues related to delegation of responsibilities and their importance in increasing the flexibility and the effectiveness of business processes. Organizations usually establish a set of business rules regulating the way business processes are managed. For example, they specify which user should perform a given work in a given situation. In a changing and highly dynamic environment, rules can not be planned in advance in a fine-grained level. What's more, in actual circumstances users may delegate work assigned to them; indeed, it is not always possible to account for every responsibility required in a moving environment. These delegation activities should be controlled. In addition, unforeseen circumstances like absence could take place. That is, we introduce a delegation model in order to allow the predefined rules to be less exhaustive and the decision-taking mechanism to be decentralized, to control the delegation activities between actors and to take into account unforeseen circumstances.

1. INTRODUCTION

In current distributed and dynamic environments, the goal of companies is to well and quickly meet with customers' requirements. In some cases, developing complete rules specifying exhaustively how actors will proceed is inaccurate, because this limits their autonomy and efficiency when changes make some predefined conditions inapplicable.

Instead of developing fully business policies, we propose to provide the ability of delegation provided that it is controlled by an effective model. There are many requirements that may drive to provide delegation capabilities:

- Making easier process management by decentralizing the control and the decision-making and allowing actors to be more autonomous and confident.
- Collaborative work in human organizations requires the use of delegation as natural and useful way to cooperate. Actors could wish to cooperate in a project.
- Responsibilities may conflict, and specific policies may require that an actor delegate some of his duties in order to separate conflicting duties.
- An actor may lack resources (e.g. time, equipment) essential for achieving his responsibilities.
- Unforeseen circumstances, such as unplanned absences (illness, leaves), may require to change actors.
- Substitution: in some situations like business mission, the employee needs to delegate the achievement of the responsibility he ensures to another employee.

To deal with these requirements, we introduce a multi-level delegation in order to make business rules less complex and flexible, processes more efficient, and management and control more flexible.

In this paper, we address issues related to delegation of pieces of responsibilities and their importance in increasing flexibility of business processes. Selecting some parts of responsibilities gives the delegator great flexibility in choosing which work he/she wants to delegate.

By granting autonomy to actors and allowing them to delegate and to decide which parts of responsibilities they want to delegate, the development of the business rules by the manager is greatly simplified. In fact, the decision-making and the process control will be distributed between him/her and the other actors of the organization. Thus, the process manager has to define significant rules on a coarse-grained level without seeing details whereas actors that are allowed to delegate define exhaustively how tasks should be achieved and by whom. Therefore, this approach satisfies the process manager requirements as well as ones of the participating actors. The process manager will have less complex rules to handle (this fact is time-saving) and actors will be more autonomous and confident.

The paper is organized as follows: in section 2 we discuss related work and present our contributions. In section 3, we introduce a delegation model for flexible business process modeling, we provide a meta-model and we illustrate our model with a case study. Section 4 concludes the paper.

2. BACKGROUND AND MOTIVATION

The literature provides a considerable work dealing with various aspects of delegation. Delegation can take many forms. Gasser and McDermott [5] address user-to-machine delegation; they define it as "the process whereby a user in a distributed environment authorizes a system to access remote resources on his behalf". Henry and Gladny [7] deal with machine to machine delegation; they consider requirements for a digital library that emulates massive collections of physical media for clerical, engineering, and cultural applications. Nagaratnam and Lea [9] discuss process-to-process delegation in the distributed object environment. Sandhu et al. [11] address delegation among the role administrators. Delegation addressed in [2], [6], [7], [8], [9] and [11] is related to rights in a security context. Schaad and Moffett [1] address delegation of obligation and authorizations. Becker et al. [3] deal with delegation in distributed software process management allowing a client in interorganizational development processes to delegate parts of net-based process models to contractors.

Delegation addressed in most common work is unconstrained and without any conditions, that is not convenient and may cause frustration. In addition, delegation is often defined as a substitution mechanism of all or a subset of actor's roles to one or more other actors such as in [2], or the ability of a user to delegate to another user some permissions related to a role [2] or single tasks [4].

Nevertheless, in some cases an actor needs to delegate only some functions held by his/her role. Furthermore, in some cases, role-based delegation is required. For instance, if the "loan manager" is absent, loan manager's responsibilities can be delegated to other employees based on their capabilities (roles) rather than their identities (individual actors). For instance, "Offer_preparing" can be delegated to the role "loan manager's assistant".

In this paper we focus on human delegation where a user delegates a part of his responsibilities to another user. This can be done directly or through membership to roles. These issues of delegation were informally discussed previously in [10]. We identified three main kinds of delegation: actor-to-actor, actor-to-role and role-to-role delegation. Each of them can be based on roles, functions and/or operational goals. In this paper, we study in depth these issues. To the original work, we add some extensions which enhance the effectiveness and the totality of our approach.

In summary, our research provides the following contributions:

- Delegation addressed in this paper can be based not only on functions, roles and operational goals as proposed in [10], but also on more coarse-grained

responsibilities (business processes and business goals) as required. This kind of delegation requires more confidence and autonomy of the delegatee.
- Current approaches focus only on Who, What and Whom facets of the delegation and omit the Why and How ones. In this paper, we discuss also the latter ones. The Why facet controls and justifies the delegation activities.
- We provide a meta-model including all concepts useful to define delegation capabilities, and we formalize their semantics by the means of formal logic.

This paper is the first attempt to model delegation of multi-level responsibilities in the context of business process flexibility.

3. MULTI-LEVEL DELEGATION MODEL

In order to satisfy the flexibility requirements related to business process modeling, we introduce in this section a new delegation model based on multi-level responsibilities. The proposed model reuses basic concepts introduced in [10] and extends them with new concepts. We will first present a summary of the basic concepts; then, we introduce the new concepts related to delegation. Examples used throughout the paper for illustrating concepts concern the loan handling process in a bank.

3.1. Overview of the Role-Based Approach for Modelling Flexible Business Processes

The central concepts in our approach are the role and the function. A role can represent competency to realize particular functions, e.g. "an engineer", and can embody authority and responsibility, e.g., "a project supervisor". A role can be responsible for the achievement of a business_process (BP) or a business goal. A function (i) is a collection of operational goals satisfied by performing operations, (ii) is hold by one role, and is a part of a BP. An organization is structured as a network of BPs in order to achieve business_goals. A business_goal is achieved by performing a BP which comprises many functions. An actor belongs to organizational_units, can play several roles based on his responsibilities and qualifications and performs functions specifying work steps in a BP. Organizational_units can be firm's branches or describe firms collaborating to achieve common processes.

$ACTORS,\ ROLES,\ FUNCTIONS,\ O\_GOALS,\ OPERATIONS,\ BPS,\ B\_GOALS,\ ORG\_UNITS$

define sets of actors, roles, functions, operational goals, operations, business processes, business goals and organizational units, respectively.

Let

$a \in ACTORS,\ r,\ r_1,\ r_2 \in ROLES,\ f \in FUNCTIONS,\ op \in O\_GOALS, o \in OPERATIONS,\ bp \in BPS,$
$bg \in B\_GOALS,\ ou \in ORG\_UNITS$

$Can\_play(a,r)$ means that a can play r.
$Comprises(f, op)$ means that f comprises op
$Satisfies(op, o)$ means that op is satisfied by achieving o.
$is\_responsible(r, bg)$ means that r is responsible for the achievement of bg.
$is\_responsible(r, f)$ means that r is responsible for the performance of f.
$Participates(r, f)$ means that r participates in the achievement of f by performing some operations satisfying operational goals of f.
$Comprises(bp, f)$ means that bp comprises f.

3.2. Facets of the Multi-level Delegation Model

We now introduce the supplementary components related to delegation. As mentioned in Section 2, we define five facets of the delegation capturing these questions:

- Who delegate the responsibility?
- To Whom the responsibility is delegated?
- What is the delegated responsibility?
- Why delegation takes place?
- How delegated work should be performed?

These facets are represented respectively by the entities: *Delegator, Delegatee, Responsibility, Context, Instructions.*

An actor can delegate parts of his responsibilities to another actor which performs these responsibility parts; this can be done directly or through membership to roles. Delegation is controlled by the means of the relation Can_delegate: a 5-tuple with five attributes representing the five facets. $Can\_delegate(dtor, dte, resp, c, i)$, means that dtor (or the members of dtor if dtor is a role) can delegate the responsibility resp to dtee (or the members of dtee if dtee is a role) in the context c, forcing the achievement instructions i. Throughout the paper we will use the terms dtor, dte, resp, c and i to denote the actors/roles involved in the delegation (delegator and delegatee respectively), the responsibility to delegate, the context of the delegation, and recommendations or directives to be provided by the delegator to the delegatee.

An actor can take part in more than one delegation in different roles. In addition we extend the relation Can_hold [10] by two new relations between the entities Role and Function, which are Is_responsible and Participates. Similarly, two new relations are defined: Is_responsible, between the entities Role and Business_process, and between Role and Business_goal respectively. We will discuss these concepts.

- Who and whom facets: Our model supports individual delegation as well as role-based delegation. The delegator and the delegatee can be either actors or roles. Then, it is possible to define role-to-role, actor-to-actor and actor-to-role delegations. We assume that it is no significant to define role-to-actor delegation.
- What facet: The delegated responsibility can be at different levels of refinement (operational_goal, function, role, BP, business_goal).
- Why facet: The fourth facet is the context of delegation which answers the question "Why the responsibility is delegated". Context can be: unplanned absence, illness, leave, collaborative work, saving of time, lack of resources, decentralization of work, conflict of duties, etc. Responsibilities that an actor can delegate to another actor can differ depending of the context of delegation. For instance, a loan manager can delegate the function "Offer_validating" to his assistant in the context of "Lack_of_resources" or "Absence", but not in the context of "Conflict_ of_duties".
- How face: The last facet defines the way of specifying "How to achieve the delegated responsibility?" The delegator has to provide it to the delegatee. Confidence allowed to the delegatee depends on his/her competency, autonomy and experience. Delegation requires that the delegatee has sufficient experience and capacity to perform work. It may also give the delegatee some new responsibilities. The delegatee is responsible for performing the delegated work. The delegator is responsible for ensuring that the work was well carried out.

There are several ways of delegating a work. The delegatee may have no autonomy; he/she has to precisely follow delegator directives for achieving the delegated work. The delegator can give some recommendations but it is in the responsibility of the delegatee to decide how the delegated work is fulfilled. The delegator can also delegate a work without any recommendation, this requires a high level of confidence and analysis on behalf of the delegatee which has total autonomy, and he/she decides and acts without contacting the delegator.

For example, if the "Loan_manager" delegates the function "Loan_handling" to the "Loan_assistant", he/she can precise some recommendations for its achievement.

Recommendations and directives are defined by the delegator. They can be fine or coarse-grained, planned or ad-hoc. If they are coarse-grained, the delegatee has to enforce and refine them.

3.3. The Meta-Model of Delegation

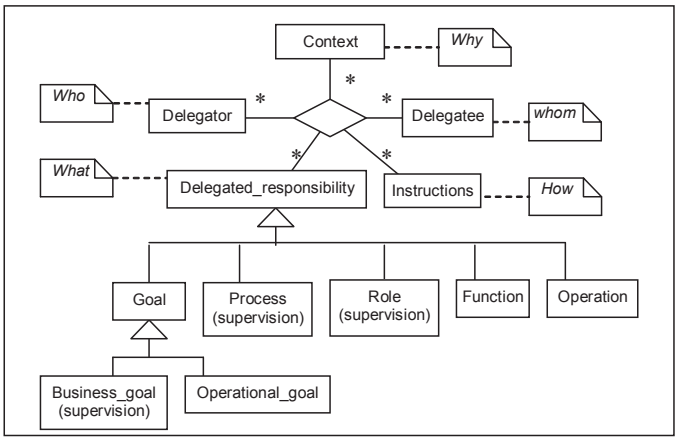
The meta-model of our delegation framework is represented by an UML diagram in Figure 1.

We represent now the delegation formally:

$DELEGATORS, DELEGATEES, D\_RESPONSIBILITIES, CONTEXTS, INSTRUCTIONS$

are set of delegators, delegatees, delegated responsibilities, contexts and ways.

Figure 1. Meta-model of delegation



$DELEGATORS \subseteq ACTORS \cup ROLES$, $DELEGATEES \subseteq ACTORS \cup ROLES$,

$D\_RESPONSIBILITIES \subseteq B\_GOALS \cup B\_GOALS \cup ROLES \cup FUNCTIONS \cup B\_GOALS \cup OPERATIONS$

$INSTRUCTIONS = \{$, *"Recommendations", "Directives"*$\}$

We now represent formally rules expressed by our model:

$\forall r, r_1, r_2 \in ROLES, f \in FUNCTIONS, p \in B\_GOALS, o \in OPERATIONS, \forall dtor \in DELEGATORS,$
$dtee \in DELEGATEES, resp \in D\_RESPONSIBILITIES, \forall c \in CONTEXTS, w \in WAYS, i \in INST$

Hypothesis 1
If dtor can delegate f to dtee, then dtor can delegate any operational_goal comprised in f to dtor, he/she can also delegate any operation associated with that operational_ goal to dtee.

$Can-delegate(dtor, dte, f, c, i) \wedge Comprises(f, p) \rightarrow Can-delegate(dtor, dte, p, c, i)$
$Can-delegate(dtor, dte, f, c, i) \wedge Comprises(f, p) \wedge satisfies(o, p) \rightarrow Can-delegate(dtor, dte, o, c, i)$

Hypothesis 2
If dtor can delegate his/her responsibility of achieving bp to dtee, then dtor can delegate any function f comprised in BP to dtee. He/she can thus, according to hypothesis 1, delegate to dtee any operation and any operational_ goal associated to f.

$Can-delegate(dtor, dtee, bp, c, i) \wedge comprises(bp, f) \rightarrow Can-delegate(dtor, dtee, f, c, i)$

Hypothesis 3
If dtor can delegate bg to dtee, then dtor can delegate to dtee any bp reaching bg. He/she can thus, according to hypothesis 2, delegate to dtee any function associated to bp.

$Can-delegate(dtor, dte, bg, c, i) \wedge reachs(bg, bp) \rightarrow Can-delegate(dtor, dte, bp, c, i)$

Hypothesis 4
We suppose that role-to-actor delegation is not possible and express this rule as follows:

$\neg Can-delegate(dtor, dte, resp, c, i) \wedge dtor \in ROLES \wedge dte \in ACTORS$

Examples of instantiation of the model:

$Can-delegate($" $loan\_manager$","$loan\_assistent$","$loan\_handling$",
$saving\_of\_time$","$recommendations$")

means that any actor who is member of the role "Loan_manager" can delegate the function "Loan_handling" to any actor who is member the role "Loan_ assistant" in the context of "saving of time" and the delegator has to provide recommendations to the delegatee.

3.4. The Delegation Process

In this section, we specify the different steps of a delegation. The delegator has to specify with respect to the predicate can-delegate (i) the responsibility to be delegated, (ii) the context of the delegation, (iii) a list of delegatees being able to receive the delegation in the determined context. The choice of the most appropriate delegatee is in the discretion of the delegator; it depends on the importance of the delegated responsibility and the delegatee competency. The selected delegatee should agree to receive the delegation. Once the delegatee is selected, both the delegator and the delegatee will agree on control and coordination methods which depend on the delegatee confidence, competency and autonomy.

Then, the delegator defines the directives or recommendations required for the enactment of the delegated responsibility. The refinement level of these recommendations or directives depends on the kind of the responsibility and the delegatee competency. Particular responsibilities should be carefully delegated. The delegatee has to refine the delegated responsibility following the delegator recommendations or directives. Some responsibilities require to be refined by the delegatee because each individual has his specific method to realize given tasks.

Supervising the delegation : in some cases, the delegator has to supervise the progress states of the delegated parts of the responsibility. In other cases, the delegatee does not have to return to the delegator the intermediary inputs and outputs associated with the delegated responsibility. Thus the delegatee has to contact the delegator when the delegated responsibility is achieved.

In all cases, once the delegated responsibility is achieved, the delegator can revoke the delegation and have to measure the quality of the achieved work. We represent in Figure 2 the algorithm capturing the main phases of the delegation process. Metrics can be used to measure the variance between the required results and the obtained ones. Then, the delegator can decide to improve the obtained results. These aspects are out of the scope of this paper and will be discussed in a future work.

3.5. Illustration

For illustrating the semantics of our model, we use the case of a loan handling process in a bank.

Figure 2. Algorithm of delegation

Algorithm1. The delegation process

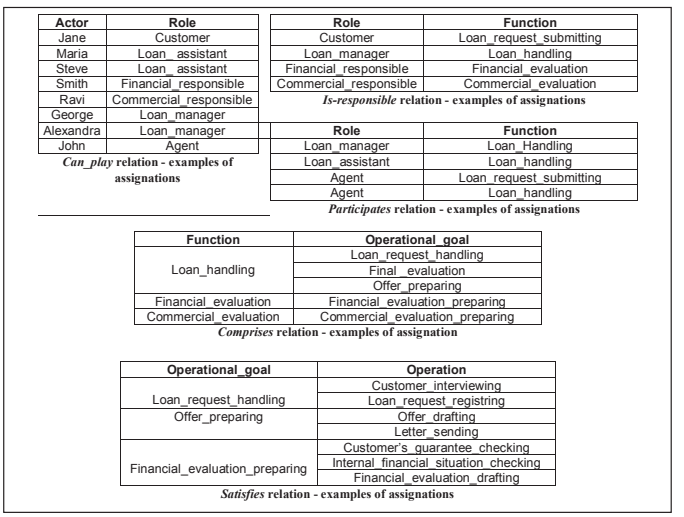
INPUT: $dtor_i \in DELEGATORS, resp_j \in D\_RESPONSIBILITIES, c_k \in CONTEXTS$

Let *Establish-dtee* a function which, for a given 3-tuple $(dtor_i, resp_j, c_k)$ return a sorted list $\{(dte_l, inst_m)\}$ such that $dte_l \in DTE, inst_m \in INST$ and $can-delegate(dtor_i, dte_l, resp_j, c_k, inst_m)$.

BEGIN
$List-dte \leftarrow Establish-dte(dtor_i, resp_j, c_k)$
if $List-dte \neq \emptyset$
  $path \leftarrow 1$
  while $path \neq 0$ **do**
    If $agree(List-dtee[path])$
    $path \leftarrow 0$
    endif
  endwhile
endif

if $List-dte = \emptyset$ or $path = length(List-dte)$
$Success-delegation \leftarrow false$

Figure 3. Examples of assignations



Actor	Role
Jane	Customer
Maria	Loan_ assistant
Steve	Loan_ assistant
Smith	Financial_responsible
Ravi	Commercial_responsible
George	Loan_manager
Alexandra	Loan_manager
John	Agent

***Can_play* relation - examples of assignations**

Role	Function
Customer	Loan_request_submitting
Loan_manager	Loan_handling
Financial_responsible	Financial_evaluation
Commercial_responsible	Commercial_evaluation

***Is-responsible* relation - examples of assignations**

Role	Function
Loan_manager	Loan_Handling
Loan_assistant	Loan_handling
Agent	Loan_request_submitting
Agent	Loan_handling

***Participates* relation - examples of assignations**

Function	Operational_goal
Loan_handling	Loan_request_handling
	Final _evaluation
	Offer_preparing
Financial_evaluation	Financial_evaluation_preparing
Commercial_evaluation	Commercial_evaluation_preparing

***Comprises* relation - examples of assignation**

Operational_goal	Operation
Loan_request_handling	Customer_interviewing
	Loan_request_registring
Offer_preparing	Offer_drafting
	Letter_sending
Financial_evaluation_preparing	Customer's_guarantee_checking
	Internal_financial_situation_checking
	Financial_evaluation_drafting

***Satisfies* relation - examples of assignations**

A customer's loan request is accepted only if its features are compatible with the financial and commercial strategies and interests of the bank.

The process starts by a customer loan request, then, an agent registers this request, which will be next evaluated by both the financial and commercial departments. The first evaluation is performed by the financial person responsible and involves financial aspects related to both the customer and the bank, for instance, the guarantees provided for refunding the loan. The commercial evaluation is performed by the commercial responsible and involves commercial aspects like the possibility to acquire new regular customers and is performed by a loan manager.

Basing on the commercial and the financial evaluation, the loan manager performs the final evaluation and he may reject the request; in this case an agent writes the refusal letter. He/she may also propose a counterproposal which will be prepared by the loan manager's assistant. He/she may as well accept the request, then the loan manager's assistant establishes a complete proposition including the duration, the amount, the interest rate, the refunding instructions, etc. We provide some assignation examples in Figure 3.

Roles involved in this process are:

$$"Customer",\ "Financial\_responsible",\ "Commercial\_responsible",$$
$$"Loan\_manager",\ "Loan\_assistent",\ "Agent"$$

In the following, we present a possible instantiation of the delegation model.

$$BUSINESS\_PROCESSES = \{"Loan\_handling"\}$$

$$ACTORS = \{"Jane","John","Maria","Steve","Smith","Georges","Alexandra","Ravi"\}$$

$$ROLES = \begin{Bmatrix} "Customer","Agent","Loan\_manager","Loan\_assistent","Financial\_responsible", \\ "Commercial\_responsible" \end{Bmatrix}$$

$$FUNCTIONS = \begin{Bmatrix} "Loan\_request\_submitting","Loan\_handling", \\ "Financial\_evaluation","Commercial\_evaluation" \end{Bmatrix}$$

$$\theta\_GOALS = \begin{Bmatrix} "Loan\_request\_handling","Commercial\_evaluation\_preparing", \\ "Financial\_evaluation\_preparing","Commercial\_evaluation\_preparing" \end{Bmatrix}$$

$$OPERATIONS = \begin{Bmatrix} "Customer\_interviewing","Loan\_request\_registring", \\ "Customer's\_garantee\_checking","Internal\_financia\_situation\_checking", \\ "Financial\_evaluation\_drafting","Condition\_evaluating", \\ "Couterproposal\_drafting","refusal\_letter\_drafting","Offer\_drafting" \\ "Letter\_sending" \end{Bmatrix}$$

$$Can\_play("Jane","Customer"),$$
$$Can\_play("Smith","Customer"),$$
$$Can\_play("John","Agent"),$$
$$Can\_play("Maria","Loan\_assistent")$$
$$Can\_play("Steve","Loan\_assistent")$$
$$Can\_play("Smith","Financial\_responsible")$$
$$Can\_play("Georges","Loan\_manager")$$
$$Can\_play("Alexandra","Loan\_manager")$$
$$Can\_play("Ravi","Commercial\_responsible")$$

$$Is\_responsible\_for("Customer","Loan\_request\_submitting")$$
$$Is\_responsible\_for("Loan\_manager","Loan\_handling")$$
$$Is\_responsible\_for("Financial-responsible","Financial\_evaluation")$$
$$Is\_responsible\_for("Commercial-responsible","Commercial\_evaluation")$$

$$Participates("Loan\_manager","Loan\_handling")$$
$$Participates("Loan\_assistent","Loan\_handling")$$
$$Participates("Agent","Loan\_handling")$$
$$Participates("Agent","Loan\_request\_submitting")$$

$$Comprises("Loan\_handling","Loan\_request\_handling")$$
$$Comprises("Loan\_handling","Final\_evaluation")$$
$$Comprises("Loan\_handling","Offer\_preparing")$$

$$Satisfies("Loan\_request\_handling","Customer\_interviewing")$$
$$Satisfies("Loan\_request\_handling","Loan\_request\_registring")$$
$$Satisfies("Offer\_preparing","Offer\_drafting")$$
$$Satisfies("Offer\_preparing","Letter\_sending")$$
$$Satisfies("Financial\_evaluation\_preparing","Internal\_financial\_situation\_evaluating")$$
$$Satisfies("Financial\_evaluation\_preparing","Financial\_evaluation\_drafting")$$
$$Satisfies("Financial\_evaluation\_preparing","Customer's\_garantee\_checking")$$

We identify in the following some examples illustrating delegation.

Example 1.

$$Can-delegate("George","Maria","Loan\_manager","saving\_time","Rrecommendations")$$

This is an actor-to-actor delegation which means that "George" can delegate his role "Loan manager" to "Maria" in the context of "time_ saving", he has to give her recommendations.

This means also that "George" can delegate to "Maria" all functions, operational_ goals and operations associated with this role. Thus, "Maria" can perform these responsibilities as well as delegate some of them to other roles/actors participating in the functions of delegated role.

Example 2.

$$Can-delegate("George","Maria","Loan\_handling","Lack\_resources","Directives")$$

This is an actor-to-actor delegation which means that "George" can delegate the function "Loan_handling" to "Maria" in the context of "Lack_of_resources", he has to give her directives.

This means also that "George" can delegate to "Maria" all operational_goals and operations associated with this function.

Example 3.

Can – delegate(" *Loan _ manager*","*Loan _ assistent*","*Laoan _ manager*", "*Urgent _ situation*","*Directives*")

This is a role-to-role delegation which means that any actor member of the role "Loan_manager" can delegate this role to any actor member of the role "Loan_assistant", in the context of "Urgent_situation" and with directives

DISCUSSION

In our example, the "loan_manager" can create new operational_goals or functions if needed. For instance, with reference to his experience, he may judge that throughout the year, in particular periods, instead of delegating all the operations of the operational goal "Loan_request_handling" to an agent, he performs him-self the operation "Customer_interviewing" and only delegate the operation "Loan-request_registring" to an agent. Thus, after interviewing the customer, he may stop the process even before "loan_request_registering" if he judges that it is useless to continue the process and to perform the operation "Loan_request_registring" followed by the operational goal "Financial_evaluation_preparing", etc. knowing that in any way (even if the financial evaluation is positive), the loan request will be rejected. An agent can not take the decision of stopping the loan handling process in a beginning stage; the loan handler can do it. Stopping the process saves the time of the actors participating in the rest of the process including the financial responsible, the decision of the loan manager avoids him to perform a useless financial evaluation knowing that the commercial evaluation will stop the process later.

In other circumstances, the loan manager may prefer that the loan request handling be performed by his assistant rather than an agent, he may judge that the loan manager's assistant may, in the stage of loan request handling, be able to propose a counterproposal if needed, rather than taking this decision later, this is also time saving.

Furthermore, in this example, the business manager has only to specify the process phases on a coarse-grained level (as level process, goal and functions). The "Loan_manager" is responsible for the function "Loan_handling" has to enforce and refine the manager's specification in a lower level using operational_goals and operations.

For instance, the manager can only specify the steps of a process as top-level functions, the role holding each function of the process has to specify its achievement using operational goals and operations. However, if the manager identifies only processes allowing the achievement of a business goal, actors holding the role which is responsible for each business process have to define exhaustively functions representing the process steps. Nevertheless, he can delegate parts of this responsibility to other roles (for instance, specifying the steps as top-level operational goals and operations or the achievement of some function fragments consisting of a number of operational goals including their relationships).

4. CONCLUSION

In this paper we discussed the importance of delegation in flexibility and effectiveness of business processes, and we proposed a multi-level delegation model which supports three types of delegation (actor-to-actor, actor-to-role and role-to-role delegation), and five levels of delegated responsibility (role, function and operational_goal, business_goal and process). The ability to delegate responsibilities greatly simplifies the process management and control by decentralising management and decision-making.

The multi-level delegation proposed in this paper responds to actual requirements related to the decentralisation of decision-making by allowing actors to be more autonomous. Our approach meets also requirements of collaborative work. It resolves problems related to conflict of duties, lack of resources (e.g. time, equipment), unforeseen circumstances, such as unplanned absence (illness, leave) and actors' substitution.

The work presented in this paper is the first attempt to model delegation based on roles, functions, goals and processes.

Delegation mechanisms raise many issues which need further research such as:

- Controlling that delegation is not ill-advisedly used.
- Revocation of delegation.
- Management of delegation.
- delegation in the context of inter-organisational collaborative work
- Tool support.

REFERENCES

[1] Schaad, A., Moffett, J. (2002) Delegation of Obligations. 3rd IEEE International Workshop on Policies for Distributed Systems and Networks.

[2] Barka, E., Sandhu., R. (2000) A role-based Delegation Model and Some Extensions. Proceedings 23rd National Information Systems Security Conference.

[3] Becker, S., Jäger, D., Schleicher, A., Westfechtel. B. (2001) A delegation Based Model for Distributed Software Process Management. In Ambriola, V., ed.: Proceedings 8th European Workshop on Software Process Technology (EWSPT). LNCS 2077, Witten, Springer (2001) 130–144

[4] Dowson, M. (1987) Integrated project support with Istar. IEEE Software, 4(6).

[5] Gasser, M., McDermott, E. (1990) An Architecture for practical Delegation in a distributed System. IEEE Computer Society Symposium on Research in Security and Privacy.

[6] Goh, C., Baldwin, A. (1998) Towards a more Complete Model of Role. Proc. of 3rd ACM Workshop on Role-Based Access Control.

[7] Henry, M., Gladny (1997) Access Control for Large Collections. ACM Transactions on Information Systems, 15(2), 154-194.

[8] Lampson, B., Abadi, M., Burrows, M., Wobber, E. (1992) Authentication in Distributed Systems: Theory and Practice. ACM Transactions on Computer Systems.

[9] Nagaratnam, N., Lea, D. (1998) Secure Delegation for Distributed Object environments. USENIX Conference on Object Oriented Technologies and Systems.

[10] Saidani, O., (2006) Nurcan, S. A Role-Based Approach for Modelling Flexible Business Processes. Workshop on Business Process Modelling, Development, and Support (BPMDS), T. Latour and M. Petit (Eds.), Luxembourg, pp. 111 - 120.

[11] Sandhu, R., Bhamidipati, V., Munawer., Q. (1999) The ARBAC97 Model for Role-Based Administration of Roles. ACM Transactions on Information and System Security, 2(1).

An Optimal Query Execution Plan for Database Systems

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ABSTRACT

A major decision for the query processor of the database management system in centralized as well as distributed environments is how a query can produce the result as efficiently as possible. The typical query optimizer will not necessarily produce an optimal query plan. It simply tries to find the best possible plan within a minimum amount of time using mostly semi-accurate statistical information. In this paper, we discuss major issues regarding query optimization for relational database management systems, and expand the optimization issues for distributed database systems (DDBSs) to show how the query optimizer can choose an optimal plan for efficient execution of those queries that require multiple-site participations for producing the result. An algorithm that can be used toward more efficient query processing is presented. Our algorithm examines frequently used queries, and identifies two categories of groups of queries. First, a group of queries requiring the same procedures (including operations used), and second, a group of queries requiring data from the same site (or set of sites) for producing the result

1. INTRODUCTION

Query processing in a database environment refers to a series of activities involved in updating and retrieving data from database and it can be divided into four major phases: decomposition phase (consisting of scanning, parsing and validation), optimization phase, code generation phase, and execution phase [1]. Even though in this paper, we are mainly concerned about optimization and related issues regarding this phase of query processing, we believe a brief examination of all phases can be valuable [also see references 2, 3, 4, and 5].

Decomposition (Scanning, Parsing, and Validation) – The job of the *scanner* is to identify the language tokens found in the query, whereas the *parser* checks the query syntax. *Validation* is done to make sure that all relations and their attributes are valid and meaningful.

Optimization –There are generally many different methods that can be used to process a query and compute the result. *Query optimization* is the process of choosing the most efficient strategy for computing the result.

Query Code Generation – Once an "optimal" execution plan is produced by the query optimizer, it is the job of the *code generator* to generate the code for executing the plan.

Query Execution – The runtime database processor is responsible for executing the code (generated by the query code generator), whether in compiled mode or interpreted mode, to produce the response to the query.

We now return our attention on query optimization which is the focal point of this paper. Query optimization sub-module of the query processing module in centralized as well as distributed environment has been a subject for significant research and development. The term *optimization* is in a sense a misnomer (as claimed in [4]) because in some cases the efficient execution plan selected by the query optimizer is not necessarily the optimal strategy, but it is in fact just a *reasonably efficient* strategy for executing the query [4]. Hence, when dealing with query optimization, it would necessary to examine plans for different execution strategies. The process of selecting the execution plan for a given query can be divided into several detailed plans such as designing an efficient algorithm for executing an operation, the order of executing relational algebra operations, choosing the specific indices to use, and so on. In addition, there are other issues that are of particular interest for a distributed environment that are discussed in the next section.

2. DISTRIBUTED QUERY PROCESSING

The query optimizer chooses the most efficient query execution plan at the relational algebra level. In other words, the query optimizer attempts to find a relational algebra expression that is equivalent to the given expression, but it is more efficient to execute. This issue of finding *equivalent expression* needs to be discussed in great details and it is beyond the scope of this paper. Interested readers are encouraged to see [5]. In a distributed environment there are essential aspects of the query processor that have to be considered alongside those for centralized databases [6]. While distributing data across different sites allows those data to reside where they are most needed, but it also makes them accessible from other sites. Therefore, to process a query initiated at one site, we might need to make some data movements among several sites. And since transmission of data and messages across communications lines has a tendency to slow down the whole process, the order of data movement (that is, what data from which site should be moved first, what data should be moved next, and so on) among sites must be considered as an essential aspect of query processing for distributed database systems. One other essential aspect, worthy to consider, regarding query optimization for distributed database systems is the existence of multiple processor in the network. This allows for parallel processing of queries (and sub-queries) and data transmission which could lead to a faster response [6]. In our approach, as we will see in Section 3, these issues play a vital role in producing the optimal execution plan.

3. "OPTIMAL" EXECUTION PLAN

In both, centralized and distributed database systems, it is the responsibility of the query optimizer to transform the query as submitted by the user into an equivalent query that can be executed more efficiently. To do this, the query optimizer estimates the evaluation cost of each strategy and decides if the chosen strategy has the least cost. One process in estimating the execution cost of a query is to estimate the result size of each operation in each possible execution sequence. This is of prime interest because the size of the intermediate relations plays a significant role in the performance of an execution strategy. Unfortunately, there is no general consensus on the method of estimating the size of intermediate results. Among different techniques that have been proposed in the literature the one that is given in [7] is based on the Discrete Fourier Transformation. Their algorithms present tradeoffs between accuracy of the approximation and memory requirements. The estimation of size of the intermediate relations is based on statistical information about the relations, their attributes, and indexes. One problem regarding this approach is that most systems do not update the statistics on every change. This could lead to inaccurate estimates, and thus selection of strategies far from optimal. An alternative approach has been examined in {8 and 9] and others. Discussion of their approach, which in fact is dynamic query execution, is beyond the scope of this study.

The selection of a good strategy statically can be made effectively by the prediction of execution costs of the alternative plans prior to actually the executing the query. The execution cost is basically expressed as the combination cost of CPU, I/O and the communication costs (for distributed systems). In centralized systems, many cost functions ignore the CPU factor and emphasize on I/O cost. They compare different evaluation plans in terms of the number of block transfers between secondary storage and main memory. This (i.e., efficient memory management) has attracted the interest of many researchers such as [10, 11, and 12]. Whatever the cost factor (CPU or I/O, or both, plus communications for DDBSs), to estimate the cost for a given plan, the query optimizer estimates the cost of individual procedures making up the plan, and adds them together to get the total cost of

executing the query. The process of cost estimation for individual procedures is repeated for those procedures used in different execution plans, and thus, it could become a very time consuming task. To overcome this problem, authors in [13] suggest the design of a query optimizer that examines current queries and generates a master plan for each group of queries requiring the same set (or subset) of individual procedures. The task of identifying similar queries that can be grouped together can in turn become cumbersome if not done efficiently. The fact that in the distributed database system the data reside in different locations can be a cause of many difficulties in query processing and optimization. In a DDBS each site may initiate a query, and may access data at that site and/or at several other sites on the network. In fact, the query may be broken into a set of sub queries that must be executed in order to produce the result of the query. In our approach, for an efficient process, we design an optimizer which examines frequently used queries, and identifies the following two categories of groups of queries: 1) Groups of queries requiring the same procedures (including operations used), and 2) groups of queries requiring data from the same site (or set of sites) for producing the result. Each of these two categories of queries is explained below and an algorithm that generates these groups from a set of queries is given in Section 4.

1. Groups of queries requiring the same procedures (including operations used) - For these groups, the query optimizer generates a super-query execution plan for each group before breaking it into a set of sub queries for execution. Of course, as mentioned earlier, the task of grouping queries can become costly if not done efficiently. Since Join operation is one of the most time consuming and costly operations in query processing, we take into account the Join operation as the first criterion for grouping queries in this category. That is, the query optimizer must begin this process by grouping queries that have Join operation in common (i.e., Joining the same relations as their operand.) Next, the query optimizer identifies those queries that have in common, binary operations (other than the join) such as the Cartesian Product. Finally, it reviews the remaining queries to identify and group those queries that share the same predicates (or part of them for compound predicates) for Selection operation. For each of the above groups, the query optimizer combines participating queries into a super-query before breaking it into a set of sub-queries for efficient execution of each query member of the set.
2. Groups of queries requiring data from the same site (or set of sites) for producing the result - For these groups, the query optimizer generates a super query execution plan according to data being used, and then breaks it into a set of sub-queries (one sub-query for each site participating in the plan) for efficient execution of sub-queries. This minimizes the amount of data movement among sites. In addition, the nature of DDBSs and the existence of multiple processors in the network allows for parallel processing of these sub-queries and simultaneous data transmission between sites. This could significantly speed up the process of producing the result. Furthermore, the query optimizer can follow the same process discussed earlier for the first category of groups for even more efficient execution of these sub-queries. That is, each sub-query of a group in second category, can be treated as a *base* query of the first category. In other words, each sub-query of the second category becomes a super-query discussed for the first category of groups of queries.

4. THE ALGORITHM

This algorithm generates two groups of queries. A group of queries requiring the same procedures (including operations used) and a group of queries requiring data from the same site (or set of sites) for producing the result. It also generates a group of queries belonging to both of the above groups

The algorithm reads as its input a set of queries and generates as its output the sets of "groups" of queries discussed above.

Algorithm:

Input: A set of queries Q = {q1, q2, …, qn}.

Output: Three sets of groups of queries G_1, G_2 and G_3.

Step 1: Scan queries in Q to identify

a. those queries requiring the same relations that must be JOINed for producing the results. Call this set P (P is a subset of Q) and
b. those queries requiring data from the same site(s) for producing the results. Call this set T (T is also a subset of Q).

Step 2: Scan queries in (Q – P) to identify queries requiring the same relations that are operands for *binary* operations (other than JOIN) for producing results. Call this set R (R is a subset of (Q – P))

Step 3: Scan queries in (Q – P – R) to identify queries requiring the same relations that must use the SELECT operation with common set (or subset, if compound predicate) of predicates. Call this set S (S is a subset of (Q – P – R))

$G_1 = \{P, R, S\}$

$G_2 = \{T\}$

$G_3 = \{G_1 \Omega G_2)$

End Algorithm

5. CONCLUSIONS

There are different techniques used by the DBMSs in processing and optimizing high-level queries submitted by users. In this paper, we first discussed the major issues regarding query plan evaluation for query processing and showed how the query optimizer can choose an optimal plan for efficient execution of queries. We then discussed an efficient process for designing an optimizer which examines frequently used queries, and identifies two categories of groups of queries. One groups of queries requiring the same procedures (including operations used), and one groups of queries requiring data from the same site (or set of sites) for producing the result. Finally, we presented an algorithm which examines frequently used queries, and identifies those two groups of queries.

REFERENCES

1. C. Connoly, C. Begg, and A. Strachan, "Database Systems," 2nd Edition, Addison-Wesley, 1999.
2. S. Movafaghi and H. Pournaghshband, "Data Warehouse Query Processing and Optimization Architecture," Proceedings of the Software Engineering-Research and Practice Conference, June 2004.
3. J. Yang, et. al., "Tracking the Challenges of Materialized View Design in Data Warehouse Environment", Proceedings of the 7th International Workshop on Research Issues in Data Engineering," 1997.
4. R. Elmasri, et. al., "Fundamental of Database Systems," 4th Edition, Addison-Wesley, 2003.
5. A. Silberschatz, H. F. Korth, and S. Sudarshan, "Database System Concepts," 5th Edition, McGraw-Hill, 2006.
6. D. Bell, and J. Grimson "Distributed Database Systems," Addison-Wesley, 1992.
7. K. Srac, O. Egecioglu, and A. E. Abbdi, "Iterated DFT Based Techniques for Join Size Estimation," Proceedings of ACM-CIKM Conference, 1998.
8. P. Bodrik, J. S. Riordon, and C. Jacob, "Dynamic Distributed Query Processing Techniques," Proceedings of ACM-CS Conference, 1989.
9. R. L. Cole and G. Graefe, "Optimization of Dynamic Query Evaluation Plans," Proceedings of ACM-SIGMOD Conference, 1994.
10. B. Nag and D. J. DeWitt, "Memory Allocation Strategies for Complex Decision Support Queries," Proceedings of ACM-CIKM Conference, 1998.
11. L. Bouganin, O. Kapitskaia, and P. Valdurier, "Memory-Adaptive Scheduling for Large Query Execution," Proceedings of ACM-CIKM Conference, 1998.
12. L.D. Shapiro, "Join Processing in Database Systems with Large Main Memories," ACM-TODS, vol 11, no 3, 1986.
13. H. Pournaghshband, A. R. Salehnia, "What makes a Query Processor Efficient: Optimization Issues for DBMSs," Proceedings of Association of Management Conference, 1999.

A Prescriptive Approach to Business Process Modelling

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ABSTRACT

Business process modelling approaches are expected to describe business processes and prescribe advices for decision makers to implement changes to business processes for improvement or reengineering projects. Being prescriptive means that predictive advice becomes outputs to facilitate the construction of a "to-be" situation with the inputs including proposed changes and the "as-is" situation. Much effort has been made both on the descriptive ability to give a precise and close description of existing business processes and on the analysis of potential problems and changes impact. However, little work has been done to prioritise the prescriptive ability, therefore reducing stakeholders' involvements and slowing down the transition from the "as-is" situation to the "to-be" situation through change. This research proposes a prescriptive approach to business process modelling comprising a variable-oriented meta-model and an associated methodology. This approach utilizes concepts from quantitative modelling and feedback control theory to impose a systematic transformation process. A case study of an electricity distribution division illustrates the applicability of the developed approach.

1. INTRODUCTION

Business process modelling is an essential step of Business Process Improvement (BPI) and Business Process Reengineering (BPR), both of which targeting existing business processes. Given the complexity of an organization and the hefty cost incurred by the implementation of business processes, the possibility of experimenting with proposed changes to real systems is difficult to attain. This suggests research on business process modelling may be achieved from two aspects: the descriptive modelling, and the prescriptive modelling. Descriptive modelling focuses on the elicitation and the representation of business processes so that related knowledge can be understood and shared. The intention of prescriptive modelling is to provide process analytical support through modelling and facilitate process evaluation and alternative selections by giving predictive advice. Descriptive modelling approaches are favoured at the early stage of business process improvements and in reengineering projects, and at the moment proposed changes are evaluated, a prescriptive model grows more desirable, because knowing and sharing the effect a change will induce on an overall organization with stakeholders and justifying whether this effect is expected become primordial.

Recent modelling approaches offer the prescriptive ability through the addition of organizational concepts, eg. goals, and non-linear causal relationships. The use of these prescriptive elements helps to elicit the rationale of existing business processes and estimate the potential effect of a change. However, because of the qualitative expression of information, the preciseness of the analyzed results and the usefulness of justifying decisions are limited. Also, a systematic process support is missing when dealing with increased complexity.

Focusing on prescriptive ability, this research proposes a quantitative business process modelling approach comprising a variable-oriented meta-model and an associated methodology. This approach complements descriptive modelling approaches and is suitable to be applied at the stage where changes to existing business processes are to be evaluated for the construction of a "to-be" situation.

This paper gives an analytical summary of the existing business process modelling approaches in terms of their prescriptive and descriptive dimensions. The discussion is then directed to the desired properties of a business processes modelling approach owning the prescriptive ability. The variable-oriented meta-model is presented in the fourth section, followed by a description of the methodology in the fifth section. A case study is conducted with the presence of the methodology to illustrate the applicability of the proposed approach.

2. BACKGROUND

A business process is a main component of an organization. In a business process, a sequence of atomic activities is conducted to deliver a service to customers for the achievement of a goal.

Business process modelling approaches fall into three classes, descriptive, semi-prescriptive and prescriptive.

A number of modelling approaches have been developed to represent an organizational view of a business process, each one emphasizing on a given aspect. Activity-oriented approaches, eg. IDEF0 (Mayer, Benjamin et al. 1995), (IBM, 2002) highlight a specific ordering of activities in a business process. Role-oriented approaches (Ould, 1995) go beyond the mechanistic thinking in activity-oriented approaches and embrace the consideration of responsibilities undertaken by an organizational unit. A role involves a collection of responsibilities which are carried out by a set of activities (Ould, 1995). This approach brings a business process into the social context of an organization and highlights that business process redesign is not only an effort to optimise the order of activities, but also a restructuring of the organization's resources, eg. physical and human resources, and organizational hierarchies. Actor-oriented approaches make another organization concept, the actor, explicit, and introduce an aspect of implementation of a business process into process modelling. An actor is "the physical entity that personifies an instance of the role at any given moment" (Prekas and Loucopoulos, 2000). Additionally, object-oriented modelling (Wang, 1994) considers business processes as a set of objects interrelated with each other.

Some semi-prescriptive organization-oriented approaches (Yu, 1996), incorporate intentional elements into the description of a business process and provide a certain degree of analysis by offering a rationale of business processes.

One proposed methodology (Gong, Li et al., 2004) has a prescriptive ability by building cause and effect relationships among business process variables using the facility of causal loop diagrams, from system dynamics research (Forrester, 1961). This methodology emphasizes the significance and efficiency of utilizing cause and effect relationships in the analysis of business processes. However, its applicability is limited to guidelines, and a lack of a formalized mechanism reduces its applicability for nontrivial projects.

3. THE EXPECTED PROPERTIES OF A PRESCRIPTIVE MODELLING APPROACH

The quality of a prescriptive modelling approach depends on the quantity of trustworthy analyzed results and the degree of the controllability on a real system, gained from these results.

3.1 Quantitative Modelling

Whether a constructed model is scientific and is a close enough representation of a real system is critical to determine the degree of trust in the results. Quantitative modelling is "based on a set of variables that vary over a specific domain while quantitative and causal relationships have been defined over these variables" and its quantification is considered as a way to build a scientific model. (Bertrand, 2002).

The existence of variables is a precondition to construct a quantitative model. Research into quantitative management (Anderson, 1994) has considered that an organization is an amalgamation of variables. Furthermore, the business process level is the location of conducted activities, and data collected from this level can

be used as a feed into variables in a constructed quantitative model. This ensures the model is a close representation of the organization in reality.

Generated quantitative results from the model are numerical and allow closer scrutiny than qualitative results. This helps decision makers conduct evaluations and make their decisions.

3.2 Controllability

The controllability of a prescriptive modelling approach embodies itself from two aspects.

Firstly, in models developed with this approach, the controllability is demonstrated by the ease of the traceability of the impact that a change may cause when this change is applied to such developed model. The concept of feedback loop originates from the servomechanism control theory (Porter, 1950) in the field of engineering, and is developed as a component in the research of system dynamics (Forrester, 1961) to model and analyze social systems. The use of feedback loops facilitates making both this traceability and the effect caused by changes clear. A control mechanism is built in whenever a loop is formed.

Secondly, the controllability on a real system can be secured from analyzed results. Measurements, as a quantitative utility, are recognized as an efficient management tool. The ability to measure something is a precondition to control it (Kaplan &Norton, 1992). A number of performance management frameworks based on measurements (Platts and Tan 2002), (Keegan, Eiler et al. 1989), (Cross and Lynch, 1988), (Kaplan and Norton, 1992) have been developed to enable an efficient use of data. Incorporating variables representing common characteristics of data, that are measurements collected from the business process level, into a model, enables relating analyzed results with the measurements, and corresponding variables of a model with activities that can be conducted for the implementation of changes.

4. A PROPOSED PRESCRIPTIVE BUSINESS PROCESS MODELLING APPROACH

This prescriptive business process modelling approach is developed to achieve these expected properties. This approach consists of two components, a variable-oriented meta-model and a methodology.

4.1 A Variable-Oriented Meta-Model

The developed meta-model is an abstraction over quantitative aspects of business processes and a set of developed concepts is to be used with the proposed methodology. Additionally, this meta-model also serves as a reference for the later formalization and automation of organizational knowledge management.

The concepts developed in this variable-oriented meta-model are defined here.

Variable: a symbol containing different values under different circumstances. Each variable may be refined into a strategy variable, a process variable or an operational variable.

Strategy variable: a symbol that represents a property of an organizational strategy.

Operational variable: a symbol that represents a common characteristic from a set of data which are derived from measurements of actual activities of an organization. Operational variables have actual measurements as values.

Process variable: a symbol that serves as a bridge between operational variables and strategy variables.

Value: a numerical quantity associated with a variable. A "Value" entity has two sub-entities, measured value and deferred value. These two sub-entities are, respectively, the numerical quantity obtained from organization data and the numerical quantity obtained from the transformation of a set of variables' values according to a mathematical formula.

Relationship: a quantified causal relationship between two variables. A change on a variable' value results in a change of another variable's value. This relationship is either implicit or explicit.

Mathematical functions: a mathematical function defines how a change on a variable's value will affect other variables' values.

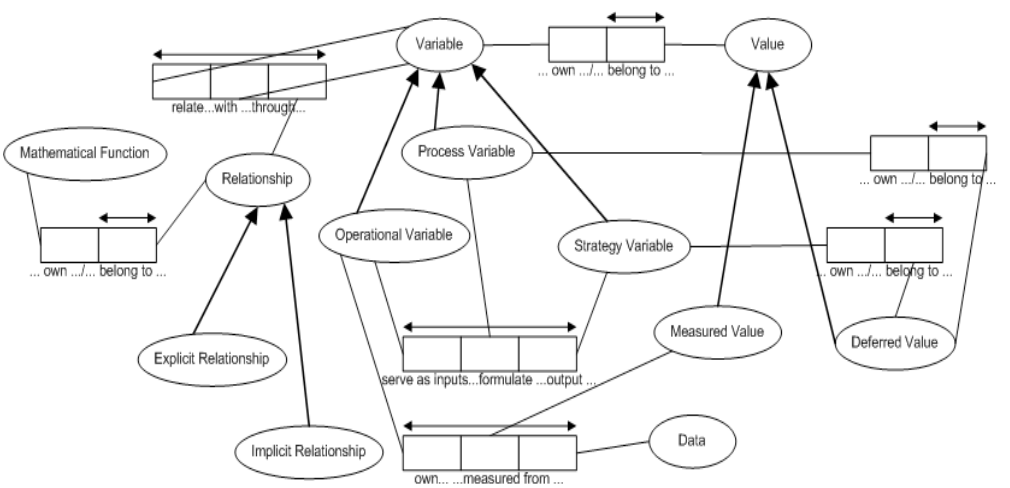
Explicit relationship: when a relationship between two variables is deferred from available knowledge, this relationship is explicit.

Implicit relationship: when two variables relate with each other in a way which cannot be derived from available knowledge, this relationship is implicit.

Operational variables have measured values while strategy variables and process variables have deferred values. The values of operational variables serve as inputs to calculate values of process variables, which themselves are used as inputs into strategy variables.

This meta-model presents the quantitative aspects of business processes and yet it is not purely mathematical as these variables are classified in an organizational context. By integrating concepts from organization management (Loucopoulos, 2003), variables, scattered in an organization, are shelved at three levels: the operational level, the service level, and the strategy level. Operational variables belong to the operational level, where business processes are conducted as sequences of atomic activities. Process variables belong to the service level, at which business processes deliver services. These two levels contribute to the achievement of organizational strategies at the strategy level which accommodates strategy variables. It is prescriptive in that variables at the three levels are interrelated in a logical "input-process-output" order (Platt &Tan, 2002). The achievement of organizational strategies is justified by the values of strategy variables outputted

Figure 1. Variable oriented meta-model



from the transformation of values of operational variables through process variables. Values of operational variables are collected from data gathered from real happenings of business processes, as this ensures the validity of the justifications and enhances the efficiency of control.

4.2 A Methodology

This methodology provides process support to instantiate concepts developed in the meta-model and presents the way in which the prescriptive ability is achieved in four steps. This methodology complements qualitative modelling approaches and is applied at the later stage of business process analysis when changes are proposed and evaluated.

The presentation of this methodology is accompanied with the conduction of a case study to illustrate its applicability. The background of this case study is set in the distribution division in an electricity group. This division is responsible for the transportation and delivery of electricity to consumers. With the opening of the European electricity market, the monopoly position of this division is challenged by future competitors. The distribution division responds to these challenges by a redesign of its business processes through a customer-oriented perspective. Research work (Kavakli & Loucopoulos, 1999), (Prekas & Loucopoulos, 2000), has been done to describe existing business processes, analyze the factors which have led to changes, and propose changes to these existing processes. This current research builds on this previous work and plans to apply the proposed approach as a further step in the transition to a "to-be" situation.

Step 1: Represent an Organization with a Generic Set of System Variables

The generation of a set of system variables is the process of representing a quantitative view of a whole organization. This step is necessary in that having a set of system variables is a precondition to fit variables, introduced by changes, into a global view of an organization and thus observe the changes effect in the context of the organization rather than within the limits of local areas where these changes occur.

The varieties of organizations and the complexity of variables result in the difficulty of generating a method with which such a set of variables can be developed. The concept of system variables is a reminder that a high level view should be taken in the extraction of these variables, as plunging too early into specifics risks missing a global view. The developed four levels view helps to discriminate system variables and to serve as a guidance to extract the proper ones. These four levels are business process implementation dependent, business process design dependent, organization dependent, application domain dependent. At the business process implementation dependent level, each atomic activity of a business process is conducted and thus variables from this level are the most specific. System variables should be elicited from a unique level, this level being higher than the business processes implementation dependent level. It is recommended to extract variables by starting from the highest level and going down to the suitable level of interest. This top to bottom method has the advantage of building a global but simplified view at the beginning and gives the possibility of zooming into a specific picture later. Figure 2 gives examples of variables at each level.

In this case study, system variables from a distribution division are elicited as listed in Figure 3 at the organization dependent level. These variables represent main states of main objects in this division.

Figure 2. Variables in the four levels view

Application domain dependent level	Eg. the number of customers
Organization dependent level	Eg. the number of customers who contact with PPC office
Business process design dependent level	Eg. the number of customers who visit PPC office personally
Business process implementation dependent level	Eg. the number of customers who visit PPC office personally during January 2006

Figure 3. Elicited system variables from the electricity distribution division

System Variables at the organization dependent level	
Object: Customers	The number of potential customers
	The number of customers who apply for connections
	The number of customers who sign contracts
	The number of customers who get connected
	The number of customers who get disconnected
Object: Electricity	Electricity in demand
	Electricity available to be distributed (network capacity)
	Electricity ready to be used
	Electricity measured
	Network capacity used
	Network capacity unused
Object: Material	Material in use
	Material in inventory
	Material in construction
	Material idling
Object: Payment	Payments billed
	Payments made
	Payments recorded

Step 2: Transform Changes to Variables

The second step consists in transforming changes into variables. Changes are proposed and expressed in the format of goal hierarchies which consist of strategy goals, sub-goals and operational goals (Kavakli & Loucopoulos, 1999). Changes might be limited to the operational level in order to improve existing business processes; alternatively, changes might occur across the operational level, the service level and the strategy level, because organizational strategies are shifted to new ones. Updated strategy goals usually underlie expected states of objects. Because these states are observable and quantifiable, they are used as labels of variables to represent the changed strategies. Sub-goals bridge strategy goals with operational goals and they achieve strategies by relating to a business process or to a service. Process variables are elicited from these sub-goals. The labels given to these process variables vary with the characteristics of these sub-goals. They might be strategy variables associated with a business process or a service. They also might be properties of the transition between two states of an object. When a sub-goal refers to a service, its variables can be extracted from possible criteria to justify this service. Operational variables are elicited from these operational goals and they represent either properties of an atomic activity or common properties of several atomic activities. When an operational goal involves more than one atomic activity, the use of process variables at the business process design-dependent level narrows the gap between process variables from sub-goals and operational variables, and also eases the communication and understanding of the relationships among variables, although using these intermediary process variables is not necessary.

Changes in this distribution division not only take place at the operational level but also reach the strategy level; therefore, the transformation is conducted at the three levels of the organization. The figure 4 shows examples of each used heuristics including elicited variables and their corresponding goals. When operational variables are elicited from the operational level, corresponding atomic activities are identified for the later specification of relationships among variables.

Step 3: Specify Cause and Effect Relationships Among Variables

This step involves two tasks. The first task is to locate variables causally related and the second task is to quantify these relationships with mathematical functions.

There are three ways to trace the causal relationships among variables. Firstly, deduced goal hierarchy from qualitative analysis (Kavakli & Loucopoulos, 1999), (Yu, 1996) is a resource to relate operational variables with strategy variables

Figure 4. The transformation of changes to variables

The level where changes take place	The classes of goals where changes occur	Heuristics used in the transformation	Examples
Strategy Level	Strategy goals	Expected states of an object	Goal: improve customer satisfaction Variable: customer satisfaction
Service Level	Sub-goals	Expected states of an object	Goal: improve load forecasting methods Variable: the preciseness of forecasted load
		Expected states of an object and related business processes	Goal: improve customer satisfaction for new installation requests Variable: customer satisfaction for new installations
		Properties of a transition between two states of an object	Goal: improve load increase satisfaction Variable: load increase satisfaction
Operational Level	Operational goals	Properties of an atomic activity	Goal: Minimise the waiting period for new installations Variable: the time of installation construction when customers ask for new installations
		Common properties of several atomic activities	Goal: Minimise the waiting period for new installations Variable: the waiting time for a new installation which involves the atomic activities, "installation construction", "service order creation", "the communication between service Dept. and studies. Dept."

through process variables. This resource offers an initial sketch of relationships among variables. Secondly, the identification of atomic activities that operational variables share enables building possible links among the related variables. The third way is to fit system variables into a network of elicited variables, ensuring that all system variables are embedded into such a variable network and that this network is a comprehensive view of the organization. In this network, system variables play the role of process variables or strategy variables.

The relationships among variables should be quantified. Explicit relationships are quantified by using available knowledge. Implicit relationships, often appearing with the introduction of new variables, exist because of common sense, intuition and experience. The transformation of implicit relationships to explicit relationships is a process of proving them scientific. The feasibility of the transformation resides in the presence of data, either gathered from history or collected from experiments.

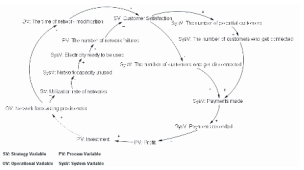
Figure 5 gives a partial view of the identified causal relationships.

Step 4: Causal Loop Analysis

A loop is a set of variables linked together by a circular dependency chain. This step consists of highlighting loops and checking whether variables expected to be controlled belong to a loop or relate themselves with variables belonging to a loop. As a loop is a control mechanism on system behaviours, this step, in essence, is a way to identify or introduce control mechanisms. The observation of the loops helps to check the effect of changes and impose control to adjust unexpected effects. When a loop contains variables linked by decision information flow, the control is enabled through decisions from human beings and thus requires human beings' interventions. Variables linked by decision information flow are only causally related when a decision is made. When options exist for making a decision, multiple decision information flows can be built to form loops. These related variables, as controllable variables, should be emphasized because they are the places where human beings have the ability to affect system behaviours.

In the case study, causal loops are identified to analyze the effect of changes and where controls are imposed to limit unexpected effect. The distribution division expects to obtain information of which proposed changes will bring most benefit

Figure 5. Causal relationships among elicited variables



and also be compatible with investment capabilities. The "investment" variable is therefore considered as a decision variable, and decision information links connect "investment" with other variables representing proposed changes. The observation of these loops shows the way each proposed change affects the achievements of organizational strategies, but also how each proposed change affects each other. For example, when the investment is made to improve "network forecasting preciseness", the chance of network modification will be reduced when customers apply for new installations. Consequently, customer satisfaction will be improved because of the reduction of the waiting time for network modification, and this will lead to the increase of the number of customers who get connected, and thus increase the revenue. However, this investment also improves the utilization rate of electricity networks and thus the reduced available electricity load could be a cause to network failures at peak time. This will negatively affect customer satisfaction and eventually reduce revenue. These two loops, as shown in figure 5, will therefore balance each other and likely lead to a stable situation.

This methodology takes qualitative results from qualitative modelling approaches as inputs, processes them through four steps, and outputs a model containing variables representing a quantitative view of business processes. Data collected from the implementation level is fed into the model to output the values of the variables of interest. This enables a quantitative observation of system behaviours and paves the road toward the evaluation of proposed changes.

This case study illustrates the applicability of the proposed approach. In this case applied with the developed approach, the effect of changes on an organization is observed quantitatively and the trace of implemented changes at the operational level affecting organizational strategies becomes explicit.

6. CONCLUSION

The developed prescriptive approach to business process modelling, incorporating concepts from quantitative modelling and control theory, enables a quantitative modelling of business processes with variables, and provides a systematic process of taking qualitative inputs to outputting quantitative outputs. In contrast with current modelling approaches, it represents a complete shift from the emphasis on the descriptions of business processes to the prescription and facilitates the transformation from a situation with proposed changes to a "to-be" situation; it takes a quantitative view and represents organization-oriented concepts with variables; it provides a systematic process to support the quantitative transformation from qualitative knowledge of business processes; it has a certain formalism that increases the possibility of automated analysis to tackle complicated applications.

Future work will focus on the evaluation of change effects and the construction of a "to-be" situation. Also, the development of automated support tools is planned in order to increase the applicability of this approach.

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REFERENCES

Anderson, David R. (1994), An introduction to management science: quantitative approaches to decision, 7th ed., St. Paul, Minn.: West Publishing.

BEA Systems, IBM, Microsoft: Business Process Execution Language for Web Services, Version 1.0. IBM developer Works (2002). Available from http://www-106.ibm.com/developerworks/webservices/library/ws-bpel1/

Bertrand, J.W.M. and Fransoo J.C. (2002), Operational management research methodologies using quantitative modeling, International Journal of Operational and Production management **22**(2): pp.241-264.

Cross, K.F. and Lynch, R.L. (1988), The SMART way to sustain and define success, National Productivity Review, Vol. 8, No. 1, pp.23 - 33.

Forrester, J.W. (1961), Industrial Dynamics. Cambridge: MIT Press; Pegasus Communications: Waltham, MA.

Gong, R.., Li, Q. Liu X., Wang Q. (2004), Modeling for business process design: a methodology based on causal loop diagram. Systems, Man and Cybernetics, 2004 IEEE International Conference on.

Kaplan, R.S. and Norton, D.P. (1992), The balanced scorecard - measures that drive performance, Harvard Business Review, Jan./Feb., pp.71 - 79.

Kavakli, V. and Loucopoulos, P. (1999), Goal-Driven Business Process Analysis Application in Electricity Deregulation, Information. System 24(3): pp.187-207.

Keegan, D.P., Eiler, R.G. and Jones C.R. (1989), Are your performance measures obsolete? Management Accounting: pp.45 – 50

Loucopoulos, P. (2003), The S3 (Strategy-Service-Support) Framework for Business Process Modelling. CAiSE Workshops.

Mayer, R.J., Benjamin, P.C., Caraway, B.E., Painter, M. (1995), A framework and a suite of methods for business process reengineering, in Grover, V., Kettinger, W.J. (Eds),Business Process Change: Reengineering Concepts, Methods and Technologies, Idea Group Publishing, London, pp.245-90.

Ould, M. (1995), Business Processes-Modelling and Analysis for Re-engineering and Improvement. John Wiley &Sons, Chichester.

Platts, K.W. and Tan K.H. (2002), Designing Linked Performance Measures - A Connectance Based Approach. Pre-prints 12th International Working Seminar on Production Economics, Innsbruck, Austria.

Porter, A. (1950), Introduction to servomechanisms, Methuen; Wiley.

Prekas, N. and Loucopoulos, P. (2000), A unifying framework for representing structural and operational aspects of electricity sector deregulation. Requirements Engineering Journal 5(1).

Wang, S. (1994), OO modelling of business processes, Information System management, pp.36-43.

Yu, E. and Mylopoulos, J. (1996), AI modelling for business process reengineering, IEEE Expert, pp.16-23

A Decision Support System for the Ecological Selection of a Facility Location: A Multi-Criteria Approach

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ABSTRACT

In this article the authors develop a decision support system for the selection of facilities location using a modification of the Brown Gibson model. The decision process of selecting an area in urban and rural environments is using objective factors considered by Gibson model and subjective factors which were determined using empirical data. The selected approach is built around a multi-criteria methodology with reference to objective and subjective criteria, which constitute the quantitative and qualitative parameters of the system, respectively. The model excludes any critical factors that may distort its usefulness, by choosing among pre-selected areas that fulfil certain minimum pre-requirements. Research findings provide useful indications that can improve the body of knowledge of location-theory. In addition, they can contribute to the development of policy proposals for the Greek state regarding the issues of: selection of location and residence, regional development, decentralisation as well as the study of the non-homogeneous and in-balanced development of areas in urban and rural environments.

Keywords: Brown-Gibson, location, multi-criteria, urban, rural

1. INTRODUCTION

Decisions on site investments are usually based on a number of parameters, with particular hierarchies or combinations of factors considered for particular circumstances. An enormous deal of attention in the literature has been given to optimal location factors in industrial location decision (Jungthrapanich and Benjamin, 1995), but not so much in residential location. It would not be wrong to say that not every factor in the literature is appropriate for every industry or location. Moreover, these factors are likely to differ over time, type of business or area specific features.

To date, in the literature, there has not been a well-defined linkage between all these factors and location selection. In addition, most research do not investigate whether all these factors are still recognised and well documented in practice or not. The intent of this study is to develop a multi criteria evaluation method for area selection in rural and urban environments. Its specific objectives are to:

- review previous models and identify their strengths and weaknesses;
- investigate dominating factors for people or companies deciding to locate their residence or office, respectively, using particular geographical areas with emphasis on rural and urban environments;
- develop a new model that overcomes the weaknesses of the previous models by combining all the necessary subjective and objective factors that influence area selection;
- provide a more efficient and effective framework on which to base decisions;
- apply the model to an example decision involving the selection of two facilities

Its strength is that for the first time all subjective criteria are not determined with the aid of subjective quantification techniques or assigned from personal preferences but their estimation is based on a large scale questionnaire. The model excludes, the use of critical factors, as it considers that choosing an area for residence means that certain minimum (or critical) requirements are already well fulfilled by these areas.

The article starts with a list of quantitative and qualitative factors that influence area selection. It tries to identify the optimal location factors that fit most advantageously with the residence internal environment. Then the model is developed based on Brown-Gibson's work and with reference to the selected optimal location factors. In section 3, an application of the model is conducted, through a five step process, by selecting two residential sites, one in urban and another one in rural (natural) environment with the objective in mind to determine which site offers the best environment for residence. Finally, in section 4, conclusions are highlighted.

2. DEVELOPMENT OF THEORETICAL MODEL

Although location decisions have theoretically developed quite well for a long time now, an analysis of the literature shows that there still exists a gap between theory and practice, particularly with respect to the residential location question. The approaches summoned in location theory are found to be narrowed in application in actual decisions from the fact that they involve a large number of qualitative and quantitative factors (Juthrapanich and Benjamin, 1995; Badri et al, 1995; Atthirawong and MacCarthy, 2001).

Past research on location decisions often deals with a single objective; while the criteria involved in proposed models are mainly related to cost or to dimensions that are translated into numerical values. However, location selection is a multiple criteria decision making analysis (MCDM) by nature, as the decisions depend on a number of factors (Yang and Lee, 1997). Therefore, there is a need to expand the methods used in order to take into consideration a broad range of factors including objective and subjective aspects. (Keen and Scott-Morton, 1978; Roy and Vincke, 1981; Jacquet-Lagreze and Shakun, 1984; Roy 1988; Zopounidis, 1990, 1995a, 1995b; Hurson and Zopounidis, 1995).

There are four basic categories that deal with the problems of the above nature (Siskos, 1984): (a) multi-criteria mathematical programming, (b) theory of multi-criteria usefulness, (c) theory of superiority relations, and (d) theory of multi-criteria monotonous regression. However, the most common methods in selecting residence sites among alternative solutions are the Electre method (Huylenbroeck, 1995; Dias and Mousseau, 2006), the Promethee method (De Keyser and Peeters, 1996; Le Téno and Mareschal, 1998, Macharis et al, 2004) and the Analytical Hierarchical Process –AHP (Saaty, 1986, 2000), which has been found to be an effective and practical approach that can consider complex and unstructured decisions (Partovi, 1994). For example, the AHP method was adopted for the location and development of a hospital unit according to the following four steps: a) hierarchical definition of building goals, characteristics and

criteria, b) collection of data and comparison by pairs based on selection priorities, c) use of the eigenvector method for the hierarchy of decisions, d) synthesis of priorities in general axis and rating of alternative decisions (Sinuany et al, 1995). The same method has been used for the selection of the location area of a restaurant unit in Taipei (Tzeng et al, 2002). In that problem five main characteristics are involved: transport, site, marketability, financial factors, competition and environment, and eleven criteria such as cost of rent, delivery cost, transportation network, parking places, number of passing-by persons, number of competitors, intensity of competition, size of the commercial area, infrastructure of the area, refuse disposal and sewage capacity.

According to Kahraman et al (2003), the selection of residence site is generally regarded as multi- multiple criteria decision making problem that involves quantitative and qualitative criteria and it is not advisable to use conventional methods (Kioxos et al, 2002). Chau et al, (2000) asses the cost effectiveness of an environmental assessment scheme based on economic benefit-cost ratios developed for various criteria. However, such approaches of the cost-benefit nature require that all factors have to be expressed in monetary values, which may lead to wrong conclusions due to: (a) possible errors that occur from the estimation of the monetary flow under uncertainty conditions (existence of probability of alternative values in the future monetary flows), (b) the expected inflation rate (Kyriazopoulos, 2002) and (c) the difficulty in quantifying and eventually use of the qualitative factors through the use of multidimensional statistical models (Srinivasan and Kim, 1988).

For our purpose, the Brown-Gibson model (Brown and Gibson, 1972; Lipovatz-Kremezi, 2003) has been selected. It is a technique for integrating qualitative and quantitative criteria in decision making. We utilize the Brown-Gibson model to cope with both the objective and subjective parameters of the system which describe the ecological behavior of buildings with respect to multiple criteria. We first define the objective criteria for each site (urban and rural) based on the total costs. Then, define the subjective criteria and establish its value. Identify the weighting coefficients pertaining to the importance/weight of the objective and subjective criteria. Finally, calculate the total priority grade for each site (urban and rural) through the combined objective and subjective criteria. Both the weighting coefficients and the priority order of each site regarding each criterion have been found through a survey, based on a questionnaire developed for this purpose. The questionnaire was administered to a number of students' families from academic institutions all over Greece. Based on the above, the site that concentrates the highest grade is selected and the final conclusions are extracted

As an assumption, we accept that the examined buildings are of similar characteristics in terms of properties, mechanical systems, construction materials, etc that can be defined accurately. This will eliminate any biased in air quality (Djukanovic et al, 2002; Tse et al, 2004), thermal or acoustical comfort, so any differences will be contributed to the urban or rural environment rather than the different building characteristics. However, any technical interventions or possible new installations that will be required to improve indoor air quality and/or thermal and acoustical comfort - so that the final measurements will be inside the allowable limits - will be parameterized.

3. THE AREA SELECTION MODEL

One of the most challenging activities deals with the process of matching the organization with its environment in the most beneficial way. This means selecting the external environment itself, via a selection process, to fit the organization.

The area selection model uses several strategic factors to fit the residence with the specific area that best meets its requirements and needs. It has two stages. The purpose of stage one is to determine what factors an area should have to fit most advantageously with the residence internal environment. These factors are referred to as the area Optimal Location Factors (OLFs). The purpose of stage two of the model is to develop the model itself based upon a combination of the Optimal Location Factors (OLFs).

3.1 Determination of Optimal Location Factors

The area selection model recognises the need of some Optimal Location Factors (OLFs) which are identified as belonging to the following two categories: (1) the subjective factors (AK_i) and (2) the objective factors (YK_i).

The *first category*, subjective factors, is characterised by qualitative type criteria such as quality of education, quality of healthcare, quality of entertainment and recreation, quality of natural and material goods, accessibility and availability of transportation, potential growth of the area and employment conditions, pollution problems and ecosystem, crime rate-security, traffic problems-parking areas, companionship-solidarity-sociality. The nature of these factors is of qualitative character as they cannot be given monetary values.

The *second category*, objective factors, is characterised by quantitative type criteria including amongst others, construction cost, cost of preventing pollution, cost for thermal comfort and acoustical comfort, energy cost, and residence cost

A possible third category could also be included, named critical factors. A location factor is considered as critical if it prevents the location of a residence at a specific area despite of the other, possible preferred conditions that occur. For example, an area that lacks schools could not be considered as a potential site for residence in spite of the other subjective or objective factors that may be attractive. In other words, there can not be any trade-off with respect to these factors

3.2 Model Formulation

A modified Brown-Gibson's method was used where for each site i, a location measure, called "total priority mark, B_i" is calculated (Brown and Gibson, 1972; Lipovatz-Kremezi, 2003), based on:

$$B_i = n(AK_i) + (1-n)YK_i \quad (1)$$

Where:

v is the objective factor decision weight with values $0 \le v \le 1$

AK_i is the objective factor measure for area i with values $0 \le AK_i \le 1$ and $\sum_i AK_i = AK_{urban} + AK_{rural} = 1$

AK_{urban} is the objective factor measure for urban environment i

AK_{rural} is the objective factor measure for rural environment i.

YK_i is the subjective factor measure for residence i with values $0 \le YK_i \le 1$, and

$\sum_i YK_i = YK_{urban} + YK_{rural} = 1$

YK_{urban} is the subjective factor measure for urban environment i

YK_{rural} is the subjective factor measure for rural environment i.

The development of the model was based on the following three assumptions:

Assumption 1 (Critical Factors):
There already has been made a pre-selection of specific areas that fulfil certain minimum pre-requirements and this minimizes the usefulness of the critical factors. Therefore the only optimal Location Factors (OLFs) that will be used are the subjective and objective factors. At this stage, one should appreciate the importance of critical factor, because their inclusion may even exclude an area from considering it, as it doesn't fulfills the minimum requirements imposed by them.

Assumption 2 (Objective Factors, AK_i)
Basically all objective factors are measured in monetary units. However, for the sake of the model, they all are converted into dimensionless indices. Therefore, the objective factor measure Ak_i for area i is determined mathematically by the expression:

$$AK_i = \left[c_i \sum \frac{1}{c_i} \right]^{-1} \quad (2)$$

where c_i is the total objectivity factor cost for area i.

There are three restrictions imposed by formulae [2]

a. the area with the minimum cost must have the maximum measure
b. the relationship of the total objective factor, AK_i, for each area as compared to all other areas must be preserved, and
c. the sum of the objective factor measures must equal one, i.e. $\sum_i AK_i = AK_{urban} + AK_{rural} = 1$

Assumption 3 (Subjective Factors, YK_j)
All subjective factors are mathematically expressed for an area i, as:

$$YK_i = \sum_{j=1}^{n} W_j R_{ij} \quad (3)$$

where: W_j is the weight of subjective factor i relative to all subjective factors (pair-comparison), and R_{ij} is the weight of site i relative to all potential sites for subjective criterion j.

Both subjective factor weight, W_j, and site weight, R_{ij}, are determined based on the use of a special questionnaire which has been distributed in a representative sample of students' families. In fact, this is one of the modifications made in Brown-Gibson's method, which determined these two factors with the aid of a subjective quantification technique known as preference theory (Fascal, 1965).

The questionnaire was given to 400 families of students from various Greek educational institutes, with a covering letter explaining the purpose of the survey. The sample was random selected as in the academic institutions the families of the students come from all the social, economic and professional ranks and from all the geographical and administrative areas of the country (urban, semi-urban, rural, etc.), thus having all these demographic, cultural, and other characteristics that makes the sample as representative of the Greek population as possible. The development of the questionnaire was based on three pre-requisites: a) the questions take into account the ability and willingness of the interviewee to participate, b) the answers is short-easy and with a logical sequence and clarity, c) the data processing and the final investigation of the real volition and trend of the sample are feasible.There were 150 replies, which represented 37.5% of the responses. A follow-up of the survey was conducted in July 2006. An additional 54 completed responses were returned, yielding a total of 204 replies, which represented 50.75% of the responses. The pre-test of the questionnaire was conducted with 3 lecturers and 5 students' families in order to ensure that there were no items with multiple interpretations or that were biased, inappropriate or unclear. Furthermore, the measurement items were based on a comprehensive review of relevant literature. Therefore, it can be concluded that the measure developed in this study has content validity.

4. APPLICATION OF THE AREA SELECTION MODEL

To illustrate how the area selection model works, two residential sites have been selected, one in urban environment and another one in rural (natural) environment. The objective was to determine which site offers the best environment for residence.

Patission area which belongs to the municipality of Athens was selected as characteristic urban area, located in a rather small distance from the city centre. It has good accessibility for the provision of goods and services (education, healthcare, recreation areas, markets, etc), the same quality of transport means and infrastructure as Athens, it is highly populated with a wide range of people-income, the cost of living is relatively low, and it has highly environmental (pollution) problems.

For the rural environment, the municipality of Psachna in the Evia island was selected. Psachna is the capital of a small municipality located at a distance of about 16km from the city of Chalkida (the capital of Evia island). Seated at the edge of Dirfis' mountain, it has good quality of transport infrastructure. Being close to the main road connecting Chalkida and Athens makes it quite accessible for the provision of goods and services. Its location characteristics, being next to the mountains in a natural environment makes it a low polluted area, thus fulfilling the minimum requirements and characteristics of the present research.

With the application of the area selection model to the problem of choosing between the above two residential areas, an exercise is carried out below, which briefly contains the following steps.

Step 1
A Table is constructed that shows both the technical data as well as the calculation of the objective criteria expressed by formulae [2]. The aim is to translate each areas objective factors expressed in monetary figures to dimensionless information. A total of five selection criteria are used, including: construction cost, cost of technical interventions for improvement of indoor air quality, cost for thermal comfort, cost for acoustical comfort and residence cost

Step 2
Next the preference frequency of each subjective criterion is calculated by processing the data selected with the questionnaires using SPSS-11 software. Then the weighting coefficients, W_j, for each subjective criterion are determined. A total of ten criteria was used, such as quality of education, quality of healthcare, potential growth of the area and employment conditions, pollution problems and ecosystem, quality of entertainment and recreation, crime rate-security, traffic problems-parking areas, companionship-solidarity-sociality, accessibility and availability of transportation, and quality of natural and material goods,

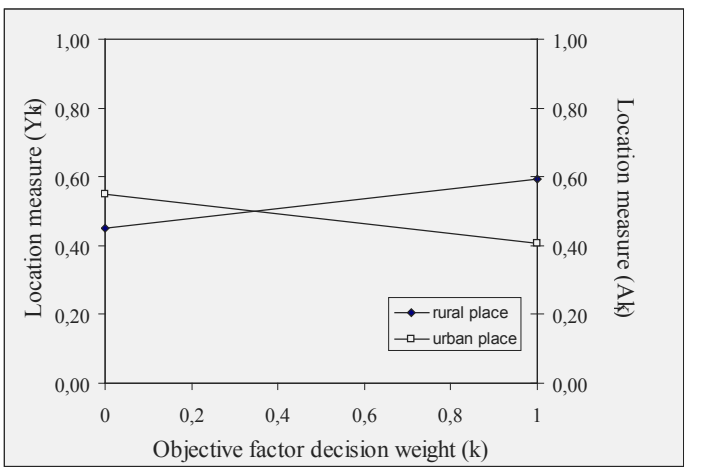
Once this information is identified the next step of the model is to prioritise each area i with respect to each subjective criterion j selected according to the preferences frequency of the interviewees. Finally the value of the subjective criterion (YK_i) for each site i is determined using equation [3] with the pre-condition, that $\sum_{j=1}^{n} YK_j = 1$. This results that $YK_{urban} = 0.548$ and $YK_{rural} = 0.452$.

Step 3
The weighting coefficient v was calculated to be v=0.415 and 1-v=0.585. It results from the weighting mean and according to the frequency of appearance of each value. It should be mentioned that the weighting coefficient v shows the weightiness according to the willingness of the interviewees between objective and subjective criteria.

Step 4
Having calculated, all the independent variables of equation [1] for each site, i, its "total priority mark, B_i" can be estimated but always assuming that $\sum_{i=1}^{n} B_i = 1$. This gives that:

B_{urban}=0.415*0.4052+0.585*0.548=0.4888
B_{rural}=0.415*0.5948+0.585*0,452=0.5112

Figure 1. Sensitivity of location measures to changes in objective factor decision weight, v



Step 5
Finally a sensitivity analysis is performed to examine the influence of the change in ν value on the final decision, see Figure 1. However, the research is possible to turn to more analytical results regarding the preferences and the selection of the people (regarding e.g. age of gender).

In our specific example, the results of the sensitivity analysis, indicating that for values of $\nu<0.34$, the urban residence site is preferred; otherwise the rural residence site should be selected.

5. CONCLUSIONS

The selection of a residential site involves the consideration of a large number of quantitative and qualitative criteria that have to be taken into account. Inevitably, this involves multiple and conflicting objectives which although are quite well recognized, their consideration have not been adequately addressed in analysis, yet.

Therefore, one of the most challenging activities is to match the organization with its environment in the most beneficial way, involving all these factors. Its significance has increased recently, due to economic downtimes and the people's environmental consciences. However, existing theories do not provide satisfactory solutions in selecting such sites. One reason for this appears to be the complicated and multidimensional nature of the problem itself. Another reason is that the proposed models suffer from the lack of a procedure that combines objective and subjective factors in an concise manner. Also many of the factors that should be considered in determining the problem cannot confine monetary values thus creating an aching void in location theory.

This article has presented a numerical model for area evaluation. It incorporates a procedure that derives a location measure, for both an urban and rural areas based upon subjective and objective considerations. Moreover, it facilititates sensitivity analyses, thus ascertaining the accuracy of the input data. It offers several advantages over previous models, which among others include:

1. Use of a two-stage model for evaluating alternative quantitative and qualitative factors first, and then evaluating specific areas between the chosen ones. Here the critical factor has not taken into consideration and the sites chosen for comparison have already been pre-selected, so the importance of the critical factors as such is negligible.
2. Incorporates the use of a questionnaire to provide solutions for the selection of subjective criteria, thus deviating from the original Brown-Gibson model which determines these factors with the aid of a subjective quantification technique known as preference theory.
3. Simultaneously considers all decision-making criteria (i.e. subjective and objective factors) to derive an optimal selection.
4. Permits ordinary ranked prioritization of decision-making criteria. For example, the assessment of the subjective criteria shows the following preferences in descending order: quality of the healthcare (17.0 %), quality of education (16.7%), potential growth of the area (13.3%), environmental pollution (12.9%), quality of security and criminality (11.9%) with the rest criteria following with lower percentage.
5. Easy to change objective factor estimates (i.e. model parameters) and solve for a new solution with little effort.

While the model presented in this article provides a powerful decision-making tool for area selection, the information it generates with sensitivity analysis possesses some limitations. One of these is that changes beyond the boundaries defined by sensitivity analysis cannot be interpreted. Such changes can be determined by using the model as a simulation tool. That is, the change can be observed by making a parameter change in the model and resolving the problem to see the simulated effect of the change in the new solution.

There are many other techniques that could be used for location analysis, such as the Analytic Hierarchy Process (AHP) process, but the present method offers some appealing advantages. One of the most important issues of AHP is what criteria should be set as the core evaluation criteria, who will select them and how. This is because using evaluation criteria that are not valued to begin with will risk that the analysis itself becomes meaningless. Another thing is that AHP assumes the system elements are uncorrelated and are unidirectionally influenced by a hierarchical relationship, thus introducing the assumption of independency among the various criteria of decision-making. There is a great deal of subjectivity as the user is asked to subjectively evaluate pairs of attributes on a point scale. However, when it comes to modified Brown-Gibson method, all criteria are set by a large group of people with different demographic characteristics through a questionnaire, thus removing the problems with criteria, hierarchy and subjectivity, as things are seen from different angles

Conclusively, we consider that this article has improved the body of knowledge of location-theory and has aided the decision process involved in residence site selection by guiding management to make better and more objective decisions. This was achieved by modifying and improving the Brown-Gibson's method, where instead of using the preference theory to determine the subjective factors, a questionnaire was designed. This is very importance for the Greek state as it contributes to the development of policy proposals, regional development, and decentralization; while prevents the deteriorate phenomenon that causes the non-homogeneous and in-balanced development of areas in urban and rural environments.

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REFERENCES

Atthirawong, W., MacCarthy, B., 2001. Identification of the location pattern of manufacturing plants in Thailand. Proceedings of the 6th International Manufacturing Research Symposium, Cambridge, UK, 9-11 September, pp.1-13.

Badri, M. A., Davis, D.L., Davis, D., 1995. Decision support models for the location of firms in industrial sites. International Journal of Operations and Production Management, 15 (1), 50-62.

Brown, P. A., Gibson, D. F., 1972. A quantified model for facility site selection – Application to a multiplant location problem, AIIE Transactions, 4(1), 1-10.

Chau, C.K., Burnett, J., Lee, W.L., 2000. Assessing the cost effectiveness of an environmental assessment scheme, Building and Environment, 35(4), 307-320.

De Keyser, W., Peeters, P., 1996. A note on the use of **PROMETHEE** multicriteria methods. European Journal of Operational Research, 89(3),457-461.

Dias, L. C, Mousseau, V., 2006. Inferring **Electre's** veto-related parameters from outranking examples, European Journal of Operational Research, 170(1), 172-191.

Djukanovic, R., Wargocki, P., Fanger, P.O., 2002. Cost-benefit analysis of improved air quality in an office building, Proceedings: Indoor Air 2002, pp. 808-813. [Available: http://www.ktsensor.com/download/Cost%20benefit%20from%20improved%20air%20quality.pdf]

Fascal, J., 1965. Forced Decisions for Value, Product Engineering, April 12, 36(8), 84-85.

Hurson, Ch., Zopounidis, C., Johnson 1995. On the use of multicriteria decision aid methods to portfolio selection, The journal of Euro-Asian Management, 1(2), 69-94.

Huylenbroeck, G., 1995. The conflict analysis method: bridging the gap between **ELECTRE,** PROMETHEE and ORESTE, European Journal of Operational Research, 82(3), 490-502.

Jacquet-Lagreze, E., Shakum, M., 1984. Decision support systems for semistructured buying decisions, European Journal of Operational Research, 16, 48—56.

Jungthirapanich, C., Benjamin, C., 1995. A Knowledge-based Decision Support System for Locating a Manufacturing Facility, IIE Transactions 27, 789-799.

Kahraman C., Ruan Da, Dogn I., 2003. Fuzzy group decision-making for facility location selection, Information Sciences, 157(19), 135-153.

Keen, P., Scott-Morton, M., 1978. Decision support systems: An organizational perspective, Reading, MA: Addison-Wesley, Inc.

Kioxos, P., Thanos, G., Salamouris, A., Kioxos, A., 2002. Operational Research, Athens: Sychroni Ekdotiki. (in Greek).

Kyriazopoulos, P., 2002. Modern types of management for SMEs, Athens, Sygxroni Ekdotiki.

Le Téno, J.F., Mareschal, B., 1998. An interval version of **PROMETHEE** for the comparison of building products' design with ill-defined data on environmental quality, European Journal of Operational Research, 109(2),522-529.

Lipovatz-Kremezi, D., 2003. Elements for economical analysis of industrial investment plans, Athens: G. Gelpesis.

Macharis, C., Springael, J., De Brucker, K., Verbeke, A., 2004. **PROMETHEE** and AHP: The design of operational synergies in multicriteria analysis. - Strengthening **PROMETHEE** with ideas of AHP, European Journal of Operational Research, 153(2),307-317.

Partovi, F. Y., 1994. Determining What to Benchmark: An Analytic Hierarchy Process Approach. International Journal of Operations and Production Management, 14 (6), 25-39.

Roy, B. (1988). Des critères multiples en recherche opérationnelle: pourquoi?, in Rand (ed.), 1987. Operational Research `87, North-Holland, Amsterdam, 829-842.

Roy, B., Vincke, Ph., 1981. Multicriteria analysis: Survey and new directions, European Journal of Operational Research, Vol. 8(3), 207-218.

Saaty, T. L., 1986. Axiomatic Foundation of the Analytic Hierarchy Process, Management Science, 32, 841- 855.

Saaty, T.L, 2000. Fundamentals of Decision Making and Priority Theory. 2nd ed. Pittsburgh, PA: RWS Publications.

Sinuany-Stern, Z., Mehrez, A., Tal A.-G., Shemuel, B., 1995. The location of a hospital in a rural region: The case of the Negev, Location Science, 3, 4, 255-266(12).

Siskos, J., 1984. Systemes d'evaluation et aide a la decision interactive en presence de criteres multiple, These d 'Etat en Sciences de Gestion (Universitere de Paris-Dauphine).

Srinivasan, V., Kim, Y., 1988. Designing expert financial systems: A case study of corporate credit management, Financial Management, 17(3), 3244.

Tse, M.S., Chau, C.K., Lee, W.C., 2004. Assessing the benefit and cost for a voluntary indoor air quality certification scheme in Hong Kong. Science of The Total Environment, 320(2-3), 89-107

Tzeng, G.-H., Teng, M.-H., Chen, J.-J., Opricouci, S., 2002. Multicriteria selection for a restaurant location in Taipei, International Journal of Hospitality Management, 21(2), 171-187(17).

Yang, J., Lee, H., 1997. An AHP decision model for facility location selection. Facilities, 15(9/10), 241-254.

Zopounidis, C., 1990. La gestion du capital risqué, Ed. Economica, Paris.

Zopounidis, C., 1995a. Evaluation du risqué de defaillance de l'enterprise: Methodes et cas d'application, Ed. Economica, Paris.

Zopounidis, C., 1995b. Decisions financiers et analyse multicritere, Encyclopedie de Gestion, 2nd edition.

Scenarios for Mobile Virtual Communities of Students

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ABSTRACT

Virtual communities have emerged in the 1990s since the creation of the Web as a tool that made the internet accessible for the citizens at large. Mobile Virtual Communities (MVCs), which have been recently gaining more momentum in research and industry, are expected to be the next step in the development of virtual communities. Tools to enhance the students' experience in the campus environment can play an important role in education. This paper suggests several new ways in which MVCs can be utilized to enhance the students' life experience on campus at the educational, organizational, and communal levels.

INTRODUCTION

Virtual Communities

Humans gather and form groups in order to accomplish tasks that cannot be accomplished otherwise. Cities, schools, and workplaces are the classical meeting places where communities form. The Internet provided the infrastructure for the formation of other forms, but nonetheless similar, communities. Virtual communities meet in virtual places, such as the Internet. In virtual communities, we meet to discuss different issues and collaborate on many different projects, from politics to shopping. Chat rooms, bulletin boards, and email groups are some of they ways that we use to team up and form virtual communities.

Preece suggests a working definition for virtual community (what she calls online communities) that is broad enough to cover a wide range of communities but precise enough to fit into social science definitions (Preece, 2000). According to Preece, an online community consists of:

- Socially interacting *people*, performing special roles or satisfying their needs.
- A *purpose*, which is the reason behind the community.
- *Policies* to govern people interaction.
- *Computer Systems* that support social interaction.

Virtual communities are social systems that allow individuals to bond without completely depending on physical interaction rituals. Such physical rituals can still be present in virtual communities, but they are not the only mean by which interaction takes place. Interaction is enhanced and augmented by the virtual dimension.

Mobile Virtual communities

With the proliferation of wireless technologies and mobile devices, users are expected to practice their roles in virtual communities while they are on the move. New virtual meeting places are being created, with no clear sight of an end. Therefore, a new form of virtual communities with mobile users can only be a natural result of the mobile and wireless technology advancement and embracement. Such communities are called *Mobile Virtual Communities* (MVCs) and they continue to form a very promising research field. At the same time, telecom operators continue to look for the kind of applications that will increase revenues from 3G mobile subscribers (Ahonen & Barrett, 2002).

Different aspects of mobility have been researched during the last few years, dealing with the vision of MVCs, the appropriate technologies, the appropriate user interfaces, the intelligent mobile agents' usefulness, as well as a myriad of applications ranging from leisure to health. Research has been also trying to find a solution to security, privacy and trust issues, in addition to profitable business models.

El Morr and Kawash (El Morr & Kawash, 2007) have Classified MVCs into three categories based on the degree of virtualization they permit, their degree of mobility they embrace, and the degree of cooperation they allow. According to this classification, communities can be purely *physical*, at one end, where members meet in physical places in order to participate in community activities; or at the other end they can be purely *virtual* where they only meet online. In addition, community members can be *immobile*, tied to one place, or can be *mobile*, on the move. Finally, cooperation can take the shape of a simple *notification* which is a limited form of cooperation, or a full *collaboration* through a coordinated activity such as project building (Turban, King, Viehland, & Lee, 2002).

Researchers are proposing new mobile collaborative models based on mobile technologies (El Morr, 2007; El Morr & Kawash, 2007; Kawash, El Morr, & Itani, 2007). Education is one of the prominent potent fields that can profit form MVCs. In this paper, we will propose several scenarios where MVCs can create new opportunities for students' life on campus, enhancing several aspects of their experience: the educational, organizational or communal aspects. These scenarios help us pinpoint some of the challenges that need to be addressed to make these communities a reality. In addition to technological feasibility, these challenges include security and privacy, usability, and personalization.

MOBILE VIRTUAL COMMUNITIES SCENARIOS ON CAMPUS

In what follows, we will show the utility and importance that an MVC can play on campus to enhance the student experience. We will follow a scenario based approach that gives tangible examples on how an MVC can enable new communication channels among students in terms of notification and cooperation.

Scenario 1: Communal MVC: Mobile Club

The Human Rights Club has been active on York Campus for many years. Club members were very active in organizing debates, distributing flyers, publishing news releases, motivating students for upcoming demonstrations in town, and managing human rights awareness campaigns.

This year the Human Rights Club has launched a new service "MVC-Rights" that is intended to exploit the massive student use of mobile phones. The club members launched a marketing campaign for their new service, students interested with the service have been told to subscribe to MVC-Rights, signing up with their mobile phone numbers and subscribing to pre-set communities of interests: Middle East, Haiti, Afghanistan, Sri Lanka, Canada, etc. When the MVC-Rights was launched, the categories were pre-set by the MVC-Rights administrator in order to try the concept, but the club was planning to enable the members create their own communities at a later stage.

Each member was able to send and receive news to other community members about issues related to the life of the community and to the club in general. Members could receive the messages on their mobile phones through SMS (Short Messaging Service) or via email, and could also send the information via either of these two means of communication. In addition, members could collaborate to reply to questions coming from each other about a particular topic; in the latest Middle East crisis they were able send latest breaking news, notifications about

TV debates, and community meetings, demonstrations and other activities. Finally, the community has made use massively of the mobile technology in two major aspects: conducting polls on the fly, and call for immediate action, or urgent meetings; this immediacy enabled the club members to conduct a vibrant community life during human rights crises.

Scenario 2: Organizational MVC: Bus Schedule on the Spot

Valentina lives in downtown Toronto; it takes her about one and a half hour to reach York University. Her trip consists of a bus, subway, and another bus ride to reach the university. It is very important for her to accurately know the bus schedule, but the problem is that the printed bus schedules consist of time estimates; bus delays due to traffic, weather, and breakdown conditions are very common. The situation that bothers her most is when she is going back home from her 7:00-10:00 p.m. class and she has to wait for the bus to arrive, unaware of the exact arrival time. So many times she was hungry and wished she could buy a snack form a nearby store but she didn't want to risk leaving, fearing that she might miss the next bus.

Valentina is happy tonight, she has subscribed to the on-campus new MVC, "MVC-Bus". She entered into a Web-based system her phone number and the time and days she would like to be notified, the bus routes she is interested in receiving notification for, the bus stops she is interested in, and few other parameters. The MVC-Bus Website stated that it is able to notify Valentina for bus arrivals on the designated bus stops for the designated bus routes on the dates and times that she has chosen. Besides, the MVC-Bus allows Valentina to pull on her mobile, at any moment, the list of buses that are arriving to the bus stop nearest to her position; the MVC-Bus is able to track the exact bus locations using GPS and Valentina's location using her GPS-enabled phone. Valentina felt relieved tonight; before standing in the queue she took a look at her mobile phone and has seen the exact arrival time of Bus route number 196B going to Sheppard Avenue, the bus still needs at least 15 minutes. She went to a nearby store bought a snack and came back on time, she felt less frustrated and was glad to manage her time more efficiently.

Scenario 3: Educational MVC: Assignments on the Move

Ning is a very hard working student; he takes his work seriously. Since he entered York University he quickly realized that work in the university is different than in high-school, and that he cannot continue working alone because some assignments are required to be done in groups and some courses are project-based and hence they should be completed in teams. Even though he enjoyed working in a group, one of the major difficulties he and his group members encountered was how to setup meeting times for the assignments.

Last week, he was so happy to know that a new MVC called "MVC-Assignment" has been launched on Campus. MVC-Assignment allows interested students to organize in communities that can be created on demand and then destroyed when there is no more need for them. He decided to establish a *usability community* for his usability project team members in order to facilitate collaboration among the team members during the Fall term. Members use a Web-based application to enter their mobile phone numbers and some notification criteria such as the day and time the student would not like to receive notifications. During the following week, Ning needed to organize a meeting on-the-fly with all or some of the team members. He sent a meeting request notification to all other members, some of whom received meeting inquiry notifications on their mobile phones and responded to it. Ning could easily use his mobile phone to consult a campus map that shows the locations and availability of the team members. He notifies whoever is available to meet in 30 minutes in the student center to have a quick Q&A session in order to clarify few issues related to the project or to discuss new ideas.

Few weeks later, Ning and his team colleagues found that this MVC was also useful to do fun stuff and to enhance their social ties. In so many instances during the semester, Ning and his colleagues searched for each other in order to have a cup of coffee and a chat. Occasionally, Ning received jokes form other team members and invitations to parties. Slowly, some of the team members became close friend and at the end of the semester they were debating if they want to keep this MVC on or to create another permanent one and possibly invite new colleagues to join the community.

DISCUSSION

Although virtual communities have been developed to support learning(Liebregt, 2005; Miao & Haake, 2001; Prasolova-F, rland, & Divitini, 2003; Sourin, Sourina, & Prasolova-Førland, 2006), none to our knowledge has ventured in mobile virtual communities. Mobile Virtual Communities are still emerging, and their application could cover a wide spectrum, from mobile games to education. The previous scenarios suggest that MVC can be suitable to enhance campus life experience including educational, organizational and communal aspects. The scenarios are presented in order of increasing challenges to the feasibility, adoption, and maintenance of the suggested MVCs. The feasibility of these MVCs is correlated with the availability of the required technologies for the services. Adoption and maintenance require these MVCs to provide for sociability and usability. Some of the concerns relate to the policies that should regulate these MVCs, the user interface used, privacy of the members, and security of the data gathered from the communities.

Technological Feasibility

A service providing MVC-Rights does not require more than email and SMS distribution lists, making the implementation and deployment of such a service an easy task. MVC-Bus heavily depends on location determination technologies (LDT), such GPS. In order to generate accurate live bus schedules, it is important that the exact locations of the buses are determined in real time. However, some "diluted" implementations are possible, which require the cooperation of bus operators. In one implementation of such a service, called TraVcom, the bus operators update the bus schedule regularly, using specialized mobile devices or even mobile phones (Kawash et al., 2006). Valentina in Scenario 2 can still make use of the service even if her phone is not GPS-enabled. She can simply key-in the bus stop number and the bus route number to get an accurate arrival time. MVC-Assignment also requires the use of LDT. Cheaper alternatives to GPS can be deployed on campus. Tracking members and generating live maps with the indication of member's locations is an important factor.

All of the three MVCs can be sustained with basic forms of interaction, such as SMS. Since it may not be always possible to support advanced features (such as LDT), these services must be implemented allowing the broadest possible base to users to participate, and at the same time allowing any interested user to take full advantage of the provided features.

Adoption and Maintenance

Assuming that the interest in joining a community already exists, adoption of these communities requires usability, trust, and privacy.

A determinant factor of usability is user interface requirements, an issue that originates from the limited mobile device processing power, screen and keypad/keyboard size. Mobility also enforces constraints on the interaction so that new interaction styles should be created (Kristoffersen & Ljungberg, 1999). The right interface design should be investigated in order to enable a friendly and enjoyable experience. The collaboration tools should be studied in close partnership with the students (the end users); their satisfaction is the key success factor for such MVCs. For instance in MVC-Bus, a member should be able to pull the real-time bus schedule with little interaction with the device. A map that shows the proximity of a user in MVC-Assignment, indicating the positions of other near-by members, should be carefully designed.

The willingness of students to adopt an MVC service also highly depends on their trust of it. For instance, MVC-Assignment requires members to be willing to expose some of their private information, particularly their location. The MVC-Assignment service must be secure enough so that this information is not compromised to unauthorized parties, and also must be capable of giving the user's the option of being "non-trackable". Privacy and security policies should be developed, communicated and enforced.

Finally, personalization is a factor that can drive adoption since users will be able to tailor the service to their own needs; the service's ability to provide different levels of privacy is essential for some MVC adoption. Examples of personalization could be seen in a user choosing the bus route number, the bus stops of interest, the notification method desired (SMS, mail or both), the time, etc. For instance, it is important that Ning to be able to choose to be invisible to other members of the community.

CONCLUSION

While telecom companies are in quest for "killer" applications that can drive traffic and improve their revenue, we contend that Mobile Virtual Community services are the future such applications. We foresee these services may induce a similar social and business impact similar to the Web and email impacts.

The recent technological advancements in wireless and mobile computing have made Mobile Virtual Communities possible. The scenarios presented in this paper can be implemented using existing technologies. For instance, Kawash et al. (Kawash, El Morr, Charaf, & Taha, 2005) present a computer system that can support MVC-Bus, mentioned in Scenario #2. However, the full advantage of these services may not be realized without further deployment of advanced services, such as location determination, and without the constant enhancement of others, such as security.

REFERENCES

1. Ahonen, T., & Barrett, J. (2002). *Services for UMTS: Creating Killer Applications in 3G*: Wiley.
2. El Morr, C. (Ed.) (2007) Encyclopedia in Mobile Computing & Commerce. IDEA Group Inc.
3. El Morr, C., & Kawash, J. (2007). Mobile Virtual Communities Research: A Synthesis of Current Trends and a Look at Future Perspectives. *International Journal for Web Based Communities, 3*.
4. Kawash, J., El Morr, C., Charaf, W., & Taha, H. (2005). *Building Mobile Virtual Communities for Public Transport Awarness.* Paper presented at the IEE Mobility Conference 2005 (2nd International Conference on Mobile Technology, Applications, and Systems), Guangzhu, China, pp. 1-7.
5. Kawash, J., El Morr, C., & Itani, M. (2007). A Novel Collaboration Model for Mobile Virtual Communities. *International Journal for Web Based Communities, 3*(1).
6. Kristoffersen, S., & Ljungberg, F. (1999). *Making place to make IT work: empirical explorations of HCI for mobile CSCW.* Paper presented at the Proceedings of the international ACM SIGGROUP conference on Supporting group work, Phoenix, Arizona, United States, pp. 276-285.
7. Liebregt, M. (2005). *Collaborative Virtual Environments in education.* Paper presented at the 2nd Twente Student Conference on IT, Enschede.
8. Miao, Y., & Haake, J. M. (2001). *Supporting problem based learning by a collaborative virtual environment: a cooperative hypermedia approach.* Paper presented at the the 34th Annual Hawaii International Conference on System Sciences.
9. Prasolova-F, E., rland, & Divitini, M. (2003). *Collaborative virtual environments for supporting learning communities: an experience of use*. Paper presented at the Proceedings of the 2003 international ACM SIGGROUP conference on Supporting group work.
10. Preece, J. (2000). *Online Communities: Designing Usability supporting Sociability*. USA: John Wiley & Sons Ltd.
11. Sourin, A., Sourina, O., & Prasolova-Førland, E. (2006). Cyber-Learning in Cyberworlds. *Journal of Cases on Information Technology, 8*(4), 55.
12. Turban, E., King, D., Viehland, D., & Lee, J. (2002). Electronic Commerce a Managerial Perspective. In (2nd ed., pp. 242-246): Pearson.

Improving Organizational Systems: Incorporating General Systems Theory and Design Principles

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ABSTRACT

A crucial factor for understanding system behavior is observing how the parts interact (Atwater & Pittman, 2006). However, the very act of analysis (defined as studying the parts in isolation) makes it impossible to understand a system and its underlying dynamics (Ackoff, 1981). This paper highlights the need to revamp our current approach to systems analysis and design and incorporate more systems thinking and system modeling into the development of organizational systems.

INTRODUCTION

The design of organizations and organizational information systems has been guided by the use of several underlying principles. These design principles are a result of an over-reliance on one mode of thinking – the application of analysis and functional decomposition, based on the *scientific method*. While the scientific method has been the cornerstone of the majority of advancements in our knowledge and the development of new technologies, an over-application and over-reliance on some of the modes of scientific thinking can actually be detrimental for the design of organizational systems.

Another mode of thinking – *systems thinking* or general systems theory, when used in combination with principles from the scientific method, may actually lead to greater insights, expanded viewpoints, and better designed organizational systems.

THE SCIENTIFIC METHOD AND ORGANIZATIONAL DESIGN

The industrial revolution ushered in the use of machines to increase worker productivity. Since machines could only be designed for very specific, repetitive tasks, it became necessary to redesign work and workflow in order to take advantage of specialized machines. Workers went from having multiple skills and general, wide-encompassing tasks to narrow, repetitive or specialized tasks. Adam Smith published the famous *Wealth of Nations* in 1776, where he described this new concept – *the division of labor*. The development of the machines that led to the industrial revolution could be directly linked to the accumulating scientific and engineering knowledge resulting from increased understanding provided by the application of the scientific method.

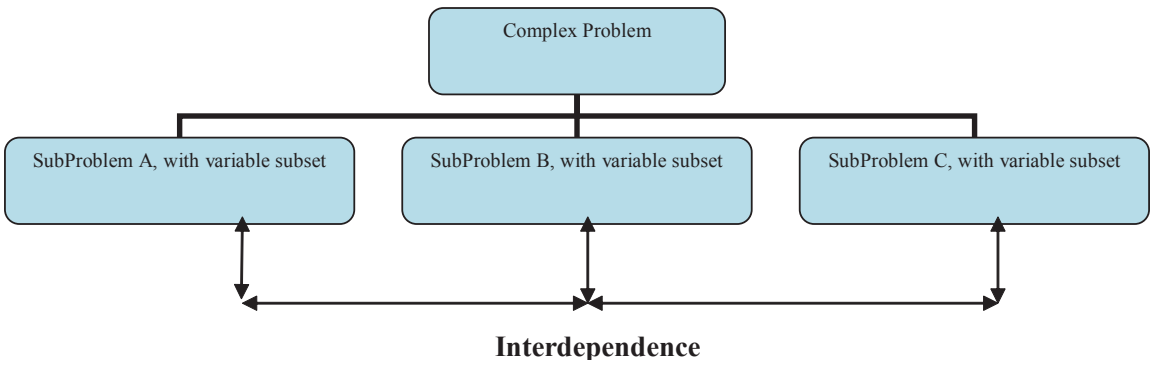
A basic principle from the scientific method is the notion of seeking truth and developing an understanding of nature or natural phenomena by breaking-down or decomposing complex systems into their elemental components. Thus, biologists are able to understand organisms by focusing on the parts (or subsystems) that make-up or compose them. An understanding of the parts helps in understanding the functioning of the whole.

The notions of understanding complex phenomena using this approach were then applied to the design of artificial, man-made systems, and organizational design. The primary organizing (design) principle from the scientific method is *functional decomposition*. Functional decomposition is a design principle whereby a complex problem is solved by breaking it down into smaller, more manageable and simpler sub-problems. This design principle, together with the use of machines and specialization of labor, led to the development of mechanistic or bureaucratic organization designs.

SIDE EFFECTS OF THE SINGLE PARADIGM

Problem solving based on the scientific paradigm can be thought of as composed of two primary parts: (1) Analysis and (2) Design. The analysis step of problem solving relies on understanding problems and phenomena by examining the individual parts in order to understand the functioning of the whole. After problems and phenomena are understood, the design step then seeks to design a solution by simplification via functional decomposition, or identification of sub-problems and specialization. This method limits the variables and complexity of the problem and, in the case where mathematical models may be applied, reduces the computational space. This has been the dominant, meta-model for isolating and solving management and organizational problems.

Figure 1. Detail complexity and dynamic complexity



However, this problem solving orientation reduces one type of complexity only to produce more of a different kind of complexity. Senge (1990) defines two types of complexity: *detail complexity and dynamic complexity*. Detail complexity involves situations where there are numerous variables, data, and although the relationships may be complex, they can often be modeled mathematically to achieve optimal solutions. Problems involving detail complexity are the focus of management science techniques and or techniques that require the use of computer-based solution. Dynamic complexity involves the interaction of the decision variables through time. While detail complexity is reduced through the application of functional decomposition and specialization or partitioning of the problem space, the very act of partitioning will result in an increase in the number of interacting components (partitions), and creates a complex web of interdependent components that share inputs and outputs (see Figure 1).

Thus, over-reliance on the problem solving methods based on the scientific approach has resulted in one type of complexity being traded-off for another. The problem-solving mindset of the scientific approach when decoupled from an understanding of system thinking, results in a limited understanding of organizational problems and problem solving. Specifically, managers often fail to realize: (1) cause and effect are often separated by time and space, (2) problem solutions that fix a problem in the short-run often create or exacerbate problems in the long-run, and (3) because of system effects (inter-dependent components) and system dynamics (multiple, non-linear feedback loops) short-term results may differ strongly from long-term results which then affects one's ability to learn from and correct past mistakes or decisions (Forrester (1971); Atwater & Pittman, (2006).

In order to understand these issues and understand how to deal with the two types of complexity, the next section discusses systems theory and systems thinking.

SYSTEMS THEORY AND ORGANIZATIONAL DESIGN

General Systems Theory (GST, or systems theory) was originally conceived by von Bertalanffy (1969) in 1945, and has been expanded, clarified, and applied to many different areas of science and thought. The concept of *systems thinking* refers to the set of cognitive strategies or systems related thinking strategies that may be applied to solve problems and or understand complex phenomena. Systems thinking behaviors are based on the original notion of general systems theory. An important area of study that arose out of general system theory (well to some extent, but mostly from engineering and computer technology) to aid in the understanding of complex systems is - *system dynamics*.

SYSTEMS DEFINED

A system may be defined as a set of interdependent components which is unified by design to accomplish one or more objectives (Kast & Rosenzweig, 1972). A system is thus an artificial creation, a way of thinking about and organizing complex phenomena. When defining or creating a system, a boundary is defined. The boundary separates the internal components from the system's external environment. A closed system does not interact with the environment, whereas an open system is one that shares information, energy or physical flows with the outer environment.

Although the system concept is very simple, its power as a problem-solving and design paradigm originates from its elegant simplicity, and this gives rise to the ability to create abstraction tools which then provide insight into problem structure and problem resolution. The systems approach thus provides a structure from which several modes of thinking are derived. *System thinking* is holistic thinking and includes notions of feedback, time delays, and dynamic interplay between components.

In essence systems thinking may be described as a paradigm or a "world view," where phenomena are viewed holistically and interconnected (Manni & Maharaj, 2004). Systems thinking may also be viewed from a more detailed and cognitive processing perspective. Richmond (1997) delineates the following cognitive processing or thinking skills or tracks that fully-define systems thinking: (1) Dynamic thinking, or examining or framing a problem or pattern of behavior over time, (2) System-as-cause thinking, or viewing the system's behavior as a result of the system itself, and thus under the control of decision makers. In essence, one must define the system boundaries in a meaningful way. (3) Forest thinking, or viewing the "big picture." This is the ability and skill to effectively see above the functional areas or silos and perceive the system of interrelationships and interdependencies that connect the component parts. This is a central feature of systems thinking and serves to strongly differentiate this mode of thinking from scientific thinking, which views and seeks to understand phenomena by understanding the parts first. (4) Operational thinking, or examining, in detail, the structure and nature of relationships; at *how* the variables affect one another, not simply that they affect one another. (5) Closed-loop thinking, is realizing that causality tends to follow a feedback loop whereby causality does not run in just one direction, but loops-back to change one or more causes and that causes can affect one another.

SYSTEM DYNAMICS

The area of system dynamics incorporates the systems thinking skills into a modeling framework that allows the problem solver to apply a systems approach to understand the complex system interactions.

Forrester (1961) first articulated notions of system dynamics and their proper modeling. Underlying the need for systems dynamics is the realization that many of today's problems in business, policy and human affairs are not only complex and difficult to solve but that many of our efforts aimed at solving these difficult problems result in "unintended side-effects." In fact, in many cases our solutions and decisions result in causing our problems. In other words, today's solutions become tomorrow's problems (Sterman, 2002).

The notion of "unintended side-effects," may actually be viewed from the standpoint of incomplete modeling. In other words, in an effort to apply scientific problem-solving methods, many problems are analyzed, decomposed to smaller subsets, and then solved by means of decision modeling, optimization, and other techniques. However, as stated previously, analysis and design of the problem domain may reduce detail complexity but when modeled from a system dynamic perspective, isolated subsystems and systems beyond the problem boundary may still interact – in other words, dynamic complexity has not been accounted for properly. Thus, notions of "unintended side-effects," may be viewed as "un-modeled interactions" from a system perspective.

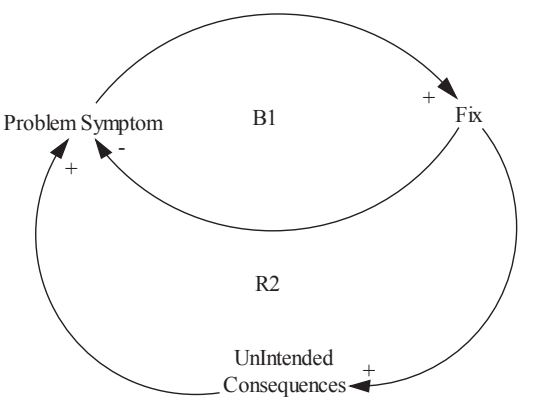
A primary tool used in system dynamics is the Causal Loop Diagram (CLD, shown in Figure 2). The CLD is an important modeling tool to help understand system dynamics, to facilitate holistic thinking, time delays, feedback loops, and all of the cognitive processing and systems thinking strategies.

System thinking is not always intuitive, commonly performed or easily understood, even by intelligent managers or educated individuals (Sterman, 2000). A number of empirical studies have confirmed this assertion (Sterman & Sweeney, 2000; Pala & Vennix, 2005). Many common mistakes by managers may be traced to incomplete understanding of system dynamics, and Senge (1990) has documented these common pitfalls using system archetypes, documented using CLDs, as in Figure 2.

BUILDING EFFECTIVE ORGANIZATIONAL SYSTEMS

A basic premise of this paper is that both paradigms are necessary to build effective organizational systems: System Thinking and Scientific Thinking. Organizational systems may be thought of as being composed of operational and decision

Figure 2. Causal loop diagram (CLD), "Fixes that Backfire"



making tasks performed by humans and machines (computers), within defined organizational structures, and that may interface across organizational boundaries and interact with other systems. Essentially, organizational systems may be designed in a myriad of ways, but are generically defined by tasks, structures, people, and machines.

Traditional information systems development techniques and methodologies have stressed functional decomposition. Thus, traditional analysis and design tools have tended to model information requirements, processes and tasks from a functionalist (scientific) viewpoint. As a result, two primary "un-anticipated side effects" have resulted: (1) information systems (that support the basic business system) have failed because of a failure to understand the human component of systems – the socio-technical system viewpoint, and (2) business systems have failed because an overemphasis on functional decomposition has led to business processes that are too fragmented, with too many information interfaces and "hand-offs" required to coordinate the entire business process (defined as the ability to provide a requisite value to an end customer). Both of these major failures are the result of a lack of system thinking, modeling and design.

THE SOCIO-TECHNICAL SYSTEM FAILURE

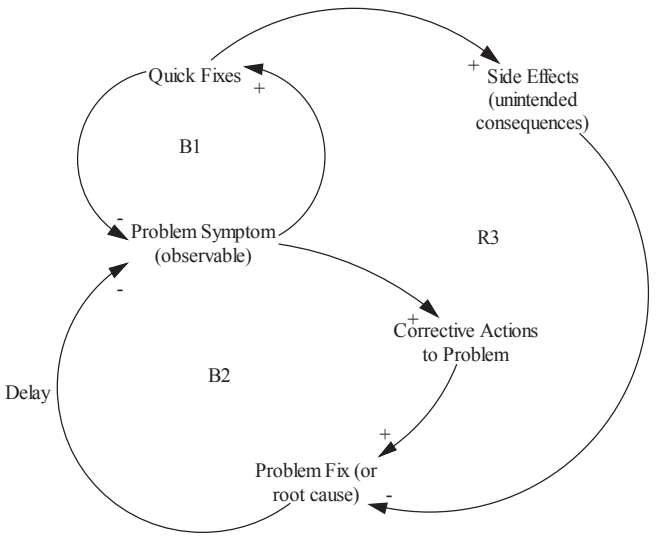
A hypothetical company is faced with the problem of making better product positioning and advertising decisions based on market research data. The hypothetical company scenario involves a product manager (who reports to the division manager), a market analyst (market research department) and a division manager (responsible for budgeting, deploying a sales force, etc.). The major problem symptom is that the product manager does not always have the best information on which to base his decisions. Based on an incomplete understanding of the situation, management decides to build a decision support system to help supply important sales, market, and demand information. The new DSS employs built-in decision models that more than provides advice, but actually "restricts" the range of possible outcome or decisions that are possible. This is done to reduce variability in product positioning decisions across the corporation, thereby providing a way for more centralized control. The DSS provides normative models based on complex mathematical principles to optimize certain relationships and outcome variables.

The result: the product managers feel completely constrained by the new system. Basically, the product managers feel: (1) a *loss of control* over their decisions, which increases their stress level since they are still held responsible for their decisions; (2) they feel their jobs have reduced their ability to have a *creative intellectual outlet*; (3) because of the use of the new system their jobs have become more *routine and repetitive*, (4) they now have *fewer interactions* with market analysts because the data collected has been standardized across the corporation for increased consistency and to aid in market comparisons at the corporate level, (5) they also have *fewer interactions and communications* with the actual sales personnel (which used to be an important and *informal way of gathering rich data*) because the DSS demands greater amounts of their time and because the inputs required by the DSS do not allow for considering their old, informal, rules of thumb that typically went into their positioning decisions. Figure 3 shows a Causal Loop Diagram of the new situation.

Basically, a lack of system thinking at the start caused management to focus on a problem symptom – the lack of good information for product managers. If a more systemic approach had been used, for example, use of *forest thinking* would have enabled management to see the bigger picture and include the human component in their view of this system (i.e., this is basically the socio-technical system viewpoint that considers the human component of the system, including humans personal goals). A more in-depth consideration of the human component would reveal that product managers did not have enough information because they also did not have enough *control* in their jobs. Lack of control meant that they did not have the ability to alter or influence the data gathered by the market research department, they did not have the bargaining power to influence the division managers to elicit time and cooperation from the sales force to gather important, rich and meaningful information.

The management decision to implement the DSS was a quick fix based on an inadequate understanding of the system dynamics. An unintended side effect of this approach was an increase in the lack of control by the product managers. This effect actually looped back and added to the underlying problem (Figure 3). In addition, all of the side effects, including a *loss of control*, reduced *creative intellectual outlets,* their jobs have become more *routine and repetitive, and fewer interactions and communications* all resulted in a lower Quality of Work Life of the product managers. A lower Quality of Work Life can have even more, long-term effects on the company as personnel may have greater turnover, higher absenteeism, and lower productivity.

Figure 3. Causal loop diagram of the STS situation (Shifting the burden archetype)



Proper systems thinking would also have highlighted that good product management decision making depends on both access to the proper information (via databases, models, informal information gathered by interactions with employees and salesmen), and a motivated product manager (human component of the system). Reducing product managers' Quality of Work Life also reduces this last factor.

The actual problem or root cause in this system situation was that the *business system* was improperly designed. The next section explains the failure from the business system or business process perspective.

BUSINESS PROCESS DESIGN FAILURE

Business process design failures may be thought of as the over-application of reductionism or functional decomposition (stemming from the scientific viewpoint). In an effort to reduce detail complexity and to define work in its most basic form, managers have created work environments with many sub-processes, organizational units, and subsequently, narrowly defined jobs. The result of defining too many sub-processes is that the sub-processes require a great deal of coordination and information flow because the sub-processes are part of a set of interdependent tasks that make up the larger process or larger system. In essence, over-design leads to a reduction in detail complexity but an increase in system or dynamic complexity. Lack of coordination between sub-processes is often described as "increasing the hand-offs" or information flows required to "piece back the fragmented processes" (Hammer & Champy, 1993). The end result is less efficient organizations and decreased customer responsiveness.

HUMANS ARE NOT MACHINES

A secondary effect of poorly-defined or over-designed processes is less satisfied workers (Hammer, 1996). When designing computer-based systems, researchers from the socio-technical design perspective stress the importance of including an assessment of the human component of systems since workers attitudes and well-being can strongly influence successful organizations. Sherman, Garrity, & Sanders (2002) developed an IS success instrument, based on Garrity & Sanders (1998) model, to measure workers' quality of work life (QWL). The measure examines items such as: (1) control over work, (2) a worker's ability to schedule or manage tasks, (3) degree of autonomy, and (4) the amount of routine in work.

As work is defined and processes and work systems designed, it is vital to take the human component into account. However, a differing amount of functional decomposition is necessary for the application of management science models and computer software than is necessary for human defined work. Hammer & Champy (1993) provide a number of examples where work can be performed more effectively by a single worker with the aid of information provided by computer support (DSS and database technology for example), than by the over-design of processes into many fragmented, sub-processes. Over-design of work leads to over-specialization and lower quality of work life. Thus, a critical task is to design systems effectively that match the quality of work life needs of the human component of systems with the design considerations and reduction in detail complexity required for software systems.

RETHINKING SYSTEMS ANALYSIS AND DESIGN

Current systems analysis and design methods fail to produce system designs that account for the wider system view which includes consideration of the business process design (i.e., tasks, structures, and processes), the human element (with corresponding socio-technical concerns), and the technical design. We recommend the following changes to produce better system designs: (1) Emphasize the co-design of business process, socio-technical and information systems; (2) Emphasize modeling of both detail complexity and dynamic complexity by incorporating the use of system dynamic modeling using causal loop diagramming (CLD) in addition to traditional analysis and design tools (e.g., data flow diagrams, hierarchy charts and decomposition diagrams); (3) Emphasize the use of prototyping and multi-dimensional measurement to obtain feedback on the impacts of designs on the human and business process components of systems (Garrity, 2001); (4) Educate systems analysts and managers on systems thinking and system dynamics.

CO-DESIGN OF BUSINESS SYSTEM AND INFORMATION SYSTEM

A critical emphasis must be placed on the *co-design* of business systems (e.g., work design, organizational structures, and task definitions) and information technology systems. This is critical because the needs of the human component, as is often stressed by the socio-technical school of thought, are vital for the success of the entire system.

A balance must be forged between the needs of the human element and the requirements of the technical system component. This is because the two components are interdependent parts of a dynamic system. The nature of the interdependence (and conflict) is best understood by modeling the two types of complexity that must be accounted for in the overall system design. The use of analytical tools and modeling (e.g., data flow diagrams) is necessary to understand the detail complexity and to design aspects of the technical design. However, the use of systems thinking and dynamic modeling is also necessary to understand and design the entire business process and socio-technical system. Thus, a fundamental shift in thinking must take place in order to achieve the level of design sophistication necessary to achieve success in this wider system context.

SYSTEMS EDUCATION

System researchers have been advocating teaching system concepts and system dynamics in business schools (Atwater & Pittman, 2006; Sterman, 2000), and while this is necessary it may not be sufficient for the design of effective organizational systems. Traditional textbooks and courses on systems analysis and design continue to stress the importance of considering users and their socio-technical concerns, but these textbooks have not included tools for the modeling of interdependent components and system dynamics.

Although organizations are complex systems, the scientific viewpoint and scientific methods have dominated research and education in business schools. This can be viewed as problematic since a crucial factor for understanding system behavior is observing how the parts interact (Atwater & Pittman, 2006). However, the very act of analysis (defined as studying the parts in isolation) makes it impossible to understand a system and its underlying dynamics (Ackoff, 1981).

SUMMARY AND CONCLUSIONS

An over-reliance on the use of analysis and design techniques such as functional decomposition or reductionism strategies, have resulted in overly complex, interdependent organizational systems. Interdependent subsystems and systems often interact with each other using multiple, non-linear, feedback loops. The complex flow of interactions often creates counterintuitive behavior resulting in unintended consequences or sub-optimal results (Sterman, 2002). This paper advocates a fundamental re-thinking of systems analysis and design that incorporates a general systems theory orientation, system dynamics modeling and the use of prototyping to produce a better understanding of and to aid in the design of organizational systems.

REFERENCES

Ackoff, R. (1981). *Creating the corporate future*. Wiley: New York, NY.

Atwater, J.B. & Pittman, P.H. (2006). Facilitating systemic thinking in business classes. *Decision Sciences Journal of Innovative Education*, 4, 2, 273-292.

Bertalanffy, L.V. (1969). *General system theory*. George Braziller: New York, NY.

Forrester, J.W. (1961). *Industrial dynamics*. Pegasus Communications: Waltham, MA.

Garrity, E.J. & Sanders, G.L. (1998). *Information Systems Success Measurement*. Idea Group Publishing: Hershey, PA.

Garrity, E.J. (2001). Synthesizing user centered and Designer centered IS development approaches using general systems theory. *Information Systems Frontiers*, 3, 1, 107-121.

Hammer, M. & Champy, J. (1993*). Reengineering the corporation: A manifesto for business revolution*. Harper Business: New York, NY.

Hammer, M. (1996). *Beyond reengineering*. Harper Business: New York, NY.

Kast, F.E. & Rosenzweig, J.E. (1972). General systems theory: Applications for organizations and management. *Academy of Management Review*. December, 447-465.

Pala, O. & Vennix, J.A.M. (2005). Effect of system dynamics education on systems thinking inventory task performance. *System Dynamics Review*, 21, 2, 147-172.

Richmond, B. (1997). The "thinking" in systems thinking: how can we make it easier to master. *The Systems Thinker*, 8, 2, 1-5.

Senge, P.M. (1990). *The Fifth discipline: The art and practice of the learning organization*. Currency, Doubleday: New York, NY.

Sherman, B.A, Garrity, E.J. & Sanders, G.L. (2002). Expanding our View of Information Systems Success, in *Information Systems Evaluation Management*, edited by W. van Grembergen, IRM Press: Hershey, PA, 195-207.

Simon, H.A. (1969). *The sciences of the artificial*. MIT Press: Cambridge, MA.

Sterman, J.D. & Sweeney, L.B. (2000). Bathtub dynamics: initial results of a systems thinking inventory. *System Dynamics Review*, 16, 4, 249-286.

Sterman, J.D. (2000). *Business Dynamics: Systems thinking and modeling for a complex world*. Irwin/McGraw-Hill: New York, NY.

Sterman, J.D. (2002). All models are wrong: reflections on becoming a systems scientist. *System Dynamics Review*, 18, 4, 501-531.

Security Technologies in Mobile Networking

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ABSTRACT

Specific security technologies for mobile applications and services – such as SIM/USIM/PKI SIM cards, hash chain generated security tokens for secure Mobile IP registration and mobile agent authorization, personal and public signature servers for mobile devices, and Identity based Public Key Cryptography (IdPKC) - are surveyed. Security solution examples and needed R&D are presented. A test environment for Mobile IP security solutions using IdPKC is also proposed.

1. INTRODUCTION

Mobile networking includes both network node mobility (notebook computers, handheld PDA computers, and mobile smart phones) and network software mobility (mobile agents). Mobility also puts specific technological requirements on basic security services like authentication, authorization, and digital signing.

2. SMARTCARDS

Specific security components in user devices in mobile cellular networks are smartcards such as SIM, USIM, and PKI SIM. A SIM is a smartcard securely storing an authentication key identifying a GSM network user. A PKI SIM is a SIM with an integrated RSA co-processor and storage space for private keys. A USIM is a SIM used in 3G mobile telephony networks, such as UMTS. Apart from authenticating users to cellular networks, these smartcards also are used in other security services.

2.1 SIM Card Based Authentication to Internet Services

Authentication to Internet services mostly occurs with the vulnerable username/password method. SIM based authentication is more secure and also convenient because of the widespread use of mobile phones with SIMs. In (Schuba et al., 2004) is proposed a SIM based approach with authentication protocols using an Identity Provider (IDP) Server operated by a mobile network operator. The SIM is accessed directly from the mobile phone, through a Bluetooth link to the phone, or through a WAP Proxy Gateway.

2.2 Secure Mobile IP Registration Protocol

In (Haverinen et al., 2001) GSM authentication based on the secret key in the SIM is proposed for a secure version of the Mobile IP Registration Protocol (Perkins, 2002). The AAA protocol (Glass et al., 2000) is used to access the GSM network through a proxy server, the GSM Authentication Gateway (GAGW), which translates between the Internet AAA protocol and GSM protocols. Two Mobile IP registration round trips are required. The RANDs of the subscriber are obtained and the GSM algorithm is executed on the SIM card. Finally, the actual authentication occurs. The system has been successfully tested with

- the GAGW implemented on Windows NT
- the GAGW connected to a GSM test network
- Windows 2000 and Linux based mobile nodes.

This Mobile IP Registration Protocol is also a standardization proposal in an IETF draft (Haverinen, 2001).

2.3 SSL Integration with SIM/USIM Cards

An Over-The-Air (OTA) connection to a SIM uses Application Protocol Data Unit (APDU) commands/responses (ISO/IEC 7816-4, 2005) encapsulated in protected SMS messages. APDU communication occurs in a SSL protected GPRS/TCP channel in the communication architecture described in (Badra and Urien, 2004). The Bearer Independent Protocol (BIP), defined in the European Telecommunication Standards Institute (ETSI) specifications TS 102 223 and TS 102 124 (ETSI, 2007), is required in the mobile device with the SIM. A modified SSL Handshake Protocol, in which certificate authentication is replaced by pre-shared secret based authentication, is proposed. BIP implements conversion from APDU commands/responses to SSL Handshake Protocol messages and to data sent over the SSL channel. An EAP-TLS based Authentication and Key Agreement Procedure (AKA) is proposed for a mixed WLAN-3G environment (Kambourakis et al., 2004). The SSL Handshake Protocol uses the AAA server certificate in the home network of the mobile device.

2.4 SIM Based Mobile PC Access

In (Mäkinen et al., 2001) architectures are proposed, where mobile phone SIMs and PKI SIMs are used for access to a mobile PC, which communicates with a remote server using the SSL protocol. A remote loader (RL) applet has been developed for SIMs implemented on Java cards. The RL applet supports communication to and from the SIM over an infrared link or over GSM.

2.5 Mobile Electronic Identity

Mobile FINEID, an electronic ID for inhabitants in Finland, is based on a Mobile Signature Service (MSS) and PKI SIMs allowing users to authenticate to online services and create digital signatures with private PKI SIM keys (Finnish, 2006). Currently, PKI SIMs are issued by two Finnish operators. PKI SIM owner identities are verified by mobile citizen certificates issued by the Finnish Population Register Centre (PRC) and attached to the private PKI SIM keys.

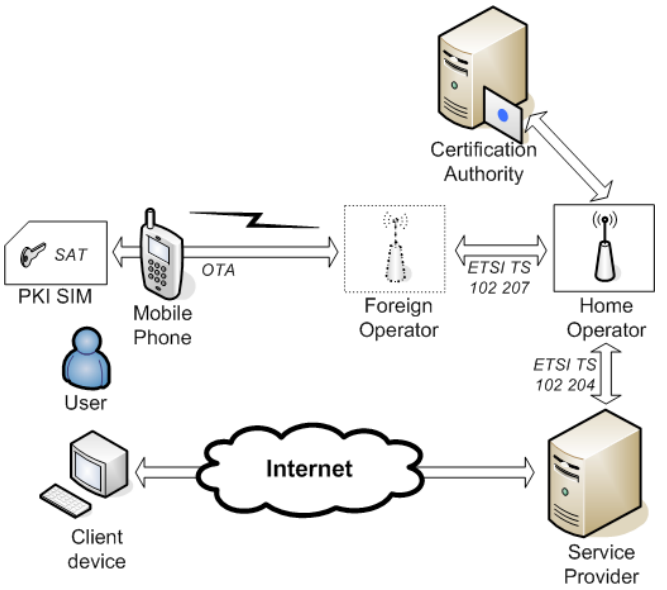
2.5.1 Technical Features of a FINEID PKI SIM Card

A FINEID PKI SIM contains a crypto processor and two PIN code protected private keys: an authentication/encryption key and a signature key. The corresponding certified public keys are stored in a directory administered by the PRC. Hashes of both public keys are stored in a PKI SIM for retrieval of correct certificates from this directory. The PKI SIMs are SIM Application Toolkit (SAT) enabled (3GPP, 2004) and contain a SAT application known as Wireless Internet Browser (WIB) (SmartTrust Case Studies, 2006). A PKI plug-in, PKCS#7 Signature Plug-In, executes cryptographic operations with the private keys through function calls executed by the WIB (SmartTrust White Papers, 2006). Function calls to and retrieval of return data from the PKCS#7 Signature Plug-In are encapsulated in SMS messages transmitted over an OTA connection.

2.5.2 MSS Architecture

The architecture of a Mobile Signature Service (MSS) is shown in Figure 1. Routing and roaming are based on public European standards. Thus, the Finnish mobile citizen certificate can in theory use any European MSS. Roaming and collaboration

Figure 1. MSS architecture



is ETSI TS 102.207 standardized, communication between the service provider and the mobile operator is based on an ETSI TS 102.207 standardized web service interface (ETSI, 2007). The interface is mainly based on SOAP (Simple Object Access Protocol), XML, and HTTP/HTTPS.

A workgroup of Finnish Federation for Communications and Teleinformatics (FiCom) has published a recommendation defining the rules for services using mobile citizen certificates and prescribing the technical interfaces for operators and service providers (FiCom, 2005). This recommendation is an application instruction for the ETSI standards TS 102 204 and TS 102 207. Extensions and adjustments to these standards are defined for limiting misuse. The purpose is to use electronic signature services independently of service providers and operators.

Example: User Authentication to a Protected WEB Service

1. The user tries to access the web service using HTTP and the web service informs the user that authentication is required and asks for the user's phone number
2. After receiving the phone number the service provider (in this case the web service) sends a signature request message, containing the user's phone number, to the mobile operator.
3. The mobile operator sends a signature request to the user's mobile phone PKI SIM, where a PKCS#1 signature is generated with the private key.
4. The PKCS#1 signature and the public key hash is sent back to the mobile operator and the user's citizen certificate is retrieved from the PRC directory based on the hash.
5. The signature is embedded into a PKCS#7 package, containing the user certificate, and sent to the service provider.
6. After successful signature verification, the user can access the protected WEB service

2.5.3 Evaluation

Currently, there are no public services for mobile FINEIDs. The architecture of current MSS systems is complex because of required SMS communication with the PKI SIM. An agreement between the service provider and the mobile operator is required for implementation services for mobile certificates. The technical specifications of operator specific PKI SIMs are confidential. Application and service development is thus mostly operator dependent.

Figure 2. Mobile signature and authentication service based on local PKI SIM access using OTA over Bluetooth

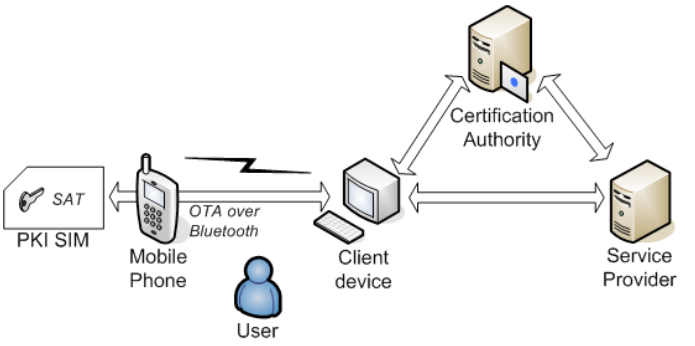
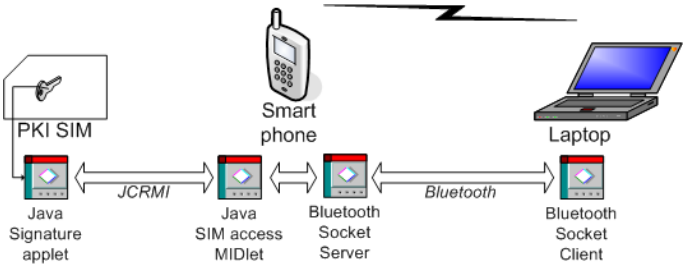


Figure 3. Bluetooth based Local PKI SIM access using the JCRMI protocol



2.6 Local PKI SIM Access

The purpose of research in Arcada Polytechnic is to develop a convenient and secure PKI SIM based signature and authentication service based on local PKI SIM access. A PKI SIM and mobile phone would then be equivalent to a smartcard in a smartcard reader. The user's client device would have PKI client functionality and the service would be operator independent. Two local PKI SIM access approaches are explored.

2.6.1 Approach for Current PKI SIM Cards

An approach is based on a proposal in (Mäkinen et al., 2001). An application residing on the user's client device (e.g. notebook computer) accesses the PKI SIM over an OTA connection using a short-link such as Bluetooth as data bearer, see Figure 2.

2.6.2 Prototype PKI SIM Supporting Access from a Java MIDlet.

A prototype PKI SIM supporting local access to PKI functionality from a smart phone application is proposed, see Figure 3.

An applet in a Java PKI SIM provides a method for signing with the private key. This method can be called remotely from a Java MIDlet installed in the smart phone using the Java Card Remote Method Invocation (JCRMI) protocol (JSR 177 Expert Group, 2004). This proposal supports the use of both the smart phone as well as a PC as a client device. When a PC is used as client device, authentication and signature data are transmitted between the smart phone and the PC over a Bluetooth channel.

3. HASH CHAIN GENERATED SECURITY TOKENS

Current network security standards propose X.509 certified PKI tokens for authentication and authorization services. However, security services based on such tokens are computationally heavy and require reliable real-time connectivity to updated Certificate Revocation Lists (CRLs). More lightweight security tokens are therefore needed by mobile network nodes and mobile agents, which usually

have limited computational and power capabilities. Lightweight tokens can be generated with one-way functions, for example as hash chains with Lamport's one-time password protocol (Lamport, 1981). Hash chain security depends on the used hash functions. Collision attack resistant hash functions are SHA-256, SHA-384, and SHA-512 with message digests of 256, 384, and 512 bits respectively (Stallings, 2006, p. 353).

3.1 Secure Mobile IP Registration

The Mobile IP registration protocol (Perkins, 2002) is in (Choi et al., 2004) protected from replay and man-in-the-middle attacks by Certificate Authority (CA) certified one-time public key authentication. The Mobile Node (MN) is authenticated by the Foreign Agent (FA) of the visited network and the FA by the Home Agent (HA) in the home network of MN. One-time public keys for MN and for each FA are generated with a one-way function from nonces chosen by HA combined with shared secrets between {MN, HA} and {each FA, CA}. The CA issues certificates for these public keys. From the CA, FA receives the public MN key certificate and HA the public FA key certificate. HA chooses and sends to the CA a new nonce during this message exchange. Both public keys and their corresponding certificates are updated by the CA after each iteration. A one-time public key (K_p) is in (Choi et al., 2004) calculated by

$$K_p = f^t(h(K_s, N_{HA})) \quad (1)$$

where K_p is the public key, K_s is a shared secret between {MN, HA} or {a FA, CA), N_{HA} is a nonce chosen by HA, h is a public hash function, and $f^t(x)$ means t successive applications of a public one-way function f to x, for example $f^5(x) = f(f(f(f(f(x)))))$.

The owner of a shared secret K_s (MN and each FA) publishes for authentication purposes a random i and $w_i = f^t(h(K_s, N_{HA}))$, where $0<i<t$. The owner is authenticated if

$$K_p = f^{t-i}(w_i) \quad (2)$$

where K_p is the corresponding public key (Choi et al., 2004).

3.2 Authorization Tokens for Mobile Agents

Authorization tokens implemented by hash chain values are proposed in a methodology called CADAT (Chained and Delegable Authorization Tokens) for mobile agent applications. Access rights are defined by issued *authorization certificates* and published hash chain values. An *authorization authority,* a controller of a set of n permissions, generates from a initial seed message m a hash chain of length n $\{h^0(m), h^1(m), h^2(m), \ldots, h^n(m)\}$, where h is a hash function, $h^0(m) = m$, and $h^i(m) = h(h^{i-1}(m))$ for $i = 1,2,\ldots,n$. Each hash value represents a permission. The authorization authority and users are assumed to have {public, private} key pairs and are represented by their public keys. An authorization authority issues a *chain contract certificate* to user A, who controls a mobile agent. User A issues for the needs of the mobile agent a *token contract certificate* to a remote host. User A then publishes the tokens to grant permissions for the mobile agent to be installed on the remote host and to access resources or services on the remote host. A hash of the mobile agent code can be included in the initial seed message of the hash chain and used to authenticate the mobile agent on the foreign host platform. The mobile agent requires no cryptographic operations to access remote host platform resources. A significant advantage of CADAT is, that mobile agents must not carry sensitive information such as cryptographic keys or even access tokens. (Navarro et al, 2004)

4. SIGNATURE SERVERS FOR MOBILE DEVICES

A signature server is often necessary for digital signing with a mobile device with limited computational and power capabilities. Two signature server solutions have been proposed, Personal Signature Server (PSS) and Public Signature Server. A PSS must require strong user authentication before a signature is created and the user of a Public Signature Server must be unambiguously identified in digital signature verification.

4.1 PSS

In (Campbell, 2003) is described a PSS installed on the personal workstation of a user. The private signing key is stored and used in a USB connected computer chip. The PSS is contacted using the HTTPS protocol. The PSS authenticates the user and sends a Java applet to the remote device. With the applet the user

- selects the document to be signed
- computes a hash of the document
- sends the hash to the PSS.

The PSS asks the user to validate the signature request with an encrypted message containing a unique token and a fingerprint of the document to be signed. After reception of a reply message with confirmed validation, the PSS creates the digital signature, stores a copy of it, and returns it to the remote device. Signatures are verified by a separate applet, which doesn't need the PSS if the public signing key is available. Revoking an existing signature key pair and generation of a new signing key pair is done at the console of the workstation with the PSS. The PSS keeps track of signed documents, stores and makes available older public keys for signature verification purposes. PSS vulnerabilities are evaluated in (Campbell, 2003).

4.2 Public Signature Server

A non-repudiation technique, called Server-Supported Signatures or S^3, based on one-way hash functions and traditional RSA digital signatures, is introduced in (Asokan et al., 1997). If h is a hash function, then a hash chain of length $n>0$ is expressed as n successive applications of h to x, $h^n(x)$, for example $h^5(x) = h(h(h(h(h(x)))))$. A hash function is "personalized" by including a user identity in x. Then h(x) actually means h(ID_user,x). If $x = K_s$ is chosen to be a private user key, then $h^n(K_s)$ is the public key. If a hash value $h^i(K_s)$, $0<i<n$, is published when a signature is created, then the signer can be identified by checking that a hash chain of the published value gives the public key. Thus n represents the maximum number of signatures, which can be created with a hash chain.

A CA is needed to define unambiguously which Signature Server (S) creates a S^3 signature. S and CA create own private/public key pairs. A user of an S must send his/her user_ID, public key K_p, maximum number of signatures n, and the address of S to the CA, which creates a public signed certificate for the delivered information. A server-aided PKI infrastructure service (SaPKI) to create S^3 signatures for mobile clients in GSM and UMTS networks has been used in a "cell phone banking" application. (Cai et al., 2005).

The Public Signature Server in (Lei et al., 2004), using RSA key pairs with an exponent e=3, creates/verifies signatures more efficiently than the S^3 technique in (Asokan et al., 1997).

The security of creating/verifying signatures is thus based on

- uncompromised private keys
- the use of secure hash functions like SHA-256
- sufficient RSA key lengths.

5. MOBILE SECURITY SOLUTIONS BASED ON IDPKC

In Identity based Public Key Cryptography (IdPKC) any string representing a user or device identity can be used as a public key from which a private key can be derived with a secret master key. Thus public key use requires no certification by a trusted third party and no CRLs are needed. Security services based on IdPKC rather than on X.509 certified PKI are therefore suitable for mobile devices with limited computational and power capabilities – especially since efficient IdPKC based encryption/decryption algorithms exist (Hwu et al., 2006).

5.1 IdPKC Basics

IdPKC was first introduced in (Shamir, 1984). The basic IdPKC operation is *pairing* e(P,Q), which is defined for a pair of discrete points, P,Q, on an elliptic curve. Elliptic Curve Cryptography (ECC) is described in detail for example in (Menenez, 1994). This pairing operation is proved to be *bilinear* with respect to discrete point addition:

$$e(P1+P2,Q) = e(P1,Q)*e(P2,Q), e(P,Q1+Q2) = e(P,Q1)*e(P,Q2) \quad (3)$$

Thus $e(2*P,Q) = e(P,Q)^2 = e(P,2*Q)$ and $e(a*P,b*Q) = e(b*P,a*Q) = e(P,Q)^{a*b}$. Two types of pairing operations, Weil Pairing and Tate Pairing, exist (Maas, 2004).

The first IdPKC scheme with satisfactory security is proposed in (Boneh and Franklin, 2002), Encryption/decryption operations are Weil Pairing based. The security level of these operations is the same as for ECC based encryption/decryption operations.

$Q_{ID} = s*H_1(ID)$ is the public key of a user or a network node and the corresponding private key is $d_{ID} = s*Q_{ID}$, where

- ID is a public identity string, for example a mobile phone number or a Network Access Identifier (NAI) with the format username@domainname or devicename@domainname
- H_1 is a hash function converting an ID to a discrete point Q_{ID} on a chosen elliptic curve.
- s is a secret master key, randomly chosen by a trusted third party called *Private Key Generator (PKG)*, which securely distributes d_{ID} to a user or to a network node.

IdPKC based encryption/decryption and signing/signature verification algorithms are described in detail for example in (Lee et. al., 2003). IdPKC security is evaluated in (Maas, 2004).

5.2 IdPKC Based Mobile Security Solutions

In (Lee et. al., 2003) is proposed a secure version of the Mobile IP registration protocol in (Perkins, 2002). An AAA server authenticates the MN and the MN authenticates the HA by signature verification. In (Hwu et al., 2006) Weil Pairing algorithms presented in (Boneh and Franklin, 2001) are tuned for some elliptic curves over the binary fields $GF(2^{163})$, $GF(2^{233})$, and $GF(2^{409})$. The evaluated performance improvement is about 30%. An IdPKC scheme based on the tuned algorithms is proposed for protected end-to-end data communication between mobile smart phone users.

A test environment for mobile security solutions using IdPKC and standard AAA protocols has been built in Arcada Polytechnic, see Figure 4. Solutions proposed in (Lee et al., 2003; Hwu et al. 2006) will be implemented, tested and evaluated for existing open source and commercial Mobile IP software. The security protocols in these solutions will also be formally verified.

6. CONCLUSIONS

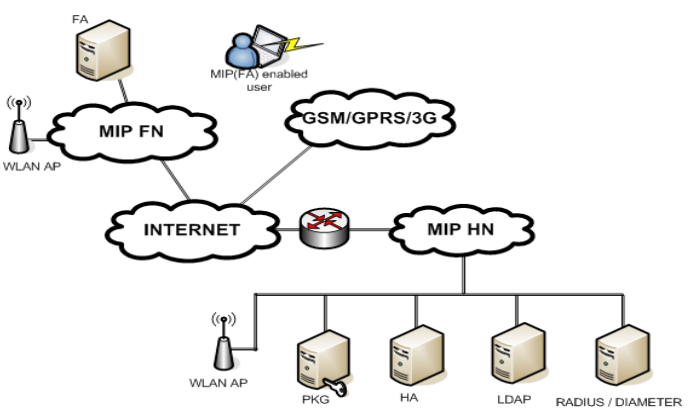
The SIM/USIM/PKI SIM cards in mobile devices in GSM/UMTS networks constitute a key technology for authentication services and digital signing in mobile networking. Other current security technology trends for mobile networking are

- the use of hash chains and IdPKC as lightweight alternatives to X.509 certification based PKI technology
- the use of signature servers for digital signing with mobile devices.

An essential mobile security service is secure Mobile IP registration for which still not standardized solutions based on SIM cards, on hash chains and on IdPKC are proposed.

More research on security requirements of mobile networking is needed, since current standardization of security solutions for mobile networking is quite insufficient for the needs of present and future mobile applications and services.

Figure 4. Test environment for Mobile IPv4 Software supporting IdPKC and an AAA protocol



REFERENCES

3GPP (2004). Specification of the SIM Application Toolkit for the Subscriber Identity Module – Mobile Equipment. Retrieved January 5th, 2007, from http://www.3gpp.org

Asokan, N, Tsudik, G and Waidner, M. (1997). Server-supported signatures. *Journal of Computer Security.* Vol. 5, Issue 1, pp. 91-108.

Badra, M. and Urien P. (2004). *Toward SSL Integration in SIM SmartCards.* Wireless Communications and Networking Conference WCNC. Vol. 2, pp. 889 – 893

Boneh, D. and Franklin, M. (2001). *Identity-Based Encryption form the Weil Pairing.* Lecture Notes of Computer Science vol. 2139, Springer-Verlag, pp. 213-229.

Cai, L., Yang, X., and Chen, C. (2005). *Design and Implementation of a Server-aided PKI Service (SaPKI).* Proc. 19th International Conference on Advanced Information Networking and Applications, AINA 2005. Vol. 1, pp 859-864

Campbell, S. (2003). *Supporting Digital Signatures in Mobile Environments.* Proc. Twelfth IEEE International Workshops on Enabling Technologies: Infrastructure for Collaborative Enterprises WET ICE. pp. 238 - 242

Choi, D.H., Kim, H., and Jung, K (2004). *A secure mobile IP authentication based on identification protocol.* Proc. 2004 International Symposium on Intelligent Signal Processing and Communication Systems ISPACS. pp. 709–712.

ETSI Publications Download Area (2007). Retrieved January 8th, 2007, from http://pda.etsi.org/pda/queryform.asp

FiCom. (2005). FiCom RY:n soveltamisohje ETSI:n MSS-standardeille V1.1. Retrieved June 8th, 2006, from http://www.ficom.fi

Glass, S., Hiller, T., Jacobs, S., & Perkins, C. (2000). *Mobile IP Authentication, Authorization, and Accounting Requirements*. IETF, RFC 2977.

Haverinen, H. (2001). *GSM SIM Authentication and Key Generation for Mobile IP*. IETF draft. Retrieved June 9th, 2006, from http://www.iptel.org/ietf/security/draft-haverinen-mobileip-gsmsim-02.txt

Haverinen, H., Asokan, N., and Määttänen, T. (2001). *Authentication and Key Generation for Mobile IP Using Gsm Authentication and Roaming.* Proc. IEEE International Conference on Communications ICC. Vol. 8, pp. 2453-2457.

Hwu, J.-S., Chen, R.-J. & Lin, Y.-B. (2006). *An Efficient Identity-based Cryptosystem for End-to-end Mobile Security*. IEEE Transactions on Wireless Communication, Vol. 5, No. 9, pp. 2586-2593

ISO/IEC 7816-4:2005 Part 4. Retrieved June 9th, 2006, from http://www.iso.org

Kambourakis, G., Rouskas, A., Kormentzas, G., and Gritzalis, S. (2004). Advanced SSL/TLS-baseds authentication for secure WLAN-3G internetworking. *IEE Proc.-Commun.,* Vol. 151, No 3, pp. 501-506

Lamport, L. (1981). *Password Authentication with Insecure Communication.* Comm. ACM, Vol. 24, No. 11, pp. 770-772.

Lee, B.-G., Doo-Ho Choi, D.-H., Kim, H.-G., Sohn, S.-W. Park, K.-H. (2003). *Mobile IP and WLAN with AAA authentication protocol using identity-based cryptography*, 10th International Conference on Telecommunications ICT, Vol. 1, pp. 597 - 603

Lei, Y., Chen, D., and Jiang, Z. (2004). *Generating Digital Signatures on Mobile Devices.* Proc. 18th International Conference on Advanced Information Networking and Applications AINA. Vol. 2, pp. 532-535.

Maas, M. (2004). *Pairing-Based Cryptography*. MSc Thesis, Technische Universitet Eindhoven, The Netherlands.

Menenez, A.J. (1994). *Elliptic Curve Public Key Cryptosystems.* USA: Kluwer Academic Publisers. ISBN: 0-792-39368-6

Mäkinen, S., Bessler, F., Wiedmer, E., Kehr, R., Schmidt, R., Bonnet, J., Lobo, C., Vieira, F., Brady, M. (2001). Towards Secured Service Access. Retrieved June 9th, 2006, from http//www.eurescom.de

Navarro, G, Garcia, J., and Ortega-Ruiz, J.A. (2004). *Chained and Delegable Authorization Tokens.* Proc. Ninth Nordic Workshop on Secure IT System – Encouraging Co-operation, NORDSEC2004, Espoo, Finland, pp. 8-14.

JSR 177 Expert Group. (2004). Security and Trust Services API (SATSA) for Java™ 2 Platform, Micro Edition, Specification: JSR-177 Version 1.0 (Final Release). Retrieved June 10th, 2006, from http://www.jcp.org/en/jsr/detail?id=177

Perkins, C. (2002). *IP Mobility Support for IPv4*, IETF, RFC 3344.

Schuba, M., Gerstenberger, V., and Lahaije, P. (2004). *Internet ID – Flexible Re-use of Mobile Phone Authentication Security for Service Access.* Proc. Ninth Nordic Workshop on Secure IT System – Encouraging Co-operation, NORDSEC2004, Espoo, Finland, pp. 58-64.

Shamir, A. (1984). *Identity-based cryptosystems and signature schemes*. Lecture Notes in Computer Science vol. 196, Springer-Verlag, pp. 47-53

SmartTrust Case Studies. (2006). Case study: Elisa. Retrieved January 8th, 2007, from http://www.smarttrust.com/mobile_solutions/mobile_solutions_case_elisa.asp

SmartTrust White Papers. (2006). SmartTtrust WIB™ Plug-ins Specification. Retrieved January 8th, 2007, from http://www.smarttrust.com/mobile_solutions/mobile_solutions_wp_wib.asp

Stallings, W. (2006). *Cryptography and Network Security.* Fourth Edition. USA: Pearson Prentice Hall. ISBN 0-13-187316-4

Variability in Business Process Families

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ABSTRACT

Variability proved to be a central concept in different domains, manufacturing, software development etc. in order to develop solutions that can be easily adapted to different organisational settings and different sets of customers at a low price. We argue that families of business process models can facilitate the installation of situated models in different organisations. We propose a representation system called MAP to capture variability in process models expressed in an intentional manner through business goals and strategies. The paper presents MAP and illustrates its use in an excerpt of a real case in the Electricity Supply Industry.

1. INTRODUCTION

Variability as a concept has proved to be useful in various engineering domains in which companies are not anymore faced to the development of a single product but to engineering product lines and families. The former represent the evolution of a given product, for example, a DVD player, whereas the latter integrates different product lines having commonality, such as DVD and MP3 player lines. Variability has been introduced to explicitly differentiate between the common and different parts in a set of similar but different product lines of a product family. Managing commonalities and variability leads to two major advantages:

a. reuse of common parts (Ommering, 2002; Tomphson, 2001) and,
b. adaptation of products to different customers and various organisational settings (Svahnberg, 2001).

Seeing the duality that exists between products and processes, our position is that business process families do exist today in companies and could beneficially be handled by introducing the concept of variability. Indeed, since the process wave initiated by Hammer and Champy (Hammer, 1994), large portfolios of business process models have been created and continue to develop as business process models are recognised as indispensable artefacts to driving business management and evolution. Besides, these portfolios evolve due to internal factors leading to business process evolution and/or external factors or mergers and acquisitions where different processes, perhaps having common parts, have to be integrated. Further, business process change is not just the replacement of one process by another. Rather process change management involves the reuse of parts of the process to be discarded, inclusion of parts of other processes, co-existence of different versions of the same process etc. As a matter of fact, one can recognize business process lines and families in current organizations today.

The foregoing suggests a move away from management of individual process to managing a set of similar processes considered as a whole, a family. Our proposal is to organize business processes as business process families and to manage variability and commonalities within the family in order to promote reuse and adaptability of business process models. We understand a business process family to be a collection of processes meeting a common goal but in different ways. For example, the goal 'admit students' can be achieved through a business process family comprising three processes that select students on the basis of a national entrance examination, a university test, or school performance respectively. The variability across the three processes is obvious. However, there is a commonality between these three processes as well: all these processes have to accept fees from the admitted student.

In this paper, we propose a modeling formalism called MAP to capture variability across business processes of a family in an intentional manner. The map is a directed, labeled, non-deterministic graph with goals as nodes, and strategies to achieve goals, as edges. Its nature allows the capture of different forms of variability through multi-edges between a pair of nodes thereby enabling many different traversals of the graph from beginning to end. Besides, using the refinement mechanism of the map, it is possible to represent variability at different levels of detail, in a hierarchy of maps. We show that this hierarchical nature permits us to represent process families as maps. We also show the power of a map to represent variability and, as an illustration, model the variations of an electricity supply process family as a hierarchy of maps.

The paper is organized in three sections. The next section introduces the MAP formalism and shows how it captures business feature variability. Section 3 presents an example and section 4 considers the adaptation of a business process model within a family.

2. CAPTURING BUSINESS VARIABILITY IN MAPS

We use the MAP formalism (Rolland, 2000) to capture variability of business processes modelled in an intentional manner.

2.1 Business Intentionality in Maps

A map is a process model expressed in a goal driven perspective. Map provides a process representation system based on a non-deterministic ordering of goals and strategies. A map is represented as a labeled directed graph (see an example in Fig. 6) with goals as nodes and strategies as edges between goals. The directed nature of the graph shows which goals can follow which one.

A *Goal* can be achieved by the performance of a process. Each map has two special goals, *Start* and *Stop* to start and end the process respectively.

A *Strategy* is an approach, a manner to achieve a goal. A strategy S_{ij} between the couple of goals G_i and G_j represents the way G_j can be achieved once G_i has been satisfied.

A *Section* is a triplet $<G_i, G_j, S_{ij}>$ and represents a way to achieve the target goal G_j from the source goal G_i following the strategy S_{ij}. Each section of the map captures the situation needed to achieve a goal and a specific manner in which the process associated with the target goal can be performed.

A section in a map can be *refined* as a map (see Fig.7). This leads to intentional process modeling as a hierarchy of maps.

As process models, maps can be compared to the various types of process modelling languages and formalisms that have emerged supporting a variety of purposes. The existing formalisms can be roughly classified according to their orientation to activity-sequence oriented languages (e.g., UML Activity Diagram), agent-oriented languages (e.g., Role-Activity Diagram (Ould, 1995)), state-based languages (e.g. UML state charts), an intention-oriented languages (e.g. Maps). The concept of goal is central in business process modelling and design. It is included in many definitions of business processes (e.g. "a business process is a set of partially ordered activities aimed at reaching a goal" (Hammer, 1994). However, most process modelling languages do not employ a goal construct as an integral part of the model. This is sometimes justified by viewing these models

as an "internal" view of a process, focusing on *how* the process is performed and externalising *what* the process is intended to accomplish in the goal (Dietz, 2004). In contrast, intention-oriented process modelling focuses on what the process is intended to achieve, thus providing the rationale of the process, i.e. *why* the process is performed. Intention-oriented process modelling such as MAP, follows the human intention of achieving a goal as a force, which drives the process. As a consequence, goals to be accomplished are explicitly represented in the process model together with the alternative ways for achieving them, thus facilitating the selection of the appropriate alternative for achieving the goal.

2.2 Modeling Business Variability in Maps

For the sake of conciseness, we use a textual notation in which goals are named by letters of the alphabet, strategies are numbers and therefore, a section named ab_i designates a way to achieve a target goal *b* from a source one *a* following a strategy *i*. Thus, the section <G_i, G_j, S_{ij}> is named ab_1 where *a* is the code of the goal G_i, *b* is the code of the goal G_j and *1* is the code of the strategy S_{ij} (see Fig. 1).

We advocate that sections are at the right abstraction level to capture business variability. We consider a section as an important process characteristic that business agents (managers, decision makers, actors…) want the business to provide and also an abstraction of a business flow. By analogy with software variability, a section can be related to the notion of a feature In FODA (Kang, 1990) for example, a feature is defined as *"A prominent or distinctive user-visible aspect, quality or characteristic of a software system or systems"*. In (Bosch, 2001), a feature is *"a logical unit of behavior that is specified by a set of functional and quality requirements"*. The point of view taken in this paper is that a *business feature* is a representation of a visible process characteristic and an abstraction of a cohesive business flow of activities expressed in an intentional manner.

Features represented in a map are related to each others by four kinds of relationships namely *multi-thread*, *bundle*, *path* and *multi-path* relationships. The relationships show the possible combination of features from which a business agent can select the appropriate ones according to the situation at hand. Let us now see how these relationships are used to express variability in business models.

The multi-thread relationship: when there are various ways to achieve the same goal starting from a source, features are related by a multi-thread relationship.

A multi-thread relationship is represented in a map by several strategies between a pair of goals as represented in Fig. 2. It shows through the strategies the different flows of activities provided to obtain the same result.

A multi-thread relationship expresses business feature variability by grouping optional features from which one or many features can be selected.

The Bundle relationship: In the case where the several ways to satisfy the same goal are exclusive, we relate them with a bundle relationship. It implies that only one way can be selected to achieve the target goal. Fig. 3 shows an example of a bundle relationship.

Figure 1. A section

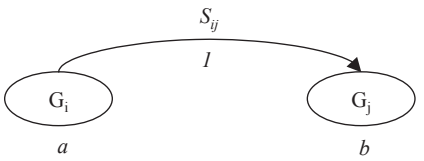


Figure 2. A multi-thread relationship

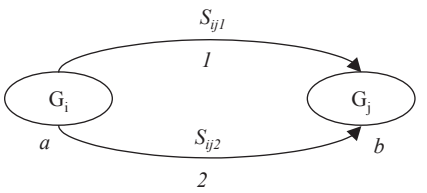


Figure 3. A bundle relationship

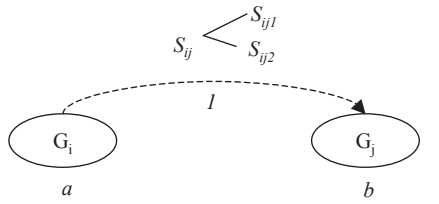
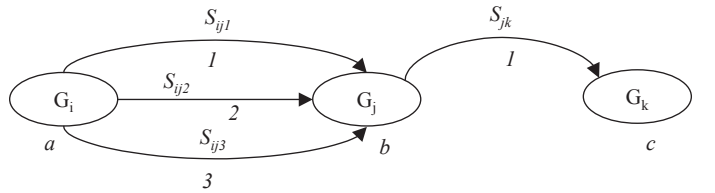


Figure 4. A path relationship



The bundle relationship expresses feature variability by grouping alternative features that are mutually exclusive.

The Path relationship: when the achievement of a target goal *b* from a source goal *a* requires the satisfaction of intermediary goals, we introduce a path relationship. It establishes a precedence/succession relationship between features expressing that in order to trigger a business flow, some other business flow must be executed first. In general, a path relationship is a composition of features, features related by multi-thread or bundle relationships or other paths. Some paths can be iterative.

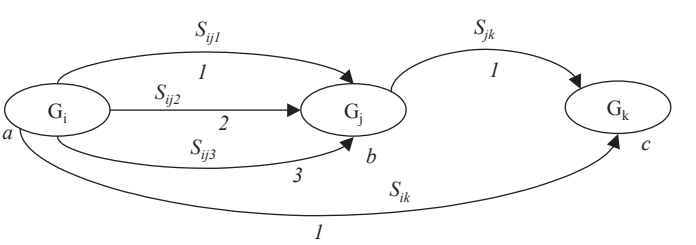
Fig. 4 represents a path relationship between the goals G_i and G_k, denoted respectively by a and c, which is composed of the multi-thread relationship containing the features ab_1, ab_2, ab_3 and the feature denoted bc_1. It expresses that in order to achieve the goal G_k, we must first select and execute one or many features among ab_1, ab_2 or ab_3 and then execute the feature bc1.

Multi-path relationship: given the multi-thread, bundle and path relationships, a goal can be achieved by several combinations of strategies. This is represented in the map by a pair of goals connected by several sections. Such a relationship is called a multi-path relationship. For example, we show in Fig. two alternative paths to satisfying the goal G_k (denoted *c*) starting from the goal G_i (denoted *a*). The first path achieves G_k through the intermediary goal G_j whereas the second path achieves G_k directly from G_i.

A multi-path relationship identifies the several combinations of business flows (represented by paths of sections) that can be executed to satisfy the same goal.

Thus, *a multi-path relationship is a means to express business feature variability by grouping the alternative paths satisfying the same goal.*

Figure 5. A multi-path relationship



In general, a map from its *Start* to its *Stop* goals represents all possible combinations of features expressed by multi-thread, multi-path and bundle relationships. Each particular combination of features is a path, from the *Start* goal to the *Stop* one, that describes a way to reach the final goal *Stop*.

2.3 Generating Variants Embedded in a Map

We notice that the bundle and multi-thread relationships are easily visible in the map. However, it is more difficult to identify all the combinations of features in a map (based on multi-path and path relationships). We propose to apply MacNaughton and Yamada's algorithm (MacNaughton, 1960) in order to discover systematically all the paths embedded in a map. The algorithm is based on the two following formula:

Let s and t be the source and target goals, Q the set of intermediary goals including *s* and *t* and *P* the set of intermediate goals excluding *s* and *t*.

The initial formula $Y_{s,\,Q,\,t}$ used to discover the set of all possible paths using the three operators that are the union (" "), the composition operator (".") and the iteration operator ("*") is :

$$Y_{s,\,Q,\,t}=(X_{s,\,Q\setminus\{s\},\,s})^*.\ X_{s,\,Q\setminus\{s,t\},\,t}.\ X^*_{t,\,Q\setminus\{s,t\},\,t}$$

And given a particular goal q of P, the formula $X_{s,P,t}$ applied to discover the set of possible paths is :

$$X_{s,P,t}=X_{s,\,P\setminus\{q\},\,t}\quad X_{s,\,P\setminus\{q\},\,q}.\ (X_{q,\,P\setminus\{q\},\,q})^*.\ X_{q,\,P\setminus\{q\},\,t}$$

In this paper we specialize the $X_{s,P,t}$ into paths, multi-paths, multi-threads and bundle relationships that we note as follows :

Multi-thread relationship between two goals k and l is denoted: $MT_{kl}=\{kl_1\ \ kl_2\ \ ...kl_n\}$ where the kl_i are the features related by the multi-thread relationship. Thus, the multi-thread represented in Fig. 2 is: $MT_{ab}=\{ab_1\ \ ab_2\}$.

Bundle relationship between two goals k and l is denoted:$B_{kl}=\{kl_1 \otimes kl_2 \otimes ...kl_n\}$ where the kl_i are the exclusive features related by the bundle relationship. In Fig. 3, the bundle relationship is: $B_{ab}=\{ab_1 \otimes ab_2\}$.

Path relationship between two goals k and l is denoted $P_{k,Q,l}$ where *Q* designates the set of intermediary goals used to achieve the target goal *l* from the source goal *k*. A path relationship is based on the sequential composition operator "**.**" between features and relationships of any kind. As an example, the path relationship of Fig. 4 is denoted: $P_{a,\{b\},c}=MT_{ab}.\ bc_1$.

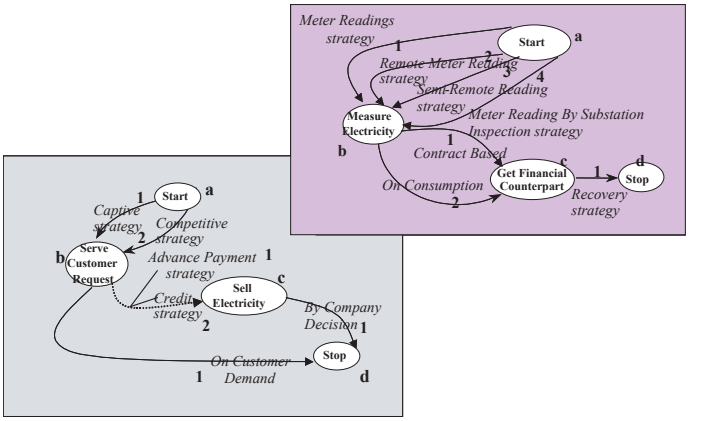
Multi-path relationship between two goals k and l is denoted $MP_{k,Q,l}$ where *Q* designates the set of intermediary goals used to achieve the target goal *l* from the source one *k*. A Multi-path relationship is based on the union operator "$\cup$" between alternative paths. Thus, the multi-path of Fig. 5 is denoted: $MP_{a,\{b\},c}=P_{ac}\quad MT_{ab}.P_{bc}$

In section 3, we illustrate the variability approach with an excerpt of a real case example and show the application of the MacNaughton-Yamada's algorithm. However, due to paper length limit, we present only the results obtained after applying the algorithm.

It can be seen that the goal of the business process family is captured in a *hierarchy of maps*. The goal associated to the root map is the high level statement about the purpose of the family. Using the refinement mechanism each section of the root map can be refined as a map and the recursive application of this mechanism results in a map hierarchy. At successive levels of the hierarchy the goal stated initially as the goal of the root map is further refined. At any given level of the hierarchy, a map describes the business process family as a set of business features and feature variability through four types of feature relationships, namely *multi-path, path, thread* and *bundle* relationships. Multi-thread and bundle introduce local variability in the sense that they allow to represent the different ways for achieving a goal directly. Path and multi-path introduce global variability by representing different combinations of business features to achieve a given map goal. Any path from Start to Stop represents one way of achieving the map goal, therefore the purpose represented in this map.

Figure 6. The ESM map sample

Figure 7 shows a refined view of the section bc_2 of this map itself expressed as a map



3. AN EXAMPLE

To illustrate our approach, we consider a business example from the ESI (Electricity Supply Industry) sector. The example is simplified to meet the paper size requirement but extracted from a real three-years project involving three large European Electricity companies and our research group (Grosz, 1998). The map of Fig. 6 provides the top level intentional view of the electricity supply business family to support Electricity Supply Management (ESM).

The map shown in Fig. 6 is organized around two key goals, "Serve Customer Request" and "Sell Electricity" that represent generic goals in the sense that they exist in any electricity distribution process. Furthermore, the map indicates an ordering constraint: in order to sell electricity to a customer, his/her request for electricity provision has to be fulfilled first.

In the ESM map, it shall be noticed that there are two different strategies to achieve each of these two goals. For example, the "Advance Payment strategy", and the "Credit strategy", are two alternative strategies to achieve the business goal "Sell Electricity". These map strategies identify two rather different business strategies to get the customer to pay for his electricity consumption. Indeed the "Advance Payment strategy" refers to a solution based on the use of payment cards to energise the customer meter whereas the "Credit strategy" refers to the more conventional solution where the electricity company provides electricity to its customer and gets paid after consumption.

Each section in the map represents a *feature* that the business process family can provide. Further, this example demonstrates the *feature variability* in the ESM family that is captured by the map. We distinguish two kinds of variability that are:

i. a variability in strategies provided to satisfy the same goal and,
ii. a variability in the combinations of strategies to fulfil the same goal.

The first kind (i) is expressed by the multi-thread or the bundle relationship. In our example, we depict a bundle relationship between the couple of goals "*Serve Customer Request*" and "*Sell Electricity*" respectively denoted *b* and *c* and composed of the two exclusive features *bc1* and *bc2* corresponding to the sections <*Serve Customer Request, Sell Electricity, Advance payment strategy*> and < *Serve Customer Request, Sell Electricity, Credit strategy* >. We also identify a multi-thread relationship composed of the features ab_1 and ab_2 corresponding to the sections <*Start, Serve Customer Request, Captive strategy*> and < *Start, Serve Customer Request, Competitive strategy* >.

The second kind (ii) is expressed by the multi-path relationship. It shows the different combinations of business flows that can be executed to satisfy the same goal. For example, given an electricity connection obtained after achieving the goal "*Serve Customer Request*", we can follow two alternative paths to stop the process. We can either respond to the customer demand applying the "*On customer request strategy*" or we can proceed with consumed electricity billing and payment

Table 1. List business features and their composition

Business features	$ab_1, ab_2, bc_1, bc_2, cd_1, bd_1$
Feature composition kind	Identified compositions
Path	$P_{a,\{b,c\},d} = MT_{ab}.\ MP_{b\{c\}d}$ $P_{b,\{c\},d} = B^*_{bc}.\ cd_1$
Multi-Path	$MP_{b\{c\}d} = bd_1 \cup P_{b,\{c\},d}$
Bundle	$B_{bc} = bc_1 \otimes bc_2$
Multi-thread	$MT_{ab} = ab_1 \vee ab_2$

through either the *"Advance payment strategy"* or the *"Credit strategy"* then stop *"By company decision"* if payment is not made after a given delay.

In order to identify all the combinations of features, we apply the MacNaughton-Yamada's algorithm introduced in Section 2. The initial formula generating all the paths between the goals *a* and *d* is: $Y_{a\{a,\ b,\ c,,\ d\},d} = (X_{a,\ \{b,c,d\},\ a})^*.\ X_{a,\{b,c\},d}.\ X^*_{d,\{b,c\},d}$. The identified paths (and therefore composition of features) are summarized in Table 1.

In the next section we will discuss how the map representation can help in customizing a business process to specific needs.

4. ADAPTING A BUSINESS PROCESS

Since a map captures a full range of features permitted in a family, the adaptation issue is of determining which features and which combination of features are relevant to the business process under design. There are two kinds to adaptation

- *Design time adaptation* permits a selection of a combination of features that results in only one path from Start to Stop.
- *Run time adaptation* allows to leave a large degree of variability in the adapted map and the desired features can then be selected dynamically at enactment time of the process.

It is possible for business people to perform this adaptation. This is because a knowledge of the business characteristics and an analysis based on these is enough to make the adaptation decision. To illustrate this aspect, we perform pay-off analysis on the map of Fig. 7. The features that form part of the adapted map are determined by an analysis of the benefits that accrue from features standing alone and in combination with other related features.

To adapt section bc_2 of the map of Fig. 6, one has to decide on how electricity should be measured and how the financial counterpart should be obtained. This leads to selecting the appropriate features and feature combinations of the map presented in Fig. 7. Each feature selection has however a payoff that can be analysed in the view of its combination to another one. The pay-off analysis for bc_2 features is summarized in the Table 2 below.

Let us consider the case where it is necessary to get financial counterparts both contract based and on consumption. The table shows that remote readings are a cost effective way to handle electricity measurement in both cases. Indeed, it is real time and therefore adapted to payment on consumption. Besides, the cost of installing remote readers can be included in the contract prices and recovered in the long term. However, the payoff table also says that remote reading, as it is automated, is not fully reliable and should be double-checked, e.g. by using substation inspection.

One possible adaptation of section bc_2 is then to keep the features ab_2 and ab_4 along with bc_1 and bc_2.

5. CONCLUSION

The notion of variability in business process families introduced here brings together a set of similar but different processes to facilitate reuse and adaptation. We use a goal driven formalism that is the MAP, to represent business process families as a set of business features and feature variability through four types of feature relationships. Once the process family has been expressed with maps, the task of building the adapted business process model to a given setting can be simply done by deciding which combinations of features are the most suited to the situation at hand. We think that expressing the variability with the map formalism is particularly useful at the adaptation phase. It exposes the business process leader to the choices that are relevant to the satisfaction of her goals in terms of the properties of the business and there is no need to deal with technical configuration details.

This paper has reported the current status of on-going work. Future work consists of (a) implementing a configuration tool to adapt a business process model of a family using the map formalism and (b) developing a software tool to support navigation in a map to select dynamically the feature most appropriate to the situation at hand.

6. REFERENCES

Bosch, J., Florijn, G., Greefhorst, D., Kuusela, J., Obbink, H. & Pohl, K. (2001). 'Variability issues in Software Product Lines'. *Proceedings of the 4th International Workshop on Product Family Engineering (PEE-4)*, Bilbao, Spain.

Dietz, J.L.G. (2004). 'Basic Notions Regarding Business Processes and Supporting Information Systems'. *Proceedings of BPMDS'04, CAISE'04 Workshops Proceedings, Latvia, Riga*, (pp.160-168).

Grosz, G., Loucopoulos, P., Rolland, C. & Nurcan, S. (1998). 'A Framework for Generic Patterns Dedicated to the Management of Change in the Electricity Supply Industry'. *Proceedings of the 9th International Conference and Workshop on Database and Expert Systems Applications, DEXA '98*.

Table 2. Pay-off summary

		Get financial counterpart	
		Contract based	**On consumption**
Measure electricity consumption	**Meter reading by meter reader**	Can be envisaged at sustainable cost if visits are achieved at a low frequency e.g. once or twice a year)	Excluded because too difficult to organise all visits at the required pace.
I.	**Remote reading**	Cost effective combination that can be done in real time. However, remote reading is not completely secure. A complementary check of electricity measurement is thus needed, e.g. by meter reader, or by substation inspection.	
II.	**Semi-remote reading**	Cost effectiveness is a linear function of the number of contracts per cluster of semi-remote reader.	Very costly if the number of customers paying on consumption, per cluster of remote reader is low.
III.	**Substation inspection**	Only possible if the connected meter readers relate to single contract. Otherwise, calls for individual reading.	Cost effective way to handle the verification of consumers invoiced by remote reading clustered on the same substation.

Hammer, M., & Champy, J. (1994). 'Reengineering the Corporation-A manifesto for Business Revolution', Harperbusiness, (pp. 233).

Kang, K., Cohen, S., Hess, J., Novak, W. & Peterson, A. (1990). 'Feature-Oriented Domain analysis (FODA) Feasibility Study'. *Technical report CMU/SEI-90-TR-21*, Pittsburgh, PA, Software Engineering Institute, Carnegie Mellon University.

MacNaugthon, R. & Yamada. (1960). 'Regular expressions and state graphs for automata'. *IEEE Transactions on Electronic Computers*, EC-9, (pp. 39-47).

Ommering, R.V. (2002). 'Building product populations with software components'. *Proceedings of the 24th International Conference on Software Engineering*, Orlando, Florida.

Ould, M.A. (1995). 'Business Processes: Modeling and Analysis for Reengineering and Improvement', *John Wiley & Sons*, may, (pp. 224).

Rolland, C. & Prakash, N. (2000). 'Bridging the gap between Organizational needs and ERP functionality'. *Requirements Engineering Journal*.

Svahnberg, M., Van Gurp, J., & Bosch, J. (2001). 'On the notion of variability in Software Product Lines'. *Proceedings of the Working IEEE/IFIP Conference on Software architecture*.

Thomphson, J., & Heimdalh, M.P. (2001). 'Extending the Product Family Approach to support n-Dimensional and Hierarchical Product Lines'. *Proceedings of the 5th IEEE Symposium on Requirements Engineering*, Toronto, Canada.

Geeks and Gods: ICT's Debt to the Arts

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ABSTRACT

With each new object and phenomena humankind discovers, develops or invents, a new set of words must be coined or adopted to describe them. Words are not neutral, carrying with them associations and connotations based on their previous applications and alliances, and augmented by their shapes, sounds, rhymes and rhythms. Many words which are now embedded in ICT's, retain and continue to be colored by these earlier meanings, some of which are drawn from myths. The method of vocabulary-building utilized by ICT's reflects its openness to new ideas and users.

Keywords: connotation, nomenclature, lexis, coining, portmanteau, neologism, phoneme. alliteration

INTRODUCTION

In *A short history of the Web* (1995), Robert Cailliau describes how he and Tim Berners-Lee attempted to coin a 'catching' name for the system that they and others had been developing. Cailliau is 'determined' that the name should not 'again be taken from Greek mythology' and when Berners-Lee suggests the term *World-Wide Web,* Cailliau admits to liking it 'very much', (with the proviso that it was 'difficult to pronounce in French'). Cailliau's anecdote illustrates many of the influences affecting the coining of names and terms by ICT practitioners.

NAMING CONVENTIONS

O'Grady, Dobrovolsky and Katamba suggest that '….human language must be creative – allowing novelty and innovation in response to new thoughts, experiences, and situations' (1996:1). As young men engaged in a new enterprise, and given the prevalence of Greek gods and goddesses (and their Roman equivalents) in the nomenclature of many existing (and less flexible) scientific disciplines, Cailliau's and Berners-Lee's reluctance to draw on classical Greek mythology is understandable. Cailliau and Berners-Lee also had the advantage, enjoyed by others working in ICT's, of functioning in an enterprise which was relatively unstructured and unconstrained by generations of practice. This is illustrated by comparing the development of ICT's lexis with the lexis of astronomy. For instance, an examination of the nomenclature of our solar system, reveals the Earth to be the only planet not named after either Roman or Greek gods/goddesses. The planet names of Venus, Mars, Mercury, Jupiter and Saturn were assigned by the citizens of ancient Greece and Rome for their perceived likenesses to the deities, the beautiful goddess Venus giving her name to the bright planet, and the god of war Mars, to the red planet and so on (Carter, 2002). Once this convention was established, the naming of celestial bodies discovered later (such as the planets Uranus and Neptune, and the [now] dwarf planet Pluto) was constrained by notions of consistency and enforced by bodies such as the International Astronomical Union (IAU) which continues to regulate the lexis assigned to significant new heavenly objects.

Thus, when James Christy discovered Pluto's moon in 1978 and wanted to name it after his wife Charlene, he was refused permission by the IAU. The closest he was able to come was by choosing *Charon*, the Greek mythological ferryman of the dead, whose name, when given an English pronunciation, is phonemically similar to the first syllable of his wife's name. Charon is also appropriate (in IAU terms) in that Charon served as ferryman to Pluto, the god of the Underworld. (Carter, 2002). Even objects identified and named more recently, such as Sedna - the most distant known object in the solar system (discovered in 2004) (Brown, undated) and Quaoar, a Kuiper Belt object found in 2002 (Trujillo,undated) retain the mythological theme, being named after gods from an Innuit and an indigenous north American culture respectively.

In contrast to astronomy, the absence in ICT's of organizations functioning in a similar way to the IAU has allowed ICT practitioners to immortalise themselves and/or their loved ones. Debian – a linux distribution, is a portmanteau of the names of its creator - Ian Murdock and his then girl friend, (now wife) (Debra). Likewise, awk – a computer pattern /action language, is an acronym of its developers' last names: Aho, Weinberger and Kernighan. (http://en.wikipedia.org/wiki/List_of_computer_term_etymologies) O'Grady et al. point out that some 'systematic constraints' are essential in language creation if meaning is to be maintained, noting that 'If well-established words were constantly being replaced by new creations, the vocabulary of English would be so unstable that communication could be jeopardised' (1996:3). While this is a consideration in a new discipline, as long as neologisms remain relatively small in number, they are no more difficult to assimilate by practitioners than other discipline-specific words – be they classed as meta-language or jargon. The randomness in the terminology of ICT's however, does have the potential to affect the understanding of users expecting consistency and coherence.

Despite Cailliau's and Berners-Lee's antipathy, the lure of the lexis of the Greek myth remains strong in ICT's, especially where the function of the task is reflected semantically in the name, such as in the operating systems of Oracle and Delphi. It was to the prescient Greek Oracle living in a cave in Delphi that the troubled turned for guidance, just as the operating systems are intended to smooth the path ahead. Similarly, a Trojan horse (a malicious program designed to look like legitimate software) effectively carries with it the original mythic notion of an unsuspected and deadly attack. Users must share this cultural knowledge in order to gain this depth of understanding.

There is a further dimension to this Greek mythic nomenclature. In discussing news media, Veronika Koller notes that, 'By favouring particular metaphors in discourse, journalists can reinforce, or even create, particular mental models in their readers' cognition' (2004:3). Ancient Greek and Roman civilizations have long served as metaphors for high learning in both the rational and creative arts in the West, and when lexis from these eras is assigned elsewhere, it carries this metaphorical dimension with it. In disciplines like astronomy, which has a long and venerable history, such metaphorical transference serves to reinforce its status, but in new disciplines, such as the ICT's, such transference has the potential to *build* status.

The comparatively unstructured environments that ICT software and hardware developers work in, gives them greater freedom to coin or adopt a lexis with a humorous or larrikin edge. The founders of Yahoo! took the name from Swift's *Gulliver's Travels* (1969:260) where it referred to a repulsive, barely human creature, and a quick scan of the Web's wikipedia reveals others: Google beginning as 'googol', a tongue-in-cheek boast about the quantity the search engine would be able to search (a googol is 1 followed by 100 zeros); Sosumi (so-sue-me) – a system sound in Apple Computer's System 7 operating system, dryly reflecting the company's long history of litigation with Apple Records, and the web browser Mozilla, being a portmanteau of Mosaic-Killer (it replaced the Mosaic browser) and Godzilla (a cinematic monster). Wikipedia even cites itself as being named for the 'wiki wiki' or fast shuttle buses at Honolulu Airport (http:en.wikipedia.org/org/wiki/List_of_computer_term_etymologies), and the fact that it's one of the few places where information on computer terminology origins is readily accessible, underscores the lack of focus by ICT's on naming conventions. In addition, it suggests a certain playfulness and lack of seriousness both by the coiners of names and their recorders.

A characteristic of many of these newly coined ICT terms is their catchiness, a quality which Cailliau was also keen to see in the nomenclature of the World-Wide Web.

LOVING THE LEXIS

What is catchiness? What makes one word or term more attractive, or lovable than another? Little analysis of the term World-Wide Web is necessary to identify its most salient feature of alliteration. Alliteration, in its simplest form the 'repetition of the same sounds – usually initial consonants of words or of stressed syllables – in any sequence of neighbouring words' (Baldick, 1991:5), is achieved in this term by the identical initial sounds or phonemes (graphically represented by 'w') in all three words, and by the identical final phonemes (represented by 'd') of the first two words. In addition, the phonemes represented by 'd' and 'b' in the final two words, are similar.

While alliteration aids pronunciation, so too does the consistent consonant-vowel order across all three words. Consider the alliterative qualities of 'frosts and fogs', a word combination liable to trick the tongue into saying 'frosts and frogs'. The repetition of the same sounds in words is easier to pronounce than changes in patterns, a preference illustrated by the coining of nonsensical reduplicatives such as easy-peasy and teeny-weeny.

The denotation and connotations of a word or term are also important. Denotations do not remain constant over time or space, 'queer' and 'gay' being contemporary examples of words which have enlarged their meanings to the point where earlier meanings have been largely subsumed. While the denotation of 'World-Wide' has remained constant, 'web' now links strongly (it could be argued *more* strongly with particular generations) to a computational *denotation*, rather than to its earlier meanings. The *connotations* of 'web', at the time of Berners-Lee's adoption of it, were charming and organic (spiders' webs, the webby feet of ducks), and may have contributed to the 'catching(ness)' Cailliau describes. As far as we know, Berners-Lee didn't engage in these analytical processes consciously, and its not possible to say whether he did so unconsciously, though the attractiveness of alliteration suggests it.

SOUNDS AND SEMANTICS

The sound of a word is important in deciding on its 'rightness' for the new phenomenon it seeks to describe. Onomatopoeic words mimic the phenomena they describe closely (chicks *cheep*; dogs *woof)* and non-onomatopoeic words can also carry a sound match which seems 'right'. Widget (an interface component) was a word adopted from the 1924 play, *Beggar on Horseback*, where it describes a mass-produced object (which was never identified) but which represented a 'purely mercantile commodity that has no artistic or spiritual value' [http://en.wikipedia.org/wiki/Widget_(computing)]. The second syllable represented by 'get', echoes the more common word 'gadget', and so carries with it the semantic connotations of that word. It is likely that widget is more generally known now as an ICT term than as the undefined but soulless object in the 1924 play, and the same might be true of portals, although portals carry with them a rich heritage.

THE POWER OF PORTALS

The idea of a gateway or portal to another world is common in myth and fantasy, and far older than the use of the same notion in ICT's. While ICT portals take researchers to other domains of data, the use of portals in myths is more complex. In creation myths, the passing of portals has immense consequences for humankind – as in Adam and Eve's expulsion from their carefree existence in the Garden of Eden (unleashing the world's woes upon their descendants), and in the carrying away of Persephone by Pluto into the Underworld (leaving a legacy of cold and sunless months each year). While in its most general sense a portal is just a gate (from the Latin *porta*) (Skeat, 1983:403), when heroes pass through literal or metaphorical portals in works of myth and fantasy, they enter strange and dangerous landscapes of physical and psychological testing, or as the mythologer Joseph Campbell describes it , the 'fateful region of both treasure and danger' (1993:58). Their journeys are very different to those of researchers who enter portals knowingly in search of information relevant to their purposes, for heroes are commonly unaware of the imperative that drives them, or of the profound (usually psychological) changes to come.

In *The Hobbit*, (Tolkien:1974) Bilbo's route to psychological growth takes the form of a quest (to win back the dwarves' gold from the dragon Smaug). When Bilbo sets off alone down the tunnel to the fearsome dragon Smaug, and hears the dragon snoring, he stops at first, frozen with fear, but then forces himself on. As the narrator (Tolkien) says: 'Going on from there was the bravest thing he ever did … He fought the real battle in that tunnel alone, before he ever saw the vast danger that lay in wait.' (1974:197). Bilbo's physical journey *down* into the earth, is metaphorically a journey *down* into the unconscious, where he struggles to overcome the limitations of self (legitimate fears for his own safety), and gains the wisdom and mental strength which he later uses to end the disastrous stand-off between the dwarves and Lake men. In Henderson's words: 'the essential function of the heroic myth is the development of the individual's ego-consciousness – his awareness of his own strengths and weaknesses – in a manner that will equip him for the arduous tasks with which life confronts him' (1978:101). While computing portals can't be described as dangerous, they continue the connotations of 'newness' and 'otherness' from their mythic origins, which in turn alert the ICT user to their function.

CONCLUSION

As ICT's continue to evolve, so too does the lexis. Web logs have become blogs, which in turn have coined blogging and blogsters, while using Google has resulted in googling, having googled or having been googled. Rules of engagement or netiquette (a portmanteau - net plus etiquette) have emerged, and perhaps soon even netiquettic googsters will accept Spamsters. Presently the nomenclature of ICT's is dominated by the West, but the emerging powers of India and China are likely to add to the language and cultural mix in the future, either through their official languages or through the portmanteaux of Hinglish and Chinglish.

REFERENCES

Baldick, C. (1991) *The concise Oxford dictionary of literary terms.* Oxford University Press: Oxford

Brown, M. (undated) *Sedna.* Available at http://www.gps.caltech.edu/~mbrown/sedna, accessed in September, 2006

Cailliau, R. (1995) *A short history of the web.* (speech presented at the launching of the European Consortium, Paris, 2 November 1995) available at http://www.netvalley.com/archives/mirrors/robert_cailliau_speech.htm, accessed in September, 2006

Campbell, J. (1993) *The hero with a thousand faces.* HarperCollins: London

Carter, L. (2002) *Curious about astronomy?* available at http://curious.astro.cornell.edu/question.php/number=372, accessed in September, 2006

Henderson, J. (1978) Ancient myths and modern man. In *Man and his symbols.* (pp.95 - 156). Ed. C. Jung. Pan Books: London

http://en.wikipedia.org/wiki/Widget_(computing)

Kaufman, G., Connelly, M. (1924) *Beggar on horseback*

Koller, V. (2004) *Metaphor and gender in business media discourse: a critical cognitive study.* Palgrave Macmillan: New York

O'Grady,W., Dobrovolsky, M., Katamba,F. (1997) *Contemporary linguistics: an introduction.* Longman: Harlow, U.K.

Skeat, W. (1983) *Concise etymological dictionary of the English language.* Oxford University Press: Oxford

Swift, J. (1969) *Gulliver's travels*. Random House: New York

Tolkien, J.R.R. (1974) *The hobbit.* Allen & Unwin: London

Trujillo, C. (undated) *Frequently asked questions about Quaoar.* Available at http://www.gps.caltech.edu/~chad/quaoar/ accessed in September, 2006

Wikipedia, the free encyclopedia Available at http//en.wikipedia.org/wiki accessed in September, 2006

TIM TAM: A Teaching Initiated Modification of the Technology Acceptance Model

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ABSTRACT

The Technology Acceptance Model (TAM) and its variants have proven to be a useful tool in explaining user uptake intentions. With the drive to use new eLearning environments, cost-benefit analyses have been given little attention with the consequent 'Has there been a commensurate improvement in learning?' question largely unanswered. Analysis of technology uptake issues relating to learners informs teachers and educational administrators of the most efficient use of new learning technologies. This paper proposes the need for an educational, context-sensitive variant of the TAM as a basis for grappling with the educational value question, whilst maintaining learning quality.

Keywords: Technology Acceptance Model, TAM, EduTAM, technology uptake, educational technology acceptance.

INTRODUCTION

Recent research undertaken within the Information Systems arena, has related to the modelling of technology uptake in the Technology Acceptance Model (TAM). TAM has shown promise in defining the underpinning behavioural reasons why users embrace new computer technology. Much of this research has culminated in the pulling together of TAM-related research within a seminal article presented in Information Systems' Management Information Systems Quarterly (MISQ): *"User Acceptance of Information Technology: Toward a Unified View"* (Venkatesh, Morris, Davis, & Davis, 2003). The purpose of this paper is to review the development of TAM-related research that culminated in the Venkatesh paper, to identify the key factors and issues most relevant in "porting" this research practice into ICT education technology research, and in particular, the factors important in the adoption of new eLearning programs.

NEW TECHNOLOGIES IN EDUCATION – THE NEED FOR COST BENEFIT?

During the past twenty to thirty years, there has been a development of technologies at the forefront of the communication revolution. These have centred on the development of sophisticated communication channels championed by the telephone, the PABX (Private Automatic Branch eXchange), the FAX (facsimile) and recently, the internet and mobile telephone (Yi-Shun, Hsin-Hui, & Pin, 2006). A communication revolution involving the merger of three global industries: the telephone, computer and entertainment industries (Sanayei & Sadeghi, 2004); (Crafts, 2005). A revolution manifested in sales pitches that focus on consumer experiences underpinned by access to content-rich information in a form that only broadband, multimedia can deliver ("Telstra - Product & Services: 3G Mobile Phones,").

Whilst similar cutting-edge technologies aren't widely used in education, educators have shown that they aren't backward in taking on-board new technologies. The advocates of automated teaching methods used enabling technologies such as teaching machines and early computers in innovative ways, but mainly as adjuncts to traditional "face-to-face" methods (Niemiec & Walberg, 1989). In all these cases, the mooted replacement of the traditional teacher didn't eventuate.

The communication revolution encompassing cheap, highly accessible, multimedia technologies has resurrected the idea of replacing the teacher, with "learning from home" (Jared, 2005); (van Schaik, Barker, & Moukadem, 2005). Much is now possible with these technologies with interaction, instant response, extensive research capacity and simulation, available to the teacher. These technologies are no longer content delivery vehicles, but increasingly a way of providing student-centred, self-paced, eLearning programs (Turker, Gorgun, & Conlan, 2006). Government and education administrations see the rapid rise in these eLearning programs as a way of cutting delivery costs (particularly labour costs) without decreasing quality. Consequently, education administrations are funding these types of programs (Solomon, 2005).

But with the increased expenditure, 'Has there been a commensurate improvement in learning?' A TAM analysis could be part of the attempt to answer this question.

Beastall suggests that current spending on these technologies hasn't seen the improvement in learning to the extent it might have (Beastall, 2006), with Harris and Weller advocating the need to evaluate these programs using cost benefit analyses (Harris, 2003);(Weller, 2004). Cost benefit analyses should have significant currency amongst local educational administrations who must ensure their scarce funds are being used to achieve the richer eLearning environments promised (Solomon, 2005). However, analyses able to determine the degree of success of eLearning programs are often not included within the cost benefit assessments educational administrations undertake. The subsequent scepticism this can generate will drive the need for the eLearning dollar to be stretched further. The extent of student acceptance of these programs is therefore fundamental to their ultimate success (Flynn, Concannon, & Bheachain, 2005).

Thus, research into the decisive factors involved in the uptake of eLearning technologies, will have significant value for education administrations in their eLearning investment decision-making (Ndubisi & Chukwunonso, 2004).

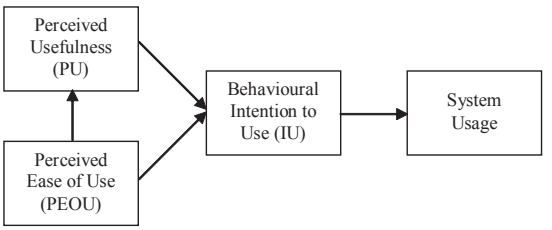
Much can be made of the experience the business world has had in technology uptake research issues. Perceptions of information technology have taken on new meaning in the business world where it's crucial the "right" choices be made to lead to the successful adoption of information technology and the monetary benefits such adoptions bring.

In ICT education, the success factors aren't as clearly defined in pure "dollar" terms, but technology uptake modelling is just as relevant (Chang, 2002). The benefits aren't immediately realized but are longer term and less tangible, leading to monetary and non-monetary benefits (Conlon, 2000). To this end, understanding the determining factors that drive a successful acceptance of an information technology education program should be an imperative. Deriving the factors thus becomes crucial to designing relevant educative programs (Ellis, 2001) for modern, apparently technologically literate students, who appears to have little time or patience in utilising courseware that they see as irrelevant.

TAM AND TAM-LIKE MODELS

In the information systems research field, the TAM (F. D. Davis, 1989) has been used to explain the key behavioural factors involved in the uptake of computer technology. This model was adapted from behavioural science's Theory of

Figure 1. Technology acceptance model



Source: (Money & Turner, 2004)

Reasoned Action (TRA) (Fishbein & Ajzen, 1975), with the underlying principal being that individuals adopt a specific behaviour if they perceive it leading to positive outcomes.

The TAM adaptation identifies Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) as the principal behavioural constructs influencing users' Intention to Use (IU) (F. D. Davis, 1989).

The model has had wide acceptance as a reasonable predictor of information technology uptake. Studies since, (Taylor & Todd, 1995); (Szajna, 1996); (Gefen & Straub, 1997) and (Doll, Hendrickson, & Deng, 1998), confirm it as a useful instrument for investigating and forecasting user information technology acceptance. Many of these studies support the moderate explanatory limitations of the two factors (PU and PEOU), with the model accounting for 40%-50% of the variance in computer technology usage (Ifinedo, 2006).

Recent efforts have been undertaken to improve TAM by including factors that account for a greater part of the variance (Venkatesh & Davis, 2000); (Venkatesh & Morris, 2000); (Gefen & Straub, 1997); (McFarland, 2001); (Wright & Granger, 2001). One positive advance is the inclusion of characteristics of the Theory of Planned Behaviour (TPB). (Ajzen, 1991); (Pavlou & Fygenson, 2006) particularly in predicting the adoption of computer-related technologies for specific computing environments. Examples include the take-up of e-commerce within small business communities, and the evolution of TAM to include Wireless Internet via Mobile Device (WIMD) specific factors (J. Lu, Chun-Sheng, Chang, & Yao, 2003) with the latter study describing extra social factors such as individual differences, technology complexity, facilitation and trust.

The explanatory power of these modified models is further enhanced by structural equation modelling (Alshare, Miller, & Wenger, 2005) that combines TAM and TPB factors.

The original generality and simplicity of applications attributed to TAM have been supplanted by targeted technology-specific variations with superior explanatory power (Venkatesh et al., 2003). TAM and modified TAM models are also beginning to be described in educational contexts, particularly in relation to tertiary student attitudes to technology uptake (Drennan, Kennedy, & Pisarki, 2005), (Wolski & Jackson, 1999b).

TAM IN AN EDUCATION CONTEXT

It isn't unusual in the research world to take activities from one set of research endeavours and migrate these to another, throwing new light on research within the latter (Day & Jorgensen, 1995). Migrating the ideas espoused by Venkatesh and others into an educational technology uptake setting would seems valuable. In an educational context, TAM could be used to describe the effectiveness of new technologies introduced into classrooms (Welsh, Wanberg, Brown, & Simmering, 2003) or to evaluate the effectiveness of new teaching programs (Cheung & Huang, 2005) with a technology focus. eLearning programs would seem to be suitable (Liaw, 2001). Educational administrations might be able to use a TAM evaluation of pilot eLearning programs to determine the effectiveness of these programs before committing to full roll-outs (Ifinedo, 2006).

So, is the use of TAM in an educational context possible? If so, how? To answer these questions, it would be useful to review the literature for successful use of TAM in educative environments and determine whether there is a need for modification, adaptation, or complete rejection of the approach. The modification of TAM as described by Venkatesh that used meta-analysis in the formulation of the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003), is a useful starting point. In this meta-analysis, there were two key issues in developing the UTAUT: the degree of robustness or the explanatory power of the model, and the degree of applicability in specific contexts (Venkatesh et al., 2003). This seminal work reflected thoughts of others (Rose & Straub, 1998) and (Szajna, 1994) in relation to these issues. So, to what extent have these two issues been raised within the information systems field of research?

Robustness of the Davis general TAM model had been tested many times (F. Davis, 1986), Straub's study verified the effectiveness of TAM in information technology but sought to recommend the development of a cultural dimension (Straub, Keil, & Brenner, 1997), McFarland's testing of TAM in relation to technology used for mail surveys (McFarland & Hamilton, 2006). Horton et al. considered the application of the technology acceptance model in explaining intranet usage in two organizations: a bank and engineering firm (Horton, Buck, Waterson, & Clegg, 2001). Lu & Gustafson verified PEOU and PU as factors when they determined there was an intermediatory exploring stage in the technology uptake process (H. P. Lu & Gustafson, 1994). Finally, Wober & Gretzel verified the TAM in their survey conducted among tourism operators (Wober & Gretzel, 2000).

The degree of applicability into specific contexts has necessitated modifications to TAM. Wu and Chen extended TAM with the antecedent variable of trust and elements of the Theory of Planned Behavior (TPB), to better understand behavioural intention in using on-line tax products (Wu & Chen, 2005), Whetton & Walker compared TPB (Ajzen, 1991), TAM and Diffusion of Innovation Theory (Rogers, 1995) in the uptake of health informatics systems and moderated TAM with a Diffusion Innovation effect (Whetton & Walker, 2002). Gurajan reinforced Whetton et al. when they identified health-care informatics literature describing the inappropriateness of TAM, and that specific adaptations were necessary for health-care (Gururajan, Toleman, & Soar, 2004). Finally, Venkatesh & Ramesh illustrated the Microsoft Usability Guidelines (MUG) (Agarwal & Venkatesh, 2002) outperform TAM in a wireless usability study (Venkatesh & Ramesh, 2006).

It is clear that TAM modelling is a useful instrument with significant robustness, in determining technology acceptance in many general applications. On the other hand, for greater applicability, TAM applied to specific environments has been shown to need either modification or adaptation. In the attempt to use a generalised TAM within specific contexts some of its explanatory power and usefulness can be lost. How does a generalised TAM lose its usefulness in an educational context?

THE CASE FOR AN EDUTAM?

There have been studies in the application of TAM or TAM-like models within educational settings. Wolski is concerned about TAM failing to include normative factors relevant in an education setting (Wolski & Jackson, 1999a). Drennan et al. conducted a study of first year management students with results that suggest student satisfaction is influenced by positive perceptions toward technology, and an autonomous learning mode – a significant adaptation of TAM (Drennan et al., 2005).

Cheung & Huang propose a partial use of TAM with modification – the addition of IT Diffusion Model factors - in their study of how the internet is used in university learning from a student's perspective (Cheung & Huang, 2005). Selim evaluates the use of the World Wide Web as a teaching and research tool amongst students and proposes a Course Webs Acceptance Model (CWAM) adaptation of TAM (Selim, 2003) which essentially validates TAM with a course website usage variation. Similarly, McFarland adds an age factor to TAM to better explain eLearning program uptake (McFarland, 2001). Legris et al. suggest that TAM is useful if human and social processes are included (Legris, Ingham, & Collerette, 2003). They describe a simple student environment which TAM is good at explaining but suggest more complex environments should include supplementary Innovation Model factors.

The limited literature suggests there are aspects of TAM that are useful in analysing educational technology acceptance and more broadly, technology-orientated educational programs such as eLearning programs. So, while TAM has wider usage and usefulness in the business community, to be a greater predictor of program success in an educational setting would require modifications with factors that aren't included in a generalised TAM.

In the technology world, the need to understand technology acceptance has been driven by the savings that can be made by an effective technology implementation.

In an educational setting, a similar impetus should also be clear but is undervalued (Finkelstein & Scholz, 2000). This maybe because of the lack of solid research undertaken over recent years into the concepts of technology acceptance in education. The little research that has been completed indicates that TAM and TAM-like models are showing some robustness in their explanatory power as predictors of technology acceptance and the consequent success of technology-based education programs. In particular, with proposed eLearning programs it would be consistent to apply TAM methodologies to evaluate degrees of success. What is also clear is that using a broad, general model is not sufficient. The application of TAM in specific educational settings necessitates the substantial modification of the model, usually by adding humanistic factors described by other models (Wright & Granger, 2001); (Wolski & Jackson, 1999a), (Ma, Andersson, & Streith, 2005).

CONCLUSION

What is needed now? Firstly, work can be undertaken in testing a generalised TAM within different educational environments to confirm the need for setting education specific modifications. Secondly, use can be made of a meta-analysis similar to Venkatesh's with applications of TAM that are education specific (Venkatesh et al., 2003). Thirdly, the education specific criteria so gleaned could then be used to propose an education specific modified TAM (Pan, Gunter, Sivo, & Cornell, 2005), that is, an EduTAM. Finally, an EduTAM should be verified and tested by applying it to existing education programs and maybe new and emerging learning environments, such as podcasting and mobile technology-based learning. In relation to the original proposition (looking for factors that modify TAM for the specific eLearning context), it is clear that TAM, in a modified form, could be a significant tool for predicting the success of new technology-based environments, such as the latest eLearning programs, within an educational setting. For an eLearning strategy this would mean that an EduTAM could be used to identify the important criteria. These criteria can then be used to set up specific educational administrative practices that bring technology uptake issues into the forefront of planning considerations, and to create strategies that are "student-centric" in relation to eLearning program acceptance. Finally these strategies could be used to address EduTAM issues within eLearning training programs delivered to teachers.

Hence, education administrations would be able to predict with greater confidence that funded eLearning programs would deliver commensurate improvements in learning.

REFERENCES

Agarwal, R., & Venkatesh, V. (2002). Assessing a Firm's Web Presence: A Heuristic Evaluation Procedure for the Measurement of Usability. *Information Systems Research, 13*(2), 168-186.

Ajzen, I. (1991). The Theory of Planned Behavior. *Organizational Behavior & Human Decision Processes, 50*(2), 179.

Alshare, K., Miller, D., & Wenger, J. (2005). An Exploratory Survey of Student Perspectives Regarding Search Engines. *Delta Pi Epsilon Journal, 47*(2), 75-82.

Beastall, L. (2006). Enchanting a Disenchanted Child: Revolutionising the Means of Education Using Information and Communication Technology and e-Learning. *British Journal of Sociology of Education, 27*(1), 97-110.

Chang, C.-K. (2002). *Record Desktop Activity as Streaming Videos for Asynchronous, Video-Based Collaborative Learning*. Taiwan.

Cheung, W., & Huang, W. (2005). Proposing a Framework to Assess Internet Usage in University Education: An Empirical Investigation from a Student's Perspective. *British Journal of Educational Technology, 36*(2), 237-253.

Conlon, T. (2000). Visions of Change: Information Technology, Education and Postmodernism. *British Journal of Educational Technology, 31*(2), 109-116.

Crafts, N. (2005). The 'Death of Distance.' *World Economics, 6*(3), 1-14.

Davis, F. (1986). *Technology Acceptance Model for Empirically Testing New End-User Information Systems: Theory and Results.* Unpublished Doctoral Dissertation, Massachussetts Institute of Technology, Boston, MA.

Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly, 13*(3), 318-340.

Day, D., & Jorgensen, C. (1995). The transfer of research information within and by multicultural teams, *Information Processing & Management* (Vol. 31, pp. 89-100).

Doll, W. J., Hendrickson, A., & Deng, X. (1998, Fall). Using Davis's Perceived Usefulness and Ease-of-Use Instruments for Desision Making: A Confirmatory and Multigroup Invariance Analysis. *Decision Sciences, 29,* 839-869.

Drennan, J., Kennedy, J., & Pisarki, A. (2005). Factors Affecting Student Attitudes toward Flexible Online Learning in Management Education. *Journal of Educational Research, 98*(6), 331-331.

Ellis, A. (2001). Student-Centred Collaborative Learning via Face-to-Face and Asynchronous Online Communication: What's the Difference?

Finkelstein, M. J., & Scholz, B. W. (2000). *Dollars, Distance, and Online Education: The New Economics of College Teaching and Learning.*: Oryx Press, 4041 North Central at Indian School Rd., Phoenix, AZ 85012-3397 http://www.oryxpress.com.

Fishbein, M., & Ajzen, I. (1975). *Belief, Attitude, Intention and Behavior: An Introduction to Theory and Research*. Reading, MA: Addison-Wesley Publishing Company.

Flynn, A., Concannon, F., & Bheachain, C. N. (2005). Undergraduate Students' Perceptions of Technology-Supported Learning: The Case of an Accounting Class. *International Journal on E-Learning, 4*(4), 427-444.

Gefen, D., & Straub, D. (1997). Gender Difference in the Perception and Use of E-Mail: An Extension to the Technology Acceptance Model. *MIS Quarterly, 21*(4, December), 389-400.

Gururajan, R., Toleman, M., & Soar, J. A. A. A. (2004). *Necessity for a New Technology Acceptance Model to Predict Adoption of Wireless Technology in Healthcare*. Paper presented at the National Health Informatics Conference (12th : 2004 : Brisbane (Qld)).

Harris, P. (2003). ROI of E-Learning: Closing in. *T+D, 57*(2), 30-36.

Horton, R. P., Buck, T., Waterson, P. E., & Clegg, C. W. (2001). Explaining intranet use with the technology acceptance model. *Journal of Information Technology (Routledge, Ltd.), 16*(4), 237.

Ifinedo, P. (2006). Acceptance and Continuance Intention of Web-BAsed Learning Technologies (WLT) Use Among University Students in a Baltic Country. *The Electronic Journal on Information Systems in Developing Countries, 23*(6), 1-20.

Jared, L. (2005). Breaking down the Confines: An E-Learning Resource for All, at Home and at School. *Educational Media International, 42*(2), 135-141.

Legris, P., Ingham, J., & Collerette, P. (2003). Why do people use information technology? A critical review of the technology acceptance model. *Information & Management, 40*(3), 191-204.

Liaw, S.-s. (2001). Developing a User Acceptance Model for Web-based Learning. *Educational Technology, 41*(6), 50-54.

Lu, H. P., & Gustafson, D. H. (1994). An Empirical-Study of Perceived Usefulness and Perceived Ease of Use on Computerized Support System Use over Time. *International Journal of Information Management, 14*(5), 317-329.

Lu, J., Chun-Sheng, Y., Chang, L., & Yao, J. E. (2003). Technology acceptance model for wireless Internet. *Internet Research, 13*(3), 206-222.

Ma, W. W.-k., Andersson, R., & Streith, K.-O. (2005). Examining User Acceptance of Computer Technology: An Empirical Study of Student Teachers. *Journal of Computer Assisted Learning, 21*(6), 387-395.

McFarland, D. J. (2001). The Role of Age and Efficacy on Technology Acceptance: Implications for E-Learning.

McFarland, D. J., & Hamilton, D. (2006). Adding contextual specificity to the technology acceptance model. *Computers in Human Behavior, 22*(3), 427-447.

Money, W., & Turner, A. (2004, 5-8 Jan. 2004). *Application of the technology acceptance model to a knowledge management system.* Paper presented at the 37th Annual Hawaii International Conference, Hawaii.

Ndubisi, N. O., & Chukwunonso, N. C. (2004). On-line learning adoption intention : comparing the predictive power of two competing models.

Niemiec, R. P., & Walberg, H. J. (1989). From Teaching Machines to Microcomputers: Some Milestones in the History of Computer-Based Instruction. *Journal of Research on Computing in Education, 21*(3), 263-276.

Pan, C.-C. S., Gunter, G., Sivo, S., & Cornell, R. (2005). End-User Acceptance of a Learning Management System in Two Hybrid Large-Sized Introductory Undergraduate Courses: A Case Study. *Journal of Educational Technology Systems, 33*(4), 355-365.

Pavlou, P. A., & Fygenson, M. (2006). Understanding and Predicting Electronic Commerce Adoption: An Extension of the Theory of Planned Behaviour. *MIS Quarterly, 30*(1), 115-143.

Rogers, E., M. (1995). *Diffusion of Innovations* (Fourth Edition ed.). New York: The Free Press.

Rose, G., & Straub, D. (1998). Predicting General IT Use: Applying TAM to the Arabic World. *Journal of Global Information Management, 6,* 39-46.

Sanayei, A., & Sadeghi, M. (2004). Globalization & Knowledge Economy. *Journal of International Marketing & Marketing Research, 29*(3), 153-163.

Selim, H. M. (2003). An Empirical Investigation of Student Acceptance of Course Websites. *Computers & Education, 40*(4), 343-360.

Solomon, G. (2005). Shaping E-Learning Policy: Virtual Education Is Growing Swiftly, and along with It, Debates Surrounding Teacher Quality and Jurisdiction, Funding, Accreditation, Assessment, Unions, and More. *Technology & Learning, 25*(10), 26-26.

Straub, D., Keil, M., & Brenner, W. (1997). Testing the technology acceptance model across cultures: A three country study. *Information & Management, 33*(1), 1-11.

Szajna, B. (1994). Software Evaluation and Choice: Predictive Validation of the Technology Acceptance Instrument. *MIS Quarterly, 17*(3), 319-324.

Szajna, B. (1996). Empirical Evaluation of the Revised Technology Acceptance Model. *Management Science, 42*((1)), 85-92.

Taylor, S., & Todd, P. (1995). Assessing IT usage: The Role of Prior Experience. *MIS Quarterly, 19*(4), 561-570.

Telstra - Product & Services: 3G Mobile Phones [Electronic Version], 1. Retrieved 12/04/2006 from http://www.telstra.com.au/video/index.htm?tR=4ts.

Turker, A., Gorgun, I., & Conlan, O. (2006). The Challenge of Content Creation to Facilitate Personalized E-Learning Experiences. *International Journal on E-Learning, 5*(1), 11-17.

van Schaik, P., Barker, P., & Moukadem, I. (2005). Using a Digital Campus to Support Electronic Learning in Lebanon. *Innovations in Education & Teaching International, 42*(2), 157-166.

Venkatesh, V., & Davis, F. D. (2000). A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies. *Management Science, 46*(2), 186.

Venkatesh, V., & Morris, M. G. (2000). Why Don't Men Ever Stop to Ask for Directions? Gender, Social Influence and their Role in Technology Acceptance and Usage Behaviour. *MIS Quarterly, 24*(1), 115.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User Acceptance of Information Technology: Toward a Unified View. *MIS Quarterly, 27*(3), 425-478.

Venkatesh, V., & Ramesh, V. (2006). Web and Wireless Site Usability: Understanding Differences and Modeling Use. *MIS Quarterly, 30*(1), 181-205.

Weller, M. (2004). Learning Objects and the E-Learning Cost Dilemma. *Open Learning, 19*(3), 293-302.

Welsh, E. T., Wanberg, C. R., Brown, K. G., & Simmering, M. J. (2003). E-Learning: Emerging Uses, Empirical Results and Future Directions. *International Journal of Training and Development, 7*(4), 245-258.

Whetton, S., & Walker, J. A. A. (2002). *The Diffusion of Innovation: Barriers to the Uptake of Health Informatics*. Paper presented at the National Health Informatics Conference (10th : 2002 : Melbourne (Vic.)).

Wober, K., & Gretzel, U. (2000). Tourism Manager's Adoption of Marketing Decision Support Systems. *Journal of Travel Research, 39*(2), 172.

Wolski, S., & Jackson, S. (1999a). Technological Diffusion within Educational Institutions: Applying the Technology Acceptance Model.

Wolski, S., & Jackson, S. (1999b). *Technological Diffusion within Educational Institutions: Applying the Technology Acceptance Model*. U.S.
Arizona.

Wright, K. M., & Granger, M. J. (2001). Using the Web as a Strategic Resource: An Applied Classroom Exercise.

Wu, I.-L., & Chen, J.-L. (2005). An extension of Trust and TAM model with TPB in the initial adoption of on-line tax: An empirical study. *International Journal of Human-Computer Studies, 62*(6), 784-808.

Yi-Shun, W., Hsin-Hui, L., & Pin, L. (2006). Predicting consumer intention to use mobile service. *Information Systems Journal, 16*(2), 157-179.

A Framework for Business Process Modeling and Alignment

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ABSTRACT
This paper proposes an enterprise architecture framework that allows modeling organizational components for reuse and co-development, emphasizing their traceability and alignment at both design and execution time. It focuses on describing how entities interact in the context of business processes and relate to goals, actors and supporting systems. To facilitate the analysis of the architecture models, a set of five views that separate multiple organizational concerns is also introduced.

1. INTRODUCTION

Representing knowledge about an organization proves to be a challenging task since it requires several of its aspects to be represented in a coherent and integrated way. Failing to deliver such representation hinders the assessment of the organization, as well as the detection of problems and areas of improvement. For an organization to change it must be self-aware, meaning that if the knowledge on the organizational components is not shared and understood there will be a gap between the actual state of affairs and the state as perceived by the different stakeholders. In addition, information systems accentuate these issues as they facilitate information sharing and process automation, regardless of the quality of the information and how processes are aligned with the organization goals. Despite investments on systems and technology, organizations often do not have the adequate methods that enable the management and coordination of these systems to support planning, decision making, controlling and, especially, to leverage competitive advantage.

Enterprise architecture results from the process of representing and aligning the components that are required for the management of the organization. It is the set of representations required to describe a system or enterprise regarding its construction, maintenance and evolution (Zachman, 1987). It concerns the structure of the things of relevance in the enterprise, their components, and how these components fit and work together to fulfill a specific purpose within the organization. Identifying the architecture of the enterprise should therefore be considered as a fundamental step to understand and align the organizational components.

Extensive related work can be found on the literature. ANSA was likely the first project to propose views, claimed to provide complete coverage of information processing systems (ANSA, 1989; Herbert, 1994). The views on enterprise, information, computation, engineering and technology were later taken up in open distributed processing standards. The concept of view enables separating the multiple concerns of a system in such a way that they can be individually addressed and later composed in a global representation. Thus, this concept shares a common goal with other approaches to enterprise architecture.

RM-ODP (Farooqi, 1995; ISO, 1995; Schurmann, 1995) aimed at integrating and maintaining consistency between multiple distributed-systems standards. It includes descriptive elements that provide a common vocabulary and prescriptive elements, known as viewpoints, which constrain what can be built. Specifically, it defines the enterprise viewpoint for system boundaries, policies, and purpose; the information viewpoint to represent distributed information; the computational viewpoint for decomposition of system into distributable units; the engineering viewpoint for description of components needed and, finally, the technology viewpoint for describing the implementation details of components.

The Zachman Framework (O'Rourke, 2003; Zachman, 1987) is used both from modeling and management perspectives. It describes the subjects needed for developing and documenting the enterprise architecture in a matrix. The vertical axis defines multiple perspectives on the architecture while the horizontal axis offers a classification of its artifacts. Its rows are structured around the perspectives related to user roles, namely Scope, Enterprise Model, System Model, Technology Model and Detailed Representations, while the six columns focus on separating Data (who), Function (how), Network (where), People (who), Time (when) and Motivation (why). The framework is independent of specific methodologies, but does not define how to integrate the information within each cell, nor how to describe how to trace such information neither how to specify the artifacts within each cell (Frankel, 2003).

This paper proposes an enterprise architecture framework that emphasizes the traceability and alignment between organizational components, facilitating their reuse and co-development. It focuses on describing how entities interact in the context of business processes and relate to organizational goals, actors and supporting systems. The components of the proposed framework and its underlying UML representation (OMG, 2004) are presented in section 2. In order to facilitate the analysis of the architecture, section 3 describes a set of five views that separate organizational, business, information, application and technological concerns. Section 4 introduces the concept of context to enable aligning the designed components with their corresponding execution so that organizational self-awareness can be maintained. Finally, section 5 provides concluding remarks.

2. THE FRAMEWORK

The architecture defines and relates the fundamental concepts required to describe the enterprise in a set of blueprints. The current section describes these concepts as packaged UML classes. Section 3 describes the five views that encompass these packages.

An organization can be abstracted as a collection of business nouns that interact as described by verbs. The nouns represent the concepts within the organization that are of interest regarding the purpose of the model. The verbs are enterprise activities that define how work is done and how value is added, thus describing its business processes. These abstractions are modeled as entities, roles and activities. Entities (business nouns) display behavior by playing a number of roles. Activities (business verbs) specify how roles collaborate in order to achieve a given purpose.

2.1 Entity

An organization is composed of entities. An entity can be a person, place, machine, resource, event that has meaning in the context of the business and about which some information can be stored because it is relevant for the purpose of the model.

Entities can be classified, in the object-oriented sense, according to its attributes and methods. These features can be either intrinsic or extrinsic. Intrinsic features describe the entity in isolation, while extrinsic features arise from its relationships. For example, the entity "person" has intrinsic features such as age and sex, and

extrinsic features such as job position and salary, which derive from a relationship between the person and its employer. The state of the intrinsic features may change over time but always characterize the object, whereas extrinsic features are only meaningful while a relationship is valid.

Entities may also relate structurally to other entities, as in the case when an entity is composed by other entities. An entity class may also be specialized. Entities may interact with other entities only by playing roles in the context of a specific business activity. An entity is represented as a UML Class.

2.2 Role

A role is the observable behavior of an entity in the scope of a specific collaboration context, representing its features when it collaborates with other entities in the context of an activity. An entity relates to zero or more role classes through the stereotyped «play» relationship. Each role represents a subset of its external or extrinsic features in the context of a specific collaboration as defined in a role model.

Roles aim at separating the different concerns that arise from the collaborations between the entities fulfilling an activity. A role may be bound to multiple entities. Binding a role to an entity means that a specific instance of that entity is able to express the behavior defined by the role. It also means that the attributes and method of the role will be part of the entity's feature set. A role is also a type and may be classified according to its features, so it can be generalized and aggregated as a class. Roles are described in role models that describe how roles are structured and how they collaborate in order to fulfill a task. The role model may also specify constraints. Roles are described as UML Classes.

The structural relationships between roles are shown on class diagrams. Role models are packages that comprise a class diagram to describe the role structure and a UML dynamic diagram to describe its collaborations. The class diagram depicts the roles and the role associations required to fulfill a task. It also describes any constraints or business rules that govern the role associations.

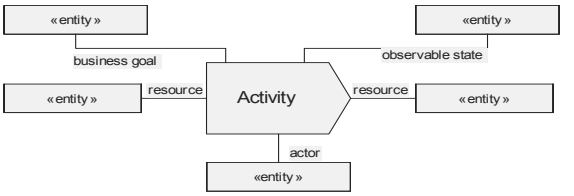
Figure 1 shows the structural dependencies between two roles, Employee and Employer, both defined in the "Works For" role model. It also depicts the binding between two entities, Person and Organization, and the two roles Employee and Employer. An activity is described by a number of role collaborations as seen on Figure 1 (right). This notation is closer to that of UML (OMG, 2004) and BPMN (BPMI, 2004).

The diagram in Figure 1 uses roles to separate the Person's external attributes from its intrinsic attributes. It can be observed that the job position and salary are extrinsic attributes and are dependent of the specific role Employee. Moreover, the role model makes clear that the Employee role relates with the Employer role, in the context of the "Works For" collaboration. Separating the intrinsic from extrinsic features allows entities to be designed independently of the activities that use them. This not only improves the reusability of the entities but also the ability to understand why a specific feature is expressed.

2.3 Activity

An activity is an abstraction describing how entities collaborate in order to produce a specific outcome. It aims accomplishing some task which, given an initial state, will always end in finite time and in a recognizable end-state. An activity may also be functionally decomposed into further activities. An activity specifies what entities are required to realize a task. As seen earlier, roles are used to separate the description of the actual entity features from the features required by the collaboration in context of the activity. In this way, activities and entities are described separately, and roles may be reused in different activities.

Figure 2. Common roles played by entities in the course of an activity



An activity often results from a number of interacting entities playing a set of roles specialized from four generic roles: resource, actor, observable state and goal (v. Figure 2). The resource role is played by the entities that are used as input to the activity. Resource entities are handled by a number of actors to generate output resources. An entity plays an actor role whenever is performing active behavior, such as entities modeling people, mechanical devices or information systems. During these operations, actors may contribute to the achievement of business goals.

From a methodological viewpoint, activities must relate to at least one entity playing the role of observable state. An observable state models a state of affairs that is of interest to a stakeholder. It can be seen as an indicator that results from performing the activity. This criterion can be used to decide if an activity can be further decomposed: decomposition is only meaning if all of its sub-activities produce at least one observable state. It is worth mentioning that the observable state set depends on the purpose of the architecture. For instance, the set of states in an architecture that will be used to identify information system requirements will likely be more fine grained detailed than the set used to describe the core activities of an organization from a strategic perspective. Observable states are detached from how activities are coordinated.

2.4 Activity Coordination

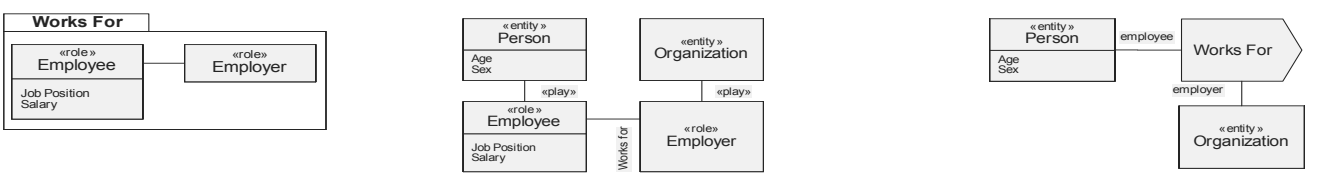
Coordination means linking together different parts of a system to accomplish a collective set of tasks. In the case of activity coordination, it means describing how activities are linked together so that they define a business process. The common definition of business process found in the literature defines it as a coherent collection of activities that takes one or more kinds of inputs and creates an output that is of value for an internal or external customer (Hammer, 2001; Verharen, 1997).

A process is coordinated and goal-driven. In this sense, a business process is a coordinated set of activities, but the converse may not be true. It is possible to describe activity coordination in different ways, such as using explicit control or data flow between activities or using events or pre-conditions. Activity coordination is represented using any of UML's dynamic diagrams, such as an activity diagram.

2.5 Role Types

The roles entities are able to play depend on the purpose of the model and on the specific organization. However, a number of basic roles are fundamental for organizational modeling:

Figure 1. The Works For role model showing the dependencies between two related roles (left); binding roles to entities (center); activity classifier (right)

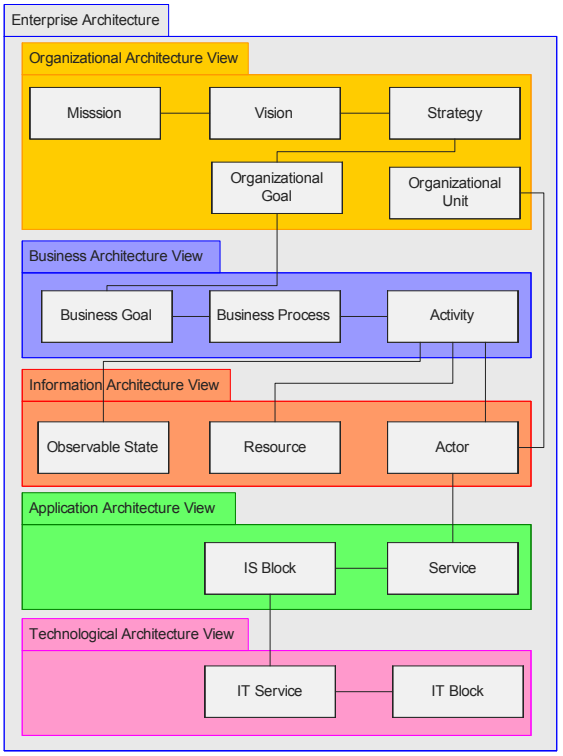


- **Mission**. A statement of enterprise's purpose.
- **Vision**. A statement on how to transform the mission into action.
- **Strategy**. A business process describing how to accomplish the vision.
- **Organizational Goal**. The goals achieved by the strategic process.
- **Business Goal.** A measurable state that the organization intends to achieve. Goals are achieved by entities involved in activity execution.
- **Resource**. The capacity of an entity to be managed by business process activities, including the ability of being consumed, incorporated, monopolized, or accessed.
- **Observable State.** A state of affairs that is of interest to a stakeholder in the context of the enterprise architecture. Observable states can guide the task of activity functional decomposing.
- **Actor**. An animate entity capable of active behavior. Actors model people, computer systems, mechanical tools or any other devices used to perform the operations required by an activity. Since entities only collaborate through roles, classifying an entity as an actor depends on the roles the entity is able to play, i.e., on the type of collaborations it participates in. This means that some entities may be potential actors but in a specific organizational case, they are just inanimate entities. The status of actor is transient and context dependent, meaning that the same entity could be an actor in the context of a process and a resource in the context of other. Actors are able to perform the set of services required to play a role. This means an actor is then responsible for providing such services. In case of people, these services are correlated to the skills, capabilities and other attributes pertaining to the person that are relevant to assign her to a role in the scope of an activity. In case of computerized systems or machines, the services represent the operations and functions that these devices put into play during the role assignment.

3. ARCHITECTURAL VIEWS

The architectural views aggregate and relate the fundamental roles played by the entities. They are defined to facilitate the analysis and development of the entities' roles through the separation of its different organizational concerns. Each view is individually represented and organized as a UML package that owns its model elements (v. Figure 3).

Figure 3. The enterprise architecture framework



3.1 Organizational Architecture View

This view deals with the aspects related with the organization but not to the specific business it conducts nor with the mechanisms used to accomplish the creation of value. It therefore includes concepts such as the enterprise mission, vision and strategy and the definition of organizational units.

3.2 Business Architecture View

The business architecture view synthesizes how business strategy is implemented and how processes are defined. The functional requirements of the business process support systems can be extracted from this view.

An activity describes the roles required for its operation. These roles are played by the organization entities and include actor role, resource role and observable state role. An activity requires one actor or a combination or team of actors to be executed. The actor represents a person, a machine or device, or an information system. An actor provides the services require for fulfilling the business role required by the activity. A resource is used as input or output of an activity during its operation. A resource is usually created, used, transformed or consumed during the operation of the activity. An observable state is specific resource role that is used as a means to observe the status of an activity. An activity is performed during a specific period. As a precondition for its enactment, all of the business roles must be fulfilled by specific entities. These entities will be engaged in playing their roles for the duration of the activity. The activity post condition is that all of the roles will have finished playing their part.

3.3 Information Architecture View

The information architecture describes what the organization needs to know to run its processes and operations as described in the business architecture. It defines a view on the business information that is system and technology independent. It is an abstraction of the information requirements of the organization and provides a high-level logical representation of all the key information elements that are used in the business as well as the relationship between them (Gilchrist, 2003; Inmon, 1999).

3.4 Application Architecture View

The application architecture view fulfills two goals: making explicit how business requirements are supported and allowing efficient management of the organization's entities. To satisfy these goals, the application architecture should be derived top-down from the analysis of the business and information architectures.

The application architecture defines the applications needed for data management and business support, regardless of the actual software used to implement the systems (Gilchrist, 2003). It functionally defines what application services are required to ensure processes and entities are supported in acceptable time, format and cost (Spewak, 1992). It describes the characteristics, styles and interactions among multiple applications. The architecture of a business process support system is described as a structure of Information System Blocks, each representing an organized collection of Services designed to handle organization information.

3.5 Technological Architecture View

The technological architecture view represents the technologies behind application implementation as well as the infrastructure and environment required for the deployment of the business process support systems. These concepts are abstracted as an Information Technology Block. An IT block realizes or implements IS blocks through number of technological Services.

4. ALIGNING DESIGN WITH EXECUTION

The concepts previously described enable capturing design-time aspects and assessing the static alignment between these aspects. Whereas this enhances the organization's self-awareness, it does not make explicit how to continuously and dynamically maintain this self-awareness. Aligning the organizational design with its execution entails capturing the current state of its active entities, i.e. actors and the particular interactions between them that change the state of resources, actors or activities. Actors interact using specific roles. Because of these interactions, actors continually change their own state, the state of activities and the state of resources.

A collaboration of resources and actors within an activity defines an interaction context that reflects the observable state of the activity, its actors and other resources. Actors are capable of engaging in multiple activities and to switch between them, potentially playing a different role on each. Several interaction contexts result from the different states of affairs related to the particular activities or roles where the actor is participates. When resuming a suspended activity the actors must be aware of the current state of affairs of the corresponding interaction context.

Figure 4 depicts the relationship between interaction contexts, actors, resources and activities. At design-time, the focus is on capturing goal, resource and actor roles related to an activity. However, during activity execution the observable features are actor interactions, which first create and then modify interaction contexts. These changes may trigger further changes on additional entities. In summary, modeling activity execution entails capturing (1) how actors interact, (2) how these interactions modify interaction contexts and (3) how interaction contexts trigger changes on the state of activities and other resources and actors. Defining models and modeling concepts to capture actual execution facilitates comparing the actual interactions of actors with activities and resources and the detection of errors or the discovery of emergent behaviors that improve the organization's effectiveness.

Figure 5 illustrates the interaction contexts and the relationship to design-time modeling concepts. The interactions captured are related to the collection of cards information for a mail application. These interactions resulted in two interaction contexts, the former shared by actors Peter and Maria and the latter, between Peter and the integration team. In the first context, Peter plays the role of task performer, Maria and the integration team provide resources for Peter. Successive interactions change the interaction context state, reflected by pending commitments. This interaction context modifies state of three activities.

Figure 4. Actors, resource, activities and interaction contexts

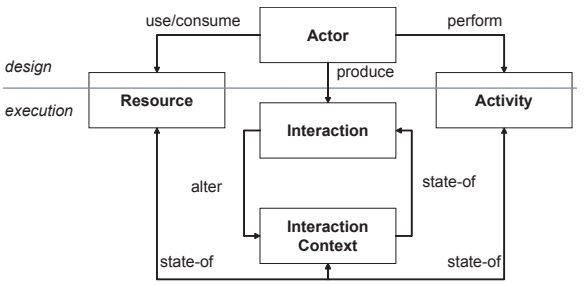
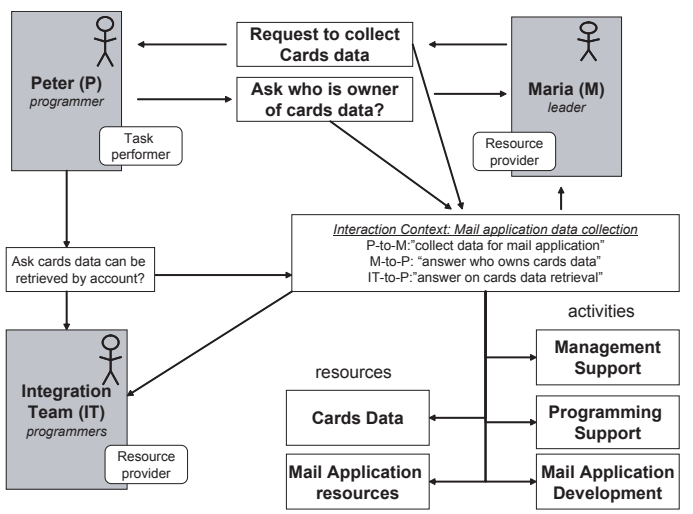


Figure 5. The "mail application data collection" interaction context



Interaction contexts are defined to capture execution. Identification and modeling of interactions contexts provides groupings of interactions exhibiting higher similarity with actual execution than other abstractions, such as activities. Interaction contexts relate to several activities and resources. Conversely, activities and resources relate to several interaction contexts. This means that interaction contexts are not part of activities or resources. Rather, they are a different concept. Moreover, actors activate their tasks according not only to task factors, but also to time, location, personal or inter-personal factors. Regarding interaction contexts as entities allows identifying interaction context emergent properties such as its priority and activation rules. This enables the discovery of actor scheduling heuristics and interaction rules. Analyzing interaction history makes also possible to find usage patterns and to discover tasks in a bottom-up fashion, facilitating the alignment between organizational models and actual execution (Zacarias, 2006).

5. CONCLUSIONS

Enterprise architecture consists of defining and understanding the different elements that shape an organization and how those elements are inter-related. This paper presents a framework for expressing the components of an architectural model for process-oriented organizations using five separate views that are integrated with the enterprise architecture model to facilitate its evolution. In this way, alignment becomes the process of continuously guiding the enterprise resources to exploit opportunities and cope with environmental changes.

The framework defines the fundamental concepts and their relationships. It also makes use of the object-oriented paradigm, exploiting mechanisms such as specialization and aggregation, with the goal of maximizing reusability and facilitating the discussion and communication of the models, thus promoting understandability.

REFERENCES

ANSA (1989). *ANSA Reference Manual, Release 01.00*. Architecture Projects Management Ltd., Cambridge,.

BPMI (2005). *BPMN 1.0 Specification*. http:// www.bpmn.org

Farooqi, K., Loggripo L., Demeere J. (1995). *The ISO Reference Model for Open Distributed Processing: An Introduction*. Computer Networks and ISDN Networks.

Frankel, D., Harmon P., *et al* (2003). *The Zachman Framework and the OMG´s Model Driven Architecture*. Business Process Trends.

Gilchrist, A. Mahon B. (2003). *Information Architecture: Designing Information Environments for Purpose*. Facet Publishing.

Hammer, M., Champy J. (2001). *Reengineering the Corporation: A Manifesto for Business Revolution*. Nicholas Brealey Publishing.

Herbert, A. (1994). An Overview of ANSA. *IEEE Network*. 8 January.

Inmon, W. (1999). *Data Architecture – The Information Paradigm*. QED Technical Publishing Group.

ISO (1995). *ISO/IEC 10746 ODP Reference Model*. International Standards Organization.

OMG (2004). *Unified Modeling Language: Superstructure, version 2.0, Revised Final Adopted Specification (ptc/04-10-02)*. http://www.omg.org/cgi-bin/doc?ptc/2004-10-02.

O'Rourke, C. Fishman N., Selkow W. (2003). *Enterprise Architecture Using the Zachman Framework*. ISBN 0-619-06446-3. Course Technology.

Schurmann, G. (1995). The Evolution from Open Systems Interconnection (OSI) to Open Distributed Processing (ODP). *Computer Standards and Interfaces*, Vol. 17.

Spewak, S. Steven H. (1992). *Enterprise Architecture Planning: Developing a Blueprint for Data, Applications and Technology*. Wiley-QED Publication.

Verharen, E, (1997). *A Language-Action Perspective on the Design of Cooperative Information Agents*. CIP-Gegevens Koninklijke Biibliotheek.

Zacarias M., Pinto H.S., Tribolet J. (2006). A Context-based Approach to Discover Multitasking Behavior at Work. *Task Models and Diagrams for User Interface Design (TAMODIA '06) International Workshop.*

Zachman, J. (1987). A Framework for Information Systems Architecture. *IBM Systems Journal*, vol. 26, no. 3, pp. 276-292.

Case Study: Overcoming the Headache of the E-Mail Inbox Through Training

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ABSTRACT

How do we overcome the nightmare of the email inbox? This paper details a two-phase research programme to demonstrate the need to give employees training regarding email communication, and conduct both seminar based training and computer-based training. Detailed results show that email training can lead to significant improvements in the way employees use email within the workplace with computer-based training showing a greater improvement. While email is a powerful information system tool, it can be optimised to further maximise its benefits and to make the email inbox more manageable.

INTRODUCTION

Nowadays employees are overwhelmed by the volume of email communication (Levitt, 2004), lose important items (Whittaker and Sidner, 2004), and feel pressured to respond quickly (often within seconds Jackson et al., 2003), among may other concerns. The major research stream in this field is trying to reduce such "email defects" by designing and building improved email systems designed from an understanding of email usage (Rohall et al., 2004). Although such systems aim to improve email communication, could providing simple education to email users provide, at worst, an interim solution to reduce email defects?

The major source of the email issues within an organisation is likely to be the end-user, as he or she creates and receives the email that periodically causes problems. The 'back to education' approach is based on identifying the *major* problems that users face with email and administering training (both seminar and computer-based to determine which has the more enduring effect) to help users to become more effective email communicators. Although the approach sounds simple and has been successfully applied in many other arenas, will it be successful for improving email communication?

To date, there is very little literature on the role of seminar and computer-based training in improving email communication. This paper is a subset of a paper published by Jackson and Culjak's in 2006. It aims to explore organisational email defects and their management by employee email training in seminars or computer-based modes. The research was conducted in two phases. In the first phase, an interpretive case study was conducted within a department to discover how email was used and viewed by employees. The second phase of the research involved an evaluation process that determined the effectiveness of two training approaches (seminar based and a combined approach of computer-based and seminar based training created by Jackson) to reduce the email defects identified from the first phase and improve the way employees use email.

OPTIMISING EMAIL COMMUNICATION

There are several approaches to improving organisational email use for everyday communication. Some authors suggest that organisations need to implement policies on how individuals use email within the workplace (Cushing, 2002; Duane and Finnegan, 2004). For example, Dudman (2005) suggests that organisations have policies on the retention and deletion of email, while Watson (2001) states that organisations should monitor employee email use to ensure that policies are followed.

Some organisations have taken a stand by banning email communication at certain times in an attempt to encourage employees to work without email (Cushing, 2002; Best, 2003; Wray, 2003). While this approach will force employees to communicate without email for one day a week (or, in the case of Phones 4U, stop employees using email for internal communication (Best, 2003)), it does not address the issues associated with ineffective email use, but rather, simply avoids them.

Email education within organisations tends to focus on hardware and software issues without taking into account the requisite communication skills (Hallewell, 2000). Most employees are not taught how to become effective electronic communicators (Nantz and Drexel, 1995). There is a tacit assumption that because employees can read and write, they can use email effectively. However, Hallewell (2000) suggested that employees need training on the 'human side' of email rather than just how to use email. He argued that email training focuses on how to send and receive email messages, without being taught when it is appropriate to do so (Hallewell, 2000). Indeed, even the most educated of employees can lack basic skills for expressing themselves effectively (Davenport, 1997).

Several issues relating to the quality of written email messages have been identified. In order to achieve both fast and understandable communication, elements associated with quality content and format must be considered when writing email messages (Brandenburg et al., 1999). Factors that contribute to the quality of the content of email messages include (Brandenburg et al., 1999):

- Tone, Courtesy, Conciseness, Clarity and Correctness

Factors that contribute to the quality of format include (Brandenburg et al., 1999):

- Personalisation; Paragraph and sentence length and layout

The above quality-oriented factors contribute to well written email messages. Several earlier studies have identified instances in which these factors have not been present, leading to ineffective email use. Frazee (1996) reported that 65% of all email messages fail to give the recipient enough information to act upon. Participants in the Whittaker and Sidner (1996) study commented that some employees failed to take into account the context of their message before they sent it. Participants stated that they would often receive one line replies to messages without knowing the context. Messages of poor written quality are likely to be difficult to read and may take longer to read and understand (Brandenburg et al., 1999). Poorly written emails containing misspelled words and typing errors are also likely to create a negative impression on the reader (Lea and Spears, 1992). The socially detached nature of email also means that individuals may include content they would not normally communicate verbally (Alonzo and Aiken, 2004). Brandenburg et al (1999) suggest that email is often abused because it is easy to use.

Much of the recent literature that focuses on improving email use within organisations looks at the development of new software tools that are embedded within or replace existing email applications. These tools are designed primarily to aid the user in managing their mailbox, by providing additional functions such as search facilities, enhanced user interfaces and the ability to track conversations. While these tools may be aiding users to manage their email on the recipient side, they do not help users to write effective emails, nor cover the most appropriate methods to do this. Missing from the literature on e-mail management are solutions and theories based on employee email training. One of the key questions in this emerging stream that needs to be determined is the effectiveness of both computer-based and traditional seminar based training in enabling employees to write more effective emails and reduce the problems often associated with email communication.

For the training of employees in effective email communication, many training methods are available and the method selected depends on a number of different factors. Such factors include the organisation size and set-up, the nature of the organisation and its trade/business, and the systems and processes that are used.

Seminar based training (SBT) refers to traditional classroom training, taught by one trained in the skills required. Computer-Based Training (CBT) (also known as computer aided instruction and computer assisted learning) is the use of the computer for training and instruction, and is commonly used for acquiring skills in the use of computer packages or acquiring specific knowledge (Whalley, 1998). Henke (1996) stated in 1996 that computer-based training was a fast growing field. Even earlier, Filipczak noted that 43 percent of all U.S. organisations with more than 100 employees were using CBT as part of their training programmes (Filipczak, 1993). However, around the same time Russ-Eft, stated that only 40 percent of companies surveyed used CBT (Russ-Eft, 1994). Considering that this statistic was noted more than ten years ago, 40% is quite a high figure.

While the use of CBT has been documented and discussed, what is lacking from the literature is evidence of whether computer-based training has more enduring effects compared to seminar based training, and whether computer-based training is more effective for training employees in the use of email.

METHOD

The research seeks to improve workplace communications by investigating the way email communication is used and exploring the role of employee training in managing the issues identified. The research adopts an interpretivist approach, as the research takes place within an organisational environment, and although the research conducted was both qualitative and quantitative the research focuses on capturing information within a social environment in an organisation, rather than a laboratory (Walsham, 1995). Two stage research involved a the Professional Development (PD) Department at Loughborough University. Professional Development is a central support unit within Loughborough University that offers staff and students services to help develop their full potential. The PD department consists of 23 staff.

The first phase of the study highlighted problem areas with the way email is used within organisations. The problem areas (email defects) relate to the inefficient and ineffective uses of email within an organisation. They pertain to all aspects of email use, including the quantity and quality of emails generated within organisations, as well as the configuration of the email application itself. In order to identify the potential problem areas with email use a web-hosted internal survey was conducted and a questionnaire was developed. This method was selected because the ability to distribute the questionnaires to a wide geographical area was vital due to a number of employees being based at different locations throughout the United Kingdom. Several open-ended questions were used to capture how many emails were received by employees and how employees categorised the importance and relevance of each email. A series of closed attitudinal questions were used to gauge how email was used and how the employees viewed organisational email use. Each questionnaire was live for a period of two weeks. Sixteen responses were received from PD, giving a response rate 70%.

The second stage determined the effectiveness of both seminar-based and a combined seminar/computer-based training approach to reducing email deficiencies as will be described below. The research aims to establish which training approach is the most effective at reducing email defects and if certain defects are more receptive to the training than others. The long term impact of the two training approaches were analysed, to determine if any improvements in email use could be sustained. Further details help explain the evaluation approach used, below.

Computer-Based Software Development

The software was designed to work with Microsoft Outlook as it recognised as the defacto corporate email standard. The computer-based email training application has been built so that it flags potential defects within an email by parsing each email and highlighting the defects to the sender before the email is sent. The software can identify certain defects within the recipient field, the subject line, message body and with attachments, providing the user with the opportunity to change the email before it is sent. Details of the parsing algorithm used are published elsewhere (Jackson et al., 2005).

If an email has been previously parsed and still contained deficiencies when the user tries to resend the message, the potential defects will still be shown to the user in the 'Mail Report' window. Any remaining potential defects will be shown to the user regardless of the number of times that a user has edited the message. The user also has the option to ignore the defects identified by the software and to send the email once it has been parsed. It was important that the user had full control over sending an email as this gave them confidence in using the system and being able to override it. If the real time trainer did not identify any potential defects within an email, then the email would be sent to the users outbox, ready to be sent to the server.

Developing the Seminar Based Email Training Programme

The SBT summarised the common problems with email use that can exist within the workplace. Training was tailored for PD by focusing on the problems highlighted from the questionnaire results together with examples from other research. It was important to highlight the common problems with email communication in order to enable participants to understand the magnitude of some of the issues.

The training programme identified defects that individual employees can help reduce, by improving the way they use email. Employees were given training on how to manage their inbox, including the use of folders and filters. Defects that related to the configuration of an organisations email system would also be brought to the attention of management in a report covering the questionnaire results.

The main section of the training focused on areas of email use that individual employees could improve. This included asking employees to consider whether it is necessary to send an email, or whether another medium such as such as the telephone would be more appropriate. The employees were also asked to consider to whom they were sending their email message, and whether all recipients needed to be copied in (cc-ed). The participants were given advice on how to write effective subject lines and emails that contain clear concise messages. The training also covered other aspects of email best practice, such as managing the inbox. This was considered important, as it will enable participants to better manage and prioritise their incoming email.

Measuring Improvement

Both SBT and CBT were conducted using sender and recipient pairs in order to measure the effectiveness of both SBT and CBT. The senders had an established email communication relationship with their recipients, in that they made regular contact with each other via email. Steps consisted of:

1. Once the sender / recipient pairs were established, the recipients would receive training on how to evaluate the emails they receive from their pair(s).
2. The recipients evaluated up to 20 emails that they received from their paired sender(s) over a specified timeframe.
3. After the senders' email had been evaluated, the senders would then receive SBT on the best practices of email, even if they were going to use CBT.
4. Once the senders had received training the recipients were asked to evaluate up to a further 20 emails they received from their paired sender over a specified timeframe.

The recipients were asked to mark each email against a set of nine criterions derived from the email defects identified in the questionnaires. The difference in the scores before and after the sender received training would indicate the success or failure of the training. The recipients would be asked to date and evaluate the emails that they received after the senders had their training. This would enable the author to determine if any improvement could be sustained, or if the effect of the training was limited.

To determine the effectiveness of the SBT, the scores both before and after training were averaged for each sender / recipient pair. The average for all participating pairs was calculated to determine the overall effect of the training for each of the criterion. The t-test statistic was used to determine the significance of the SBT at reducing each of the defects represented by each criterion. The results indicate which aspects of email use are most receptive to SBT.

RESULTS

Following SBT the t-test analysis shows that four out of the nine criteria showed significant initial improvements. The four significant improvements were:

- Better written emails that were easier to read. (at the 90% level)
- Better written emails that were more concise and to the point (significant at the 95% level)
- Better use of the subject line which made it easier to assess the importance of the message (significant at the 90% level)

- Better use of the subject line which made it easier to know what the message is about (significant at the 95% level)

The t-test analysis also showed a significant (at the 90% level) initial improvement in the PD senders' ability to choose the most effective communication medium for a message as shown by table 1.

The initial effect of the SBT can diminish over time. The results showed that seven of the criteria had higher average overall scores after one month than during the first two weeks after the SBT, indicating a reduction of the impact of the SBT across these criteria. The only criteria where the effect of the SBT did not diminish after four weeks was the senders' ability to specify clear deadlines and the senders' ability to write subject lines that enabled the recipient to gauge the importance of the message.

Table 1. Mean effect of SBT on how emails were evaluated within PD

Criterion	Before Training	After Training Weeks 3&4	Diff	Significance from (2 tailed) t test
The suitability of email as the communication medium	1.55	1.18	-0.38	0.057
The email is easy to read	1.56	1.46	-0.10	0.696
The email is straight to the point	1.59	1.29	-0.30	0.184
The relevance of the message to me	1.60	1.71	+0.11	0.741
If it is an actionable email:				
It tells me what is expected of me	1.83	1.65	-0.19	0.341
It states when action is required	2.36	1.87	-0.49	0.221
The subject line contains sufficient detail for:				
Me to assess the importance of the message	2.26	1.70	-0.56	0.006
Me to understand what the message is about	2.08	1.65	-0.43	0.073
Approx how long did it take to read and understand this message? (Seconds)	49.92	47.78	-2.14	0.491

Table 2. Mean effect of CBT on how emails were evaluated within PD

Criterion	Before Training	After Training (4 weeks)	Diff	Significance from (2 tailed) t test
The suitability of email as the communication medium	1.34	1.05	-0.29	0.157
The email is easy to read	1.48	1.15	-0.33	0.081
The email is straight to the point	1.30	1.10	-0.20	0.101
The relevance of the message to me	1.48	1.35	-0.13	0.525
If it is an actionable email:				
It tells me what is expected of me	2.05	1.00	-1.05	0.034
It states when action is required	2.40	1.30	-1.10	0.028
The subject line contains sufficient detail for:				
Me to assess the importance of the message	1.79	1.93	+0.15	0.660
Me to understand what the message is about	1.81	1.63	-0.18	0.067
Approx how long did it take to read and understand this message? (Seconds)	43.49	27.00	-16.49	0.102

Table 3. Average for SBT and CBT within PD four weeks after training

Criterion	4 weeks after SBT Training	4 weeks after combined training	Difference
The suitability of email as the communication medium	1.18	1.05	0.13
The email is easy to read	1.46	1.15	0.31
The email is straight to the point	1.29	1.10	0.19
The relevance of the message to me	1.71	1.35	0.36
If it is an actionable email:			
It tells me what is expected of me	1.65	1.00	0.65
It states when action is required	1.87	1.30	0.57
The subject line contains sufficient detail for:			
Me to assess the importance of the message	1.70	1.93	(0.23)
Me to understand what the message is about	1.65	1.63	0.02
Approx how long did it take to read and understand this message? (Seconds)	47.78	27.00	20.78

The initial impact of the combined training (SBT and CBT) resulted in improvements across eight of the nine evaluation criterions as shown by table 2. The only criterion not to show an initial overall improvement was the senders' ability to write emails that are easy to read, despite this criterion showing significant initial improvements for the SBT at PD. Only one of the criteria showed a significant (at the 90% level) initial improvement. This was in the senders' ability to write effective subject lines that enable the recipient to know what the message is about.

Six of these initial improvements in CBT had been sustained or had shown further improvement. The only criteria where the overall initial impact of the training had diminished were in the senders' ability to choose the most suitable communication medium and their ability to write effective subject lines that convey the importance of the message and enable the recipient to know what the message is about.

The t-test analysis showed that four of the nine evaluation criterions showed significant improvements four weeks later for the CBT. The four significant improvements were:

- Better written emails that were easier to read (significant at the 90% level)
- Better written actionable emails that state what action is required of the recipient (significant at the 95% level)
- Better written actionable emails that clearly state any when action is required (significant at the 95% level)
- Better use of the subject line, which made it easier to know what the message is about (significant at the 90% level)

The significant finding from this research is that when comparing the impact of the combined training approach with a single SBT approach, the results from the PD study suggest that the impact of the combined approach is more sustainable than the SBT on its own as shown by Table 3.

CONCLUSION

While existing studies identified a number of problems with email use, this project sought to research the specific email problems within the PD organisation with the intention of reducing the highlighted defects. While the generalisability of this research is impossible due to the study being of one organisation, in the UK context, the findings are indicative, and suggest that there are many deficiencies with the way email is used within today's organisations. Such defects relate to both the written quality and quantity of email received and the ineffective configuration of an organisations email systems and can increase the amount of time spent dealing with email and can lead to tasks being carried out incorrectly or not at all. Several important implications arise from the study, as outlined below.

First, the study has added to current theory on email management in organisations by providing numerous insights relating to email defects in companies, and their management by various types of training. Second, the findings demonstrate that SBT can improve employee use of email, although the initial impact of the training can diminish over time. The results highlight that the impact of SBT can vary on the specific areas of email use that are improved, with some criteria showing greater improvement than others. However interestingly, the combined training approach (seminar based and computer-based training) did produce improvements that were sustained. Further research is needed to better understand this finding.

Second, the findings from this paper may help similar organisations to PD to become more effective in managing their email communication systems. It is recommended that organisations examine their current email communication policies and develop a "snapshot" of how their employees use email. Such information will provide an organisation with a useful foundation from which to build their training in order to increase their employee effectiveness by email education. If an organisation decides to deploy an email training programme, it is recommended that it not only focus on the sender side of how to write more effective emails, but also on the recipient side, for example training can be given on how a recipient can manage their inbox. It is also recommended that any training programme aimed at improving email use should also take into account other communication media used within the organisation, so that the effectiveness of communication in general can be improved.

REFERENCES

Alonzo, M. and Aiken, M. (2004)."Flaming in electronic communication."Decision Support Systems 36(3): 205-213

Best, J. (2003). “Phones 4U bans staff from email.” ZD Net UK at URL: http://news.zdnet.co.uk/communications/0,39020336,39116502,00.htm (viewed 24/04/05)

Brandenburg, M., Wasson, L. E. and Woodall, K. L. (1999). “An examination of e-mail use among fortune 500 companies.” Academy of Managerial Communications Journal 3(2): 75 - 90

Cushing, K. (2002). Should we ban email? Computer Weekly

Davenport, T. H. (1997). Information Ecology, Oxford University Press, New York

Dudman, J. (2005). “Make e-mail work for you.” ComputerWeekly.com at URL: http://www.computerweekly.com/Articles/2005/05/03/209692/Makee-mail-workforyou.htm (viewed 16/06/05)

Duane, A. and Finnegan, P. (2004). Managing email usage: A cross case analysis of experiences with electronic monitoring and control. Sixth International Conference on Electronic Commerce

Frazee, V. (1996). “Is email doing more harm than good?” Personnel Journal 23

Filipczak, B. (1995). “Learning Styles Escape the Classroom! Panic in the City.” Training 32(3): 46.

Hallewell, B. (2000). “Softening the organisational impact of email.” Training Journal(November 2000): 32-34.

Henke, H. (1996). Learning Theory: Applying Kolb’s Learning Style Inventory with Computer Based Training. at URL: http://sage.sdsu.edu/compswiki/uploads/CompsWiki/learningtheory.pdf (viewed 02/11/2005)

Jackson, T. W. and Culjak, G. (2006). “ Can Seminar and Computer-Based Training Improve the Effectiveness of Electronic Mail Communication within the Workplace?” 17th Australisian Conference on Information.

Jackson, T.W., Burgess, A. and Edwards, J., ‘’Optimising the Email Communication Environment’’, IRMA, IRMA, San Diego, California, USA, May 2005, pp. 819-820

Jackson, T. W., Dawson, R. and Wilson, D. (2001). “The Cost of Email Interruption.” Journal of Systems and Information Technology 5(1): 81 - 92.

Jackson, T.W., R. Dawson, and D. Wilson, “Understanding Email Interaction Increases Organizational Productivity,” *Communications of the ACM,* August 2003, pp. 80-84

Lea, M. and Spears, R. (1992). “Paralanguage and social perception in computer-mediated communication.” Journal of Organizational Computing 2(3-4): 321-341.

Levitt, M., “Email Usage Forecast and Analysis, 2000-2005,” IDC Report # W23011, September 2000.

Nantz, K. S. and Drexel, C. L. (1995). “Incorporating electronic mail into the business communication course.” Business Communication Quarterly 58: 45 - 51.

Rohall, Steven L., Gruen, Dan., Moody, Paul., Wattenberg, Martin., Stern, Mia., Kerr, Bernard., Stachel, Bob., Kushal, Dave., Armes, Robert., Wilcox, Eric., ReMail: a reinvented email prototype, Extended abstracts of the 2004 conference on Human factors and computing systems, April 24-29, 2004, Vienna, Austria

Russ-Eft, D. (1994). “Computer-based training, computer-assisted instruction, electronic performance support systems, and déjà vu.” Human Resource Development Quarterly 5(3): 207-213.

Spamhaus. (2005). Increasing Spam Threat from Proxy. at URL: http://www.spamhaus.org/news.lasso?article=156 (viewed 23/04/05)

Walsham, G. (1995) The Emergence of Interpretivism in IS Research, *Information Systems Research*, 6(4), 376-394.

Watson, G. (2001). “E-mail surveillance in the UK workplace - a management consulting case study.” Aslib Proceedings 54(1): 23 - 40.

Whalley, R. M. (1998). “Towards realising the full benefit of computer aided learning.” Industrial and Commercial Training 30(2): 53-62.

Whittaker, S. and Sidner, C. L. (1996). Email Overload: Exploring Information Management of Email. CHI Conference Proceedings, Vancouver, BC Canada.

Wray, R. (2003). “Phones4U boss says staff must face up to work without email.” Guardian Unlimited Online at URL: http://www.guardian.co.uk/online/news/0,12597,1045417,00.html (viewed 24/04/05)

How the Application of Management Information System (MIS) Affects Business Value (BV) in the Airline Industry

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ABSTRACT

This article is based on the utilization of the MIS and Decision Support Systems (DSS) as significant factors influencing the BV of an airline. Authors state that a contemporary airline company needs to increase its investments in IT, specifically MIS and DSS applications. This hypothesis is based on the analysis of business needs of passenger airline pricing for such airlines as British Airlines, KLM, LOT (Polish Airlines), Svet Aero as well as on the research carried out with airline executives and their clients. The included examples illustrate that the payback period for investments in MIS/DSS – even during unfavorable economic environment - is less than a year.

INTRODUCTION

This article is based on a utilization of the MIS and DSS as significant factors influencing the BV of an airline. There is a significant difference between N.G. Carr [2004] and P.A. Strassmann [2004] in this regard. Carr states that the industries are saturated with IT applications, incremental investments in IT do not give an enterprise a strategic advantage, and strategic importance of IT has significantly decreased in recent years. Strassmann, who also advocates reduction in investments in IT, states in his book Squandered Computer [2004] that the differentiator is in *how* the IT investments are spent. Strassmann's position, rather than Carr's, is closer to ours.

Based on our research in pricing of passenger airfares, we state that today's enterprise needs constant development of the IT, MIS, and DSS applications. This development in turn drives up the enterprise's BV: both tangible and intangible assets of an enterprise. Our results can be extrapolated to the tourist, transit, and telecommunication sectors.

SCOPE AND HYPOTHESIS

In this article, we prove that the role of IT has not diminished. On the contrary, its strategic importance has changed from automation of repetitive processes to process management and management control. Based on our research, enterprises dealing with services distribution – specifically airlines – experience the growth of their IT role and along with it, the growth of their BV. The growing role of IT is caused by the volume and complexity of creating and distributing passengers' airfares. These factors drive the need of using a special class of MIS systems called the IV Generation systems.

In this article we use the following research approach:

- The first part includes the results of heuristic decision support procedures analysis
- The second part includes a CASE study of a practical example of the Generation IV MIS and the corresponding BV calculation

Since airlines do not release their operational effectiveness "hard data", we were not able to provide detailed research on BV calculation methods. However, we managed to apply our BV calculation method to the real production data.

Any airline, to be competitive, needs to implement coherent strategies to lower its costs and operating risks. The key element of operating risks is maintaining effective pricing strategy (prices too high will deter potential customers while prices too low will unnecessarily lower the profit margin). These simple on the surface requirements need a lot of data, complex transactions, and effective distribution to satisfy both the airlines and their customers. Consequently, the IT solutions need to be more sophisticated that the ones currently dominating the airline pricing market.

This article also includes the implementation procedures and IT roles in this implementation. It is based on our experience and research in analysis, design and implementation of IT solution in organizations like BA (British Airways), KLM (Royal Dutch Airlines), LOT (Polish Airlines), Malev (Hungarian airlines) and SvietAero (Ukrainian Airlines). Within the scope of our research, we issued questionnaires to:

- Airline managers and executives; to seek their opinions about the pricing decision support systems
- Clients; to seek their opinions about their experiences buying airline tickets

The research is based on the requirements of effective pricing strategy and its implementation evaluated from the pricing analyst (PA) point of view. The PA's role within an organization is to prepare and justify pricing decisions for pricing managers (PM). Based on PA's recommendations, PMs decide on price changes. The key criterion for this decision is profit optimization; the key success factor is a flexible pricing strategy.

In this article, we will prove the following two hypotheses:

H.1 The complexity of airfare pricing and distribution systems requires the use of IV Generation MIS systems.

H.2 The use of IV Generation of MIS system increases airlines' BV.

The hypothesis H1 is proved based on the research of pricing procedures in presented airlines. Hypothesis H2 will be illustrated by a specific example of a BV calculation in the context of Generation IV MIS.

In summary, we can say that the main thrust of this article is the analysis of decision-making processes and their control in the airline pricing industry as well as the role of MIS. As mentioned earlier, these findings can be applied to a wide spectrum of service distribution and their pricing strategies.

SELECTED THEORETICAL FOUNDATIONS OF MIS USED FOR DECISION-MAKING PROCESS IN AIRLINE PRICING

In order to achieve significant benefits from this class of systems, the design has to support flexible pricing strategy: pricing analysts need to have the capacity to easily access relevant information, have tools that support their analysis and

decision making processes, and allow for effective distribution of price changes through many sales channels. This implies that the MIS system needs to provide a complex set of tools and techniques ranging from typical transactional applications to simulation models and DSS functionality.

We can categorize the various MIS application based on their complexity using the concept of the MIS generation [D. J. Power - 2002]. The industry uses various methods to classify MIS; the most common are classifications presented by: E. Turban, J.E. Aronson, Ting-Peng Liang [2004], and K.C Loundan J. Loundan, [2006].

To classify MIS systems used to support the implementation of pricing strategy in airline industry, we applied a classification method that includes both hardware and software criteria and well as business functions [J.Kisielnicki, -2005].

Generation I – A database-supported transactional system used for reservations, sale of airline tickets, and inventory management.

Generation II – A database-supported on-line transactional system used for reservations, airline tickets sales, and inventory management. Also includes sales monitoring functionality and revenue management for each individual flight in a given time period.

Generation III –A Generation II system that also includes modules allowing for benchmarking an airline against the competition. This system would include a statistical modeling tool allowing for trend analysis, forecasting, etc.

Generation IV –A Generation III system that also includes modules allowing for the implementation of a pricing strategy based on probability, knowledge database, and heuristic methods to obtain an optimal profit from each sale.

Recommended MIS is a Generation IV system that includes the following elements:

Data warehouse, as an element of Generation IV MIS system, would incorporate historical, current, and future airfare information such as price, rules, flight information, fare class, where the sale originates, etc.

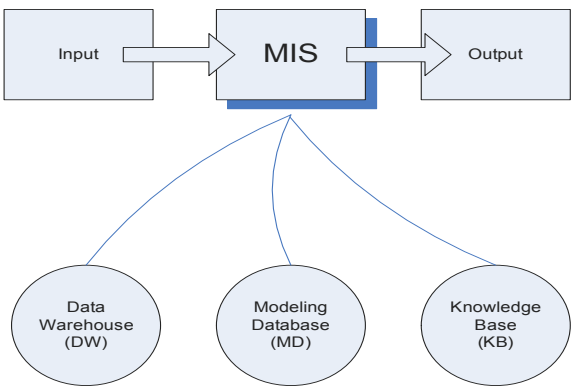
Modeling database would include yield management algorithms helping with the following decisions:

1. What price should be set for the next sold ticket; using marginal calculus models
2. What combination of prices will bring an optimal profit/revenue for each flight; using optimization and simulation models

In addition, the models would include the elements of risk assessment (for example: how many group tickets could be sold on each flight; the probability of groups returning their tickets; could the returned tickets be resold, etc.).

Knowledge base would include information about the competition, financial results of earlier promotions, etc.

Figure 1. Elements of generation IV MIS system used for pricing decision support in an airline industry



Source: Personal research

MIS itself uses all price changes as in input, and converts them – using all three supporting elements (DW, MD, and KB) – into new airfares.

Where a sophisticated MIS does not support pricing decisions, airlines are not able to establish a competitive price. Thus:

1. The airline is loosing revenue if its price is higher than the competition; plane flies empty
2. The airline is loosing profit if its prices are too low

A well-designed MIS allows for fast access to relevant data, correct pricing decisions, and effective distribution of pricing changes to travel agents, web sites, local airline offices, etc. All three elements are critical to a successful pricing strategy and its implementation.

Our hypothesis that the Generation IV MIS are required for the effective management of pricing policy was confirmed by the results of 20 interviews carried out amongst managers and executives (of airline companies) who attended the MBA program at Warsaw University. 16 interviewees, when asked for the characteristics of the adequate pricing decision support MIS, described the Generation IV MIS. Two of them described the Generation III and two described the Generation II.

Also of interest are customers' opinions about the quality of information available from the airlines. The questionnaire issued to the research sample of 80 graduate MBA students[1] of Warsaw University and the University of Trade and Law in Warsaw indicated that 80% were unsatisfied with the service provided by the travel agents and airline local sales offices. The key reasons were partial and unconvincing information about the tariffs and all associated rules (cancellation, changing dates, upgrades, etc.). While not all the blame can be put on the IT, airlines with complete and trustworthy information about their flights available through all sales channels will have better financial results than their competition. Without sophisticated calculations, we further state that this would lead to an increased BV.

ROLE OF A PRICING ANALYST AND MIS IN AIRFARE PRICING PROCESS

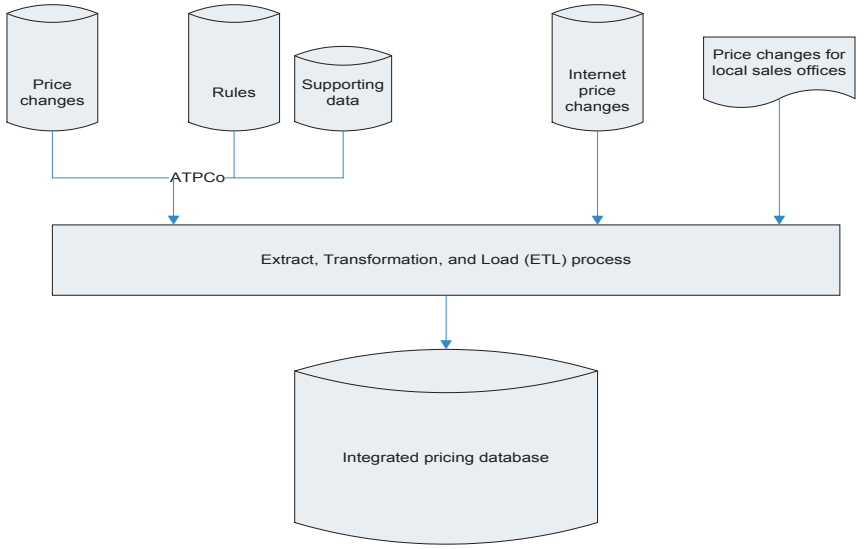
Pricing information in the airfare pricing process is both an input and an output. The output decides if an airline's pricing strategy is effective.

Is my price competitive? This is the key question that pricing managers as well as airline executives ask themselves every day. The Internet created a price transparency unheard of in the past. Every client, even if he buys his ticket from a travel agent in the end, checks the Internet first. Moreover, the competition is only a mouse-click away. This environment punishes uncompetitive airlines very quickly. In our context, uncompetitive airlines are those that do not react (i.e., analyze changes, decide on pricing changes, distribute the new price) to market changes quickly and accurately. Without a decision support system airlines would have to employ a high number of pricing analysts at a high cost and without a guarantee that they would find all the relevant pricing changes, recommend the right decision, and distribute price changes to all sales channels. Effectively, most airlines accept a compromise between costs and benefits; they employ fewer pricing analysts and in return have delayed and imperfect reactions to the competitors' pricing changes.

Generally, it is understood that designing a pricing strategy (for both products and services) requires creativity. Changes in consumer market trends, macroeconomic changes, market segmentation, airline revenue, and profit force pricing analysts to constantly monitor the effectiveness of current pricing strategy and make (timely) adjustments. Consistent maintenance of effective pricing strategy is not a simple task – the most common trap is a straight pricing competition that not only hurts the individual airline but the industry as a whole.

In addition, pricing analysts need to review several hundred daily price changes using very primitive transactional applications just to find out what is happening on the market. Currently, applications available in the researched airlines do not have mechanisms to tailor all price changes to the needs of individual analysts, do not provide decision support functionality, and are not connected to the price changes distribution systems. Hence, the necessity of employing an army of pricing analysts who sift daily price changes, make decisions (or recommendations) based on their own knowledge and experience, and pass it to another department for distribution. To mitigate the costs, airlines outsource data entry tasks (required for distribution) to countries like India where salaries are much lower, almost

Figure 2. Key element of the IV generation MIS specialized in pricing changes analysis



Legend:

ATPCo – Airline Tariff Publishing Company is the key source of market changes; it distributes all airline tariffs to all companies that buy their subscription. ATPCo distributes prices, rules, and various supporting data (code tables for countries, cities, airports etc.) ATPCo sends all changes five times a day during a week and twice a day during weekends.

The Internet price changes can be automated using screen-scraping techniques. Most airlines however are still using manual processes to monitor the Internet price changes.

Price changes originating from local sales offices (LSO) can also be automated using the workflow management process techniques. Most airlines however are still using manual processes to submit price change proposals and issue approvals.

The ETL process accesses source data, formats them, and updates the integrated database used by pricing analysts to monitor changes.

Source: Personal research

everybody speaks English, and the relatively high percentage of workforce has been educated in the UK. The time difference is also an advantage to European airlines: when their working day comes to a close and all their pricing changes are ready for distribution, staff in India begin their working day and initiate the distribution process.

In most airlines the entire process is supported by IT, but only on a transactional level (Generation I and II). To provide fast sometimes instantaneous - reactions to the market changes, airlines need a Generation IV MIS. The application of MIS would significantly help with pricing analysis, decision making, and distribution, allowing for a precise and fast response to pricing changes. MIS would integrate all sources of price changes; tailor the price changes to pricing analyst markets, and aid in decision-making processes. Figure 2 presents the key elements of such a subsystem.

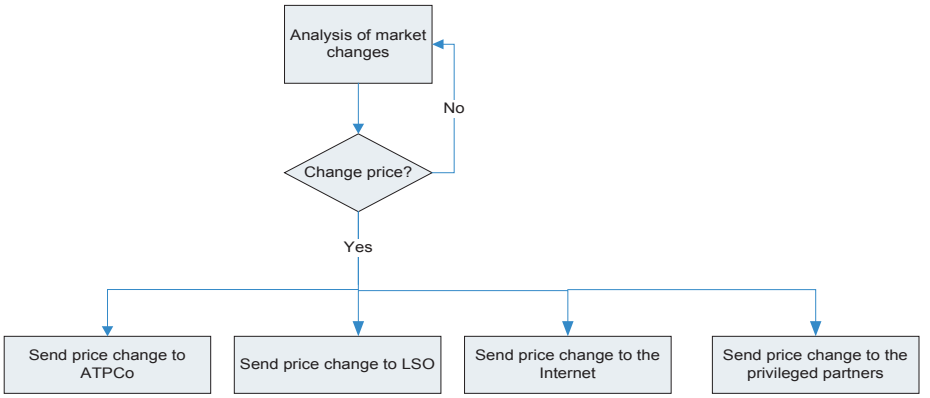
One of the key reasons to use the Generation IV MIS is the sheer volume of fares stored in the integrated database. Our research indicates that in any given moment there are approximately 200 million tariffs (this includes ATPCo distribution and SITA distribution directly to the Global Distribution Systems). Loew [2004]. The number of changes made each year is estimated at 1 billion. Loew [2004].

In addition to airfare price changes, there are also airfare rule changes that influence customers' buying decisions: ticket return policy, length of stay, travel dates and travel dates changes, etc. The number of rule changes is estimated at 1.5 million a year.

The decision making and distribution of the Generation IV MIS supporting the pricing management in airline industry is presented below:

To illustrate the challenges facing airlines, a hypothetical airline company MyAir will be used (the need to use a hypothetical airline is due to the fact that the researched company did not agree to release its data as it would provide a competition insight into its operations). Let us assume that MyAir owns 50 aircrafts, has an annual revenue of $1 billion, and operates on 10 000 markets (where a market is defined as an individual flight, for example London-NYC; the flight NYC-London would be a separate market). Let us further assume that MyAir makes approximately 1 million price changes a year and analyses approximately 5 million price changes issued by other airlines. This translates into reviewing 13 700 prices and rule changes every day (assuming normal distribution). Every delay in MyAir response would mean either revenue loss (if prices are too high) or profit loss (if prices are too low) Loew [2004].

Figure 3. Decision support and distribution of price changes processes in generation IV MIS



Source: Personal research

Table 1. Sample set of prices and rules associated with a booking class. This information is sent for each airline, market, travel date, purchase place etc.

Class	Price	Rules
Business Class	pP-(1) P-(N)	R1 Rs
Economy Class	P (N+1) RmP (M)	R1 Rw
Economy Plus	P(M+!) Rk P(K)	R1 Rp

Legend:

P – price of a ticket in a given booking class

R – rules associated with a booking class and ticket price

Source: Personal research

Every airline can change prices and rules five times a day for every market and any future dates. Additionally, normal distribution does not really happen: airlines can change 30% of their prices in a single filing, make only minor adjustments for quite some time or suddenly make drastic changes. Since there is no legislation on how far in advance the price or rule changes can occur, there is no way to predict when the high volume of these changes might arise.

It is also important to understand that not all price changes are equally important. It is estimated that each airline has 90% of revenue from 1% of its markets. Therefore prioritizing markets and price changes is critical to the effectiveness and efficiency of price changes monitoring.

An additional challenge that airlines face is monitoring rule changes. Every airfare is a combination of its price and associated rules. Table 1 presents the illustration of airfares and relationships between prices and rules.

The pricing process is completed in four stages:

Stage 1: Monitoring Competitors' Pricing

The monitoring of competitor's pricing is an ongoing task. Pricing analysts have to check the price changes of competing airlines at least twice a day on each market. They use the integrated pricing databases presented in Figure 2. While market changes could trigger a potential price change, the evaluation of current pricing does not happen in isolation of internal influences. Every price change needs to go through analysis in three internal systems:

1. Revenue accounting
2. Reservation system
3. Yield Management

Stage 2: Monitoring Competitors' Airfare Rules

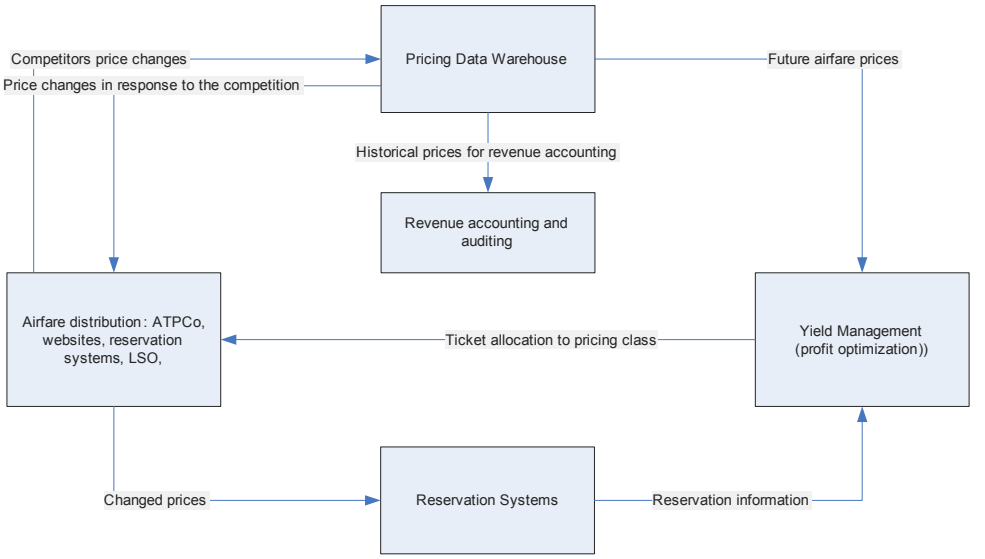
Since airfare pricing is influenced not only by the dollar amount but by rules as well, every pricing analyst has to review the changes in rules. The relationship between airfare and rules is complex: each airfare has multiple rules and each rule is linked to multiple airfares. The analysis of this relationship is not straightforward. As an example, let us use an airfare from London to NYC offered for $1,050 with a condition that a passenger will not stay in NYC on Saturday. The same airfare from London to NYC is offered for $850 with a condition that a passenger will stay in NYC on Saturday. At a first glance, this pricing difference does not seem logical; after all, the cost of the flight is the same regardless where a passenger will be on Saturday. However, this particular rule has been used for market segmentation: most business travelers want to come home before the weekend, while people who go for vacation typically want to spend a weekend at their destination. Therefore, a change in a rule saying that airfare from London to NYC is the same regardless of the length of stay in NYC means that the price for business travels has dropped by $300. Since the rule might affect more that one market, pricing analyst needs to carefully review all rule changes, associate them with all airfares, and then review the impact of the changes.

Changes in rules are as important as changes in prices; with one rule change such as in the example given above, competitors can change thousands of airfares in one filing. Table 1 presents that the relationship between airfares, prices, and rules is further augmented by the risk assessment as well as revenue/profit simulation to predict financial results of price changes.

Stage 3: Pricing Decision

An airline typically has many pricing managers, each responsible for a set of markets or market segments. The pricing manager receives recommendations for all of them on a daily basis, assesses each change in tactical and strategic context, and approves or rejects the change.

Figure 4. Data flow between internal systems using current and proposed prices



Source: Personal research

Stage 4: Price Change Distribution

Once a new set of prices is approved, it has to be distributed to all sales channels. Each airline has several distribution channels (refer to Figure 3): ATPCO or SITA (the main ones), LSOs, airlines' websites, travel agencies throughout the world, their websites, various privileged partners, etc. The importance of sales through an airline's own web site grows since the overall cost of such sale is much lower: there are no intermediate costs and all tickets sold by the Internet are e-tickets (less expensive than traditional paper tickets).

Worldwide distribution adds extra complexity to airfare pricing: the price is different depending on where the sale is taking place. For example, the return ticket Johannesburg-NYC-Johannesburg bought in Johannesburg will be less expensive than the same return ticket NYC-Johannesburg-NYC bought in NYC, because tickets bought through the Internet are priced based on the place of departure. In addition to the base price, pricing analysts need to take into account local taxes, airport fees, agents' commissions, etc. Moreover, all price changes have to reach all sales channels at the same time.

Price changes to the LSO are typically distributed via email, fax, or a telephone. While it is a fast and effective solution it is a short-term one. In the long term, airlines struggle with controlling this process and ensuring that price changes requested by the LSO are properly analyzed, evaluated, and decided upon.

Theoretically, yield management can mitigate pricing errors. Let us use the MyAir example: MyAir has a plane with 100 seats and these seats are divided into five pricing classes: very expensive, expensive, average, cheap, very cheap. Each of these pricing classes has allocated 20% of all seats. The yield manager monitors daily reservations and depending on the progress and various risk factors changes the seat allocation in each class. If very expensive airfares are selling well, the yield manager will increase the allocation in this class to 25% and will decrease the allocations in other pricing classes. If the very cheap tickets are selling fast, the yield manager might close this class altogether and allocate remaining tickets to the other classes. One of the risk factors that the yield manager also takes into account is group tickets: these should be less expensive if it was not for the risk of return. Typically, yield managers do not advise to have more that one group in each flight. Regardless of how well yield managers optimize the pricing of remaining seats, they act after the sales/reservations have been made – the lost revenue and lost profit due to inadequate original pricing cannot be recovered. It can only be adjusted for the future.

Yield managers rely heavily on IT support; to arrive at the best balance of prices in each class, they use a combination of marginal economical models, simulation, and optimization techniques.

An example of a costly pricing error made by a low-cost carrier was setting a promotional price for Warsaw-London market at Euro 1. The intent was to start at a very low price and then raise it. At the same time, BA started its promotion and was selling its tickets at a price lower than the low-cost carrier. The low-cost carrier was not able to recover the losses incurred during the Euro 1 promotion and effectively could not compete with BA. As a result, during the July-August vacation season, the low cost carrier lost Euro 100K in this market alone.

THE INFLUENCE OF PRICING DECISION SUPPORT SYSTEMS ON COMPANY'S BV

There are many different approaches in evaluating BV: how each department contributes to the company BV, what the reasons of growth or decline of BV are, etc. In this section we will present how IT, and specifically Generation IV MIS, influences BV. Even though our research indicated that IT significantly influences the BV, we can not derive precise and scientific function that defines this dependency. Therefore this part of the article is a CASE study; we will identify the influence of the Generation IV MIS on the passenger airline company's BV. The term BV, as mentioned earlier, represents both tangible and intangible assets of a company. It is also an important indicator of its market value. Since the assessment of a BV is complex, there are many methods of defining and calculating it E. Brynjolfesson, L.M. Hitt, [2003], Remenyi, D., A. H. Money, et al. [2000] P.A.Strassmann, [1990, 1999]. In literature, in addition to the BV, the use of "goodwill" of a company quite common G. Jones, N.J. Morgan, [1994] A.H. Millichamp, [1997]. Generally, we understand the BV of a company is a difference between the company's assets and its liabilities. The analysis and evaluation of different approaches to defining and calculating BV is not in scope of this article.

The results of using Generation IV MIS and its effect on a company's BV are presented in the Figure 5. The relationships between the investment in such MIS and BV benefits is defined based on the analysis of the Generation IV MIS for our hypothetical airline company MyAir.

Let us assume that MyAir has annual sales of $140 million (daily sales of approximately 4 million). The investment in IT in 2004-2005 was approximately 25 million (infrastructure and operational costs are not included). 80% (16-18 million) of this cost was spent on the new Generation IV MIS.

In this article, we used the estimates of future revenues as an indicator of BV. From this potential revenue we subtract labor costs (including professional development of pricing analysts), marketing, research and development costs required to maintain competitive edge in IT, and higher taxes incurred as a results of increased sales. We state that a company can generate additional sales due to effective and efficient IT including the Generation IV MIS.

The influence of Generation IV MIS is calculated according to the following formula:

$$BV = (P\text{-}aP) – W.$$

Where:

- BV – annual increase of company's value due to the use of IV Generation MIS ($).
- P – annual increase of company's revenue achieved due the improved pricing processes (S).
- a – indicator of the effectiveness of pricing analysts using lower generation MIS.
- W –implementation costs of IV Generation MIS ($).

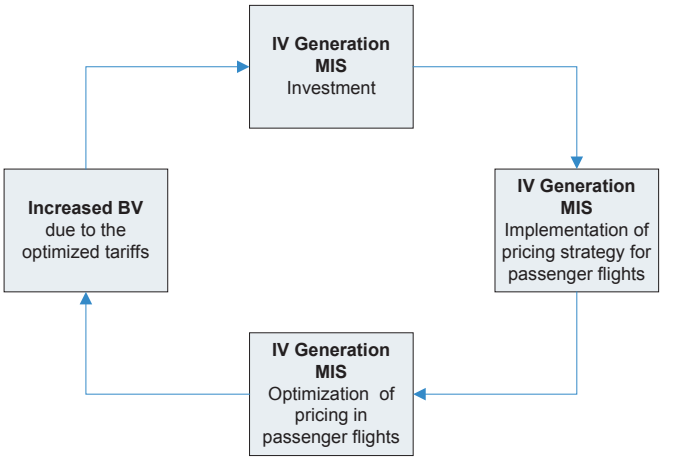
Let us assume that MyAir looses approximately $100 000 daily ($30 million annually) due to an ineffective pricing policy. In addition, MyAir looses between 2%-5% revenue ($20-50 million) due to the late responses to competitors' price changes. Using the above equation, we have:

- P=$50-80 million annually
- a is estimated at 0.7 –0.8
- W = $16-18 million

Year 1: BV is between 0 to 6 million; Generation IV MIS will pay for itself.
Year 2: BV is between $16-25 million

Based on the estimated cost of MIS and revenue, we see that the costs of the IV generation MIS will be paid off during the first year of its operations.

Figure 5. Dependency between the investment in MIS and BV



Source: Personal research

AMR research estimates that airline companies that consider pricing management as a key element of its strategy have 10% increase of revenue [Scott 2003]. Based on our research, the revenue increase depends 70% on the qualification of pricing analysts and 30% on the IV Generation MIS.

CONCLUSION

In this article we presented the complexity of airfare pricing and pricing distribution, included estimated volume of transactions and data, and indicated how investment on IV Generation MIS increases airline BV. We estimated that at any given moment, there are approximately 200 million airfares and the annual number of price changes is 1 billion. Therefore, in order to maintain effective, efficient, and flexible pricing strategy, airlines need to use sophisticated IT solutions. Based on our research (questionnaires, interviews, analysis of several airlines, and literature), we state that the Generation IV MIS meets these requirements. In addition, the Generation IV MIS directly influences airline BV, and even the significant cost of the IV generation MIS implementation is returned within one year. Paraphrasing Mark Twain, we can say that Carr's forecasting of the diminishing role of IT is highly exaggerated and certainly does not apply to the passenger airline industry.

BIBLIOGRAPHY

E. Brynjolfesson, L.M. Hitt, [2003], Computing Productivity: Firm – Level Evidence, MIT Sloan Working Paper No.4210-01 (June)

Carr, N. G. [2004], Does IT matter? : Information technology and the corrosion of, competitive advantage. Boston, Harvard Business School Press.

G. Jones, N.J. Morgan,[1994] Adding Value, Routledge, London - New York, p.. 80

J.Kisielnicki, H.Sroka, [2005], Business Information Systems, Placet, Warsaw

J. Loew [2004], Draining the Fare Swamp, Journal of Revenue, and Pricing Management Special issue IATA Revenue Management and pricing conference. Vol. 3, April p.5

K. J. Loundon, J.P. Loundon [2006], Management Information Systems- Managing the Digital Firm, Pearson Prentice Hall, New Jersey

A.H. Millichamp, [1997], Finance for Non-Financial Managers, Letts Educational Aldine Place, London, p. 195

D. J. Power ed. [2002], Decision Support Systems: Concepts and Resources for Managers, Quorum Books division Greenwood Publishing

Remenyi, D., A. H. Money, et al. [2000. The effective measurement and management of IT costs and benefits. Computer weekly professional series. Oxford; Boston, Butterworth-Heinemann

K. Scott [2003], Driving demand profitable with, pricing, AMR research

P.A.Strassmann, [1990], The Business Value of Computers, Pub. Strassmann, Inc.

P.A.Strassmann, [1999], Information Productivity, Pub. Strassmann, Inc.

P.A.Strassmann, [2004]. Squandered Computer, Pub. Strassmann, Inc.

E.Turban, J.E.Aronson, Ting-Peng Liang [2004], Decision Support Systems and Intelligent Systems, Prentice Hall,

Van Grembergen W. [2004], Strategies for Information technology Governance, IDEA Group Publishing,

K. Scott, [2003] Driving Demand Profitably with Pricing, AMR Research

ENDNOTE

[1] 25% of the sample had more than 5 flights in a year, 60% has between 3 to flights in a year, and 15% had 1 or 2 flights in a year.

Study on How Service Usefulness and Privacy Concern Influence on Service Acceptance

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ABSTRACT

As the highly improved Internet and information technology has led to the diversification of users' demands, personalization service attract lots of attention as a means to meet highly diversified demands of users. However, personalization service costs a lot. Also concerns over a possible violation of privacy have been raised since the service uses technology to find out the users' profiles. This research studies the advantages individuals acquire from personalization service and how privacy concern influences service acceptance. Research on related documents and information gathering from e-commerce sites derived six representative types of service. Questionnaires were utilized to research privacy concern according to services, service usefulness, and service acceptance. As expected, privacy concern has a negative relation to acceptance while service usefulness has a positive relation to it, thereby resulting in an offset between two variables. Moreover, they play a different role depending on what kinds of service or information should be provided. The results derived from this paper will help the e-commerce sites provide personalization service by collecting personal information while protecting users' privacy.

Keywords: Personalization, Personal Information, Privacy Concern, Service Usefulness, Service Acceptance

1. BACKGROUND AND OBJECTIVES

During a recent decade, the development and wide spread of Internet has made that technology be part of our everyday life. Such advance has also led to a diversification of users' demands and an increase of their buying power. Thus, to gain more customers, a wide range of service should be provided. Toward the ends, most companies are striving to utilize Internet more effectively.

Considering further developed e-commerce and Internet, the businesses' dependency on the Internet must have increased as well.

Lately, personalization has been under the spotlight as an effective way to attract more customers by satisfying their various needs. Among them, personalized websites by engaging in a one-on-one marketing have been proved successful in eliciting customer loyalty(Kim Myung-Hee, 2003).

However, there are some barriers to personalized Internet service through websites, such as, technological problems or possible privacy violation.

So, the potential of that service has not been fully realized except few cases, like My Yahoo.

This paper primarily addresses a possible balance between personalization and privacy since personalization service requires gathering of users' private information. Also it seeks to document the specific services of personalization and how privacy concern responds to each.

2. THEORETICAL BACKGROUND

2.1 Definition and Characteristics of Personalization

According to Allen , Kania and Yaeckel, personalization means providing goods and services personalized to the users' specific needs(Allen, Kania and Yaeckel, 1998). To do this, finding out users' particular requirements is essential, which is the same with collecting their profiles. In the past, information was derived from personal data provided by the user himself.

Recently, however, more specified and various personal profiles can be obtained through more sophisticated frameworks, such as, search engines, site transaction logs, cookies, shopping carts, and forms. Search engines can profile the opinions stated by a user in the news, chatting groups or other official online forums, thereby compiling his social and political standpoints. Site transaction logs collect and analyze specific information on the pages that the user visits. Of the most popular use are cookies, which track down personal information over a single websites or thousands of ones, and of which technology is advancing each day.

2.2 Effectiveness of Personalization

Peppers and Rogers(1994), and Rogers stated that personalization is an important factor in a success in a newly structured e-commerce market. Personalization is also an effective means to elicit customer loyalty, thereby, obtaining a competitive. Merits of personalization do not stop there. From a user's standpoint, he can save time to search the information and also has a wide array of options available to him(Allen, Kania and Yaeckel, 1998).

Despite some negative opinions on the personalization, a survey conducted by one American research firm revealed that American Internet users are willing to provide their private information as long as the website does not use it for other purposes or disclose it without his explicit consent(Kevin Mabley, 2001).

According to the survey by Intelliquest, more than a half responded that personalized service is the very reason for visiting a certain website. 56% said that the service is interesting while 54% said it attracts their attention. 53% said that the service is very useful, and 45% responded it provides the needed information.

As such, personalization draws users' attention as well as saves time and cost in exploring information, thus, is of much value to users. To sum up, the wide spread use of personalization is expected.

2.3 Definition of Privacy and Private Information

The concept of privacy first came up in a book, *"The Right to Privacy,"* by Samuel D. Warren and Louis Brandeis(Samuel Warren and Louise Brandeis, 1890). They defined privacy as 'a right to be alone, not disturbed by anyone.' Since then, with the development of Internet, there have been worries over a possible disclosure of private information to a third party, and a subsequent violation of privacy. Accordingly, the concept itself has been evolved to 'an active right to prevent others from acquiring personal information.'(Bang Seok-ho, Kim Eun-

Ki, Kim Jin, 2001). Currently, the concept, privacy is defined in a legal term as follows; supremacy of private life and inviolability of freedom is a right not to be disclosed of personal life; a right to protect and control personal information; a right whose protection is in an urgent need as informationization of the society is rapidly progressing.

Usually information contained in privacy is the information about a living person, and its contents would include personalized symbols, words, sound, or multimedia approached by a name or a social security number(Kim Jung-woo, 2001).

3. HYPOTHESES, FRAMEWORKS AND METHODS

3.1 Hypotheses and Frameworks

The most difficult obstacle in realizing personalized service is the problem s related to privacy(Allen, Kania and Yaeckel, 1998). Such problems are arisen because while personal information makes possible personalized goods and service, depending on the purposes of its usage, it can also pose a threat to the user himself.

Kenneth claimed that the main issues concerning privacy are: what kinds of personal information is being collected for what purposes; who did the gathering?; whose information is being subjected?; how much the collected information is being utilized(Kenneth C. Laudon & Carol Guercio Traver, 2002). These issues have been spawn a variety of opinions since sellers and buyers of personal information are taking a different view. Kenneth said that sellers claim that collecting personal information leads to target ads for specific users, thereby helping them explore goods and service that they would find interesting. In addition, businesses can save expenses since they can narrow down the target customers. Then, the industry, as a whole, can increase the effectiveness of advertisements, and the increased profits will go to service improvement in the form of free-of-charge online contents. Also, businesses can predict demands on new goods and services by surveying profiles and history of online activities of users.

On the other hand, some people claim that gathering private information of users not only damages their expectations for privacy during they are on-line but also discourages them from searching sensitive or controversial issues or websites. Most important, users do not know that they are being profiled, and companies are reluctant to let them know. In fact, it is so easy to collect information anonymously and to change information about collection policies without any notices to users.

The most problematic issue over privacy protection is a virtual absence of users' control over their private information. As a countermeasure, some countries are setting up a number of protection mechanisms. In many countries, for instance, e-commerce law stipulates that individual consent be required to gather personalized information.

A study which hypothesized that the lower control over information would lead to highly violated privacy showed that people who think they have power over the usage of their information perceive less requiring privacy. Another study showed that the less power over their information led to more negative attitudes towards the secondary usage of the information (Kim Eun-kyung, 2003).

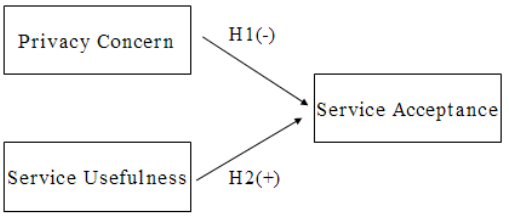
When information is being utilized for secondary purposes without a consent, privacy is being violated (Culnan M.J. and Bies, R.J., 1999). And privacy concern is alleviated when information is being collected for the first purpose, when users retain control over the future usage of their information, when the utilized information is related to the e-commerce that she engages and when information is used in appropriate survey on users.

Adding all these previous results, we can derive our first hypothesis.

H1. Concern for privacy of personal information will have a negative effect on service acceptance.

Laufer and Wolfe concluded that individuals do not willingly disclose their information unless it will be utilized in a fair and positive way to promote their economic and social benefits (Laufer, R. S., & Wolfe, M., 1977). Moreover, previous studies have indicated that two seemingly contradicting sides of information disclosure, gains and potential threats, are balanced (Delega, V.J., Metts, S., Petronio, S., & Margulis, S. T., 1993). That is, people would disclosure their information as long as such act would be reciprocated, which is when gains would surpass potential dangers (Thibaut, J., & Kelley, H. H., 1959).

Figure 1. Framework



Such information exchange in the society also applies especially when users believe in an analysis of cost-benefit. Under that principle, people will give up privacy of their private information when such act would give them benefits, especially when the potential value exceeds potential dangers. However, this presupposition has not been empirically proved under different scenarios of privacy-benefit trade-off cases (Culnan, M.J. and Bies, R.J., 1999). So, the following hypothesis is drawn.

H2. Service usefulness of personalized service will have a positive effect on service acceptance.

3.2 Methods

To confirm the aforementioned hypotheses, previous studies were used to find different types of online personalized services. In Allen et al.'s study, it is divided into 5 types of personalization: Personalized Experience, Personalized Information, Personalized Care, Cross & Up-Selling, Personalized Community. Another studies suggested 4 different types of personalized services: visiting and inquiring after someone´s health, differentiation of web pages and auto-updating about interest contents, and personalized information into providing information reflected user's inclination and providing recommended information and so on(Kim Jonh-won, 2001). Based on the previous research, we restructured the services into six personalized services: greetings, customized pages, notices for credit card payments, customized according to users' tastes, introducing goods in tune with users' past purchases, service in need of a wide range of personal information.

Date is collected through questionnaires surveying 139 persons of whom males are 86(56.6%), females 53(43.3%). For the age, below 24 are 14(10.1%), 25 through 34 are 107(77%), and above 35 are 18(12.9%). Occupations are divided into four groups; college students 73(52.5%), administrative positions 37(26.6%), specialists 25(17.8%), and none of the above 5(3.1%). Questionnaires have a scale of one to seven with 12 questions which are divided into five sub-questions. From question number 1 to 6, privacy concern is measured, while from number 7 to 12, service usefulness and service acceptance are surveyed. For each personalized service, required personal information for service is derived. Then privacy concern for the service was asked for the most private information for the service. For instance, the service 2 is about the personalized web front showing current stock prices of interest. To service this, information such as log-in and Favorite stock information is required. Then the privacy concern question was asked for the favorite stock information.

4. RESULTS AND IMPLICATIONS FOR FUTURE STUDIES

4.1 Results

To analyze the results, the average points of six types of service are drawn first. Through this, how the respondents rate each service on privacy concern, service usefulness, and service acceptance is derived. As a result, among six kinds of service, the highest one in privacy concern turns out to be the one which requires monthly income, social security number, and workplace contact number.

On service usefulness and service acceptance, service that provides information about favorite stocks is rated the most useful one.

To analyze a casual relationship among two independent variables, privacy concern, service usefulness and service acceptance. Table 2 shows that the results of multiple linear regression. The following. R square for greeting service is 0.496, indicating that privacy concern is not much related to service usefulness and acceptance.

Table 1. Average points for each service

Information	Service (1~7 points)	Privacy Concern	Service Usefulness	Service Acceptance
Log-in, Name	[Greetings] On your website, "Hello, 000. Good morning" Such service requires your name on the page.	5.15	3.17	2.95
Log-in, Favorite stock information	[Customized web page] On your website, Samsung Electronics 493,000(from yesterday 2,000▼), SKT 180,500(from yesterday 1,000▼) This service provides you with favorite stock information. Such service requires an input of your favorite stock (company name).	5.14	4.91	4.56
Log-in , Credit Card Number, Credit Card Payment Day	[Notice for credit card payments] On your website, "Mr./Ms. OOO, two days are left for OO card monthly payment. Do you want to do it now? Such service requires you to give your credit card number and payment date to an website.	5.56	4.06	3.58
Log-in, Favorite Sports Team	[Customized service according to users' tastes] On your website, "News for today's match between FC Seoul and LG Twins" This service gives you latest information on your favorite sports team. Such service requires you to provide your favorite sports team information with the website.	4.59	4.40	4.16
Purchase History (Name , price, date of purchase)	[Introducing goods in tune with users' past purchases] 'Mr./Ms. OOO, A new book on Toeic by OOO has just released. Do you want to find out more information? This service analyzes your past purchasing pattern and recommends you other goods. Information of your purchasing history, price and date is required for such service.	4.85	3.99	3.68
Monthly Income, Social Security Number, Workplace Contact Number	[Service in need of various personal information)] "Mr./Ms. OOO. We will compare your current monthly insurance payment with a new insurance without dividends for singles." This service recommends goods in accordance with your information. Such service demands an input of social security number, monthly income and workplace contact number.	5.68	3.10	2.47

For the customized web page service, R square is .668, however, privacy concern, which is -0.95, does not affect much on service acceptance.

As in the case of the notice service for credit card payment, R square is .646; privacy concern -.170; service acceptance .884. This implies that privacy concern has a negative relationship with service acceptance while service usefulness has a positive one with it. Similar probability is also .000 for service usefulness, .047 for privacy concern, implying a highly reliable result.

For the customized service according to users' tastes, R square is .695; privacy concern, -.168; service usefulness, .970. This means that privacy concern has a negative effect on service acceptance while service usefulness has a positive effect on it. Similar probability is also .000 for service usefulness, .009 for privacy concern, indicating a highly reliable result.

Service introducing goods in tune with users' past purchases has .670 R square, -.077 privacy concern, and .929 privacy usefulness. Such result means that service usefulness is positively related to service acceptance while privacy concern is negatively related to it.

For service in need of various personal information, R square is .618; privacy concern -.139, service usefulness .839. This says that while privacy concern has a negative effect on service acceptance, service usefulness has a positive effect on it. Similar probability is .000 for service usefulness, indicating reliability, however, privacy concern records .056, a much less reliability.

Lastly, a result analyzing a relationship between the average for privacy concern and service usefulness and service acceptance on each six types of service is followed as: R square .694, privacy concern -.153, and service usefulness .932.

As such, for all the service and its subsequent collection of information, privacy concerns have a negative effect on service acceptance while service usefulness has a positive effect on it. In sum, in the remaining service except the ones for greetings, favorite stock information, and introducing goods in tune with users' past purchases, privacy concern is negatively related to service acceptance. Moreover, service usefulness is positively related to service acceptance in all above six types of service.

4.2 Implications for Future Studies

This paper is limited in a number of ways: the samples are not representative in a matter of age, restricting only in 20s and 30s; they are also highly educated people with college degrees, at the very least; a sample of 139 persons is also unrepresentative; only six types of online services are surveyed while there are countless numbers of available service on the Internet; the implication of this research is limited only on the current e-commerce. There is no guarantees for the coming online trades, such as, m-commerce or u-commerce.

Thus, studies on various markets (e-commerce, m-commerce, and u-commerce) as well as on a wide variety of people, age groups, and education, for the sake of much improved data reliability, are needed.

Table 2. Results of multiple linear regression coefficient

Information / Service	R Square	Non-standardized coefficent B		T	Similar probability
Log-in, Name [Greetings]	.496	(Constant)	1.03	2.18	0.31
		usefulness	.747	11.4	.000
		privacy concern	-.086	-1.12	.265
Log-in, Favorite stock information [Customized web page]	.668	(Constant)	.324	.685	.494
		usefulness	.962	16.5	.000
		privacy concern	-.095	-1.31	.193
Log-in , Credit Card Number, Credit Card Payment Day [Notice for credit card payments]	.646	(Constant)	.938	1.58	.116
		usefulness	.884	14.6	.000
		privacy concern	-.170	-2.20	.047
Log-in, Favorite Sports Team [Customized service according to users' tastes]	.695	(Constant)	.654	1.72	0.88
		usefulness	.970	17.5	.000
		privacy concern	-.168	-2.65	.009
Purchase History (Name , price, date of purchase) [Introducing goods in tune with users' past purchases]	.670	(Constant)	.347	.855	.394
		usefulness	.929	16.4	.000
		privacy concern	-.077	-1.12	.233
Monthly Income, Social Security Number, Workplace Contact Number [Service in need of various personal information)]	.618	(Constant)	.663	1.47	.144
		usefulness	.839	14.8	.000
		privacy concern	-.139	-1.93	.056
All of the above	.694	(Constant)	.689	1.97	.051
		usefulness	.932	17.4	.000
		privacy concern	-.153	-2.86	.005

10. REFERENCES

[1] Kim Myung-Hee (2003). A study on the effects of user satisfaction and loyalty on the perceived personalized services.

[2] Kim Eun-kyung (2003). Consumer attitude research on personal information the second use.

[3] Kim Jung-woo (2001). Law main contents and enforcement way on Information network system utilization advancement and information protection etc. No. 6 Information protection symposium.

[4] Kim Jonh-won (2001). Consumer Reaction Research on Personalization and Mutually Action. A master´s thesis, Yonsei University.

[5] Bang Seok-ho, Kim Eun-Ki, Kim Jin (2001). Research on privacy protection countermeasure that prepare to information society. Korea Information Society Development Institute.

[6] Allen, Kania and Yaeckel (1998). Internet World Guide to One-to-one Marketing. Wiley Computer Pub, New York.

[7] Christopher Kresser (1996). Special focus: web business models: Building "Webcentricity". Jupiter Communication 1996.

[8] Culnan M.J., Bies, R.J. (1999). Managing Privacy concerns strategically: The implications of fair information practices for marketing in the twenty-first centry. In C. J. Bennett & Grant(Eds.), Visions of privacy : Policy choices for the digital age(pp. 149-167). Toronto, Ontario, Canada: University of Toronto Press.

[9] Delega, V.J., Metts, S., Petronio, S., & Margulis, S. T. (1993). Self-disclosure, Newbury Park, CA: Sage.

[10] Kenneth C. Laudon & Carol Guercio Traver (2002). E-Commerce. Addison Wesley.

[11] Kevin Mabley (2001). Privacy VS Personalization Cyber Dialogue Inc.

[12] Laufer, R. S., & Wolfe, M. (1977). Privacy as a concept and a social issue: A multidimensional Developmental theory, Journal of Social Issues, 22, 24-42.

[13] Peppers & Rogers (1994). The one-to-one future. Piakus, London.

[14] Samuel Warren and Louise Brandeis (1890). The Right to Privacy. Harvard Law Review 4, 4(5), 193~220.

[15] Thibaut, J., & Kelley, H. H. (1959). The social psychology of groups. New York: Wiley.

E-Commerce Adoption Factors for SMMEs: Supporting Cases from South Africa

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ABSTRACT

The emergence of e-commerce (electronic commerce) and the impact of this new technological innovation changed the approach to business, transactions and processes. E-commerce adoption definitions generally refer to the process of conducting business online, spanning both Business-to-Business (B2B) and Business-to-Consumer (B2C) markets to reach global players, gaining market share for competitive advantage, utilising telecommunication networks. However, a number of unanswered questions pertaining to e-commerce adoption highlight issues such as; legal matters, political issues, telecommunication regulatory issues, security and trust aspects, customer relations and product selection. Many of these issues are essential ingredients to enable successful online trading, however, some uncertainties may inhibit the implementation of e-commerce initiatives such as; e-loyalty, marketing, customer experience, bandwidth issues and online customer maintenance. This paper develops a theoretical framework for e-commerce adoption based on literature, verified by case study research conducted in South Africa and proposes ten e-commerce adoption factors for SMMEs.

Keywords: e-commerce, adoption, online, case study, SMME[2].

1. INTRODUCTION

E-commerce adoption is not merely signing up an Internet Service Provider (ISP). Potential barriers such as risks, security fraud and marketing issues associated with e-commerce adoption need to be considered. Technical, business and external factors including cultural, political, legislative and environmental issues have been identified as inhibiting e-commerce adoption issues (Reichheld & Schefter, 2000:105-106; Klopper, 2002; Mohammed, Fisher, Jaworski & Cahill, 2002:204; Hoffman & Novak, 2000:179-180; Boschma & Weltevreden, 2005:2; Braga, 2005:544). These potential pitfalls could be mitigated by providing guidelines to reduce the risk of failure at the outset (or even after adoption) of e-commerce initiatives. Developing countries, including those in Africa, have become detached from the global economy mainly due to a lack of sustainable and appropriate ICT strategies and poor telecommunications infrastructure. As the focus of this paper is on small business, Rashid and Al-Qirim (2001:64) found that small businesses in New Zealand for example, are flexible and quick to react and generally rush to connect and participate in Web-based business.

2. E-COMMERCE IN AFRICAN COUNTRIES

According to Kah (2004:273), "…the fading of the industrial revolution into the dawn of the information revolution has transformed the world economy into a truly global one". Unfortunately, the emergence of this new phenomenon has created a wider gap between *information-rich* and *information-poor* countries, pulling apart *developing* and more *developed* economies. Although the initial e-commerce adoption trends were slow in Africa compared to other countries, the South African e-commerce sector, especially small businesses, has shown promising growth, albeit at a low Internet penetration level (Cloete, Courtney & Fintz, 2002:9).

Furthermore, Bhatnagar (2000:1-3) points out that telecommunications infrastructure forms an essential part in any future economic and social development of African economies. Spiegel (2004) finds factors linked to an education system – companies in India for example, compete in ICT and e-commerce as global players whereas China is often chosen for manufacturing resulting from the Chinese government's intention to encourage a culture of manufacturing. Some of these issues also emerged in the literature review.

The selection of African developing countries used in this research study was based on the e-Readiness rankings (2005) comprising of Egypt, South Africa, Morocco, Nigeria and Botswana. The Internet usage of these countries are depicted in Table 1, ranked according to estimated Internet users.

Although Internet connections are available in many African capitals, e-commerce infrastructure gaps exists between developed and developing countries and is the largest in Africa where only one in about 118 people use the Internet.

3. OBJECTIVE OF THE RESEARCH

The researchers explored the underlying issues pertaining to e-commerce adoption, specifically in a developing country to provide e-commerce adoption guidelines to SMMEs. In addition, the extent and conditions under which e-commerce is adopted

Table 1. Population and Internet usage statistics: Comparison of African countries by 'Usage % in Africa' (Source: International Internet Usage Statistics, 2005).

POPULATION AND INTERNET USAGE PERCENTAGE COMPARISON OF AFRICAN REGIONS					
Region	Total estimated population in 2006	Population as % of African (%)	Estimated Internet users	Usage % of Africa (%)	Usage % growth (2000-2005)
Egypt	71,236,631	7.0	5,000,000	21.1	1,011.1
South Africa	48,861,805	7.4	3,600,000	15.8	50.0
Morocco	30,182,038	11.6	3,500,000	15.4	3,400.0
Nigeria	159,404,137	1.1	1,769,700	7.8	784.9
Botswana	1,856,800	3.2	60,000	0.3	300.0

Table 2. E-commerce adoption definitions (Source: Literature, keywords or descriptive phrases in bold text).

Category	Author	E-commerce adoption
Causes	MacGregor and Vrazalic (2005:514)	E-commerce adoption is **a cost effective way to reach global customers and to compete on even terms with larger counterparts.**
	Castleman (2004:34) refers to a report produced by APEC(1999:12)	"Adoption of e-commerce has been advocated as a way of **reducing transaction costs**, gaining market share, streamlining business processes, achieving **competitive advantage,** and **improving relationships** with business partners for improved business performance".
	O'Keefe, O'Connor & Kung (1998:630) citing Lambkin, 1988)[1]	**Early adopters** of IT (e-commerce) can gain an **advantage** in the same way that early entrants into a market can gain an advantage.
	Fillis,Johannson & Wagner (2004:182)	The implications for non-adoption of e-business may vary where **product opportunities** may be lost due to late market entry when firms eventually decide to embrace the new technology, where often new types of products and services would already have entered the market.
Effects	Damanpour (2001:16)	Adopting the Internet's connectivity aspect for business has **changed the way companies communicate internally and externally**. **Internally**, how they buy and sell on the Web and share information. **External** communication activity increases efforts to understand **customers, suppliers, business partners and competitors**.
	Ratnasingam (2003)	Businesses are often too small and therefore unable to provide the financial resources **to retain the appropriate skill levels of staff** needed to implement or oversee e-commerce initiatives.
	Quaddus and Achjari (2005:127-129)	E-commerce adoption encompasses a **wide spectrum of business processes** and **configuration of technology resources** to facilitate how business managers perform their tasks, **interact with customers** and conduct their business.

was also examined. The development of an e-commerce adoption definition was needed to serve as a terms of reference for the research and to scope the e-commerce adoption study. Furthermore, proposing an e-commerce adoption theoretical framework requires verification from evidence obtained from local case studies. This would culminate in proposing ten e-commerce adoption factors.

4. DEFINING E-COMMERCE ADOPTION

The researchers firstly created a working definition for e-commerce adoption by selecting seven of the most descriptive and appropriate definitions found in literature. The definitions were then divided into two categories according to the frequency of keywords or overriding descriptive phrases appearing in the e-commerce adoption definitions. The categories are *causes* and *effects*, depicted in Table 2.

Using the information in Table 2, a definition for e-commerce adoption was created, reading as follows:

e-Commerce adoption *is a cost effective way to reach global players, gaining market share, streamlining a wide spectrum of business processes and technology for competitive advantage utilising telecommunication networks, improving relationships, advantageous to early adopters, willing to change and improve communication - internally and externally, ensuring sufficient resources and skilled-staff.*

5. THEORETICAL FRAMEWORK

A cause/effect view of e-commerce adoption emanated as the most feasible categorisation from literature to serve as a theoretical framework. Kah (2004:274) suggests government and industry intervention in developing countries are considered suitable drivers pertaining to causes for e-commerce adoption. The authors expanded the drivers to include SME business activity for their research. However, on the basis of Usage % of Africa (%) appearing in Table 1, Botswana (0.3%) was eliminated from this study. These causes and effects are summarised in Tables 3 and 4 respectively. For ease of use and completeness, four bibliographies are provided serving as the primary source for each of the specific countries explored.

In Table 4 the effects of e-commerce adoption of the selected African countries are depicted, summarised using impact, advantages and disadvantages as drivers.

6. SOUTH AFRICAN E-COMMERCE EXPANSION

- Eight online retailers are currently dominating the online consumer and apparel market and account for approximately 80% of all online retail sales. Motjolopane (2006:20) reports that "… Retail sales at the end of 2003 increased by 35% and grew by 25% in 2004".
- E-commerce adoption has expanded rapidly in the airline industry in South Africa. According to Hartley and Worthington-Smith (2003:151-152), the volume of online travel sales compared to Europe. The 'no frills' airline, Kulula.com is considered to be South Africa's largest revenue-generating B2C business. 1time Airline, another successful *no-frills* airline in South Africa, is claiming more than 75% of online travel transactions (Warden & Remenyi, 2005).

7. RESEARCH METHOD

According to Strauss and Corbin (1998:11), qualitative research is a research mechanism to assist researchers finding evidence not arrived at by statistical procedures or other means of quantification. In such cases, hermeneutic approaches are preferable to analyse findings (Remenyi, Williams, Money & Swartz, 1998:288). Hussey and Hussey (1997:66) suggest that case studies are often described as explanatory research used in areas where there are few theories or a deficient body of knowledge. Furthermore, Yin (1994:20-27) states that a case study is an empirical enquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not evident. Tellis (1997) alludes to the interactive nature of case studies and states the need to use multi-perspectival analysis, where the researcher is able to consider the relevant groups of participants. Evidence from multiple cases is often considered more compelling and the "… overall study is therefore regarded as being more robust" (Herriott & Firestone, 1983:14 in Yin, 2003:46).

7.1 Number of Cases

According to Yin (2003:47) the underlying logic of multiple-case studies indicates that the researcher should select each case with care in order for it either, to predict similar results (a literal replication) or predict contrasting results for predictable reasons (a theoretical replication). Five SMMEs were used to gather evidence. The SMMEs used were Case A (international travel business), Case B (mail order and electronic component store), Case C (pre-paid electricity

Table 3. Causes of e-commerce adoption: African developing countries

Government or Industry intervention to enable ICT	SMEs sector activities
Egypt - Bibliography 1	
Initiatives launched by the Egyptian government and private sector to promote ICT and e-commerce adoption. Egyptian banks lag and lack support for SET (Secure Electronics Transaction). Low usage of credit cards poses inhibiting factor for adopting e-commerce. Low e-readiness affects e-commerce adoption.	SMEs represent almost 99% of the number of companies in the private non-farm agricultural sector. Slow uptake in e-leadership and information security, connectivity, human capital and e-business.
Morocco – Bibliography 2	
Awarding of fixed-line license aimed to provide stimulation to the telecommunication sector. Fixed-line telecommunication network declined from 1999 but recovered in 2003 due to demand for Internet access and ADSL broadband services. The telecommunication operator Maroc Telecom listed on the Paris and Casablanca stock exchanges in 2004. Telecommunication market has experienced consistent growth mainly mobile sector where competition was introduced in 2000.	Due to large-scale emigration of males to France over the years has introduced an ethnic factor of not starting many small businesses. Tourism is strengthening Morocco's small business links with the West causing awareness.
Note: No suitable literature on e-commerce adoption by SMEs in Morocco was available	
Nigeria - Bibliography 3	
Government has been the sole provider of telephony and communication systems.	Current government promoting e-business among SMEs in its National IT Policy. SMEs have been made are aware of the advantages offered by the Internet and how it could assist them reach global markets and a source of information.
South Africa – Bibliography 4	
Telkom has been the sole supplier of communication links. Government promoting great support for SMMEs. Western Cape Provincial Government allocated R50 million for small business development in 2004. Electronic banking (e-banking) is being rapidly established and mobile banking (m-banking) was introduced in 2006.	SME and e-commerce sector experienced rapid growth over the last five years and Internet penetration is more evident in small business and upper income households. Common online purchases are groceries, apparel and books, By number of Websites, flowers and gifts followed by apparel, food, beverage and groceries are most popular. Online airline ticket sales have increased rapidly in South Africa.

provider), Case D (luggage store) and Case E (low cost airline) – these were all e-commerce start-up SMMEs.

7.1 Case Study Protocol

This instrument (interview schedule) as well as the procedures involved in conducting the research was developed by the authors and adapted mainly from Lubbe (2003:9) and Remenyi, Williams, Money & Swartz (1998:172-173) respectively. The interview structure consisted of three sections; Information about the interviewee/business, Demographic information and an Interview topic guide.

Only the interview topic guide is summarised below:

- **Organisation -** Strategic objectives, Reasons for adopting e-commerce in business
- **Internal -** Human resource, Impact of e-commerce, Customer demand & service, Reduced transaction costs, Critical success factors.
- **External –** Competition, Partnerships, Networks.
- **E-commerce adoption -** Operational issues of e-commerce, Adoption of ICT systems.
- **Environment –** Technical, Market, Brand.

8. CONDUCTING THE RESEARCH

In-depth open ended interviews were conducted over a period of about 12 months focussing mainly on causes and effects of e-commerce adoption within the ambit of the interview topic guide. Information was also collected to verify the theoretical framework developed in Paragraph 6. At least two, and in some

Table 4. Effects of e-commerce adoption: African developing countries

Impact	Advantages	Disadvantages
Egypt		
The e-commerce adoption process has highlighted a number of issues: e-Readiness is low. Improvements needed in e-leadership and information security, connectivity, human capital and e-business.	SMEs were offered opportunities for innovation and the emergence of new products and services. Small entrepreneurs were assisted to overcome information poverty. Entrepreneurs become more connected, more confident, less risk-averse, and more capable of making well-informed decisions. Empowering small entrepreneurs, e-commerce offered the potential for increasing exports, promoting growth and human development.	Large firms could get 'locked in' to technologies – high switching costs is a concern - Few PCs in management. Medium sizes firms have higher degree of awareness of ICTs in management and production - Few PCs in management. Small firms not aware of the role of ICT, e-infrastructure and human capital - Few PC in management. Mainly dial-up access for Internet connectivity.
Morocco		
Telecommunication services expansion - Two, Third Generation (3G) mobile licenses planned to be awarded in 2006 and the sale of a further 25% of Maroc Telecom in 2007. The economy has been subject to considerable liberalization in recent years and foreign investment is encouraged.	New ICT related career opportunities have arisen for especially women such as telecentres, call centres, Internet cafes and telephone booths. At the same time B2C business transaction opportunities are emerging and becoming feasible for selling of manufactured hand-made products in Morocco by woman. These new directions could lead to a global economy.	Small SME sector of mainly hand-made products not ideal for e-commerce.
Nigeria		
The best-performing SSA country in terms of ICT use and product diffusion can be exploited to benefit the ICT sector. Receipt of direct foreign investment. Teledensity rate has improved following deregulation of the telecoms industry - more government policy and support may be required to provide an enabling environment for wide e-commerce adoption.	The spread of cyber cafés in the country is assisting to popularize the Internet, which in turn will enhance e-business adoption.	Lack of knowledge about e-commerce benefits, finance IT skills & infrastructural support.
South Africa		
Only small sections of businesses and sectors adopted e-commerce. 18 % of businesses out of a possible 4 500 businesses listed on the Cape Town Regional Chamber of Commerce and Industry had e-commerce related Websites Internet sales account for less than 1 % of the volume of all airline ticket sales in South Africa, 'no-frills' airlines in South Africa report up to 75% of online travel transactions.	Online air travel business has expanded and become extremely competitive. Eight online retailers are currently dominating the online market and account for approximately 80% of all online retail sales.	Business organisational e-commerce adoption barriers identified: Negative attitudes, Lack of knowledge, Resistance to change, Lack of management commitment. Gaps remain between online shopping and the physical experience: Ability to judge quality, Ease of buying locally, Privacy & Security.

cases, three interviews were conducted, tape recorded, transcribed and case study reports compiled.

9. FINDINGS

In Table 5, the causes of e-commerce adoption in South African SMMEs are summarised using categories intervention to enable ICT and small business activities.

Similarly, in Table 6 the effects of e-commerce adoption are depicted using categories impacts, advantages and disadvantages.

The effects of e-commerce adoption in Table 6, indicates various aspects and some similarities between the five cases. Revisiting the case study reports and eliminating irrelevant and non-applicable information, thirteen adoption factors were developed as common phrases from the respective case evidence. Each of the adoption factors were again verified against the evidence obtained from the five cases, depicted in Table 7.

Some discrepancies and isolated factors appeared mainly due to the particular business sector. Therefore, only factors featuring in more than four cases were deemed to be representative, thereby reducing the adoption factors to ten, depicted in Table 8.

Table 5. Causes of e-commerce adoption trends: Cases of South African SMMEs

Intervention to enable ICT	SMME business activities
Case A	
Initially only telephone and facsimile considered sufficient Guests started demanding more ICT services – Internet & PCs Outsourced ICT & Website No internal IT expertise	Owner managed – 2 Partners Less than 20 employees
Case B	
Moved from manual mail order to online order system Outsourced ICT & Website Website content management system Limited internal IT expertise	Owner managed Less than 20 employees
Case C	
Cape Town city council (CCC) required services CCC collection of account arrears Internal ICT expertise	Management owned – CEO & 5 Partners/Directors Less than 100 employees
Case D	
Purchased ICT System Outsourced ICT & Website No internal IT expertise	Owner managed Less than 20 employees
Case E	
Utilising ICT to effect cost saving Bought in ICT partner company Quick to market – competition looming	Management owned – CEO & 4 Partners/Directors Less than 200 employees

Table 6. Effects of e-commerce adoption trends: Cases of South African SMMEs

Impact	Advantages	Disadvantages
Case A		
Expanded market share Website serves as online brochure & e-commerce site	Partial funds deposited before providing service International network Online booking & virtual markets Manage business from anywhere, anyplace	None detected Slow Internet access into South Africa
Case B		
First to market in SA in electronic component sector Utilising ICT to automate systems Global market	Funds deposited before providing service (pre-paid) Extensive catalogue combined with e-commerce site	Users not e-ready Online competition Slow internet access - Broadband needed to scan Website
Case C		
Utilising ICT to effect cost saving & system automation	Predictable cash flow- low and high seasons Funds deposited before providing service (pre-paid) Long contracts with municipalities, now nationally	Business expansion determined by rate of installation of e-dispensers Users not e-ready
Case D		
Same ICT system to automate entire business First to market in Cape Town in Bag sector	Entire e-commerce system and operation cheaper than new warehouse Extensive catalogue combined with e-commerce site Transaction finalised by credit card before delivering	Users not e-ready Product not ideally suited to online trading Slow internet access - Broadband needed to scan Website
Case E		
Market shake-up Utilising ICT to effect cost saving & system automation Leading LCA sector	Funds deposited before providing service (pre-paid) Automated systems No legacy systems to maintain, no royalties	Business expansion determined by external factors- fuel, interest rates & legislation Competition, new entrants to market Slow internet access - Broadband needed to spend sufficient time on Website

Table 7. e-Commerce adoption factors: Cases of South African SMMEs

#	Factor Description	Cases				
		A	B	C	D	E
1	User-friendly Web interface	√	√	√	√	√
2	Top management support	√	√	√	√	√
3	Maintaining strong links with customers	√	√	√	√	√
4	Ensuring customer acceptance	√	√	√	√	√
5	Providing up-to-date information, including prices	√	√	√	√	√
6	Regular promotions	√	√	√		√
7	Customers can track bookings via Ref. number	√	√	√		√
8	Providing support service from Web site	√	√	√	√	
9	Good technical infrastructure for fast processing	√	√		√	√
10	Open system, anyone may access to conduct business	√	√	√		√
11	Evidence of maintaining good trading partner relationships	√	√			
12	Powerful Web site with strong search engine		√			
13	When using a shopping cart, users can store its contents for later use		√	√		

Table 8. e-Commerce adoption factors for SMMEs

1	User-friendly Web interface
2	Top management support
3	Maintaining strong links with customers
4	Ensuring customer acceptance
5	Providing up-to-date information, including prices
6	Regular promotions
7	Customers ability to track orders via Ref. number
8	Providing support service from Web site
9	Good technical infrastructure to enable fast processing
10	Open system, anyone may access to conduct business

10. CONCLUSION

From the results of the research reported in this paper, it is evident that Internet usage is increasing and that e-commerce adoption in African countries tend to follow similar trends. The e-commerce adoption factors listed in Table 8 provides a guideline for e-commerce adoption for SMMEs. These factors were found to be applicable to SMMEs in South Africa, competing in the global economy - evident from the findings of the case studies. Although certain assumptions had to be made, for example the particular definitions chosen to develop the e-commerce working definition, case selection and assumptions made regarding the adoption factors. Table 8 represents the outcome based on the research activity conducted and reflects the essential e-commerce adoption factors. Furthermore, the authors are aware that the ten factors are not necessarily fixed in the given ranking and may differ in the context of other studies, applications or different market sectors. Finally, the list of ten e-commerce adoption factors could be used by SMMEs, consultants or web developers to serve as a guideline in an e-commerce SMME environment.

11. REFERENCES

Bhatnagar, S. (2000). Social implications of Information and Communication Technology in Developing Countries: Lesson from Asian success stories. *EJISDC*, 1(4), 1-19.

Boschma, R.A & Weltrevreden, J.W.J. (2005). B2C e-commerce in inner cities: An evolutionary perspective. Unpublished paper. Papers in Evolutionary Economic Geography #05.03. Urban and regional Research centre, Faculty of Geosciences, Utrecht University, the Netherlands.

Braga, C.A.P. (2005). E-commerce regulation: New game, new rules? *The Quarterly Review of Economics and Finance*, 45(2-3), 541-558.

Castleman, T. (2004). Small Businesses as Social Formations: Diverse Rationalities in the Context of e-Business Adoption. Electronic Commerce in Small to Medium-Sized Enterprises: Frameworks, Issues and Implications. Nabeel A.Y., Al-Qirim. (Ed.) Hershey, PA: Idea Group Inc.

Cloete, E., Courtney, S. & Fintz, J. (2002). Small business' acceptance and adoption of e-commerce in the Western Cape Province of South Africa. *The Electronic Journal on Information Systems in Developing Countries*, 10(4), 1-13.

Damanpour, F. (2001). E-business e-commerce evolution: perspective and strategy. *Managerial Finance*, 27(7),16-33.

e-Readiness Rankings. (2005). Retrieved August, 10, 2006, from http://www.ebusinessforum.com/index.asp?layout=rich_story&doc_id=6427

Fillis, I., Johannson, U. & Wagner, B. (2004). Factors impacting on e-business adoption and development in the smaller firm. *International Journal of Entrepreneurial Behaviour & Research*, 10(3), 178-191.

Hartley and Worthington-Smith. (2003). The e-business handbook: the 2003 review of innovation at work in South African business. Cape Town: Trialogue.

Herriott, R.E. & Firestone, W.A. (1983). Multiple qualitative policy research: optimizing description and generalizability. Educational Researcher, 12, 14-19.

Hoffman, D.L. & Novak, T.P. (2000). How to acquire customers on the web. *Harvard Business Review*.

Hussey, J. & Hussey, R. (1997). Business Research: A practical guide for undergraduate and post graduate students. Houndmills: Macmillan Press.

International Internet Usage Statistics. (2005). Retrieved May, 14, 2005, from http://www.internetworldstats.com/stats.htm

Kah, M. (2004). Chapter 15: Strategic Significance of Information Technology to Developing Countries Rutgers University-Camden, USA.

Klopper, H.B. (2002). Viral marketing: a powerful, but dangerous marketing tool. [Electronic version]. *South African Journal of Information Management,* 4(2).

Lubbe, S.I. (2003). Development of a case study methodology in the information technology (IT) field in South Africa: a step-by-step approach. South African Journal of Information Management, 5(4). Retrieved September, 21, 2005, from http://www.sajim.co.za/peer58.5nr5.asp?print=1

MacGregor, R.C. & Vrazalic, L. (2005). A Basic model of electronic commerce adoption barriers. A study of region small businessess in Sweden and Australia. *Journal of Small Business and Enterprise development*, 12(4), 510-527.

Mohammed, R.A., Fisher, R.J., Jaworski, B.J. & Cahill, A.M. (2002). Internet marketing: building advantage in a networked economy. International Edition.

Motjolopane, I. (2006). A Preliminary study into strategies for determining the level to start e-commerce adoption for success in SMEs. Unpublished Masters' Thesis, Cape Peninsula University of Technology, Cape Town.

O'Keefe, R.M., O'Connor, G. & Kung, H-J. (1998). Early adopters of the Web as a retail medium: Small company winners and losers. *European Journal of Marketing*, 32(7/8), 629-643.

Quaddus, M. & Achjari, D. (2005). A model for electronic commerce success. *Telecommunications Policy*, 29(2-3), 127-152.

Rashid, M.A. and Al-Qirim, N.A. (2001). E-commerce technology adoption framework by New Zealand Small to Medium Size Enterprises.

Ratnasingam, P. (2003). Perceived Barriers and Risks of E-Commerce Supply Chain Management Network Among SMEs in Australia and New Zealand. Electronic Commerce in Small to Medium-Sized Enterprises: Frameworks, Issues and Implications. Al-Qirim, N.A.Y. (Ed.) Hershey, PA: Idea Group Inc.

Reichheld, F.F. & Schefter, P. (2000). E-Loyalty: Your secret weapon on the web. *Harvard Business Review,* 105-113.

Remenyi, D., Williams, B., Money, A. & Swartz, E. (1998). Doing Research in Business and Management. An Introduction to Process and Method. London: Sage.

South Africa. (2003). National Small Business Amendment Act, no 26 of 2003. Government Gazette, 461(25763), 2-10, November 26.

Spiegel, R. (2004). A tale of two countries. Electronic News (North America), March 3.

Strauss, A. and Corbin, J. (1998). Basics of qualitative research: techniques and procedures for developing grounded theory (2nd ed.). Thousand Oaks: Sage

Tellis, W. 1997. The Qualitative Report. *Introduction to case Study,* 3(2),July. Retrieved November, 2, 2005, from http://www.nova.edu/ssss/QR/QR3-2/tellis1.html

Warden, S.C. & Remenyi, D. (2005). E-commerce in an SME. A case study of a South African low cost or "no frills" airline. Proceedings of the 2005 Conference of World Wide Web applications, (WWW 2005), Cape Town, South Africa.

Yin, R.K. (1994). Case Study Research: Design and Methods. Thousand Oaks: Sage.

Yin, R.K. (2003). Case Study Research: Design and Methods. 2nd ed. Thousand Oaks: Sage.

BIBLIOGRAPHY 1

Abdel-Maksound, S. & Youssef, M.A.A. (2003). Information and Communication Technology for SMEs in Egypt. SME Development Unit, Ministry of Foreign Trade. Retrieved September, 1, 2004, from http://www.sme.gov.eg/

Cecchini, S., & Shah, T. (2002). Information and communication technology as a tool for empowerment. World Bank Empowerment Sourcebook: Tools and Practices. Retrieved January, 15, 2004, from http://www.cefe.net

Dakela, S.M. (2006). Electronic commerce adoption barriers of SMEEs on tourism. Unpublished Masters Thesis, Cape Peninsula University of Technology, 2005.

Jutla, D.N, Bodorik, P. & Dhaliwal, J. (2002). Government support for the e-readiness of small and medium sized enterprises. Proceedings of the 35th Hawaii International Conference on System Sciences. Retrieved September, 1, 2004, from http://www.hicss.hawaii.edu/HICSS_35/apahome35.htm

Kamel S & Hussein, M. (2002). The emergence of e-commerce in a developing nation: case of Egypt. Benchmarking: *An International Journal*, 9(2), 46-153.

OECD. (2000). Realizing the potential of electronic commerce for SMEs in the global economy. Conference for Ministers responsible for SMEs and Industry Ministers. June 14-15.

Rizk, N. (2006). Venturing the unexplored – e-readiness assessment of small and medium enterprises in Egypt. Offshore Outsourcing – An E-commerce Reality (Opportunity for Developing Countries). Kamel, S. (Ed.) Idea Group Publishing.

Salman, A. (2004). Elusive challenges of e-change management in developing countries. *Business Process Management Journal*, 10(2), 140-157.

Singh, M. (2003). Electronic Commerce Opportunities, Challenges and Organizational Issues for Australian SMEs. Creating Business Value with Information Technology: Challenges and Solutions. Shin, N. (Ed.) Hershey, P.A.: Idea Group Inc.

SME Development Unit of the Ministry of Foreign Trade in (2003).

BIBLIOGRAPHY 2

African Studies Centre (2005). University of Pennsylvania. Retrieved July, 12, 2005, from http://www.africa.upenn.edu/Country_Specific/Morocco.htm

IMF. (2005). Public Information Notice (PIN) No.05/125. Retrieved November, 20, 2005, from http://www.imf.org/external/np/sec/pn/2005/pn05125.htm

Maroc Telecom. (2005). Group overview. Retrieved August, 12, 2006, from http://finance.vivendiuniversal.com/finance/group_overview/key-business-maroctelecom.htm

McConnell International. (2000). Retrieved July, 10, 2005, from http://www.mcconnellinternational.com

World Bank. (2005). Data & Statistics. Retrieved September, 3, 2006, from http://devdata.worldbank.org/external/CPProfile.asp?SelectedCountry=MAR&CCODE=MAR&CNAME= Morocco&PTYPE=CP

BIBLIOGRAPHY 3

Ajakaye, T., & Kanu, O. (2004). Cybercafe, cybercafe everywhere. This Day Online. Retrieved December, 2, 2004, from http://www.thisdayonline.com

Ajayi, G. O. (2003). Role of government in IT development—Status report [on] e-Nigeria. Proceedings of e-Nigeria (2003), March 10–12. Abuja. Retrieved December, 9, 2004, from Nigeria.http://enigeria.org/2003/10029003/idex.html

Hamilton, P., Jensen, M. & Southwood, R. (2004). African Internet country market profiles. Retrieved January, 10, 2005, from http://wwwbalancingact-africacom/profile1html

Ifinedo, P. E. (2004). E-government—Precursors, problems, practices and prospects: a case of Nigeria. Proceedings of the 2 004 IBIM Conference, Amman, Jordan, July 4–6.

Matambalya, F., & Wolf, S. (2001). The role of ICT for the performance of SMEs in East Africa: empirical evidence from Kenya and Tanzania, ZEF. Bonn: Center for Development Research. Discussion Papers on Development policy, University of Bonn, no. 42.

Mbarika, V., Jensen, M., & Meso, P. (2002). Cyberspace across Sub-Saharan Africa: from technological desert towards emergent sustainable growth. *Communications of the ACM*, 45(12), 17 - 21.

Mbarika, V., Kah., M., & Keita, M. (2004). The diffusion of cyber cafés in Sub-Saharan Africa: country case studies. Proceeding of the IRMA conference 2004: Innovations Through Information Technology, Louisiana, USA.

Mead, D., & Liedholm, C. (1998). The dynamics of micro and small enterprises in developing countries. *World Development*, 26, 61–74.

NITDA. (2001). National Information Technology Development Agency. Retrieved June, 23, 2004, from http://www.nitda.gov.ng/

Nwoffiah, L.C. (2006). E-commerce: the impact of Internet technology on retailing. Unpublished Masters' Thesis, Cape Peninsula University of Technology, Cape Town.

Ojukwu, D., & Georgiadou, E. (2004). An evaluation of the impact of Integrated Solutions (IBIS) on the growth of small and medium sized enterprises (SMEs) in Nigeria. Proceedings of the IRMA conference 2004: Innovations Through Information Technology, Louisiana, USA.

World Bank. (2004). Prospects for developing countries and world trade. Retrieved February, 2, 2004, from http://wwwworldbankorg/prospects/gep2001/chapt1pdf

BIBLIOGRAPHY 4

Berry E. (2003). Substantial solutions needed for economic growth and development – Trevor Manuel. Newsletter of Trade an Industrial Policy Strategies (TIPS), 27(),1-15.

Cape Gateway. (2004). Western Cape allocates R50 million for small business development. Retrieved April, 20, 2006, from http://www.capegateway.gov.za/eng/pubs/news/2004/sep/84013

Cloete, E., Courtney, S. & Fintz, J. (2002). Small business' acceptance and adoption of e-commerce in the Western Cape Province of South Africa. *The Electronic Journal on Information Systems in Developing Countries*, 10(4):1-13.

De Klerk, S. & Kroon, J. (2004). E-commerce adoption in South African businesses. *South African Journal of Business Management*, 36(1), 33-40.

Electronic Communications and Transaction Act (ECT Act. No 25 of 2002). Retrieved August, 15, 2006, from http://www.internet.org.za/ect_act.html

Farhoomand, A.F., Tuunainen, V.K and Lee, L.W. (2000). Barriers to electronic commerce: A cross country study of Hong Kong. *Journal of Organizational Computing and Electronic Commerce*, 10(1), 23-48.

Hartley and Worthington-Smith. (2003). The e-business handbook: the 2003 review of innovation at work in South African business. Cape Town: Trialogue.

Kinder, T. (2002). Emerging e-commerce business models: an analysis of case studies from West Lothian, Scotland. *European Journal of Innovation Management*, 5(3),130-151.

Motjolopane, I. (2006). A Preliminary study into strategies for determining the level to start e-commerce adoption for success in SMEs. Unpublished Masters' Thesis, Cape Peninsula University of Technology, Cape Town.

Winney, G. (Ed.). (2005). South African business guidebook 2004/2005: Internet and e-commerce. Johannesburg: Media3.

ENDNOTES

[1] Lambkin, D. (1988). Order of entry and performance in new markets. *Strategic Management Journal*, 9, 127-40.

[2] Small Medium and Micro Enterprises used in the South African context (South Africa, 2003)

Predicting Online Auction Closing Price Using Grey System Theory

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ABSTRACT

Online auctions are a very popular method to buy and sell items on the Internet. However, it is very dynamic in that it is very difficult to predict the winning bid of a given auction. There have been numerous studies to design a bidding strategy that can be utilized by bidders to ensure that they always win an auction. The closing price of an auction is not known and is dependent on several factors such as the number of auctions selling the same item, the number of bidders participating in that auction as well as the behaviour of every individual bidder. To top it up, there can be multiple auctions running concurrently at the same time. To participate in an online auction, one has to decide which auction to participate, how much to bid and when to bid. In most cases, this process is time consuming and does not always guarantee a winning bid. Knowing the closing price would definitely solve part of the problem. If the closing price of an auction is known, then bidder could then decide which auction to participate and at what price. This paper describes one technique to predict the closing price of an auction. This technique is called the Grey System Theory which has been known to be able to accurately predict values in areas where the information is insufficient. This paper also investigates the effectiveness and the accuracy of this theory when applied to online auctions. Some preliminary evaluations will be discussed.

1. INTRODUCTION

Auction is a market institution with an explicit set of rules determining resource allocation and price on the basic of bid from the market participants (McAfee & McMillan, 1987). Nowadays online auction is one of the most popular and effective ways of trading by participants bidding for products and services over the Internet (Bapna, Goes, & Gupta, 2001). Online auction has given consumers a "virtual" flea market with all the new and used merchandises from around the world. They also give sellers a global storefront from which to market their goods.

Online auction allows clients to buy and sell items by means of auctions anytime and anywhere they like. Moreover, online auctions generally last for days and weeks giving the bidders more flexibility about when to submit bids. Compared with the traditional business type, internet auctions can be a co-effective way to test-market products in an online sales environment and to liquidate dated or overstocked merchandise especially for small business owners. Besides that, by using online auction, there is no geographical limitation since both sellers and buyers do their trading in a "virtual" environment and any transaction can be made through the online banking. Moreover, due to the relatively low price and wider scope of products and services, the online auctions have attracted many bidders in the trading process. At the same time, many sellers will be attracted to the online auction as it has attracted many potential consumers. Online auctions also allow sellers to sell their goods efficiently and with little action or effort required.

There are four main types of single-sided auctions that are commonly used in traditional auctions (Klemperer, 1999) namely ascending-bid auction (also called the open, oral, or English auction), descending-bid auction (also called Dutch auction), first-price sealed bid auction and second-price sealed bid auction (also called Vickrey auction). The English begins with the lowest price and bidders are free to raise their bid successively until there are no more offers to raise the bid. Bidder with the highest bid is the winner. A Dutch auction is the opposite of an English auction, in which auctioneer begins with an initial high price and then progressively lowered until there is an offer from a bidder to claim the item. In the first price sealed bid, each bidder submits their offer for an item privately. The highest bidder gets the item and payment is based on their own bid. The Vickrey auction is similar to the first-price sealed bid auction, where the item goes to the highest bidder but he only pays a price equal to the second highest bid. Online auctions are somewhat similar to the traditional auctions but most auctions are constrained by the time. Auctions usually last for days and week depending on the seller's requirement.

Due to the proliferation of these online auctions, consumers are faced with the problem of monitoring multiple auction houses, picking which auction to participate in, and making the right bid to ensure that they get the item under conditions that are consistent with their preferences (Anthony & Jennings, 2003). These processes of monitoring, selecting and making bids are time consuming. The task becomes even more challenging when the individual auctions have different start and end times. Moreover, auctions can last for a few days or even weeks. Besides that, every bidder has his own reservation price or maximum amount that he is willing to bid for each item. If bidders are able to predict the closing price for each auction then they can make better decision on when and where or even how much they can bid for an item. In a situation where a bidder has to decide among the many auctions that are currently ongoing, this knowledge on closing price for an auction would be useful for the bidder to decide on which auction to participate, when to participate and at what price. There are other considerations that need to be taken into account to ensure that the bidder wins in a given auction. However, knowing the closing price of a given auction would definitely be an advantage because the bidder can decide where to bid and how much to bid. Unfortunately, predicting a closing price for an auction is not easy since it is dependent on many factors such as the behavior of the bidders and the number of bidders participating in that auction.

For these reasons, many investors have been trying to find a better way to predict auction closing price accurately. Neural Network, Fuzzy Logic, Evolutionary Computation, Probability Function and Genetic Algorithm, are integrated to become more commendable practical model for prediction purpose. However one particular method is to apply the Grey System Theory to predict online auction. It is a new theory and method which applies to the study of unascertained problems with few or poor incoming information (Liu & Lin, 2004). In online auction, the number of available information is limited and it is often very difficult to predict the outcome of an auction since bidders have different behavior. It is quite possible to predict the closing price of an auction using Grey Theory method and this will be elaborated in Section 4.

In this paper, we will investigate the effectiveness of the grey system theory in predicting the closing price of online auction. In Section 2, the design of grey theory system is explained. Section 3 discusses the prediction algorithm by using the grey system theory. The preliminary result is shown in Section 4. In section 5 some related works using grey theory are discussed and finally the conclusion and future work is discussed in Section 6.

2. GREY SYSTEM THEORY DESIGN

The grey system theory was first proposed by Deng Julong (1982). Grey system theory works on unascertained systems with partially known and partially unknown information by drawing out valuable information, by generating and developing the partially known information. It can describe correctly and moni-

Table 1. Attributes of traditional forecasting model

Mathematical model	Minimum observation	Type of sample	Sample interval	Mathematical requirements
Simple exponential function	5-10	Interval	Short	Basic
Regression analysis	10-20	Trend	Short	Middle
Casual regression	10	Any type	Long	Advanced
Box-Jenkins	50	Interval	Long	Advanced
Neural network	Large number	Interval or not	Short	Advanced
Grey prediction model	4	Interval	Long	Basic

tor effectively the systemic operational behaviour (Lin & Liu, 2004). Basically, the Grey system theory was chosen based on color. For instance, "black" is used to represent unknown information and "white" is the color used for complete information. Those partially know and partially unknown information is called the "Grey System Theory".

The grey system theory has been successfully applied to economical, management, social systems, industrial systems, ecological systems, education, traffic, environmental sciences, and geography (Lin & Liu, 2004). It is used successfully to analyse uncertain systems that have multi-data inputs, discrete data, and insufficient data. Grey systems theory explores the law of subject's motivation using functions of sequence operators according to information coverage. It is different from fuzzy logic since it emphasizes on objects with definite external extensions and vague internal meanings. Table 1 shows the Grey prediction model compared to other traditional forecasting models (Chiang, Wu, Chiang, Chang & Wen, 1998). It can be seen that this model only requires short-term, current and limited data in order to predict a given value.

Grey prediction is a quantitative prediction based on grey generating function, GM (1, l) model, which uses the variation within the system to find the relations between sequential data and then establish the prediction model. The grey forecasting model is derived from the grey system, in which one examines changes within a system to discover a relation between sequence and data. After that, a valid prediction is made to the system. Grey prediction model has the following advantages: (a) It can be used in situations with relatively limited data down to as little as four observations, as stated in Table 1. (b) A few discrete data are sufficient to characterize an unknown system. (c) It is suitable for forecasting in competitive environments where decision-makers have only accessed to limited historical data (Chiou, Tzeeng, Cheng & Liu., 2003).

3. GREY SYSTEM THEORY PREDICTION ALGORITHM

In this section we focus on the grey generating function, GM (1,1) which are being used in grey prediction (Deng & David, 1995). The algorithm of GM (1,1) can be summarized as follows.

Step 1. Establish the initial sequence from observation data

$F^{(0)} = \{f^{(0)}(1), f^{(0)}(2), \ldots, f^{(0)}(n)\}$.

Step 2. Generate the first-order accumulated generating operation (AGO) sequence

$F^{(1)} = \{f^{(1)}(1), f^{(1)}(2), \ldots, f^{(1)}(n)\}$.

where $f^{(1)}(k) = \sum_{i=1}^{k} f^{(0)}(i)$.

Step 3. The grey model GM (1,1)

$$F_{t+1}^{0} = a\left[-\frac{1}{2}\left(F_{t=1}^{1} + F_{t}^{1}\right)\right] + b, \qquad \forall t \geq 1.$$

Step 4. Rewrite into matrix form

$$\begin{bmatrix} F_2^0 \\ F_3^0 \\ \vdots \\ F_x^0 \end{bmatrix} = \begin{bmatrix} -\frac{1}{2}\left(F_2^1 + F_1^1\right) & 1 \\ -\frac{1}{2}\left(F_3^1 + F_2^1\right) & 1 \\ \vdots & \vdots \\ -\frac{1}{2}\left(F_x^1 + F_{x-1}^1\right) & 1 \end{bmatrix} \begin{bmatrix} a \\ b \end{bmatrix}.$$

Step 5. Solve the parameter a and b

$$\hat{a} \text{ or } \begin{bmatrix} a \\ b \end{bmatrix} = \left(B^T B\right)^{-1} B^T F.$$

Step 6. Estimate AGO value

$$\hat{f}_{T+1}^{1} = \left[f_1^0 - \left(\frac{b}{a}\right)\right] e^{-at} + \left(\frac{b}{a}\right), \qquad \forall t \geq 1.$$

Step 7. Get the estimate IAGO value

$$\hat{f}_t^0 = \hat{f}_t^1 - \hat{f}_{t-1}^1, \qquad \forall t \geq 2$$

We use the average residual error for each set of data to calculate the accuracy of the predicted data. The formula for the average residual error is given as

$$\frac{1}{n}\left(\sum_{t=1}^{n} \frac{\left|f_t^0 - \hat{f}_t\right|}{f_t^0}\right).$$

Where f_t^0 = Original data at time t

$\hat{f}$ = Predicted data at time t

n = The total number of data has been predicted

In order to test the effectiveness of grey system theory, we set up an electronic simulated marketplace. The simulated electronic marketplace consists of a number of auctions that run concurrently. There are three types of auctions running in the environment: English, Dutch and Vickrey. The English and Vickrey auctions have a finite start time and duration generated randomly from a standard probability distribution, the Dutch auction has a start time but no pre-determined end time. At the start of each auction (irrespective of the type), a group of random bidders are generated to simulate other auction participants. These participants operate in a single auction and have the intention of buying the target item and possessing certain behaviour. They maintain information about the item they wish to purchase, their private valuation of the item (reservation price), the starting bid value and their bid increment. These values are generated randomly from a standard probability distribution. Their bidding behaviour is determined based on the type of auction that they are participating in. The auction starts with a predefined starting value; a small value for an English auction and a high value for a Dutch auction. There is obviously no start value for a Vickrey auction. The marketplace is flexible and can be configured to take up any number of auctions and any value of discrete time. We assume that all the auctions in the marketplace are auctioning the item that the consumers are interested in. Our bidder agent is allowed to bid in any of the auctions at any time when the marketplace is active. It is also assumed that all auctions are selling the same item.

4. PRELIMINARY EXPERIMENTAL EVALUATION

The purpose of this experimental evaluation is to determine the efficiency and accuracy of the grey system theory in predicting the closing price of an online auction. However, to calculate the prediction accuracy of this model, we worked on the original data taken from eBay financial result (eBay, 2006), the GAAP

Diluted EPS and pro-forma Diluted EPS data between the first quarters of 2005 until the second quarter of 2006. We used four historical data to calculate the predicted value. To test the accuracy of the grey theory, the accuracy is calculated based on the residual error. It was found that the average residual error for the GAAP predicted data is 3.91% (96% accuracy) and the non GAAP or Pro-forma is 2.99% (97% accuracy). This is very promising considering the fact that only four historical data are used in the prediction.

The next step however is to investigate whether we will get similar result when we apply this theory to predict the closing price of an online auction. Using the simulated marketplace, we ran the auction from t = 1 until t = 30. We have also set most of auctions to close after t = 15. In one particular run, the closing price history for all auction running in a marketplace are shown from t = 18 until t = 25. Our first experiment is to calculate the predicted auction closing price based on three, four, five, six, seven and eight historical closing price data which is shown in Table 3. The result of the prediction is shown as below. In can be seen that the average residual error falls between 3.58% to 29.12% and the highest accuracy is using 5 historical data.

At the same time, we also calculated the predicted closing price for five more data from t = 19 to t = 30 which is shown in Table 4. It was found that the average residual error increased to a range between 4.95% to 23.88%. This result is still acceptable since the average residual error is 9.09% (or 90% accuracy). In this case, the highest accuracy is using 4 historical data. It can also be seen in both experiment that the accuracy at the highest between 5 and 6 historical data.

In the following experiment, six moving historical data were used to predict the auction closing price. That means, to predict the auction closing price at t = 24, we will use data from the last five closing (t = 18 until t = 23). We used six historical data because of its performance in the previous experiment. Table 5 shows the predicted values based on the given range. In this particular experiment, the average residual error is between 4.30% to 26.11% and the average residual error for the 5 readings is 9.85% (90%). This experiment also shows that using moving historical data, grey theory is able to predict the auction closing price more accurately by just making use of six previous data. The result of these experiments shows that grey system theory can be used to predict the auction price of an auction. The difference between actual data and original data may be contributed by other factors such as bidder's emotion, the priority of the items, and so on, which are not taken into the consideration at this point.

5. RELATED WORK

There are many researches that have been engaging in the prediction and forecasting of real world phenomenon. Chiou et al. (2003) introduced Grey Prediction Model (GPM) to plan material of spare parts equipment in Taiwan. They took three types of weapon system periodic items of planning material from 1999 to 2002, and applied GM (1,1) model to predict the planning requirement of impenitent spare parts of 2003. Through this study, they demonstrated that the GM (1,1) produced a high level of accuracy in prediction of spare parts. Lin and Lin (2004) used grey prediction to improve the efficiency of achieving accurate and speedy inspection when a coordinate measuring machine (CMM) is used to measure circularity geometric tolerance. Grey theory was applied in developing the heuristic algorithm for predicting the number of measuring points required for measuring circularity geometric tolerance. The heuristic algorithm was used to plan the number of measuring points of the next work piece and to predict the circularity geometric tolerance dimensions. This step provides a better foundation for on-line inspection to determine the number of measuring points required for measurement inspection of the next work piece. It can also predict whether the circularity geometric tolerance of the next work piece will conform to the circularity geometric tolerance dimension on the design drawing. This heuristic algorithm could also be used to

Table 2. Result performed by using Grey prediction model compared with original data collected from eBay financial result

Year and Quarter	GAAP Original Data (Million)	GAAP Predicted Data (Million)	Pro Forma (non GAAP) Original Data (Million)	Pro Forma (non GAAP) Predicted Data (Million)
2005 Q1	256.3	-	275.5	-
2005 Q2	291.6	281.939	307.2	291.989
2005 Q3	255	264.068	280.2	293.533
2005 Q4	279.2	280.132	340.1	339.796
2006 Q1	284.3	264.074	342.9	344.893
2006 Q2	250	236.932	351	366.999

The average residual error of GAAP Predicted Data is 3.91%
The average residual error of non GAAP or Pro Forma Predicted Data is 2.99%

Table 3. Result performed by using Grey prediction model compared with original data generated by agent auction

Time (t)	Original Data	Using 3 Historical Data	Using 4 Historical Data	Using 5 Historical Data	Using 6 Historical Data	Using 7 Historical Data	Using 8 Historical Data
18	83	-	-	-	-	-	-
19	85	84.991	85.959	83.085	82.032	83.658	82.315
20	82	81.982	80.783	79.591	78.544	80.445	78.617
21	73	79.080	72.911	77.550	77.541	78.401	76.919
22	83	82.385	68.748	82.989	85.024	83.568	83.232
23	82	72.999	49.673	76.938	81.999	76.986	78.571
24	69	62.014	27.036	69.425	79.467	69.695	76.945
25	81	61.523	13.162	75.478	89.432	73.732	81.368

The average residual error of using 3 historical data is 7.75%
The average residual error of using 4 historical data is 29.12%
The average residual error of using 5 historical data is 3.58%
The average residual error of using 6 historical data is 5.99%
The average residual error of using 7 historical data is 3.95%
The average residual error of using 8 historical data is 4.15%

Table 4. Result performed by using Grey prediction model compared with original data generated by agent auction

Time (t)	Original Data	Using 5 Historical Data	Using 6 Historical Data	Using 7 Historical Data	Using 8 Historical Data
18	83	-	-	-	-
19	85	83.085	82.032	83.658	82.315
20	82	79.591	78.544	80.445	78.617
21	73	77.550	77.541	78.401	76.919
22	83	82.989	85.024	83.568	83.232
23	82	76.938	81.999	76.986	78.571
24	69	69.425	79.467	69.695	76.945
25	81	75.478	89.432	73.732	81.368
26	83	62.125	86.897	64.134	75.85
27	81	55.391	81.866	50.938	67.41
28	76	44.303	78.341	38.181	60.04
29	83	36.888	79.325	28.897	56.77
30	70	21.169	72.823	11.12	45.61

The average residual error of using 5 historical data is 18.10%
The average residual error of using 6 historical data is 4.94%
The average residual error of using 7 historical data is 23.88%
The average residual error of using 8 historical data is 11.83%

determine whether the manufacturing process requires modification, in order to save human and material resources and reduce failure rate.

Wang (2002) used the fuzzy grey prediction system to predict the stock price instantly at any given time. Wang combined fuzzification techniques with grey theory to develop a fuzzy grey prediction and plugged it into a system to predict the possible answer immediately. He used the prediction system to analyze stock data and to predict the stock price promptly at a specific time. Wang, Chang, Belkasim and Sunderraman (2002) designed the real time fuzzy personalized stock information agent based on fuzzy logic. The smart agent enables the users to create their own portfolios that contain the real time watch list of personalized stocks. This application enables the user to get accurate, real time information of a pre-selected list of favourite stocks. Using fuzzy reasoning, the Web stock agent is capable of ranking the "top 10 stocks" based on their real time stock information. Since output values are calculated with the consideration of degree of uncertainty, results of the data process are precise and reliable. It saves time for user to search for stock information, and good stocks from thousands of stocks.

Hassan, Nath and Kirley (2006) proposed and implemented a fusion model by combining the Hidden Markov Model (HMM), Artificial Neural Networks (ANN) and Genetic Algorithms (GA) to forecast financial market behaviour. The tool can be used for in depth analysis of the stock market. Using ANN, the daily stock prices are transformed to independent sets of values that become the input to HMM. They drew on GA to optimize the initial parameters of HMM. The trained HMM is used to identify and locate similar patterns in the historical data. The price differences between the matched days and the respective next day are

Table 5. Result performed by using Grey prediction model compared with original data generated by agent auction

Time (t)	Original Data	Using 1-6 Historical Data	Using 2-7 Historical Data	Using 3-8 Historical Data	Using 4-9 Historical Data	Using 5-10 Historical Data
18	83	-	-	-	-	-
19	85	83.085	-	-	-	-
20	82	79.591	81.152	-	-	-
21	73	77.550	78.592	77.199	-	-
22	83	82.989	83.357	81.591	79.813	-
23	82	76.938	76.481	76.176	76.517	76.733
24	69	69.425	68.9995	71.956	74.117	72.695
25	81	75.478	72.946	80.931	84.61	82.905
26	83	62.125	63.353	78.1	82.996	82.384
27	81	55.391	50.255	73.466	79.276	81.153
28	76	44.303	37.682	71.027	77.449	83.231
29	83	36.888	28.665	91.785	80.517	91.634
30	70	21.169	11.235	69.741	76.478	94.4

The average residual error of using 1-6 historical data is 4.94%
The average residual error of using 2-7 historical data is 26.11%
The average residual error of using 3-8 historical data is 5.21%
The average residual error of using 4-9 historical data is 4.30%
The average residual error of using 5-10 historical data is 8.73%

calculated. Finally, a weighted average of the price differences of similar patterns is obtained to prepare a forecast for the next day.

6. CONCLUSION AND FUTURE WORK

This paper elaborated on the used of grey theory system to predict the closing price of an online auction. It has been shown that using this method, the accuracy rate always exceed 90%. This closing price knowledge can then be used by the bidder to decide which auction to participate, when and how much to bid. This information will also allow the bidder to maximize his chances of winning in an online auction. For future work, we will continue to investigate the effectiveness of grey theory in multiple auctions. Work need to be done to incorporate more than six historical data for prediction. It would be desirable if we can take into account all the historical data to produce an even more accurate prediction. Apart from that, we would also look into combining the grey method with other AI techniques.

In a larger context, this information about the closing price will be made use to support the development of bidder's strategies in online auction (Anthony & Jennings, 2003). Given a situation in which there are more than one potential auctions that the agent can participate, it would need to decide which auction it should participate in order to guarantee that it gets the item at the best price. In this case, the best price is the bid value that is less than the agent's reservation price. If the agent can predict the closing price accurately for each potential auction, then it would be able to make a quick decision on which of these potential auctions it should participate to maximize its gain.

REFERENCES

Anthony, P., & Jennings, N. R. (2003). Agent for Participating in Multiple Online Auction, ACM Transaction on Internet Technology, 3(3), 1-32.

Bapna, R., Goes, P., & Gupta, A. (2001). Insights and Analyses of Online Auctions. Communications of the ACM 44(11). 43-50.

Deng J. (1982). Control Problem of Grey System. System Control Letter, 1(1), 288-294.

Deng J., & David K.W. N. (1995). Contrasting grey System Theory to Probability and Fuzzy, ACM SIGICE Bulletin, 20(3), 3-9.

eBay. (2006). eBay Inc. Announces Second Quarter 2006 Financial Results, Retrieved 30 June 2006, from http://investor.ebay.com/financial.cfm.

Chiou, H. K., Tzeeng, G. H., Cheng, C. K., & Liu, G. S. (2003). Grey Prediction Model for Forecasting the Planning Material of Equipment Spare Parts in Navy of Taiwan. In proceedings of the World Automation Congress, 2004, 17, 315-320.

Chiang, J. S., Wu, P. L., Chiang, S. D., Chang, T. I., Chang, S. T., & Wen, K. L. (1998). Introduction to Grey System Theory, Gao-Li Publication, Taiwan.

Hassan, M. R., Nath, B., & Kirley, M. (2007). A Fusion Model of HMM, ANN and GA for Stock Market Forecasting, Expert Systems with Applications, 33(1), 171-180.

Klemperer, P. (1999). Auction Theory: A Guide to The Literature. Journal of Economic Surveys 13 (3), 227-286.

McAfee, R. P., & McMillan, J. (1987). Auctions and Bidding, Journal of Economic Literature, 25(2), 699-738.

Liu, S., & Lin, Y. (2006). Grey Information: Theory and Practical Application with 60 Figures, Springer-Verlag, London.

Wang, Y. F. (2002). Predicting Stock Price Using Fuzzy Grey Prediction System, Expert System with Applications, 22(1), 33-39.

Wang, Y., Zhang, Y. Q., Belkasim, S., & Sunderraman, R. (2002). Real Time Fuzzy Personalized Web Stock Information Agent, In proceedings of the Second International Workshop on Intelligent Systems Design and Application, 83-88.

Lin, Y., & Liu, S. (2004). Historical Introduction to Grey Systems Theory, In proceedings of the IEEE International Conference on Systems, Man and Cybernetics, 3, 2403-2408.

Lin, Z. C., & Lin, W. S. (2004). The Application of Grey Theory to the Prediction of Measurement Points for Circularity Geometric Tolerance, Springer, London.

E-Collaboration Tools for Government Funded Projects: NHLBI-PEN Approach and Solution

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ABSTRACT

In this paper, we present the E-collaboration system that has been designed and developed during the first year of the NHLBI-PEN Government Funded Project. We start by presenting the design phase that led to the implementation of the E-collaboration tools of the project. Then, we describe the function of each e-tool, we discuss the impact on the project that they have produced and we present open issues for further implementations of the system. Even if a specific information technology expertise was needed in order to make our system operational, we believe that it can be easily replicated and used by investigators of other government funded projects who do not already have access to an E-collaboration system.

INTRODUCTION

In order to successfully manage a research project, keep it on track and fulfill its goals, it is essential for the team to frequently discuss plans, objectives, achievements and challenges. It is also important to have the ability to share large data sets while maintaining a high level of security and privacy. Meeting and exchanging results regularly are also essential for the success of the project.

Face-to-face communications have been considered as the most appropriate medium to share ideas, comments, and opinions and to reduce misunderstanding [1]. However, large government funded projects often involve researchers from different institutions and/or departments. Therefore it is not always possible to implement this direct mode of communication due to the challenges of distance and the increasing needs of time and cost savings.

Recent developments in information and communication technologies have enabled and facilitated new forms of inter-organizational collaboration [2]. The use of E-collaboration tools introduces a new concept of time and distance, modifies human interactions, creates a novel environment for decision making and changes the classic network of face-to-face relationships into a network of virtual relationships.

E-collaboration has been defined in many ways. For the purposes of this article, we adopt the definition proposed by the guest editors of the first special issue on E-collaboration, published in 2001 in the *Journal of Systems and Information Technology by Kock et al.* They describe E-collaboration as "collaboration among individuals engaged in a common task using electronic technologies" [3]. Our system includes not only computer based technologies but also simple telecommunication devices such as the telephone. We agree with Kock [4] and we believe our system should still be considered an E-collaboration system.

In the following sections we briefly introduce the NHLBI-PEN project and describe the context that brought us to the implementation of a set of E-collaboration tools. Then, we present the hardware and software platform, a detailed description of the function of each E-collaboration tool, and the reasons for their development. We discuss the issues and challenges we experienced during development and implementation along with the limitations of our study, results achieved, and concluding comments.

THE NHLBI-PEN PROJECT

The central mission of the NHLBI-PEN project is to develop a group of well-characterized and versatile nanoscale agents that can be assembled, labeled, targeted, filled, and activated as needed for the diagnosis and treatment of various diseases of relevance to the National Heart Lung and Blood Institute (NHLBI). The project started in May 2005 and it has been funded for five years. The research activities of this project are carried out at three different institutions: Washington University in Saint Louis, University of California - Santa Barbara, and University of California – Berkeley. The teams include researchers from different cultures and scientific backgrounds where about 80% are chemists.

NEEDS ANALYSIS

Remote collaboration initiatives are not common in chemistry departments where Information Technology resources are often limited. The departments usually provide only emails as form of communication, common Internet access and occasionally the possibility to share central equipments.

E-Collaboration requires a synergistic framework based on four components: strategy, organization, process and technology [5]. We believe that a system embodying this synergy is advisable and necessary in order to be successful. Following this assumption, the senior investigators of the NHLBI-PEN project designed a roadmap with the goal of developing a set of E-collaboration tools that could overcome the potential barriers to collaboration and information sharing created by the physical separation and schedule differences between the three Universities.

The road map was based on four stages: 1) requirement gathering, to understand and identify the needs of the users, 2) requirement specifications, to identify any system requirements and user goals that must be met for the system to be successful, 3) design prototype in stages, and 4) evaluating the design to assess the system, test the software and perform usability testing.

Research has shown that it is much more economical to consider user needs in the early stages of the design [6]. In our road map, the needs and limitations of the end users were first inquired and analyzed, and then assumptions were transferred into the prototypes. This approach is well recognized as an effective strategy in designing ease-of-use products and systems [7],

The senior investigators of the NHLBI-PEN project identified four inter-organizational set of tools: information, communication, coordination and collaboration (see Table 1). For each of them, they defined a list of needs that had to be fulfilled by a specific E-collaboration tool. A time frame for implementation, based on months from the starting date of the project, was defined as well. The collaborative tools were selected among the ones presented here [8].

Given monetary constraints and the need to personalize software with specific routines, proprietary software was not a feasible option. In order to increase flexibility, independence from a third party provider was required. The system had to be highly reliable yet easy to maintain, administer and update, once fully operational. Synchronous and asynchronous tools had to be designed with the goals of increasing the communications and the sharing of data and results among the researchers. Easy access to and operation of the E-tools had to be addressed since most of the researchers in the project did not have an information technology background. Focusing on ease of use has been used to advance the product's release date [9].

In summary, the E-collaboration system had to be cost-effective (low cost of implementation), independent to industry and software/hardware vendors (open),

Table 1. Classes of inter-organizational information systems

Information	Communication	Coordination	Collaboration
WEB portal for sharing progress and general information about the project (available after 2 months). WEB portal for storing/remember events and meetings (available after 3 months). WEB site for storing goals and achievements of the researchers during skill development visits to other laboratories (available after 6 months).	Affordable conferencing system (available after 1 month). Research groups mailing list (available after 1 month). WEB site for facilitating the exchange of chemical samples between laboratories (available after 6 months).	Electronic document interchange tool (available after 4 months). System for monitoring the budget (available after 6 months).	Collaborative Planning (available after 10 months).

easy to integrate with the existing procedure/process and fast to deploy on a simple technology. [5]

NHLBI-PEN E-COLLABORATION SYSTEM

Following the plan provided in the road map, an E-collaboration system was designed and implemented. Initial use of the E-collaboration system was restricted to peripheral or uncritical activities and then implemented in full scale. This approach had many advantages: users learned to handle the new E-collaboration approach gradually without detracting from efficiency in their daily activities; technical implementation investment risks were minimized while the possibility of standardization was increased; and the E-collaboration system was tested adequately before going to full scale production.

HARDWARE AND SOFTWARE

The hardware and software platform used for providing the E-collaboration tools described in this paper, is based on a 2U rack Pentium III server class A by Ironsystems [10]. It runs Linux Debian with Apache as web server [11], PHP as scripting language [12], MySql as relational database [13], Webalizer for web statistics [14], and Postfix [15] as SMTP server. Telnet, FTP, DNS and other services have been uninstalled for security reasons. High levels of stability, fault tolerance, and availability are addressed by the use of RAID (Level 1) technology, daily backup policy on different supports (tape, external USB drive, and data storage devices), and redundant and uninterruptible power supply. Security policies are addressed by disabling physical and remote access to the server. Only a secret username has the privilege to log-in through a SSH connection from a subnet inside the Washington University in Saint Louis network. The SMTP server uses a mail relay provided by the department for spam filtering and virus protection. Specific firewall policies, directly controlled and managed by the IT office of the department of Chemistry at Washington University in Saint Louis, block access to the server except for port 80 (HTTP) and port 25 (SMTP). A daily report of the Internet traffic through these two ports is automatically created and checked regularly.

E-CONFERENCE TOOLS

The meetings of the NHLBI-PEN project are usually held in a conference room located at the School of Medicine of Washington University in Saint Louis. In order to reach a high level of participation and to increase the effectiveness of the meeting, a hybrid system, composed by an audio and a virtual office component, was developed. The audio component is based on a SoundStation VTX 1000™ Polycom system that allows communication, *via* telephone line, with the researchers in California. The two extra microphones and the speakers included in the Polycom system allow the circulation of comments, questions, and answers between all the participants (usually twenty in Saint Louis and seven in the two sites in California). The telephone service is provided by the university telephone department. The virtual office component uses a desktop sharing utility, based on VNC [16] that allows each site to be engaged in the meeting by following the PowerPoint presentations in real time. While one site actively initiates and controls their presentations, the other site can passively view. This virtual office component overcomes the limitation in following a distant presentation where the slide under discussion and the highlighted area of the slides by the presenter's laser pointer are unknown. The movements of the laser pointer are subsequently replaced by the movements of the mouse. This desktop sharing utility uses TCP/IP and it is available through a web site that works as proxy. A dedicated computer with Windows 2000 and VNC has port TCP 5900 open through the firewall. Two levels of password authentication are required to have access to the utility: one provided by VNC and the other by Windows.

E-DOCUMENTS TOOL

The E-Documents Tool is based upon PHP Advanced Transfer Manager [17], a free web content management software. It allows the researchers involved in the project to collaboratively create, publish, share and retrieve data when needed. The main features available are: upload, download, delete or modify (users can only manipulate their own files). A super-user creates folders, has full control over all the files, and manages user accounts. In order to fulfill the requirements and the needs of the researchers, the main software package was upgraded. Specific routines were designed, developed, tested and finally added to the basic package in order to have an E-Documents Tool that can provide each user with 300 Mbytes of restricted space (Personal folder) and each research unit (identified as a senior investigator plus his/her researchers) with 2 Gbytes of restricted space. The new version also has a shared folder accessible by everyone that is used for transferring files among units. Finally, a special area has been created for the exclusive use of the Internal Operating Committee members. At the end of July 2006, the E-Documents Tool had 304 files uploaded, 270 Mbyte of data stored, and 44 active users (Figure 1).

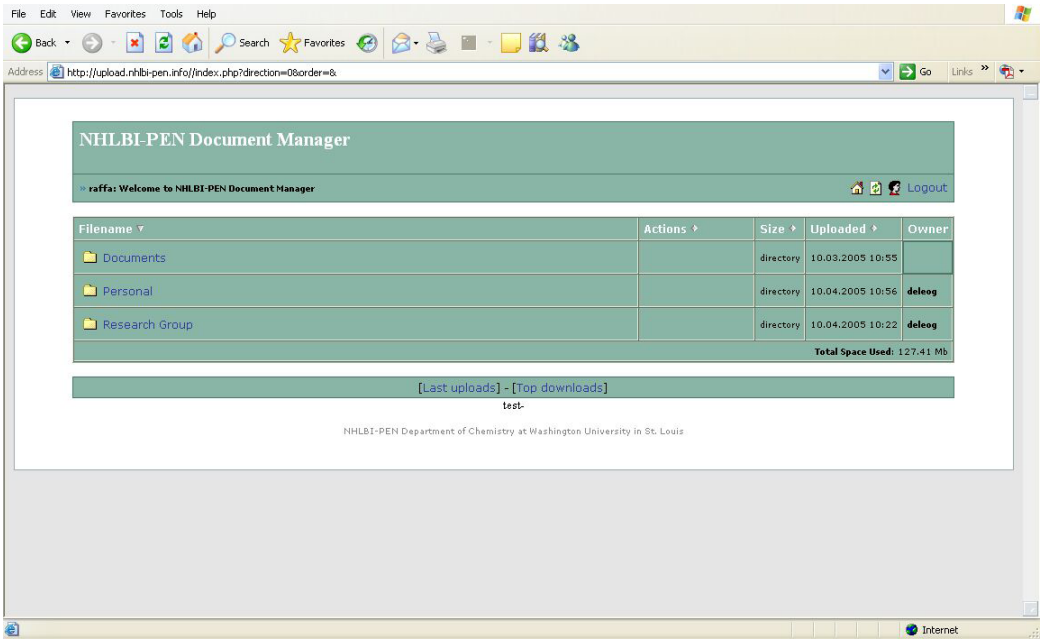
MAILING LIST TOOL

The researchers of the NHLBI-PEN project can utilize several mailing lists for easily contacting the members of each team. The mailing lists are both horizontal (for each of the 12 research teams) and vertical (for each of the 4 component: Materials Synthesis, Imaging, Animal Models, and Skills Development). The Internal Operating Committee has its own mailing list. In addition, a global mailing list that contains all the members is available.

E-RESEARCHER VISITS TOOL

The researchers of three universities are encouraged to schedule frequent short visits to other laboratories involved in the project. Throughout the year, post-doc and graduate students spend a few intensive days in other research groups to learn about additional procedures and methodologies that they have not yet experienced. The E-Researcher Visits Tool stores the researcher's name and email, information

Figure 1. The e-document tool (home folder view)

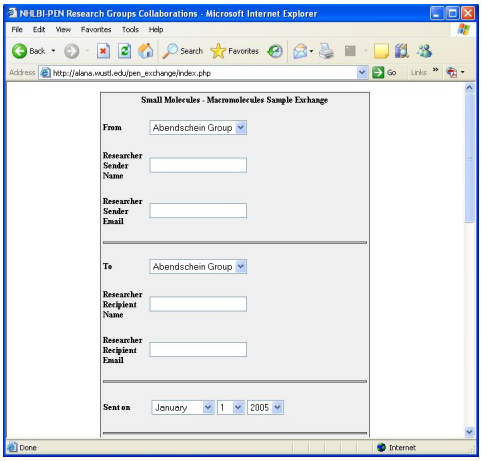


about the research group where he/she belongs, the group that he/she is visiting, and the goals and accomplishments of the visit. At the end of July 2006, the E-Researcher Visits Tool had 17 visits stored. A web site, password protected through the Apache htaccess policy, allows anyone in the project to have access to the E-Researcher Visits Tool.

E-SAMPLE EXCHANGE TOOL

The E-Sample Exchange Tool stores the information and the data of the chemical samples that have been transferred between research groups. There are two different sample exchange tools: one for Small Molecules-Macromolecules and one for Nanoparticles. A user-friendly web interface was developed in order to

Figure 2. E-sample exchange tool (insert a new record view)



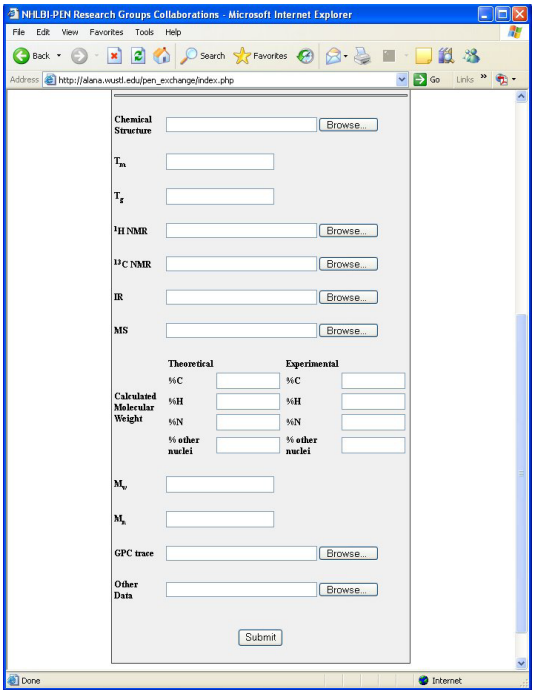
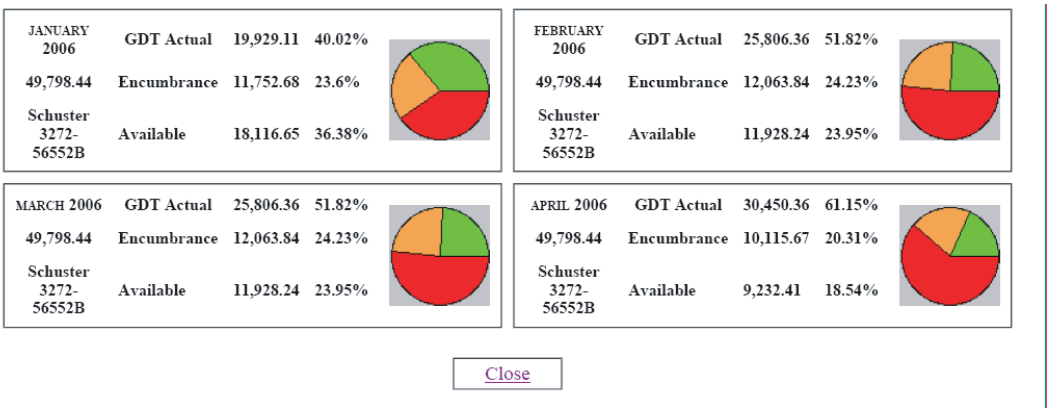


Figure 3. E-budget tool (monthly progress view)

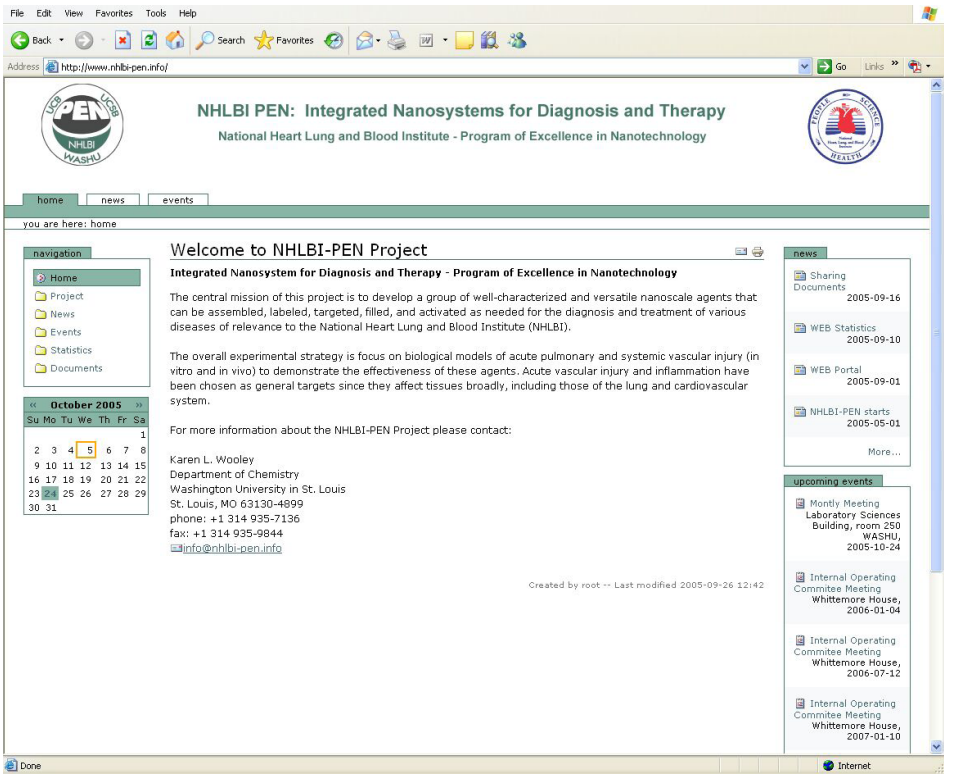


guide the researchers in creating a new record that contains general information and detailed data about the sample. General information includes the names and email addresses of the researchers who sent and received the sample, the date of sending, and an identification code. Detailed data consists of the chemical structure, the calculated molecular weight, the GPC trace, and other chemical properties. As in the case of the E-Researcher Visits tool, a web site allows anyone in the project to have access to the data. At the end of July 2006, the Sample Exchange E-Database contained 19 entries for Small Molecules – Macromolecules and 14 entries for Nanoparticles (Figure 2).

E-BUDGET TOOL

The E-Budget Tool keeps track of all the expenditures of each research group. This tool is available only to the Principal Investigator and her administration office. The budget of each research group is updated on a monthly basis and it shows the spent, the encumbrance and the available amounts. A color pie chart simplifies the visualization of the status of the budget and it is available in two formats. The first chart visualizes the research group budget situation by months, and it is used for monitoring the expenses over a long period of time. The second format gives an overview of all research groups by a selected month (Figure 3).

Figure 4. Web portal (home page view)



WEB PORTAL

The NHLBI-PEN web portal is available at http://www.nhlbi-pen.info (see Figure 4). Since the beginning of the project, the NHLBI-PEN team has been using the web portal for informing the community on new events and news. The status of the project, its progress and future plans are updated regularly. The web portal was developed using Zope [18] and Plone [19] and it provides a common interface and a single entry point to the other NHLBI-PEN E-Collaboration tools and services. The web portal contents can be easily updated by anyone, even without training in Hyper Text Markup Language (HTML).

DISCUSSION

The roadmap described in this paper is related to the first year of the NHLBI-PEN project. All the E-collaboration tools, except the collaborative planning, have been implemented and are fully operational.

The need for developing the E-collaboration tools presented in this article comes from the absence of collaborative systems at the three universities involved in the project. It is true that a teleconference system was available at each site but it was not free of charge, was difficult to reserve and the telecommunication standards used were not the same. Moreover the cost of using such systems cannot be billed directly to the grant and is not usually covered by the indirect costs of the departments. The possibility that the government agency that provides the grant would provide such E-collaboration tools free of charge does not seem realistic too.

Moreover, specific budgets for supporting IT personnel are not usually included in grant proposals. Thus, costs related to the initial investment in hardware should be considered when E-collaboration tools are planned. However, these costs would be a small percentage of the total budget of the project.

We believe the interface to our E-collaborations tools is easy to use. The researchers of the NHLBI-PEN project only need an e-mail account and a browser to have access to all the tools. Our monthly meetings have been attended often by researchers traveling in other countries or away from their offices. A wireless access point was enough for giving them the opportunity to participate. However, in order to increase the user-friendliness of our entire system, we are planning to develop a central log-in management system that stores the user's information. This would allow the user to log into each tool with the same id and password.

Bulletin boards for extended conversation and chat, where real-time text messages appear on both users screens, have not been implemented because they were not considered beneficial to the project. However, the development of a web based task list including a set of actions to be performed, pending activities, and unresolved problems is in progress. The E-Sample Exchange tools will have a "store room" section where researchers can look at the samples that are available in each group, place an order and receive the chemical at their labs. The implementation of a web based free educational tool to fulfill the skills developments component goals has been planned. Initial investigations suggested the use of Moodle [8].

Linux has been preferred to Windows as the operative system platform because more open source software is available under Linux. It is also easier to maintain once installed. We believe that the knowledge required to run a Linux server is equivalent to the one needed to administer a Windows 2000 Server.

Although the system is easy to maintain, we believe that a maintenance service (hardware and software) should be in place in order to guarantee availability of the E-tools to the researchers.

CONCLUSION

With the development of new technologies, and information communication technologies, in particular, teams have evolved to encompass new forms of interaction and collaboration. This paper demonstrates that E-collaboration tools can be used in a research funded project and that the implementation is not difficult to achieve.

The NHLBI-PEN E-collaboration system brings geographically dispersed research partners together, and supports the communication, coordination, cooperation, and sharing of data between the distant locations. We have described a system that allows the researchers of government funded projects to adopt the use of low-cost E-collaboration tools for increasing productivity and team work.

This study does not present any data about user's evaluation of the E-tools because a survey for collecting user feedbacks has not yet been developed. We only know that each E-tool has been extensively used. We are also aware that the number of the users in the NHLBI-PEN project would not have been enough statistically to make any definitive statements about the quality of our E-collaboration system.

However, we have acknowledged a transformation process from traditional (offline) communications toward hybrid services that combine elements of traditional collaboration and E-collaboration. Our E-collaboration solution is presented to improve the existing processes and provide the vehicle to establish new forms of collaboration.

Finally, we believe that a set of E-collaboration tools such the ones described, should be provided by the Universities using indirect cost budgets.

ACKNOWLEDGMENT

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REFERENCES

[1] R. L. Daft and R. H. Lengel, "Organizational information requirements, media richness, and structural design," *Manage. Sci*., vol. 32, no. 5, pp. 554–571, 1986.

[2] Madnick, Stuart E. (1991): The Information Technology Platform, in: Scott Morton, Michael S. (ed.): The Corporation of the 1990s: Information Technology and Organizational Transformation. New York, Oxford: Oxford University Press, 1991, pg. 27-60.

[3] N. Kock, R. Davison, R. Ocker, and R. Wazlawick, "E-collaboration: A look at past research and ruture challenges," *J. Syst. Inform. Technol.*, vol. 5, no. 1, pp. 1–9, 2001.

[4] N. Kock and J. D'Arcy, "Resolving the e-collaboration paradox: The competing influences of media naturalness and compensatory adaptation," Inform. Manage. Consulting, vol. 17, no. 4, pp. 72–78, 2002.

[5] Gerst, M. (2003): The Role of Standardisation in the context of e-collaboration: a Snap shot, 3rd IEEE Conference on Standardisation and Innovation in Information Technology 2003, October, 22-24, Delft.

[6] Pressman, 1992. Software Engineering: A Practitioner's Approach . McGraw-Hill, NY.

[7] Vredenburg, K., Isensee, S. & Righi, C. (2002). User-centered design: An integrated approach. New Jersey: Prentice Hall.

[8] Georgia Bafoutsou , Gregory Mentzas, A Comparative Analysis of Web-based Collaborative Systems, Proceedings of the 12th International Workshop on Database and Expert Systems Applications, p.496-500, September 03-07, 2001

[9] Karat, C. (1997). Cost-justifying usability engineering in the software life cycle. In Helander, M., Landauer, T., and Prabhu, P. (Eds), Handbook of Human-Computer Interaction. Elsevier Science, Amsterdam.

[10] http://www.ironsystems.com

[11] http://www.apache.org/

[12] http://www.php.net/

[13] http://www.mysql.com/

[14] http://www.webalizer.com/

[15] http://www.postfix.com/

[16] http://www.realvnc.com

[17] http://phpatm.free.fr/

[18] http://www.zope.org/

[19] http://www.plone.org

[20] www.moodle.com

Web Quality Model: An Application to Business Domain

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ABSTRACT

Internet Economy allows businesses to move to the virtual market and establish their online presence on the Web. In order to strive, they have to keep their customers satisfied. Customer satisfaction depends on site usability, as only usable and good-quality sites can meet users' expectations. This paper describes the Web quality model and describes the methodology used for quality evaluation in the domain of business. The model is applied to the quality evaluation of two business-oriented Web site. The paper presents the results.

1. INTRODUCTION

The notion of Networked Economy, also called the Internet Economy or the Information Economy, has dramatically changed the way in which business is being conducted: it has allowed businesses to communicate electronically and run the entire supply chain through information highways. Virtual corporations, teleworking and telecooperation have become common practice worldwide [1]. The World Wide Web has become the cornerstone of such an economy.

The ease with which businesses can reach millions of potential customers in the global audience has prompted them to establish their presence on the Web. Current Internet usage statistics estimate that almost 1.1 billion people have Internet access [2]. Surely, businesses cannot and must not ignore the opportunity to profit by moving online to the virtual market.

With the fierce competition between online businesses, it is essential to identify the factors that enable them to get the competitive edge and advance in the business world. The customer satisfaction is the bare minimum that businesses have to meet in order to succeed.

Online customer satisfaction is rooted in the usability of the Web site – if the customer experiences difficulties while using the site, cannot find the information s/he is seeking or the information doesn't meet his/her expectations, s/he may turn to one of the competitors. Only good-quality sites can fulfill customer's expectations.

Quality is always prone to subjective interpretations unless it is quantified. In order to quantify the quality of a Web site, one needs to define requirements that the Web site has to meet and for each of the requirements identify a set of measurable attributes and measure them according to the specified procedure. In other words, to evaluate the quality of the Web site, the appropriate metrics have to be defined [3].

This paper describes the general Web site quality model and applies it to the world of business. It describes the methodology that can enable qualitative analysis of Web site's measurable attributes which affect the users' perception of the site's quality.

The remainder of this paper is organized as follows. Section II describes related work in the area of Web quality evaluation and quality models used in the evaluation processes. Section III describes the Web quality model while Section IV briefly describes the evaluation process. Section V explains how the model can be used to evaluate the quality of the business-related site. Section VI describes the results of quality assessment based on the quality model. Section VII concludes the paper.

2. RELATED WORK

The elements which define the quality of a software product and relationships between them were identified in the first quality models in mid 1970s. Two well known models that emerged at that time were McCall's model [4] and Boëhm's model [5]. In the 1990s, the International Organization for Standardization (ISO) in cooperation with the International Electrotechnical Commission (IEC) established two series of standards: series ISO 9126, which defined the quality model, and series ISO 14598 which described quality evaluation process. ISO standard regards quality as "the totality of characteristics of the entity that bear on its ability to satisfy stated and implied needs" [6]. Given the similarities in lifecycle and usage patterns between Web sites and software products, the ISO model can, with some modifications, also be applied to Web sites.

Many authors have defined Web site quality models based on McCall's or Boëhm's [7][8], while others base their work on ISO standards [9] [10][11].

Generally, all of them define a set of quality factors, which usually include (in one form or the other) suitability, installability, functionality, adaptability, ease-of-use, learnability, interoperability, reliability, safety, security, correctness, efficiency, maintainability, testability, flexibility, reusability, portability, visibility, intelligibility, credibility, engagibility and differentiation.

Those Web quality models lack structure and clarity of the ISO standards. Some of them provide the list of characteristics that should be taken into account during quality assessment, but none specify the methodology to be used in the process of evaluation.

To the best of author's knowledge, a comprehensive research in the area of quantitative measurement of Web site quality in the business domain has not been conducted as yet.

3. WEB QUALITY MODEL

In order to evaluate whether the specific Web site satisfies a certain quality requirement, the Web Quality Model (WQM) is defined [3]. Based on the ISO 9126 standard, it is represented by hierarchical three-level tree structure, with the six top-level characteristics:

- functionality,
- usability,
- reliability,
- efficiency,
- maintainability, and
- portability.

Each characteristic can be decomposed into a set of subcharacteristics. A set of measurable indicators is defined for each subcharacteristic.

Figure 1 depicts the hierarchy of the WQM [3]. In the top-down view, the quality of a given characteristic depends on the quality of its subcharacteristics, which

Figure 1. Quality model hierarchy

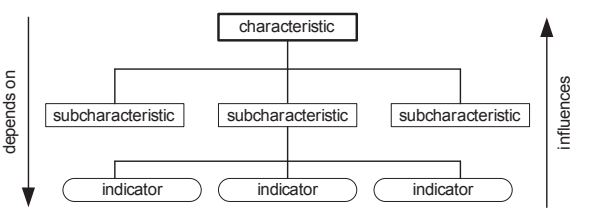
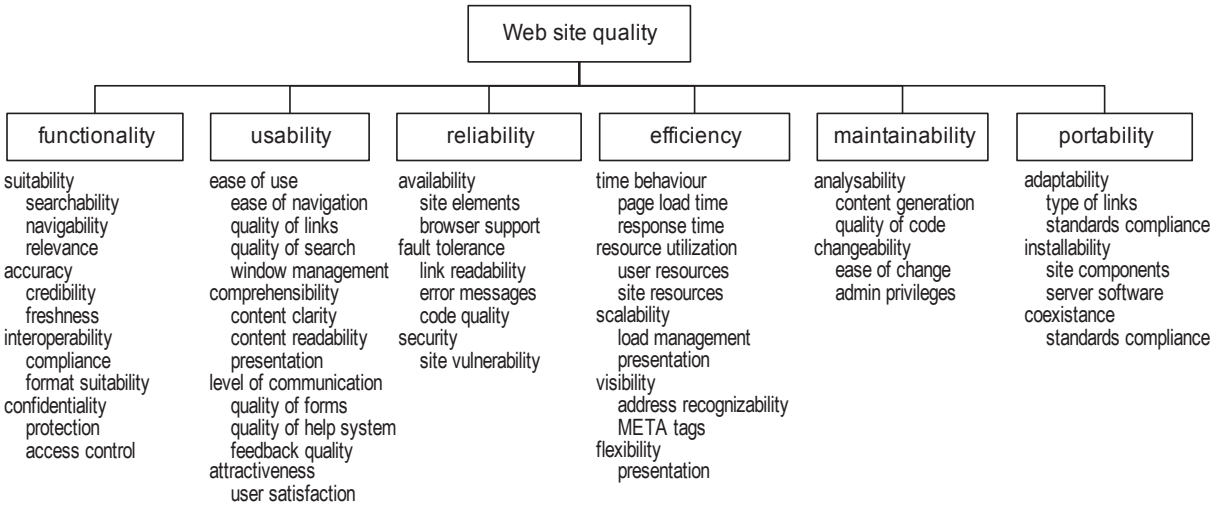


Figure 2. Characteristics, subcharacteristics and indicators of the Web quality model



in turn depend on the quality of their indicators. However, the bottom-up view starts with the indicators: the quality of each indicator affects the quality of the appropriate subcharacteristic, which in turn influences the quality of the appropriate characteristic in the WQM.

Figure 2 describes the characteristics, subcharacteristics and indicators of the WQM [3].

A. Functionality

Functionality is defined as the capability of the Web site to provide functions and properties which meet stated and implied needs when the site is used under specified conditions. The needs can be defined with respect to the type and purpose of the site and users' expectations. Functionality is decomposed into suitability, accuracy, interoperability and confidentiality. Their importance and scope depend on the purpose of the site.

B. Usability

Usability is defined as the capability of the Web site to be understood, learned and liked by the user, when used under specified conditions. Subcharacteristics are ease of use, content comprehensibility, level of communication and attractiveness.

C. Reliability

Reliability is defined as the capability of the site to maintain a specified level of performance when used under specified conditions. This doesn't involve solely the reliability of server software or network infrastructure, but the whole site from users' perspective. The subcharacteristics are availability, fault tolerance and security.

D. Efficiency

Efficiency is defined as the capability of the site to provide appropriate performance, relative to the amount of resources used, under stated conditions. Resources on the Web site may include hardware (discs, memory, CPU), bandwidth, etc. On user side, resources may include connection costs, time, bandwidth, etc. Subcharacteristics are time behavior, resource utilization, scalability, visibility and flexibility.

E. Maintainability

Maintainability is defined as the capability of the site to be modified. Modifications may include corrections, improvements or adaptation of the site to changes in environment. This characteristic is visible to developers and administrators. The users see its effects indirectly, through other characteristics. Subcharacteristics are analysability and changeability.

F. Portability

Portability is defined as the capability of the site to be transferred from one environment to another. Like maintainability, this characteristic is not directly visible to the user, but is important to site administrators, who occasionally have to transfer the site from one platform to another, or even to a completely new working environment. This characteristic is decomposed into adaptability, installability and coexistence.

For a thorough description of all the components of the quality model, the reader is referred to [3]. From user's perspective, only four characteristics contribute to the overall quality of the site: functionality, usability, reliability and efficiency. The other two characteristics influence administrator's perception of site's quality. In the remainder of this paper, the user's perception of quality is being considered.

4. EVALUATION PROCESS

Evaluation process can be applied at any stage of the Web site lifecycle. The design of a Web site typically comprises five stages:

a. requirements analysis,
b. site planning,
c. design,
d. development and
e. usage.

The process that accompanies the WQM stems from the ISO 14598 standard series and distinguishes four stages:

a. definition of quality requirements,
b. definition of metrics,
c. evaluation planning and preparation, and
d. evaluation execution.

They are described in more detail next.

A. Definition of Quality Requirements

The cornerstone of every evaluation is the clear definition of its purpose. Without clear goals, it is impossible to expect the evaluation to succeed.

Even though the evaluation process can be executed at any stage of site's lifecycle, the quality model must include relevant and measurable components and exclude those that have no meaning or relevance at the given stage. This is particularly important when site's functionality is concerned, because the functionality indicators can be defined only after site's purpose is known. An example of functionality indicators is described later in the paper.

B. Definition of Metrics

The term *metrics* is defined as "measurement method and its measurement scale which is used in measurement process to assign numerical values from the measurement scale to the measured attributes" [6].

The metrics that enable the evaluation of each indicator are selected based on the site lifecycle stage in which the evaluation is being conducted. Various metrics can be applied in different stages:

- in the development stage, the metrics is based on measurable internal attributes of the site (code quality, file size…),
- during the usage stage the metrics is related to users and their behavior and interaction with the site (user satisfaction, task execution…).

For that reason, the metrics are not the part of the proposed model, but have to be defined based on the purpose of each particular evaluation and available data. Although metrics may be reused, they have to be adapted to the function, purpose and type of site. The metrics used in this paper are derived using the *Goal-Question-Metric* (GQM) model [12].

C. Evaluation planning and preparation

Evaluation of the indicators through the use of GQM model is based on data gathering. This data can be derived from various sources, but not all sources are applicable in each stage of site development. It is important to determine what is to be measured and how and to devise the measurement and evaluation plan accordingly. Some of the sources include:

- HTML, JavaScript and CSS source code,
- visual site inspection,
- access log analysis,
- comparison with competitors' sites,
- user comments on site guestbooks,
- heuristic evaluation,
- usability testing,
- user surveys.

D. Evaluation Execution

Each metrics defines the data collection method, the attributes that are going to be measured and the criteria to be used in assessing the degree in which the measured value satisfies the stated requirements. During evaluation execution, the measure is assigned to each measured attribute. This measure reflects the relationship between the measured value and the rating scale.

When the measurement process is over, the final ratings of each indicator, subcharacteristic, characteristic and overall site quality are determined, based on their mutual relationships, using appropriate scoring techniques.

5. METRICS FOR BUSINESS WEBSITES

In order to evaluate the quality of a business website, the model has to be adjusted to suit the intricacies of the business domain. Metrics for usability, reliability and efficiency are generally domain-independent. Those metrics must be based on the available usability and accessibility guidelines and standards [13], [14], [15].

A. Functionality

Functionality metrics have to be carefully adjusted to suit the needs of the business domain. Figure 2 gives an overview of the WQM and defines subcharacteristics and indicators for functionality: it is decomposed into four subcharacteristics: suitability, accuracy, interoperability and confidentiality.

Suitability reflects the capability of the site to provide an appropriate set of functions to accomplish specified tasks. It can be decomposed into a set of measurable indicators:

- searchability – what search options are given to the user from the functional point of view? Can s/he search the entire site or also its sections? Here, care should be taken not to confuse functionality of search with its usability – functionality refers to the given set of options, while usability deals with the ease of using them.
- navigability – what kind of navigational system is at user's disposal? Is the content properly arranged into logical sections, taking into account user's perception of the company? Does the navigational system reflect internal organization of the site?
- relevance – does the online shop have a built-in shopping cart? Does it allow users to post comments about products?

Accuracy reflects the capability of the site to provide the right or agreed results or effects. It can be decomposed into two measurable indicators:

- credibility – can the information be trusted? Is the source of the information clearly stated on the page? Does the information come from credible sources? Are unregistered visitors allowed to post content (in forums, guestbooks, etc.)? Who links to the site? Where does the site link to? Does the site provide terms of usage?
- freshness – how old is the information on the site? Is there a date of publication visible on the page? Is outdated information available online?

Interoperability reflects the capability of the site to interact with user's browser and other software. Without proper rendering of the code in the browser, the user can't use the functionality provided by the site. The indicators are:

- compliance to standards – are HTML and CSS valid? Can all browsers accurately present the site? Is the visual design tailored to one specific browser?
- format suitability – are proper data formats used to convey the content?

Confidentiality reflects the capability of the site to prevent accidental or deliberate unauthorized access and allow access to authorized persons or systems. Breach of confidentiality may result in severe loss of data on the server side and loss of credibility. The measurable indicators are:

- protection suitability – is the communication secured?
- access control – is it provided? How can users be tracked? How do they log into the site? Do they use login/password or tokens?

In order to define the metrics for the indicators, various existing business-related usability and accessibility standards and guidelines may be used: Nielsen's Alertbox [16] is an excellent source. Other sources may include competitors' sites and user surveys.

B. Metrics, Measurement and Evaluation

Using the GQM model, a set of questions and metrics which are going to be used to measure the indicators is defined. Figure 3a gives an example of the questions and metrics used to evaluate searchability indicator of suitability.

Each metrics results in a rating on the measurement scale between 0 and 1. This rating defines the extent to which the measured property satisfies the requirements. The measurement gives no indication whether the property satisfies the stated requirements, so each metric has to define rating levels that relate the measured value to the level of satisfaction of the initial requirements. The measurement scale can be divided into several categories (e.g. acceptable, partially acceptable and unacceptable), but care should be taken not to use too many categories – 3 to 5 should suffice.

Each metric must define which Web site properties are relevant for the metric (e.g. number of menu items, text and background colors, layout style, number of embedded images, etc.), specify how the data should be collected (visual inspection, automatic tools and code analysis, monitoring user behavior, etc.) and define assessment criteria and appropriate rating levels. Figure 3b shows the definition of metric M4.3 from the previous example, which helps to evaluate the *searchability*. The *elementary priority* is the rating to which the level of acceptance maps and is a part of the scoring technique [17].

Metrics add up to the rating of an indicator in different ways. Some metrics are critical and must have a satisfactory rating for the overall quality to be satisfactory. Some are desirable, but not crucial for the overall quality. If the measure of

Figure 3a. Questions and metrics for "searchability" indicator

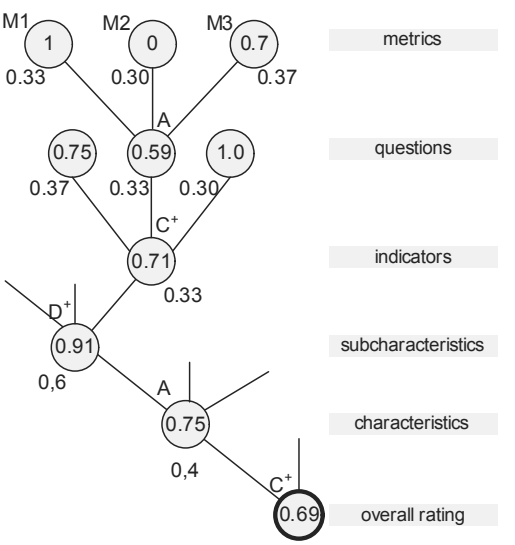
Characteristic: Functionality
Subcharacteristic: suitability
Indicator: searchability
Questions:

1. **What is the scope of search mechanism?**
   Metrics:
   M1.1. whole site can be searched
   M1.2. search can be restricted to sections
   M1.3. search can be restricted to products
   M1.4. search can be restricted to general information
   M1.5. search doesn't cover whole Internet
2. **Is advanced searching possible?**
   M2.1. search by sections
   M2.2. search by dates
   M2.3. search by locations
   M2.4. search by store subsidiaries
3. **How are the queries handled?**
   M3.1. misspelled query terms are considered
   M3.2. query term synonyms are also used in search
   M3.3. related query terms are also used in search
4. **How can search results be managed?**
   M4.1. indication of relevance
   M4.2. indication of approximate matches
   M4.3. filtering of results enabled
   M4.4. re-sorting of results enabled
   M4.5. tips are provided if no results are returned

Figure 3b. Metrics example

M 4.3. filtering of results enabled
data collection method: visual inspection
reason: Search mechanisms frequently return many matches. It is usually a good idea to provide users with the opportunity to narrow or filter the search results using additional criteria or constraints (e.g. site which sells products could enable the customers to further narrow the result set by product attributes, such as the desired size, color, manufacturer, price, etc.)
measured value: The presence of the mechanism that enables filtering of search results is being checked. It is acceptable if such a mechanism is available on every page with search results where it would be appropriate (generally where queries return too many matches), it is partly acceptable if it is enabled on a portion of pages. It is not acceptable if such a mechanism is not enabled.
elementary priority: E=1 for acceptable values, E=0 for unacceptable values, E=0.6 partly acceptable values.
sources: [11][12]

Figure 4. Example of the evaluation ratings



the critical metric is not satisfactory, the final rating is also not satisfactory. The importance of the metrics is derived from the existing usability guidelines and standards [13], [14], [15].

The same relationship maps to the upper levels of the quality model: each of the indicators affects the subcharacteristic differently, and each subcharacterstic affects characteristics differently. Finally, not all characteristics have the same impact on the final quality rating.

In order to evaluate the indicators, this paper uses the Logic Scoring of Preferences (LSP) approach, which serves as a mathematical tool to evaluate the characteristics of Web site quality. The LSP method is a general quantitative decision method for evaluation, comparison and selection of complex hardware and software systems [17]. Using LSP operators in the process of evaluation, it is possible to model different relationships between indicators: neutrality and different degrees of simultaneity (various levels of conjunction between the factors) and replaceability (various levels of disjunction between the factors). If the complexity of relationships between the metrics and indicators is less important of an issue, other models may be used. For example, in Figure 3a, in order to answer Question 1, the metrics M4.1. - M4.5. which affect the rating of the Question 1 share a certain degree of simultaneity; their relationship can be modeled by quasi-conjunction in the LSP model and is expressed as C^+ in LSP.

Ratings of one level have different impact on the upper level of the model, the evaluation criteria needs to be defined and weight factors of all metrics, indicators, subcharacteristics and characteristics determined. Various mathematical models can be applied to set the weight factors (such as SWING, AHP, etc.).

The rating process is depicted in Figure 4. At the first stage, metrics M1 - M3 are being evaluated, and ratings 1, 0 and 0.7, respectively, are given to each of the 3 metrics. Each metrics has a weighting factor (0.33, 0.3 and 0.37, respectively). The rating for the question is composed as the arithmetic middle of the metrics, taking into account their weights (indicated by A near the rating of the question). Other questions are rated in a similar manner. The ratings of those questions comprise the rating for the indicator, this time using the strong quasi-conjunction relationship (marked by C^+). The final rating of the indicator is 0.71. Next, the weighted indicators add up to the rating of subcharacteristic using strong quasi-disjunction (D^+), yielding the score 0.91. Arithmetic middle of the ratings for weighted subcharacteristic (A) is used to calculate the rating for the characteristic (0.75). Overall quality (0.69) is determined as the strong quasi-conjunction of all the weighted characteristics (C^+).

6. CASE STUDY: QUALITY ASSESSMENT OF TWO CORPORATE WEB SITES

During the study, two corporate sites were analyzed. They belong to the corporation whose core businesses are the production and distribution of food and

Table 1. Ratings of the main corporate site and the retail site

Characteristic	Main site	Retail site
Functionality	0.95	0.40
Usability	0.66	0.39
Reliability	0.86	0.83
Efficiency	0.83	0.31
Overall quality	**0.75**	**0.42**

drinks and retail. The evaluation of Web sites was conducted in May and June 2006 on the public sites, as a part of the redesign process. Two different sites were analyzed:

- main corporate site of the group, and
- retail sales site.

The WQM included 21 subcharacteristics and 44 indicators. In particular, the subcharacteristics and indicators of the functionality for the business domain were defined from scratch, as explained in Chapter V; others were adapted from previous research [3].

The data was gathered by visual inspection (menu locations, content clarity and comprehensibility, search functionality, navigation, etc.) and automated tools were used for the inspection of HTML and CSS code (length of links, number of words in the link, link availability, page length, presence of META and TITLE tags, spelling, etc.).

The indicators were evaluated by using GQM model: 56 questions were defined along with 164 metrics and relationships among them. The metrics were based on the existing usability standards, comparison with the competitors' sites and author's previous experience. The example of the metric definition is shown on Figure 3b.

In the evaluation process, each metric was assigned a rating between 0 and 1 and the LSP method was applied to evaluate the ratings of each indicator, subcharacteristic, characteristic and the final rating, depicted by Figure 4.

The final quality ratings for both sites are summarized in Table 1.

The overall rating of the main corporate site (0.75) is a fairly good one, indicating that minor improvements in site usability are needed to further enhance the user's experience. Indeed, the final summary report indicated 25 minor improvements which will be addressed in the forthcoming redesign process.

The retail sales site scored poorly (overall rating of 0.42), indicating several weaknesses that contribute to very low ratings for functionality, usability and efficiency, and consequently, overall quality rating. The final report indicates 28 major improvements that need to be addressed in the forthcoming complete redesign of the site.

7. CONCLUSION

The paper describes the Web quality model which enables qualitative evaluation of Web sites. The model is based on ISO 9126 standard. It decomposes the overall site quality into a set of six quality characteristics: functionality, usability, reliability, efficiency, maintainability and portability. The evaluation process is described and the quality model applied to two corporate business Web sites. In order to measure the indicators, the methodology uses the GQM approach to define a set of questions, which make the indicators more concrete. Each question is rated using one or more metrics by applying LSP method as the scoring technique throughout the process.

The application of the model on two business sites identified a set of weaknesses which are being addressed in the forthcoming redesign. The most notable weaknesses identified in the evaluation were related to structure and clarity of the content, page layout, navigation, searchability and categorization of items in the online store.

Internal company's user based usability survey on the same sites was performed after the WQM-based evaluation. It revealed most of the problems that were discovered using WQM. However, it required twice the time for preparation and execution, as well as more staff. These findings are in accordance with the previous research [3].

The redesign of the retail sales site is now in progress: it follows all the typical lifecycle stages and quality is being measured in each stage by applying the WQM and the metrics available at that stage.

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REFERENCES

[1] Šehović, E., Gledec, G. "Network Economy: Chance and Challenge for Adria Region", Proceedings 29th International Symposium – Electronics in Marine - ELMAR, Zadar, Croatia, 1997.
[2] Internet World Stats, URL: http://www.internetworldstats.com/, September 2006.
[3] Gledec, G. "Quality Model for the World Wide Web", Proceedings of the 8th International Conference on Telecommunications – ConTEL 2005, Zagreb, Croatia, 2005.
[4] McCall, J. A., Richards, P. K., and Walters, G. F., "*Factors in Software Quality*", National Tech.Information Service, no. Vol. 1, 2 and 3, 1977.
[5] Boëhm, B. W., Brown, J. R., Kaspar, H., Lipow, M., McLeod, G., and Merritt, M., "*Characteristics of Software Quality*", North Holland, 1978.
[6] ISO/IEC FDIS 9126-1. Information technology — Software product quality - Parts 1-4
[7] Fitzpatrick, R., Smith, P., O'Shea, B. "Software Quality Revisited", *Proceedings of the Software Measurement European Forum (SMEF 2004)*, pp. 307-315, Milan, Italy, 2004.
[8] Offutt, J. "Quality Attributes of Web Software Applications", *IEEE Software*, March/April 2002, p. 25-32, 2002.
[9] Olsina, L., Godoy, D, Lafuente, G.J, Rossi, G. "Specifying Quality Characteristics and Attributes for Web Sites", *Proceed. of International Conference on Software Engineering (ICSE '99), Web Engineering Workshop*, pp 84-93, Los Angeles, USA, 1999.
[10] Brajnik, G. "Towards valid quality models for websites", Proc. of 7th Human Factors and the Web Conference, Madison, Wisconsin, 2001.
[11] Signore, O. "Towards a quality model for web sites", CMG Poland Annual Conference, Warsaw, May 2005.
[12] Van Solingen, R., Berghout E. "The Goal/Question/Metric Method: a practical guide for quality improvement of software development", *McGraw-Hill*, 1999.
[13] Nielsen, J. "Designing Web Usability", New Riders Publishing, 2000.
[14] Lynch, P.J., Horton, S. "Web Style Guide", URL: http://www.webstyleguide.com/, September 2006.
[15] World Wide Web Consortium, URL: http://www.w3c.org/, September 2006.
[16] Jacob Nielsen: Alertbox, URL: http://www.useit.com/alertbox, September 2006.
[17] Dujmovic, J.J. "A Method for Evaluation and Selection of Complex Hardware and Software Systems", *The 22*nd *Int'l Conference for the Resource Management and Performance Evaluation of Enterprise*, CS. CMG 96 Proceedings, Vol. 1, pp.368-378, 1996.

Relational Ethics, Global Business, and Information and Communications Technology: Interconnections Explored

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ABSTRACT

This paper provides a literature review and analysis of the impact of information technology in a global business environment on relational ethics. These three variables interact in a dynamic field that supports and challenges global managers in entrepreneurial endeavors. While information and communication technology (ICT) is rapidly expanding, the opportunities for global business and relational ethics are affected by the interconnections. Drawing on current literature and insights gained from a relational approach to ethics, readers are invited to reflect on the ways that relationships influence ethical actions—and outcomes—and how they can be improved. This analysis exposes the critical issues, develops a general framework and makes recommendations for ways to work with and further develop the interconnections between global business, ICT and relational ethics.

Keywords: Relational ethics, Entrepreneur, Globalization, Privacy, Information and Communication Technology (ICT)

WHAT IS RELATIONAL ETHICS AND ITS IMPERATIVE FOR GLOBAL BUSINESS?

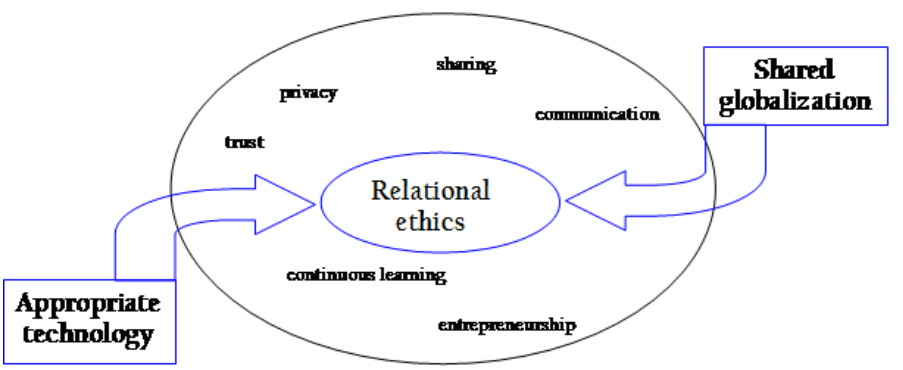
The aim of the paper is to explore the connections between global business and information and communication technology (ICT) with concern for the ways relational ethics direct stakeholder actions. The term 'relational' includes the relationships between organizational and individual stakeholders of an organization. We identify the role of appropriate technology in building and maintaining trust between individuals within and outside an organizational boundary, especially as this relates to the entrepreneurial role and mindset, and extend our view to the global business environment as the overarching context.

For Bergum (1998), "relational ethics [imply] initiating and maintaining conversation, and means that ethics is found in the day-to-day interactions of one another". Relational ethics looks at people's roles: as practitioner, administrator, team member, teacher, client, student, friend, and global 'neighbour'. This focuses on who one is, as well as what one does. Bergum and Dossetor (2005), when examining in the health sector why some kinds of relationships are better than others, provide the basic qualities of an ethical relationship; nurtured and sustained by reliance on communication and mutual concern. It is the relationship itself that supports and informs ethical interaction, activity, decision making and exchange of commodities. Philosophers have often asserted the central place that relational issues have in society and learning (Blenkinsop, 2005 and Jones, 2003). Theories of relationship have played a role in some aspects of organizational management (Tyler and Blader, 2003). Now the social and technological changes happening globally may be precipitating stronger relational imperatives.

Use of communication technology in most fields has altered the medium and pace of conversation between stakeholders around the globe. Even though the issues of privacy, trust, confidentiality and anonymity are common within the health care sector (Bergum, 1998; FPC, 2001), it is the authors' contention that caring and respecting all the parties involved in business relationships is essential regardless of the sector (Adams et al, 2005), or area of global operation. The obligations to address the above-mentioned issues remain, (for organizations as legal entities as well as for individual managers), and, in some cases, are magnified given the ability of technology to track and disseminate sensitive information. Within and across borders, the responses occurring in business relationships set the tone or atmosphere in which a relational ethic must be defined and acted upon.

The efficiency of technology enhances the ability of organizations to track customers. This parallel ability of technology to, first, identify customer needs and, secondly, to exploit this information for profits has received plenty of attention (Pham & Jordan, 2006). Using ICT to gather and disseminate product and service information can result in new business opportunities. As mature domestic markets reduce in profit potential, individuals as well as organizations seek beyond their

Figure 1. Commercial interconnections and influences revealed



geographical borders for new growth opportunities. Technology assists in this process by providing new ways of relating to existing and potential customers. This process is accompanied by the challenge of addressing the global convergence of cultures. New levels of good faith and trust may be needed to promote an atmosphere of peace and goodwill. People meet (physically and in cyberspace) and mingle in milieux which are constantly changing. Ethical relationships become central in this environment in the absence of enforceable cross-border laws and physical controls. Some dissenting voices can be found, such as Harmon (2005), who warns against a moralist approach, however, still affirms that affective and relational issues are important, although in need of balanced perspective.

The question then becomes: What kind of ethics is needed for the complexity of entrepreneurship in our times? According to Bergum and Dossetor (2005), it is recognizing that ethics is grounded in relationships. The context of these relationships can vary, but the fact remains that relationships need to be nurtured and sustained by reliance on communication and mutual concern. In Relational Ethics, the right and good relationships ultimately must concern every authentic ethical theory and impact on the relationship one has with customers (Pellegrino in Bergum and Dossetor, 2005).

Figure 1 presents the three key variables addressed in this paper. The framework reveals relational ethics impacted by the forces of technology and globalization in an atmosphere of diverse influences. The remaining discussion proceeds to address the factors in this developed framework.

THE VIEW AS (E-) ENTREPRENEUR OR INTRAPRENEUR

Working in global markets presents many challenges for management; especially in trying to create flexible solutions. Corporations have to shift their mindset to think like entrepreneurs and capitalize on growth opportunities in certain niches (Overholt, 2005).

Our definition of entrepreneur includes classical, independent innovators (individuals and/or teams), prepared for risk and a love of high returns, but also the intrapreneurs (individuals and/or teams), who are plying similar innovative skills but within and on the perimeters of larger organizations. ICT creates enhanced opportunities for entrepreneurial (networking) behaviors regardless of organizational size (Pinchot and Pinchot, 1997). In this technology-enhanced environment we cannot overlook the e-entrepreneurs. Zutshi et al (2006, p.63) define e-entrepreneurs as, "those who use the World Wide Web to interact and complete virtual transactions both with other businesses (B2B) and their consumer/customers (B2C)". The terms e-entrepreneur, intrapreneur and entrepreneur are used interchangeably in this paper.

Entrepreneurial opportunities emerge from myriad sources including stock market swings, online auctions, e-business, and unanticipated niches emerging in the global economy. Wherever commerce is found, McMillan (2003) shows the importance of markets as neither magical nor immoral but as powerful tools for improving trade and living standards. There is a challenge for managers who are unaccustomed to thinking about commerce as an instrument of social change. It is not a case of whether commerce-as-social-change should happen, but how to work with this ubiquitous global trend. Social change has occurred by market forces, so we now must navigate the new socio-economic environment with tools aligned to the changed context.

In this climate we may ask, How can entrepreneurship be improved? As organizations continue to be increasingly market driven, relational ethics must be embodied in the features needed for a market to function well to ensure that (McMillan, 2003):

- information flows smoothly
- property rights are protected
- people can be trusted to live up to their promises,
- side effects on third parties are curtailed, and
- the benefits of competition are fostered.

McMillan (2003) makes a distinction between *a* marketplace and *the* market. *A* marketplace, physical or cyberspace, is a specific venue where exchanges take place – where trade occurs. *The* market, on the other hand, is an abstraction, an overall system composed of many interdependent markets. Most transactions in society have little to do with markets. Rather, they occur among members of like minded people, mediated by different rules and relationships. McMillan (2003) sees the tradition of individual decision-making and voluntary exchange as key to the marketplace and it includes and shapes:

- reputations (costly to create and defend)
- patent policy
- intellectual property (must be protected), and
- property rights (which as the Licensing Executives Society has observed - 1997; 2006 - are found to shift as the locus of operations changes from local, hard assets to global, digital and less visible ones).

Relational issues become more central than peripheral when one enters the global marketplace. Fundamentally, Vandenberg (1999) asserts that human infants are hard-wired for relatedness. This affirms that as macro influences shape human society, micro factors between individuals will continue to set the undertone. It is human to work within a field of relational ethics.

INFORMATION TECHNOLOGY: IMPACT OF GLOBALIZATION AND THE NEED FOR RELATIONAL ETHICS

Technology can have a depersonalizing effect. The cold wall of a technology interface -- for example, a recorded phone message, or an automated teller at a bank -- can be greeted with distrust. To compete, many companies are tending to re-emphasize personalized approaches in an attempt at promoting trust. As cultural clashes are experienced, as backlashes (in the form of customer grievances) are confronted, the need to harmonize grows.

Professional institutions are recognizing the importance of issues of ethics and community responsibility. For example, the Australian Computer Society requires its members to conform to its various rules and regulations, including Ethics/Social Implications/Professional Practice (ACS, 1997). Similar guidelines are also implemented in other economic sectors. The emergence of codes of conduct, ethical standards, and at least the debate at national and international levels, are essentially evolutionary cycles, or responses to changing relational dynamics. The central position of ICT in propagating the impetus for change, as well as being the medium through which adjustment to change can occur is somewhat paradoxical. While the activities promoted are right and good, they are of little effect in themselves if action and improved ethical relationships do not occur.

ETHICS, THE (E-)ENTREPRENEUR, AND CHANGING GLOBAL CULTURE

The principles of trade and capitalism are rooted in economics and relationship, and in comparative advantage that is part of the human survival mechanism. When the human desire for creativity is considered, we are more directly in the realm of the entrepreneur and, ultimately, of relational concern and 'good' (civil) behavior if commercialization is to occur. McMillan's (2003) notion of *a* marketplace is reinforced. The classical idea that business activity need not include a social conscience is rooted less in reality in today's interconnected economies.

Ross et al (1994) in their work on continuous quality improvement show the important role good manners play for successful global business and provide a framework for export readiness with international protocol as a key step on that journey. In another view that challenges the persistent 'me-centered' mentality, Kaplan and Koval (2006) explain, 'nice' companies have lower employee turnover, lower recruitment costs, and higher productivity. Companies and people with a reputation for cooperation and fair play forge the kind of relationships that lead to improved opportunities. *Taking the long term vision*, relational ethics qualities such as caring for other people, having honor, working with honesty, competing with dignity, sharing knowledge and behaving with kindness, are important for successful global entrepreneurship.

An example of relational issues emerging in a business context has been noted by Blenkhorn and Mackenzie (1996) in the form of relationship marketing. The concept of 'mutual interdependence' as a power-control factor is present. This elevates the need to act in ways that are balanced and considerate, for instance, opening up communication, being cooperative, and demonstrating a degree of sacrifice in the relationship. Evoking relationships in commerce, at its core, is best practiced by elevating concern for the customer, a sense of ethical practice which is not only good for the customer in the short term but may also improve company performance in the longer term (Dunham, 2006). A cynical application

is noted, in that profits come from serving customers. However, from the perspective of care and concern for customers, an increased sense of responsibility is seen to emerge. Anytime customers receive good service tends to build trust and exemplifies the reciprocity at the core of economic theory.

Drake and Ross (2005) discuss customs change, bribery, child labor, human rights abuses, and integrity as the categories proposed in which deep questioning and continuous reflection are recommended, even required, if the (e)entrepreneur is to succeed in different cultures. de Geus (1998) adds to this perspective by regarding business longevity with the view that, "the corporate equivalent of pain is a crisis, which lasts long enough for most people in the organization to feel and to become convinced that something should be done". Solutions to the scenarios above represent time spent learning. Time, however, is not always abundant in the minds of entrepreneurs today. In this atmosphere, relational ethics ought to be approached so as to contribute to time management and become a time saving approach. For instance, a commercial relationship in which there is a high degree of trust will more quickly facilitate a successful transaction.

Bennett (2005) and Hladik (2006) insist it is hard to trade with those who you do not trust, or have different cultural and ethical expectations. Emerging value-sharing communities accelerate innovation in new realms of entrepreneurship and economics. The imperative to embrace relational approaches to cooperation and collaboration develops in many sectors, from traditional manufacturing through to services, including education. For example, Backhaus et al (2005) propose a dynamic collaboration model for business education that aligns with theories of knowledge and understanding attributed to Heidegger and Gadamer (Radnor 2002), and with relationship dynamics originally posited by Schutz (1966). This and other models emerging suggest continued impetus for relational approaches.

TRUST, LEARNING AND RELATIONSHIPS

Burgeoning information technology is attracting entrepreneurs in increasing numbers. The wireless and mobile revolution is proceeding and entrepreneurs are engaging in the enhanced connectivity that networking with ICT offers. This is a setting in which disruptiveness of emerging technologies (such as the Internet and nanotechnology, Horner, 2005) applies in current economic and education systems alike (Moor, 2006). Such a milieu tends to attract the global business entrepreneur, and creates opportunities in the associated market of educating the entrepreneur 'on the go.'

Bennett (2005) emphasizes identifying and addressing aspects of accountability, trust, openness, and continuous improvement. There is every reason to apply these ethics to the education of global business managers. The task becomes one not just of learning about the relational approach, but of teaching managers how to learn, as well as teaching teachers how to teach. This brings the discussion back to the continuous learning loop that is necessary for sustained relational ethics. It is not enough to rest on laurels, instead one must be poised to learn more, to stay alert to the changing needs of the people, organizations and cultures with which transactions and trade are occurring.

INFORMATION AND COMMUNICATION TECHNOLOGIES: PRIVACY AND TRUST

Technology delivers conveniences and changes the way we undertake day-to-day activities, including shopping and banking. There persists cautiousness of Internet usage by some, due to privacy and security issues. Brey (2005) notes the rise of surveillance as precipitated by bureaucratization, burgeoning capitalism, and the actions of nation states. Successful competition appears founded on information gleaned from surveillance. Large organizations are increasingly enabled through technology to manipulate personal information. In this context Brey (2005) posits that privacy is a right as well as a condition.

A number of companies are strategically reassessing Internet strategies and offering new choices to their customers. In Australia, the financial sector reveals examples of efforts at attracting increasing market share through competitive advantage opportunities overlooked by bigger players. For instance, Bendigo and St. George Banks have taken to offering more personalized customer service. This is not to say that these institutions have left the technology bandwagon behind, instead they have adopted the technology to offer choice to their customers and to reach them in rural areas, where major banks have either closed or restricted their business for efficiency purposes. In addition to rural communities, Bendigo and St. George Banks have established relationships with urban populations by offering timely, faster and personalized service and steadily increasing customer satisfaction (Owen, 2002; Lekakis, 2001; Power, 2001; Derkley, 2003).

There is a need for (e)entrepreneurs to address the fear associated with illegal or unethical access to personal information. The recent Hewlett Packard spying scandal is a case in point (Chapman, 2006). Governments across the globe are taking a strong stand against exploitation of personal information gained by companies (see Adam, 2005). Increased security and privacy measures undertaken by governments also attract controversy. The Australian government, for instance, proposed a 'Smart Card' for its citizens that would incorporate a computer chip with personal information. Questions were raised about the integrity and extent of access to information to various stakeholders (Kay, 2006; Lewis, 2006; Dearne, 2006). The same government also introduced new "smart" passports designed to improve cross border security, but is challenged as a measure that may, in fact, assist identity fraudsters by pooling sensitive personal information in a single readable source (Epstein, 2006).

CRITICAL ISSUES AND RECOMMENDATIONS

Literature review and analysis has revealed a number of critical issues for managers in a technically evolving, global environment, especially in the area of relational ethics:

- Technology, if managed well, can play a part in building and maintaining trust between individuals within and outside an organizational boundary.
- The responses occurring in business relationships set the tone or atmosphere in which a relational ethic must defined and acted upon.
- Organizations increasingly need to engage in cycles of continuous learning and applications that will confront and overcome relationship challenges.
- The central position of ICT as an impetus for change, as well as being the medium through which adjustment to change can occur is somewhat paradoxical.
- Deep questioning, continuous reflection and diligent attention to relational skills development are required if the entrepreneur is to succeed in different cultures, and
- Relational ethics attends primarily to issues of, trust, openness, understanding and engagement.

These critical issues lead to the following recommendations that may assist (e-) entrepreneurs to forge and maintain relationships as they engage in business activities:

- Leverage ICT to capitalize on communication and collaboration improvement mechanisms.
- Do not allow business relational ethics to be neglected directly or indirectly, nationally or internationally.
- Accept that relationship challenges require a continuous learning mentality at the group and individual levels.
- Understand the confounding but enlightening features of ICT in the context of relational changes in global business.
- Global business managers should engage in deep questioning, continuous reflection and diligent commitment to practical improvement of accountability, trust, and openness in the context of business and its relationship with the supply chain and beyond.

The research has suggested the juxtaposing roles of Relational Ethics, Global Business and ICT may continue to fuel research and practitioner activities into at least the medium term future.

REFERENCES

ACS (2006) Australian Computer Society: Core Body of Knowledge for Information Technology Professionals. Retrieved October 2, 2006, from www.acs.org.au/index.cfm.

Adam, A. (2005) Delegating and distributing morality: Can we inscribe Privacy Protection in a Machine? *Ethics and Information Technology*, 7, 233-242.

Adams, H., R., Bocher, R., F., Gordon, C., A. & Barry-Kessler, E. (2005). Privacy in the 21st century: Issues for Public. School and Academic Libraries. Libraries Unlimited: USA.

Backhaus, W., Bolesta, M., Creed, A., Ross, J., & Stewart, J. (2005, 9 – 12 July). *Faculty Collaboration in Teaching Global Business, MBA Teaching Process:*

A Case Analysis of Collaborative Communication Applied as a Teaching Preparation Resource in a module of the Online MBA at University of Maryland University College. Proceedings of the Academy of International Business, Quebec City: Quebec.

Bennett, J. (2005). *The Anglosphere Challenge: Why the English-Speaking Nations Will Lead the Way in the Twenty-First Century*. Maryland: Rowman and Littlefield Publishers. Lanham.

Bergum, V. (1998) Relational Ethics. What is it? *In Touch*. Volume 1, Issue 02. Retrieved September 29, 2006 from http://www.phen.ab.ca/materials/intouch/vol1/intouch1-02.html.

Bergum, V. & Dossetor, J. (2005). *Relational Ethics: The Full Meaning of Respect*. Maryland: University Publishing Group: Hagerstown.

Blenkhorn, D., and MacKenzie, H. (1996) Interdependence in Relationship Marketing. *Asia-Australia Marketing Journal*, 4(1), 25-30.

Blenkinsop, S. (2005) Martin Buber: Educating for Relationship. *Ethics, Place and Environment*, 8(3), 285–307.

Brey, P. (2005) Freedom and privacy in ambient intelligence. *Ethics and Information Technology*, 7(3), 157-166.

Chapman, G. (2006) Hewlett-Packard chairwoman resigns amid espionage scandal. Yahoo News. Retrieved October 3, 2006 from http://www.newsalerts.com/news/article/hewlett-packard-chairwoman-resigns-amid-espionage-scandal.html:top19:792122.

de Geus, A. (1998). Why some Companies live to tell about Change. *Journal for Quality & Participation*, 21(4), 25. Retrieved December 8, 2006 from http://calbears.findarticles.com/p/articles/mi_qa3616/is_199807/ai_n8793457

Dearne, K. (2006). Libs, business rebel on Access Card. *The Australian*. August 8, 31.

Derkley, K. (2003). Banks go with the New Flow. *The Age*. August 5, 5.

Drake, M., & Ross, J. (2005). Corporate integrity: Vital for global business. *Unpublished paper*.

Dunham, R. (2006). Shop at Target? You're a Swing Voter. *Business Week*, 4002, 36.

Epstein, R. (2006) Doubts raised over passport security. Transcript from AM on ABC local radio. Retrieved December 8, 2006 from http://www.abc.net.au/am/content/2006/s1807053.htm.

FPC. (2001). *Guidelines on Privacy in the Private Health Sector*, Office of the Federal Privacy Commissioner. Australia.

Harmon, M. (2005). Five Good Reasons Not to Act on Principle (Or, Why You Probably Can't Act on Principle, Anyway). *Administrative Theory & Praxis*, 27(2), 238–276.

Hladik, M. (2006). *Practical Insights. Culture, Social Structure and Change- Ethics*. AMBA 606 Organizations and the External Environment Global Business Toolbox. Retrieved July 26, 2006 from http://polaris.umuc.edu/~acreed/AMBA606-Toolbox2/themesarticles/EiR/wk3EiR.htm.

Horner, D., S. (2005). Anticipating ethical challenges: Is there a coming era of Nanotechnology. *Ethics and Information Technology*, 7, 127-138.

Jones, C. (2003). Interman and the ''Inter'' in International Relations: Watsuji Tetsuroˆ and the Ethics of the Inbetween. *Global Society*, 17(2), 135-150.

Kaplan T., L. & Koval, R. (2006). *The Power of Nice: Eight Ways to Kill the Business World With Kindness*. New York: Doubleday.

Kay, M. (2006). Smart cards to stop Benefit Misuse. *Dominion Post*. July 5, 1.

Lekakis, G. (2001). Service delivery through 'human beings'. *Australian Financial Review*. August 7, 43.

Licensing Executives Society (1997). International Conference. Taedok Science Town. Republic of South Korea.

Licensing Executives Society. (2006). Intellectual Property Valuation Primer: Everyday Business Issues and Questions on Value and Valuation. Retrieved October 3, 2006 from http://www.lesi.org/education/primer.asp.

Lloyd, S. (2001). Brand Power. *Business Review Weekly*. November 29, 48.

McMillan, J. (2003). *Reinventing the Bazaar: A Natural History of Markets*. New York: W.W. Norton.

Moor, J. (2006). Why We Need Better Ethics for Emerging Technologies. *Ethics and Information Technology*, 10(7), p115.

Overholt, A. (2005). A new path to profit. *Fast Company*. January. Issue 90, p25. Retrieved October 4, 2006 from http://www.fastcompany.com/magazine/90/interview.html.

Owen, R. (2002). Upgrade by S&P boosts Bendigo. *Courier-Mail*. May 30, 25.

Pham, L.T & Jordan, E. (2006). *Building Information Technology Capability and Organizational Learning*. Proceedings of the 20th ANZAM Conference, "Management: Pragmatism, Philosophy, Priorities. Queensland: Rydges Resort Rockhampton.

Pinchot, G. & Pinchot, E. (1997). Organizations that Encourage Integrity. *Journal for Quality & Participation*, 20(2), 10-13.

Ross, J., Ross, J., & Taylor, C. (1994). *International Protocol, A Quality Management Tool. Quality Culture, Quality for Turbulent Times*. Canadian Centre for Quality Improvement. Canada: Camrose, Alberta.

Radnor, H. (2002). *Researching Your Professional Practice: Doing Interpretive Research*. Buckingham, UK: Open University Press.

Schutz, W. (1966). *The Interpersonal Underworld: A Reprint Edition of FIRO, a Three-Dimensional Theory of Interpersonal Behavior*, Palo Alto, Ca: Science and Behavior Books, Inc.

Tyler, T. & Blader, S. (2003). The Group Engagement Model: Procedural Justice, Social Identity, and Cooperative Behavior. *Personality and Social Psychology Review*, 7(4), 349–361.

Vandenberg, B. (1999). Levinas and the Ethical Context of Human Development. *Human Development,* 42, 31-44

Zutshi, A., Zutshi, S. & Sohal, A. (2006). How Entrepreneurs Operate in the Context *of Open Source Software*. Hershey, PA: Idea Group.

Electronic Commerce Adoption Approaches by SMMEs Western Cape, South Africa

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ABSTRACT

E-commerce improves value chain integration, enables customisation and also provides smaller companies opportunity to reach customers worldwide. However the approach to e-commerce adoption poses small businesses management with many challenges, one of which is the choice of an approach to adopt e-commerce. One option is an "adoption ladder" approach proposed by a number of researchers depicting e-commerce adoption as a "step-by-step" process, from simple email to a virtual integrated business. The other option is a "managed strategic adoption" approach where proponents of this approach argue that reaching e-commerce is a result of a management decision to move directly to e-commerce, based on business goals and requirements. This approach does not follow a stepped approach. Although the literature reports on a number of aspects of e-commerce adoption, no clear guidelines are apparent to determine how Small Medium Micro Enterprises(SMMEs) should progress, or move into e-commerce. This paper investigates two e-commerce adoption approaches and reports on the approaches followed by a sample of SMMEs in the Western Cape of South Africa. In addition a conceptual model on e-commerce adoption approaches is proposed and theoretical guidelines explored to assist SMMEs to choose between the two approaches.

Keywords: E-commerce adoption, adoption ladder, managed strategic adoption, SMME

1. INTRODUCTION

A significant opportunity and challenge for businesses in the next few years will be how to deploy e-commerce initiatives. E-commerce activity improves value chain integration, enables customisation and also provides smaller companies opportunity to reach customers worldwide (Da Silveira 2003:201). An increasing number of businesses are using the Internet to trade online but not many are generating profits. This poses management with challenges to identify where e-commerce profitability lies, how it is reached and how it could be sustained (Willcocks & Sauer, 2000:7). Despite these challenges Jones, Hecker and Holland (2003:287) argue that there is limited research available on how to effectively, implement e-commerce into SMME operations. Many of these challenges could either be resolved, or at least be identified, in order to follow the most appropriate e-commerce adoption path. This needs to be done at the outset of the e-commerce adoption initiatives. Although a number of local and International studies report on e-commerce adoption paths, these do not provide clear guidelines to determine how SMMEs should progress or move into e-commerce.

Several e-commerce definitions exist but no consensus has been reached on the extent or essential parameters (Kowtha & Choon, 2001:238). In this paper, e-commerce is referred to as digitally enabled commercial transactions between organisations and individuals. Commercial transactions involve the exchange of value, for example, funds across organisational or individual boundaries in return for products and services (Laudon & Traver, 2003).

The definition of a Small Medium Enterprise (SME) varies from country to country. Da Costa (2001:3-4) finds that in the United states of America (USA) SMEs are defined as firms having fewer than 500 employees, whereas in Europe SMEs are firms with fewer than 250 employees. In Japan SMEs are firms with fewer than 100 employees. In South Africa Small Medium Micro Enterprises (SMMEs) are defined as companies having the number of employees ranging between 5 and 2000. In addition, SMMEs are classified as companies with a total turnover between 0.2 million and 64 million Rand and a gross asset value ranging from 0.1 million to 23 million Rand(South Africa, 1996; South Africa, 2003). In this paper, SMME refers to the South African definition whereas SME refers to the international definitions.

The aim of this paper is to investigate e-commerce adoption approaches and to present findings of the approaches followed by some SMMEs in the Western Cape. In addition propose a conceptual model on e-commerce adoption approaches and theoretical guidelines explored to assist SMMES to choose between the approaches.

2. BACKGROUND

The focus of this investigation is confined to the Western Cape of South Africa that accounts for 15% of the country's GDP and where 10% of the South African population resides (Wesgro 2005). In addition the Western Cape is the second most productive province, after the Gauteng province. The Western Cape's strong economy can be attributed to its unique balance of economic activities that range from agriculture, fishing and forestry in the primary sector to clothing and textiles in the secondary sector. Other sectors include automotive components, marine services and manufacture, agri-business, vibrant tourism and an increasing array of future-orientated service industries (Wesgro 2005).

Small business play a vital role in most economies throughout the world and their ability to adopt and utilise the Internet and conduct e-commerce is of prime importance to ensure that SMEs are included in the new economy (Quayle, 2002;1158-1159, Stansfield & Grant, 2003:15). For example, SMEs in the USA accounted for 51% of the private gross domestic product during the period 1990-1995. However, less than 20% were selling products and services online (Reimenschneider, Harrison & Mykytyn, 2003:270). A similar view is expressed in Grandon and Pearson (2004:82) who state that although SMEs in the USA employ more than half of the work force, few had adopted e-commerce by the end of 2003. In Australia approximately 65% of SMEs have access to the Internet, with only 15% of these actually supporting websites (Pease & Rowe 2003:2). According to Viviers and Soontiens (1998:2), South African SMMEs contributed 46% to the total economic activity. Current estimates are that businesses with less than 50 employees contribute between 39% and 45% of the GDP (South Africa, 2004a), Whilst SMMEs are reported to contribute 30% to GDP (South Africa, 2004b). Despite these contributions, the use of the Internet and related technologies has not been deployed to the extent that would be necessary for survival in a rapidly changing environment (Cloete, Courtney and Fintz, 2002:1).

2.1 E-Commerce Adoption Approaches

From the literature, it is evident that there are two possible approaches for a business to adopt e-commerce. The one approach is an "adoption ladder" proposed by a number of researchers and is a "step-by-step" process. These steps start at email and then follow to a static website, e-commerce, e-business and finally e-enterprise (Van Akkeren and Cavaye 1999; Hoque 2000; Willcocks & Sauer 2000; Parish, Kibblewhite, Woodley & Richardson 2002; Jones *et al.* 2003; Vosloo 2003; and Teo and Pian 2004).

An alternative approach is a "managed strategic adoption" where these proponents argue that reaching the e-commerce adoption stage is a result of management decisions. In this case, a business would prefer to directly adopt email, a static website, e-commerce, e-business or an e-enterprise and not follow a stepped approach. This would depend on the strategic requirements of the business (Angehrn, 1997; Blackburn & Athayde 2000; Southern & Tilley 2000; Martin & Matlay, 2001; Foley and Ram 2002; Chau & Turner, 2003; Levy and Powell 2003; Rao, Metts & Monge 2003).

2.2.1 Adoption Ladder Approach to E-Commerce

An "Adoption ladder" approach requires that businesses start on the bottom rung of the ladder and progresses upwards. Van Akkren and Cavaye (1999:4) state that e-commerce adoption is a progression and sophisticated technologies are unlikely to be implemented before entry-level activities are used more readily. An example of the e-commerce "adoption ladder" is Cisco's adoption ladder model given in Figure 1. This model is selected from other possibilities due its clarity in illustrating the "step-by-step" stages of e-commerce adoption

E-mail acts as a starting point from which more sophisticated e-commerce activities flows. Tagliavini *et al*. (2001:215-220) state that effective use of e-mail could assist SMEs to gain new customers, establish relationships and create brand loyalty by enhancing information interchange with current and potential customers as well as to carry out market research. At the second level an effective website widens the market by increasing company visibility, promoting company image, improving the quality of customer service and carrying out market research based on customer needs thus differentiating SMEs. Leong, Stanners and Huang (1998:1257) add that the three most important website objectives are to enhance the corporate image, increase brand or product awareness and to provide better customer service. A website that offers online processing facilities allows orders to be automatically forwarded and processed more quickly. Since customers are demanding more speedy service, reduction of waiting times represents a competitive advantage. Online payment processing optimizes business resources whilst increasing customer satisfaction is achieved by allowing the customer to conclude the transaction online (Tagliavani, *et al*. 2001:220). Kowtha and Choon (2001:239) confer that a website with online processing facilities requires significant dedicated investments, skill acquisition and management commitment. However, Chau and Turner (2003:4) argue that an "adoption ladder" approach is less advantageous as the potential benefit of using e-commerce increases as SMEs embark on later stages on the e-commerce adoption path, therefore suggest a non-stepped "managed strategic approach".

2.2.2 "Managed Strategic" Approach to E-Commerce Adoption

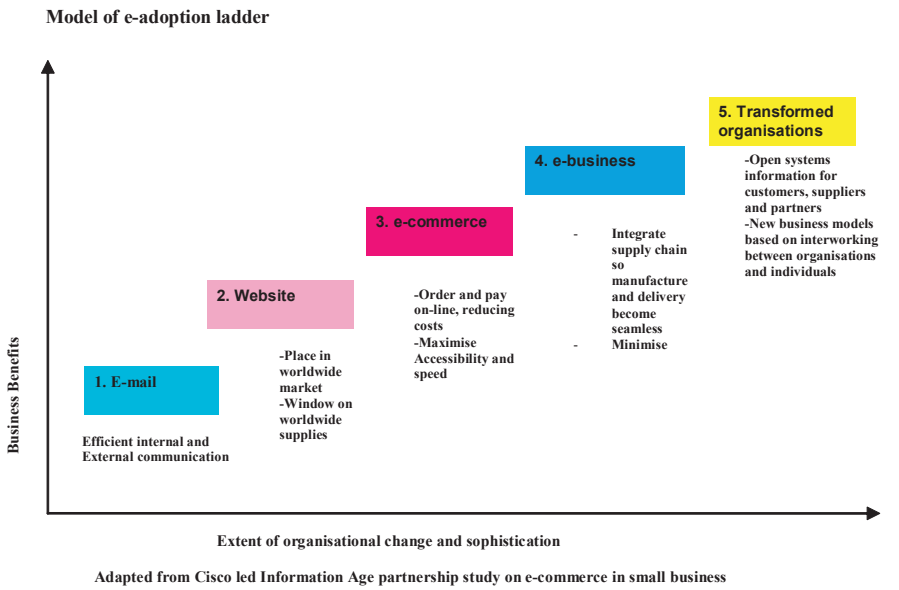
Hackbarth and Kettinger (2004: 273) argue that whilst some companies follow the "adoption ladder" approach with gradual business process improvements, others aspire to rapidly achieve business innovation with a leapfrogging strategy. According to Hackbarth and Kettinger (2004:273,281) companies adopt leapfrogging strategies when faced with more severe external competitive pressures. Businesses should scan their environment to evaluate barriers to entry, customer power, supplier power and new entrants to the market. To adopt this kind of strategy businesses must ensure internal user involvement. This includes to assess the availability of in-house IT expertise (or appreciation of IT expertise in cases of deciding when and what to outsource) and a cultural capacity to change. In addition, they should exhibit a level of comfort with new technologies and availability of resources to adopt e-commerce related technologies. Such businesses exhibit leadership in terms of senior management commitment and willingness to make an impact on people. The businesses demonstrate an accommodating business structure that accepts paradigm shifts and allows cross-functional decision making.

The two diverging approaches discussed above may lead to a point where management of SMMEs may need to pre-select an e-commerce adoption approach before embarking on the e-commerce adoption initiatives. To shed light on this problem, knowledge is required to answer some questions by learning from successful businesses that adopted e-commerce. This includes what approaches they followed, what they did right and what lessons were learned. Furthermore, propose a simple model that would assist SMMEs to choose between the "adoption ladder" and "managed strategic adoption" approach to e-commerce adoption.

3. RESEARCH METHOD

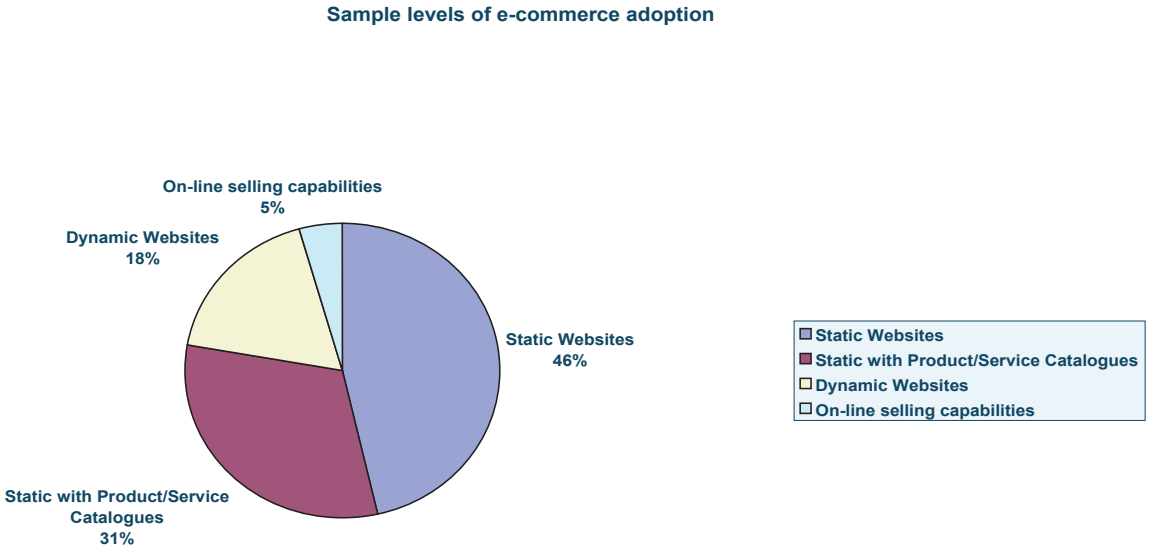
Qualitative analysis using in-depth interviews and double sampling techniques was used to gather information to determine e-commerce adoption stages and which path SMMEs used for e-commerce adoption. To determine the e-commerce adoption stage of companies, a period of three months was required, from April to June 2005. A list of 4,500 businesses registered with the Cape Town Regional Chamber of Commerce and Industry's (Chamber) website was downloaded and stored in a Microsoft Word document. There were approximately 1 000 companies that had websites. The next step was to find the Universal Resource Locator (URL) of each business to determine which of these had an active e-commerce website. Not all websites could be viewed as some websites could not be accessed. Reasons for failure ranged from File Server error, Unified Resource Locator not found, suspended websites, gateway timeouts or permission was required to access the website. The companies with more than 250 employees were deleted from the sample as well as websites with domains for sale and websites that loaded incor-

Figure 1. Cisco "adoption ladder" Parish et al. (2002)



Adapted from Cisco led Information Age partnership study on e-commerce in small business

Figure 2. Websites e-commerce stages SMMEs Western Cape



rect company profiles. The analysis resulted in a list of SMMEs selling online consisting of a sample size of 38 businesses selling online, spread across 14 different Chamber's business sectors. In some cases, only one online business was found in a sector. It would have been possible to select one business from each sector, but for richness in data analysis that allows comparison two industry sectors were selected for the study. Of the 4,500 SMMEs registered at the Chamber, 18% had websites ranging from static to dynamic interactive, where the websites offered the facility to receive payment online. Of these, only 5% had interactive websites offering facilities to receive payments online. This would qualify them being e-commerce websites. These results are depicted in figure 2.

From these results the industries selected for further analysis were the Tourism industry and Information and Communication Technology (ICT) sectors respectively. The tourism industry was selected on the basis that the tourism industry historically has been an early adopter of technology supporting inherent features making it suitable for e-commerce adoption (Wynne, Berthon,Pitt, Ewing & Napoli, 2001:421). In contrast, the ICT sector was selected as both Poon and Swartman (1999:4) and Al-Qirim and Corbitt (2002:346) found that IT related businesses were more likely to adopt e-commerce than businesses in other sectors. From these industries, SMMEs were selected for in-depth interviews from sample. The analysis would later reveal the path each SMME followed when adopting e-commerce, why they choose this approach and the benefits these companies were realizing from adopting e-commerce. The selected SMMEs owners or managers in the two industries were contacted and after numerous attempts, five SMMEs agreed to participate in the research study.

4. RESEARCH RESULTS AND DISCUSSION

Analysing the in-depth interviews indicated that SMMEs in the Western Cape are realizing benefits from e-commerce and in some cases; e-commerce was playing a strategic role depending on the owner or manager's strategic orientation for growth. Quoting one of the participants: "…if you take away the Internet we are out of business". This is an example of the importance of their e-commerce adoption commitment.

At first the researchers were concerned that these findings may be considered being biased as all five SMMEs had followed an "adoption ladder" path. Instead of going back to select more businesses from other sectors, it was decided to explore the literature again to ascertain what type of businesses would most probably have used the "managed strategic adoption" approach.

According to Warden and Remenyi (2005), 1time Airline operating in the LCA (Low Cost Airline) industry in South Africa followed a "managed strategic adoption" approach as their website was designed for e-commerce at inception. As far as could be determined, 1time Airline exhibited the necessary conditions to adopt this approach and 1time Airline may be classified as a large business as its asset value exceeds 23 million Rand and also had more than 200 employees by 2005. 1time Airline started trading in 2004 with a few staff members and from day-one, the airline management required that the Internet be the main channel for their ticket sales while selling only a small percentage via a call centre and at airports. Accordingly, 70% of airline tickets are purchased online, 20% via the call centre and 10% at airport kiosks. According to Weaver (2005:231,234) booking online air travel tickets is increasing in South Africa. Furthermore, South African Airways reported an annual increase of 200% for online sales, whilst Kulula.com (another LCA) reported that 75% of its sales are done online and the website processes over 3 million Rand in sales each day.

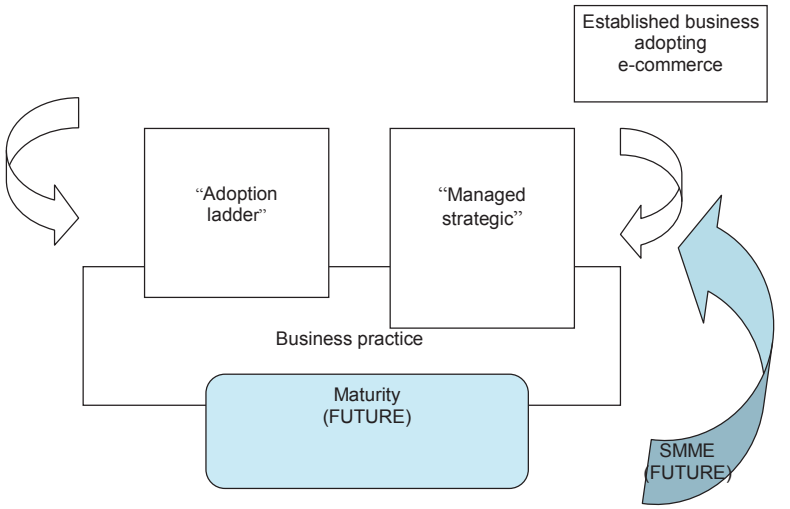
Considering the results from the 1time Airline case study, and reports from other successful airlines, provides an insight and evidence tthat larger businesses adopt a "managed strategic adoption" approach in preference to following an "adoption ladder" approach.

5. GUIDELINES FOR SELECTING AN E-COMMERCE ADOPTION APPROACH

Potential e-commerce adopters need to choose between an "adoption ladder" and "managed strategic adoption" and using the results reported in Hackback & kettinger (2002:280) obtained forty firms in the United states that had recently completed an e-business strategy the following guidelines are suggested to assist SMMEs to choose between the "adoption ladder" and "managed strategic adoption";

- The severity of external pressures evaluated by accessing the SMME market share risk, and the SMMEs customers demand for e-commerce services, If the external pressures are a high a "managed strategic adoption" would be a more suitable approach.
- Internal user involvement may be evaluated by determining the availability of In-house Information technology expertise related to e-commerce and SMME cultural capacity to change which can be assessed by the SMME' determining if they support maintaining the status quo or actively seeks participatory change. If Internal user involvement is low and the SMME does not have cultural capacity to change an "adoption ladder" approach would be a more appropriate approach to enable the SMME to gradually change and build-in expertise.
- Comfort level with new technologies maybe assessed by examining if the SMME is historically slow to respond or quick to implement new technology. Furthermore determining if IT resources are minimal or abundant to support e-commerce. Comfort level with new technologies is a key requirement for

Figure 3. Proposed model to assist SMME to adopt e-commerce



"managed strategic adoption" hence if such comfort level is non-existent an "adoption ladder" would be a more suited approach.

- Leadership in terms of Senior Management commitment to e-commerce adoption and being actively involved in the e-commerce adoption process. To follow "managed strategic adoption" Senior Management need to be committed to e-commerce adoption and willing to deal with extreme impacts. An "adoption ladder" approach on the other hand entails a modest and gradual impact.
- Accommodating and mature organisational structure, whereby there are cross functional decision making teams. SMME can assess this by examining historical approach to decision making as to whether it is interdepartmentally or cross functionally. In order to adopt "managed strategic adoption" SMMEs need to have an capability to work with cross functional decision making teams.

Figure 3 is a conceptual model showing the two approaches and SMMEs may use the provided theoretical guidelines to select an approach that best suits their organizational needs.

In conclusion, e-commerce is a process that involves various stages, namely e-mail, a static website, e-commerce, e-business and e-enterprise. E-commerce adoption in SMMEs registered with the Chamber in the Western Cape is at an early stage. Awareness campaigns would benefit those SMMEs that have not yet adopted e-commerce. By using the proposed model to explain and walk-through the various e-commerce stages potential SMME e-commerce adopters would be able to decide what the best approach would be to follow. Future empirical research is recommended to expand and add to the conceptual model and provide practical relevance for the guidelines to SMMES in the Western Cape. This would also track the severity of external pressures for e-commerce adoption in the SMMEs in the various industries.

7. REFERENCES

Al-Qirim, N.A.Y. & Corbitt, B. J. 2002. "An empirical investigation of an e-commerce adoption model in small medium-sized enterprises in New Zealand ". Paper delivered at PACIS (Pacific Asia Conference on Information Systems) 2002 conference Tokyo, Japan 2-4 September.

Angehrn, A. 1997. "Designing mature Internet business strategies: the ICDT Model». *European Management Journal*, 15(4):361-369.

Blackburn, R. & Athayde, R. 2000. «.Making the connection : the effectiveness of Internet training in small business». *Education and Training,* 42(4/5): 289-298.

Chau, S. & Turner, P. 2003. «An analysis of factors that influence the ability of SMMEs to derive benefit in four phases of electronic Commerce: 34 Australian case Studies». In Gingrich, A. (ed). *Managing IT in government, business & communities.* Idea Group Hershey, PA: 97-110

Cloete, E. Courtney, S. & Fintz, J. 2002. "Small businesses' acceptance and adoption of e-commerce in the Western Cape Province of South Africa». *The Electronic Journal of Information Systems in Developing Countries,* 10(4):1-13.

Da Costa, E. 2001. "*Global e-commerce strategies for small businesses*». Cambridge, MA: Massachusetts Institute of Technology Press.

Da Silveira, G. 2003. "Towards a framework for operations management in e-commerce». *International Journal of Operations and Production Management,* 23(2):200-212.

Foley, P. & Ram, M. 2002. "*The use of online technology by ethnic minority business: a comparative study of the West Midlands and UK*». [Online].Available WWW: http://www.sbs.gov.uk/content/analytical/research/EMB_IT.pdf (Accessed 19 November 2004).

Grandon, E. & Pearson, M. J. 2004. "E-commerce adoption: perceptions of managers/owners of small and medium sized firms in Chile». *Communications of the Association for Information Systems, 13(8):81-102.*

Hackbarth, G. & Kettinger,W. J. 2004. "**Strategic aspirations for net-enabled business».** *European Journal of Information Systems,* **13(4):273-285**

Hartley, P. & Worthington-Smith, R. 2004. «*The e-business handbook: the 2004 review of innovation at work in South African businesses*». Cape Town: Trialogue.

Hoque, F. 2000. «*E-enterprise business models, architecture and components*». Cambridge: Cambridge University Press.

Jones, C., Hecker, R. & Holland, P. 2003. «Small firm Internet adoption: opportunities forgone, a journey not begun». *Journal of Small Business and Enterprise Development,*10(3):287-297.

Kowtha, N. R. & Choon, T. W. I. 2001. «Determinants of website development: a study of electronic commerce in Singapore». *Information and Management,* 39(3):227-242.

Laudon, K. & Traver, C. 2003. «*E-Commerce business technology society*». New York: Pearson Addison Wesley.

Leong, E.K.F., Stanners, P. J. & Huang, X. 1998. «Website objectives: perspectives from Western Australian companies». ANZMAC 1998 Conference, Dunedin, New Zealand November 30 – December 2. http://pandora.nla.gov.au/pan/25410/20020805/130.195.95.71_8081/www/ANZMAC1998/ANZMAC98.html (10/07/05].

Levy, M. & Powell, P. 2003. "Exploring SME Internet adoption:towards a contigent mode"l. *Electronic markets*, 13(2)173-181.

Martin, L. & Matlay, H. 2001. "Blanket approaches to promoting ICT in small firms: some lessons from the DTI ladder adoption model in the UK». *Internet Research: Electronic Networking Applications and Policy,* 11(5):399-410.

Parish, A., Kibblewhite, G., Woodley, M. & Richardson, J. 2002."A study of the adoption of e-commerce". [Online]. Available WWW: http://www.intellectuk.org/publications/reports/A_Study_of_E-Commerce_Adoption_in_the_UK.pdf (Accessed 26 November 2004).

Pease, W & Rowe, M 2003, "Issues Faced by Small and Medium Enterprises (SMEs) and Their Take-Up of Ecommerce in Australian Regional Communities", *4th International We-B Conference 2003 (We-B03)*, Perth, Australia, November 24-25.

Poon S. & Swatman, P. M. C. 1999. "An Exploratory study of small business Internet commerce issues". *Information & Management,* 35(1):9-18.

Quayle, M. 2002. E-commerce: the challenges for UK SMEs in the twenty-first century. *International Journal of Operations & Production Management,* 22(10):1148-1161.

Quayle, M. 2002. "E-commerce: the challenges for UK SMEs in the twenty-first century". *International Journal of Operations & Production Management,* 22(10):1148-1161.

Rao, M., Metts, G. & Monge, C. 2003. "Electronic commerce development in small and medium sized enterprises a stage model and its implications". *Business Process Management Journal,* 9(1):11-32.

Reimenschneider, c. K. , Harrison, D. A. & Myykytyn, P. P. 2003. "Understanding it adoption in small business: integrating current theories". *Information & Management*, 40(4):269-285.

South Africa. 1996. "National Small Business Act". Notice 102 of 1996. *Government Gazette,* 1901:1-17, November 27.

South Africa. 2003. "National Small Business Amendment Act. Notice 26 of 2003". *Government Gazette*, 461(25763):1-10, November 26.

South Africa. 2004a. Department of Trade and Industry. "Annual review of small business in South Africa 2004". http://www.seda.org.za/summit2005/SMME%202004%20Part%20I%20SCREEN%20FINAL.pdf (Accessed 20 February, 2006).

South Africa. 2004b. Government Communications. "South African Yearbook 2004/05: Overview". www.gcis.gov.za/docs/publications/yearbook/overview.pdf (Accessed 20 February, 2006).

Southern, A. & Tilley, F. 2000. "Small firms and information communication technologies (ICTs): toward a typology of ICT usage". *New Technology, Work and Employment,* 15(2):138-154.

Stansfield, M. & Grant, K. 2003. "An investigation into issues influencing the use of the Internet and electronic commerce among small-medium sized enterprises". *Journal of Electronic Commerce Research,* 4(1):15-33.

Tagliavani, M., Ravarini, A. & Antonelli, A. 2001. "An Evaluation Model for Electronic Commerce Activities within SMEs". *Information Technology and Management,* 2:211-230.

Teo, T. & Pian, Y. 2004. "A model for web adoption". *Information and Management,* 41(4):457-468.

Van Akkren, J. & Cavaye A. 1999. "*Factors affecting the adoption of e-commerce technologies by small business in Australia – an empirical study"*. [Online]. Available WWW: http://www.acs.org.au/act/events/io1999/akkern.html (Accessed 24 October 2004).

Viviers, W. & Soontiens, W. 1998. "South African SMEs: obstacles to export to the Southern African Development Community (SADC)". [Online]. Available WWW: http://www.sbaer.uca.edu/research/icsb/1998/pdf/77.pdf (Accessed 07 February 2005).

Vosloo, G. 2003. "A conceptual framework of critical success factors for organisations to consider as they move towards full-scale B2B e-commerce". MBA study project, University of Stellenbosch.

Warden, S.C. & Remenyi, D. 2005. "E-commerce in an SME. A case study of a South African low cost or "no frills" airline". Paper delivered at ZA-WWW (World Wide Web) 2005 Conference, Cape Town, South Africa 29 to 31 August.

Weaver, P. 2005. "Travel". In Paterson, J. (ed.). 2005. The e-business handbook. The 2005 review of innovation at work in South African business, 6th edition. Cape Town: ITWeb informatica.

Wesgro 2005. "Economic overview". [Online]. Available WWW: http://www.wesgro.co.za/display.asp?id=233&linktype=1 (Accessed 06 October 2005).

Willcocks, L., & Sauer, C. 2000. "Moving to e-business: an introduction". In Willcocks, L., Sauer, C & Associates (ed.) *Moving to e-business: the ultimate practical guide to effective e-business*. London: Random House : 1- 19.

Wynne, C., Berthon, P., Pitt, L., Ewing, M.& Napoli, J. 2001. "The impact of the Internet on the distribution value chain the case of South African tourism industry". *International marketing Review*, 18(4):420-431.

Trouble in Computing: Taking "Positions" in the Discipline of Computing

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"The Connection between masculinity and technology, reflected in women's under-representation in engineering, and indeed in all scientific and technical institutions, remains strong as we enter a new era of technological change."

Judy Wajcman, TechnoFeminism, 2004

ABSTRACT

This paper explores the 'identities', and 'self positioning' of female academics working in a technical discipline. Narrative enquiry and discourse analysis are used to offer a deeper understanding of our gendered identities in relation to the dominant discourses of the computing discipline. The paper uses examples to demonstrate how the women in the study 'position' themselves, or come to be 'positioned' within the complex and contradictory discourses in the discipline. The women in the study work in the discipline of Computing where the dominant discourses around technical skills, and technical ability, along with positivist research methods are held in high esteem. In this paper I raise issues regarding the 'feminist' discourse as raised by women in the study. Some claim to work in a gender-neutral territory, and resist the feminist discourse. Others position themselves as 'feminists'. Those who claim to be 'non-feminist' have found a way to blend into the dominant technical discourse. As such they do not threaten to the status quo of their organisational setting. Conversely, those who hold the position of 'feminist' have found themselves subject to bullying, and sexist behaviour, which has led them to being constructed as the 'other' or as 'outsiders'.

INTRODUCTION AND BACKGROUND

This paper is a sub-set of work which, looks at the experiences of female academics working in the disciplines of 'computing[a] in the UK. The literature is drawn from current work about women in the academy, which is situated both in the field of 'gendered organisations', (Martin and Collinson, 2002) and the social studies of science and technology (SST). Some of the most interesting work from feminists looks closely at the relationship between technology and gender (Wajcman, 2000). Several writers such as Cockburn (1983,1985), Cockburn and Omerod (1993), Kanter (1977), Bagilhole (2002), Henwood (1996, 1998), and Wajcman (1991, 1995, 2000, 2004), have demonstrated these fields are not mutually exclusive, and that when the issues are discussed in both contexts broader analysis can take place.

Gender segregation is prevalent in the British academy where it has been argued that academic work 'is an occupation geared to and kept almost exclusively for men' (Bagilhole, 2002 pg 5). A dominant discourse of masculine values and ideals in which women are more often constructed as the 'other' or as 'outsiders' prevails. Most often the academic career path is structured according to male perceptions of what it means to be a 'successful academic' (Knights and Richards 2003). These 'masculine' values are reflected in academic outputs and in the technical rational way knowledge is debated (ibid). In the 1996 RAE[b] exercise men were almost twice as likely as women to be entered (AUT, 2004). Women's representation in the disciplines associated with technology and computer science is lower than other disciplines in British universities[c]. In subject specialisms where technology is a major feature, women's contribution to the RAE is significantly lower than women's representation in academia as a whole. Occupational segregation is both vertical and horizontal in computing (Bagilhole, 2002).

The under representation of women working in the academic disciplines of computing in the academy, is reflected further in wider British society where males dominate the design and use of technologies (DFEE 2001, Hellawell, 2001, Wilkinson, 2001). At school fewer girls are taking up computing at an advanced level, and British universities are finding that women continue to show a lack of interest in computing degrees. British industry continues to experience a major skills shortages of computer technicians and ICT professionals, (DFEE, 2001, EOC 2004) at the same time women shun careers in these fields (EOC, 2004).

GENDER SEGREGATION

Gender segregation is often explained using frameworks based on equality issues or human capital theory (Probert 2003). These frameworks are underpinned by issues concerning male power, assumptions about the division of labour in the labour market, and the relationship between paid and unpaid work in the home (Bagilhole 2002). Research within these frameworks has tended to focus on the structural and cultural influences that lead to continued employment segregation. The SST literature and much of the IS literature in gender and technology has examined the social construction of technology as a masculine domain (see Cockburn 1983, Wajcman 1991). Recently there has been a move in this research to reject an essentialist understanding of women, to focus on the experiences of the individual, recognising that 'women' are a diverse group (see Trauth 2002, Adam et al 2001, Bagilhole 2002 and Knights and Richards 2003). Theories of post modernism have focused on issues of identity, using the concepts of discourse and subjectivity, (see Henwood 1998, Hughes and Kerfoot 2002, Jorgensen 2002, Radden 2002 Whitehead 2002).

THE POTENTIAL OF DISCOURSE

This paper uses discourse as a theoretical approach, issues of identity and subjectivity are central to the narratives and discussion. Meaning is taken to be dependent on a person's subjectivity, and are situated within a historical discourse, which is constantly changing. The concept of discourse is taken from the work of Michel Foucault. Feminists have found the concepts useful in their analysis. Henwood (1998) sums up what we mean by 'discourse':

"They are not merely people's assumptions, ideas and definitions expressed through language but also the practices, formations and subject positions which follow from these". (p.39).

In these terms identity is not fixed within an individual, rather it is open to change dependent on experiences in the social world. Experiences at school, such as expectations of the way girls and boys, should behave as females or males in a heterosexual society, shape subjectivity. Subjectivity is therefore a site of dissension and conflict. The theory rejects the idea of women as a homogenous group, and places emphasis on 'difference'. The idea of a common experience of oppression of all women as a group is rejected.

In these terms, there are then a number of discourses in society, some of which are more dominant than others. The theory argues that there are 'struggles' between discourses where the dominant discourse becomes established, and that this (dominant discourse) gives meaning to the social world in which it is applied. It is argued that the dominant discourse holds the 'power' and that analysis of the 'dominant discourse' and our reaction to it can tell us about the power relations within an occupational setting. Foucault (1981) suggests that there are those in any social setting who may have a vested interest in maintaining the dominant discourse that becomes to be constituted as the norm. This does not mean that others do not contest the discourse but that they are perhaps marginalised by what is considered to be the norm or dominant discourse in that field (be it law,

education or technology). Research into discourse focuses on the way a person perceives themselves in the social world and how they 'position' themselves or come to be 'positioned' whilst working within complex and often contradictory discourses in their organisational setting. This is particularly useful to us in gaining a greater understanding of women's experiences when they are working in non-traditional subject areas such as computing, where, as we will discuss the dominant discourses may be associated with masculine values.

DISCOURSES AROUND TECHNOLOGY AND GENDER

Cockburn (1983a, 1983b, 1985) and Wajcman's (1991, 1995,) seminal work are acknowledged as the foundations of feminist technology studies (Faulkner, 2000). Cockburn's early work (1983, 1985) demonstrated how men positioned themselves in key technological roles, to the detriment of some women. Wajcman showed us how historically certain technical artefacts became symbolic of men's leisure pursuits and hence (the computer) came to be ascribed with the male identity (Wajcman, 1991). Such work has discussed technology's association with masculinity and power, which as Cockburn (1985) argued reproduced gender relations, which she described as 'hard' and 'soft' in the workplace. Much of the work in this area has focused on women's alienation and exclusion from this 'hard' culture using a structural framework. If we apply this to the academy, the pure sciences and technical disciplines can be identified as 'hard', whereas the social sciences or humanities disciplines are described as 'soft' in character. As Knights and Richards (2003) point out when terms such as 'hard' and 'soft' are used in binary oppositions, as in the case with technology, they are rarely innocent or neutral constructions. What they do is reinforce the current power and knowledge relations, thus they have the ability to sustain or transform particular identities and interests (ibid, p. 222). Both the fields of organisational gender and SST describe computing as a 'hard' discipline. The 'hard' and 'soft' distinction tends to pre-determine what is recognised as competence within the discipline, and what is considered to be of value or importance in teaching, student support, and research in the discipline.

Feminist writers have successfully applied theories of discourse to studies of gender and technology in the academy to determine why, and how women and men actively maintain or reject the dominant discourses (Clegg et al 1999, Jorgensen, 2002, Henwood, 1998). It has been argued for some time that a 'masculine discourse' surrounds the design and use of technologies in many western societies. That males from an early age consider that 'computers, like cars and others forms of hardware, constitute a naturalised part of (their) male heterosexual identity' (Clegg 2001,p.314). The male domination of computing and thus the masculine values assigned to the discourses around computing and technology, extend to the work place, where gendered relations exist in our relationship to technology just as much as they might do in the home and in education (Wajcman, 1991).

THE STUDY AND METHOD

I present here a sub-set (this is still a work in progress) of the findings of the narratives of ten women. Each of the women were interviewed for between two and four hours. The interviews were often followed up in further discussions for clarification. The women work in different educational institutions in the UK. They all work in Computing Departments in either colleges or universities. The ages of the women in this paper range from 45 – 56. Several of the women have worked in the Computing Industry, before working in the field of education. They hold positions as lecturers, senior lecturers or professor. Each of them has worked in education for a minimum of ten years.

I have taken a narrative approach allowing the women to develop their stories themselves, rather than trying to elicit direct explanations using question and answer methods (Hollway et al 2000). Using the concepts of 'discursive positioning' (Davies & Harre, 1990, 1999) I am particularly interested in how these women's self-positioning affirm or challenge the dominant discourses in computing.

FINDINGS AND DISCUSSION

The women in this study are understood as negotiating their way through complex interconnecting discourses concerning their relationship with their gender identity, sexuality and their work as academics in a technical discipline. Several themes or positions in relation to the women's identities emerged in the study. The themes resided around technical work, research paradigms, the conflict between work and family and their mothering work; both at work and at home. Whilst some represented themselves as 'different', or 'unique' because they worked in a predominately male field, others rejected issues of gender difference in their workplace. In this paper I discuss the feminist discourse and the position of 'feminist' or 'non-feminist'.

The word 'feminism' can have different connotations to it. The meaning of the term is dependant on the context and the given moment in which it is applied (Beasley, 1999). In popular culture most of us are aware of the term 'feminism', but we add our own subjectivities to make meaning of it. For myself feminism is about politics and about challenging the inequalities many women face in areas of their lives. In popular culture the term 'feminism' may have different meanings and connotations associated with it than my own interpretation.

TAKING A NON-FEMINIST POSITION

Paula and Margaret both stated that they enjoyed their work immensely. After several years teaching, both are still enthusiastic about their subject. They both enjoy teaching the technical subjects of the discipline. They work at different educational institutions where their colleagues are predominantly male.

Paula is in her late fifties; she began work in the computing industry in the early 60's. She is a senior lecturer who has worked in the computing discipline in a university for over twenty years. She has never considered, or concerned herself about working in a 'male dominated environment'; she resists any suggestion that her gender makes any difference to her workplace experiences.

"I have never, ever seen people (in work) as male or female" (Paula)

She holds strong views about feminism.

"I'm not a feminist. I've always thought that people would take me on my own abilities…… I hate the droning on of people who are victims. And I will never be a victim." (Paula)

She resists the feminist discourse. To be a feminist in her view is to be a 'victim'. She talks about being taken on her 'own abilities'; suggesting she should be employed on her own merit, regardless of her gender. When talking about her own career in computing in the university, she discusses how when her children were ill she didn't tell her head of department of any difficulties she was experiencing. Instead, she struggled to complete her work and find care for her children.

"They'd taken me on and they knew I had two young children, and I didn't want to let down the women's cause in a way". (Paula)

Although Paula clearly positions herself as a 'non-feminist', I suggest her comments about 'the women's cause' contradict her self-positioning. She as an individual does not align these comments with feminism or position herself as a feminist.

Margaret is in her early fifties, she too started her career in the computing industry. She had been head of the computing department in her institution for a number of years before taking a more senior management role. She denies there are any issues regarding gender or sexism in her workplace. She does not position herself as a 'feminist'.

"I think it (a person's behaviour) has a lot to do with that person 'character, rather than the fact that she is a woman or a man". (Margaret)

However, when talking about her career in terms of progression she stated *"there was no doubt that women had to work harder to get where they were going than the men in the (computing) industry"* and as an academic.

"I have always had to prove myself as women" (Margaret).

Here again there are some contradictions but she remains firm about her 'non-feminist' position.

Paula and Margaret resist any association with feminism, and publicly reject the feminist discourse. My analysis of their narratives and actions contradict these public statements. Both of them deny any difference from their male colleagues associated with gender and claim to work in gender-neutral territory. They reject any notions of themselves as a marginalised group.

Both women have a long history of working in computing, I suggest they have adapted and assimilated their workplace identities over time. I suggest they enjoy the high status given to the technical skills they possess, and identify with the dominant technical discourse. Taking the position of 'non-feminist', has allowed them to blend into their discipline. Allowing them to comfortably position themselves along side the dominant masculine discourse in relation to their professional identities and their work.

TAKING A FEMINIST POSITION

Hannah, and Amanda both position themselves as 'feminists'. Both work in universities in computing departments, both of them have research interests related to SST.

Hannah is in her late forties and is a senior lecture in computing. She began teaching in the discipline of computing after completing an MSc in Computing in the early 90's. Before this she had taught subjects in Literature. In her department there are thirty academics, of which five are female.

She discussed how the attitude in her department was openly hostile to women.

"I think it's, erm, there's an underlying current of misogyny, discrimination and sexism in my view. A male professor said that erm that women don't make reliable workers in the department, because they go off and have children…….he was talking about women lecturers". (Hannah).

Hannah had publicly challenged this statement in a department meeting, the male academic in question had not spoken to her since, and she felt her relationship with the majority of the male staff in the department had become somewhat tenuous.

A male member of staff had told her that other male members of staff had given the females in the department the nickname,' the hens'. This was applied to herself and the other women in the department in a derogatory way.

"If we had lunch together it was, what are you lot (the hens) up to, what are you conspiring at, and things. Actually most of the time we were discussing our children, where we could buy a good bargain, nothing related to work". (Hannah)

Amanda in her early fifties started her work in computing in the early 60's, she has worked in academia for twenty years and is a professor in her computing department. As some of her research resides in the feminist literature, her colleagues know of her feminist position. During the narrative she gave many examples of what she described as 'confrontations' about her research and her beliefs in the department. At the time of the interview she said that over the previous year there had been many times that she had thought '*to throw the towel in*' or *'just give up'* and work elsewhere. She discussed how she was concerned about the consequences for other women in department who might be associated with her and be labelled alongside her as one of the 'feminists' in the department.

" In some cases I can see that people who are my friends, are not given a job by somebody else, maybe in authority to the research director, because they're part of this Amanda (me) , soft research, feminist, colleagues, friends stuff". (Amanda)

Amanda went on to explain that this not only included the females in the department but also some of the males she closely associated with, which she described as 'pro-feminist'. She explained that the technical 'hard' research, and the teaching of technical subjects, was highly valued in her department.

"There's definitely a lot of old fashioned, 'blokiness', which is critical.

It's very hard to put your finger on it……. The technical stuff is in the hands of the men, and that's the real stuff, and so on……they are protecting some kind of, they're very protective of their own status as researchers (sic)". (Amanda)

Hannah and Amanda reject ideas of gender neutrality and challenge issues of inequality between men and women working in their departments as they arise. Both position themselves as 'feminist'. Although technically competent they have both chosen to teach and research in areas labelled by colleagues as 'soft'. Consequently, as Amanda's statements demonstrate their type of work and research may be challenged and undervalued in a department where the technical discourse is highly valued and protected.

Hannah and Amanda by their actions and nature of their teaching and research position themselves as 'feminists'. I suggest this does not allow them to blend into their workplace setting. Instead their position places them in opposition to the dominant discourse, where some of their colleagues may view them as a threat to the status quo.

CONCLUSION

In this paper it is not my intention to make any collective claims about the experiences of women working in Computing. This paper is about highlighting the complexities of our work place identities as we as individuals construct them.

In this study those women who held a position of 'non-feminist', withdrew from any discussion around issues relating to gender, and refused to acknowledge any 'difference' between men and women's attitudes to technology or technical ability. Those who positioned themselves as 'feminist', questioned the dominant technical discourse and the values attributed to positivist research methods. They are not afraid to challenge sexist behaviour or inequalities they experience in their departments.

Those who hold the position of 'non-feminist', holding a belief of gender equality or neutrality in their workplace appear to have a more satisfying work experience. I suggest that their self identities do not challenge the status quo. In contrast those positioned as 'feminists' found themselves at odds with the norms and values of the discipline leaving them open to harassment and sexism.

Issues of how we come to construct our 'self position' and 'identity' add more complexity to gender relations in the discipline. In the findings of this research there are several contradictions in the statements. As Paula's narrative demonstrates, we may interpret the word feminism from a number of perspectives, and add our own connotations to it. I suggest that for these women and their colleagues the terms 'feminist' or 'non-feminist' do not have innocent or neutral meanings attached to them.

If we wish to tackle women's under representation, or seek to understand how some women become 'marginalised', or situated as the 'other' in the discipline of computing then I suggest that in future work we need to tease out, how our self positioning and 'self identities' as women and men work to resist, or reinforce the dominant discourses of the discipline.

REFERENCES

Adam, A. and Richardson, H. (2001). Feminist Philosophy and Information Systems. *Information Systems Frontiers* 3(2), 143-154.

AUT. 2004 (On-line) http://www.aut.org.uk/index.cfm?articleid=1 last visited 1st December 2004

Bagilhole, B. (2002). *Women in Non-Traditional Occupations*. New York, Palgrave Macmillan.

Beasley, C. (1999). *What is Feminism? An introduction to feminist theory*. London, Sage.

Cockburn, C. (1983). *Brothers:Male Dominance and Technological Change*. London, Pluto Press.

Cockburn, C. (1985). *Machinery of Dominance: Women, Men and Technical Know-How*. London, Pluto.

Cockburn, C. and Ormrod, S. (1993). *Gender and Technology in the Making*. London, Sage.

Clegg, S. (2001). Theorising the Machine: gender, education and computing. *Gender and Education* 13(No. 3), 307-324.

Clegg, S., Mayfield, W. and Trayhurn, D. (1999). Disciplinary Discourses: a case study of gender in information technology and design courses. *Gender and Education* 11(No.1), 43-55.

Davies, B. and Harre, R. (1990). Positioning: The Discursive Production of Selves. *Journal for the Theory of Social Behaviour* 20(1), 43-63.

Deem, R. (2003). Gender, Organizational Cultures and the Practices of Manager-Academics in UK Universities. *Gender , Work and Organization* 10(2), 239-259.

DFEE (2001). Opportunity for all in a world of change. CM 5052. London, The Stationary Office.

EOC (2004). Plugging Britain's skills gap: challenging gender segregation in training and work. Manchester, Equal Opportunities Commission.

Foucault, M. (1981). The order of discourse. In: R. Young. (eds) *Untying the text: A poststructuralist reader*. London, Routledge.

Hellawell, S. (2001). Beyond Access ICT and social inclusion. Bell & Bain, Glasgow, Fabian Society.

Henwood, F. (1996). WISE Choices? Understanding Occupational Decision-making in a Climate of Equal Opportunities for Women in Science and Technology. *Gender and Education* Vol. 8(No. 2), 199-214.

Henwood, F. (1998). Engineering Difference: discourses on gender, sexuality and work in a college of technology. *Gender and Education* 10(1), 35-49.

Hughes, C. and Kerfoot, D. (2002). Editorial: Rethinking Gender, Work and Organization. *Gender , Work and Organization* 9(5).

Hill, P. (2004). Men leave low-status academy to women, Times Higher Education Supplement, 25th June.

Hollway, W. and Jefferson, T. (2000). *Doing qualitative research differently*. London, Sage.

Jorgensen, J. (2002). Engineering Selves: Negotiating Gender and Identity in Technical Work. *Management Communication Quarterly* Vol.15(3), 350-380.

Kanter, R. M. (1977). *Men and Women of the Corporation*. New York, Basic Books.

Knights, D. and Richards, W. (2003). Sex Discrimination in UK Academia. *Gender , Work and Organization* 10(2).

Martin, P. Y. and Collinson, D. (2002). 'Over the Pond and Across the Water': Developing the Field of 'Gendered Organisations'. *Gender Work and Organisation* 9(3).

Probert, B. (2005). 'I Just Couldn't Fit It In': Gender and Unequal Outcomes in Academic Careers. *Gender, Work and Organization* 12(1).

Raddon, A. (2002). Mothers in the Academy: positioned and positioning within discourses of the 'successful academic' and the 'good mother'. *Studies in Higher Education* 27(4), 387-403.

Trauth, E. (2002). Odd Girl Out: An Individual Differences Perspective on Women in the IT Profession. *Information Technology and People* 15(2), 98-118.

Wajcman, J. (1991). *Feminism Confronts Technology*. Cambridge, Polity Press.

Wajcman, J. (1995). Feminist Theories of Technology. In: G. E. M. S. Jasanoff, JC Peterson, T Pinch. (eds) *Handbook of Science & Technology Studies*. London, Sage.

Wajcman, J. (2000). Reflections on Gender and Technology Studies: In what State is the Art? *Social Studies of Science* 30(3), 447-64.

Wajcman, J. (2004). *TechnoFeminism*. Cambridge, Polity Pres

Weedon, C. (1997). *Feminist Practice & Postructuralist Theory*. 2nd Ed Oxford, Blackwell.

Wilkinson, H. (2001). dot. bombshell: women, e-quality and the new economy. London, The Industrial Society.

Whitehead, S., M (2002). *Men and Masculinities*. Cambridge, Polity.

ENDNOTES

[a] **Terms and Definitions**
'**Computing Discipline'** encompasses department of computing and information technology (IT), information systems (IS) and information communication technologies (ICT's).

[b] **RAE** is the Research Assessment Exercise where performance of research is judged on the basis of 'excellence' rather than equity. Public funds are allocated related to an institution/department's performance.

[c] **The under representation of women in computing`.** In Computer software engineering there are 610 female lecturers and a total of 2010 male lecturers. In IT & Systems sciences there are 440 female lecturers and a total of 1045 male lecturers. In computing and software engineering less than 10% professors are female and in IT & systems sciences around 17% are women. (The Times Higher 2004).

Supporting EBAO Planners by Distributed Ontologies and a Template for Objective-Systems

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ABSTRACT

This article gives an overview on how military planners in multinational environments can be supported by Knowledge Bases based on Semantic Web Technologies. It reflects parts of results generated during a project for the German Center for Transformation of the Federal Armed Forces from 2005 to 2007. Focus of this project was Knowledge Representation and Knowledge Processing to support EBAO-Planners. For this, firstly context-specific problems are introduced, followed by a brief description of latest enabling Technologies for Knowledge-Modelling and Knowledge-Processing. In particular problems of instance-modeling and abstraction as well as some downsides of inference engines based on First-Order-Logic (FOL) compared to Second-Order-Logic are briefly outlined. An SOL based approach for the analysis of objective-systems is conceptually shown finalized by an example from the Effects Based Approach to Operations (EBAO) context. The conclusion identifies upsides as well as problems and subjects to improvement.

1. THE EFFECTS BASED APPROACH TO OPERATIONS

The Effects Based Approach to Operations (EBAO) introduced a new way of strategic planning not only in correlating Actions and Objectives but in holistically considering Actions, Effects and different Objectives [1]. Effects can be here described as the sum of all results which are caused by actions taken within an Area of Interest, the so called *Focus Area*. The aspect of integrating different Agencies involved with different interests, such as Department of Defence, State Department etc., is emphasized within the EBAO[2]. This approach can not be considered really new [3], but last decade's information technologies enabled efficient network communication as well as Knowledge Representation (KR). These laid the cornerstone for a sufficiently effective dealing with the complexity within fields of modern military operations [4]. Amongst others these are standards in network communication, data bases and XML with its derived modelling languages including Ontology-Languages.

Ontologies allows experts to built and maintain domain specific knowledge [5, 6]. Results from NATO's Multi National Experiment 4 (MNE4) which ended in 2005 have shown that centralized and static Knowledgebase- structure as known from classical databases have crucial drawbacks in giving an situation awareness needed by planners within the EBAO [7]. The focus of this paper is to depict the potentials of Ontology technologies in the field of Multi-Agency and Multi-National Knowledge Representation (KR). As a prerequisite for all planning-work, the formalization of objectives and a mechanism to infer dependencies between those (Reasoning) represent the Knowledge Processing part. We focus on the Web Ontology Language (OWL) here, because it is an implementation of Description Logics, a W3C Standard, and well supported by an Open Source Community. In addition to this there are hardly any competitive technologies at the market [39, 40].

2. OWL: A W3C STANDARD FOR KNOWLEDGE REPRESENTATION

Ontology languages such as OWL are usually attributed to Knowledge Processing not so much as to pure Knowledge Representation [8]. OWL provides no executable methods, but requires inference engines [9], rule systems [10] or wrappers to make structure and data accessible for applications [11]. Encapsulating knowledge structure in own language systems leads to more semantically powerful structures. Amongst others property-centric modelling [12] or a dynamic and logic-based inference [13] of class structures introduce new features in Knowledge Representation. Especially the latter feature, which is missing in executable environments such as Object Oriented (OO) Programming Languages [14], can not be transferred to these without loss of expressivity [15]. Besides this flexible mechanism to create structure by descriptions, OWL offers an fully URI-based referencing mechanism for elements on class level and instance level, which leads to an native implementation of distributed – but seemingly local – KBs [16]. This feature is shown in section 2.1. New applications called Alignment and Mapping tools make use of the graph-based [17] structure of OWL Ontologies and apply distance measure methods, developed from the 70'ies on, in order to support (next to others) a semi automated similarity comparison [18] of different structures. A short overview on this topic can be found in 2.2.

2.1 Ontologies: An Distributed and Modular Approach

For decades organisations have been working on Knowledge Base Models to represent the "whole world" within one single Ontology. This central approach leads to inconsistency, redundancy, unintentionally outdated information and other strongly unwanted effects. Technically Gödel proved in 1931 that a formal system suffers from too little expressivity or from contradictious elements [19]. So seemingly the hope for a "world-system" which contains each an every concept in every perspective has maybe not died but at least suffered a severe set-back then. And this took place even long before technology came even close to a level powerful enough to handle an amount of information this large. Individual perspectives or views – in the sense of an understanding of a subject and its properties (as shown in [20]) – can be seen as reason for why a "common sense modelling" can be considered a permanent point of failure [21, 22]. Simply too many partially contradictious views exist, each with different structures, classes and properties.

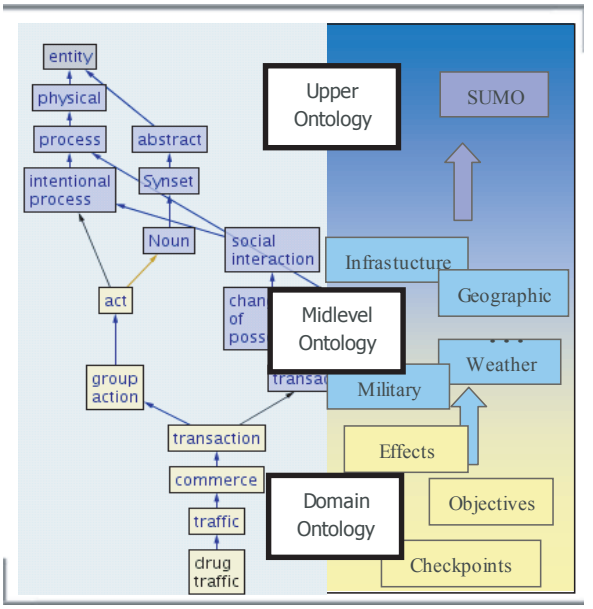
Taking this into consideration, a new way of Knowledge-modelling has been defined. The architecture of ontologies follow a three layer approach, which combines so called upper-level, midlevel and domainlevel ontologies. Once Domain-Knowledge has been made explicit it can be integrated (by means of inheritance) under more general upper Ontologies in order to assemble a KB for special purposes [23]. Figure 1 shows an example Ontology which models Drug Traffic on structure-level. Rectangles depicted in the upper part are more general concepts such as *physical*, *abstract,* or *process* and belong to the upper level of the Standard Upper and Midlevel Ontology (SUMO)-Standard [24].

Rectangles in the centre are of Midlevel, and would not be part of all ontologies, since they contain fairly common but not general concepts. The most specific level, the domain level (lower part), then represents the actual intent of the model [25]. All relations shown in the picture are inheritance relations and therefore enable a switching of different domain level Ontologies since they are of same type by definition (if they inherit from the same midlevel concepts) [26].

2.2 Comparison of Similarity Using Alignment-Tools

In order to participate in a distributed system all elements need to "know" about data structures they are working on [27]. Structures which are of no interest can be neglected but when it comes to data exchange with other participants the meaning

Figure 1. Three-level architecture of an ontology (Source: [25])

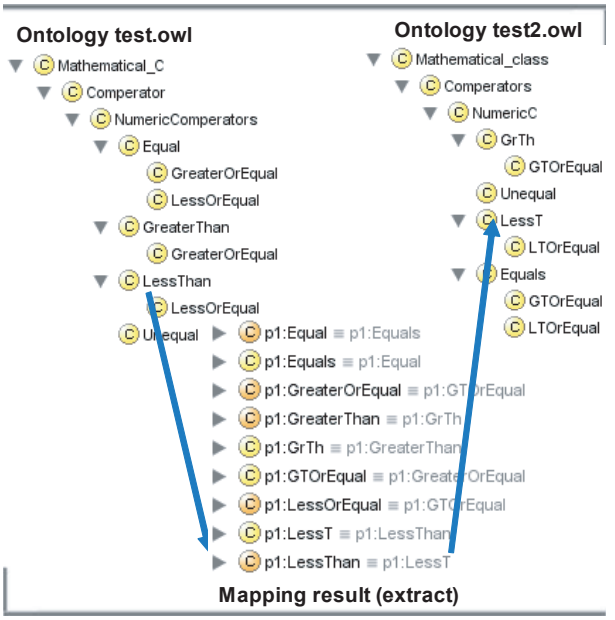


of structures and data have to be underpinned by a common understanding. Given the decentralized thought in section 2.1 it becomes highly probable for different actors to work on identical subjects but using different structures. A necessity for bridging these differences appears, if queries are to be used in different environments, class structures are to be aligned or instance-class relations are to be checked (e.g. which class does a given instance belongs to) [28].

Generally speaking differences in models can arise at two conceptual levels: Ether the modelled subject itself (Conceptualisation mismatch), or the way of modelling this subject (Explication mismatch) can differ [28]. While the first challenge is of pure semantic nature, and nearly no support but the recognition of differences can be provided, the latter situation is generally supportable by alignment tools [31]. "The way of modelling" in this context means, that a subject can be related to different other subjects on structure level (class definition). Alternatively different modelling-languages can be used. The first case can be solved by a union of all properties, if all concepts' meanings are at least comparable or equal at best [28]. If different languages have been used, a comparison depends on syntax, semantics of primitives, logical representation and the languages' expressivity [32].

Alignment helps integrate the results of different ways of modelling an identical subject under different perspectives using comparable languages. Technically the output of an alignment process is again an ontology which defines relations between classes [29]. In case OWL, specific language-elements such as *owl:sameAs* or *owl:equivalentClass* [12] are used. As an example Figure 2 shows two Ontologies about mathematical comparators and their generated mapping ontology (test.owl and test2.owl).

Figure 2. Example for tool enabled ontology-alignment



The result of this process is depicted in the middle and defines equal classes. The limits of alignment are reached, when elements within the compared ontologies are not on semantically comparable levels. In such case some properties would be match one atomic property or class in test2.owl. Integration of this kind can be done syntactically via XSLT processors. Nevertheless this approach seems very promising, since it provides – compared to manual comparison – reasonably support in analysing class dependencies [30].

3. SUPPORTING PLANNERS BY OBJECTIVE-SYSTEMS

All plans try to achieve certain objectives. The definition of objectives, which is depending on time restriction and planning scope, is often done implicitly by planners. This implicit approach seems valid, as long as the planning organization is of limited size. In case of EBAO, several Agencies and Departments are thought to plan and execute as if (at best) they were one single organisation [33]. Strictly formalized information-flows try to limit uncontrolled information exchange among planners of different departments. Hence it is by no means the case that necessary communication between information provider and consumer takes place directly [34]. Needless to say, different departments take a lot of effort to coordinate their planning processes.

But this does not imply persons involved in the planning process to be informed at all times about other-parties' intentions and plans. In order to increase the value of defined and mutually exchanged objectives, one option is to shift these objectives from paper bound media to formalized ontologies. By this, analysis methods can become (partially) IT-enabled – a process highly time consuming, if conducted manually. Of course only a portion of the objective analysis can be done by computers, but areas of high data volumes combined with relatively simple and formalizable relations can be targeted by computers very effectively. One of these areas is the detection of contradictious or depending objectives. The basic question to be answered in this section is in which way a detection of these relations can be achieved. It is not planned to give a detailed introduction into the technical questions of the mechanism itself but more an overview on the idea behind it. The basic assumption for the added value of this mechanisms is, that if planners knew that their actions and effects influence other agencies during planning time they would be able to avoid unwanted (mostly competitive) effects during execution.

3.1 An OWL- Objective Ontology

A single Objective describes, speaking abstractly in the context of this work, an (internal) state of a set of concepts at a certain point in time. For this an objective needs means to define its target concepts, the desired values to be connected with these and a mechanism to determine if the objective is to be taken into consideration in current planning. The mentioned Ontology counts about 70 classes and 60 properties which are not to be introduced here completely. We focus on core-concepts which are connected to numerous other concepts defining mathematical expressions, actions, user-interaction, or reference constructs.

Figure 3 shows concepts formalized as Unified Modelling Languages (UML) classes.

At the lower left hand side, the Objective-class carries information about EBAO specific categories (*DIME_Category* Diplomatic, Information, Military, Economic), a textual description and Instances for predefined user-interaction. The description of which concept to be changed by which values, is given by references to *ObjectiveTargetChange*-Objects.

Figure 3. Core-concepts of the objective-ontology

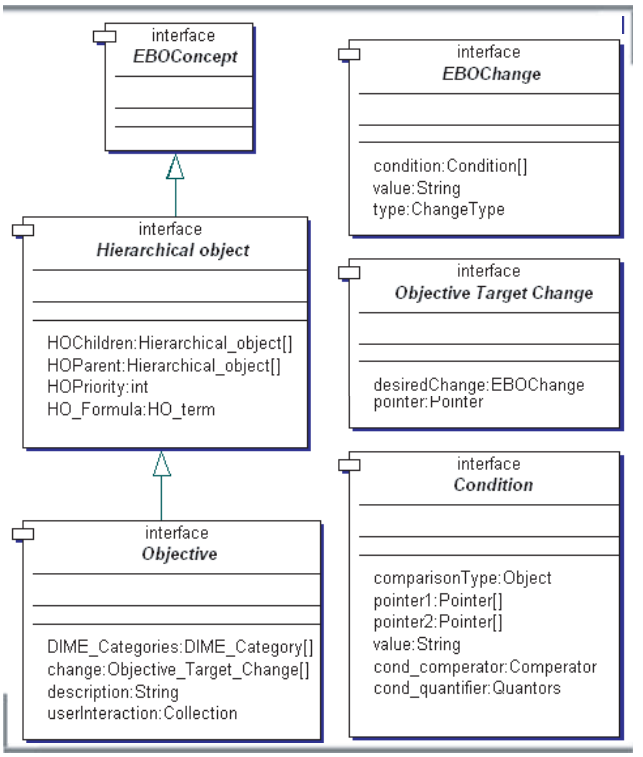
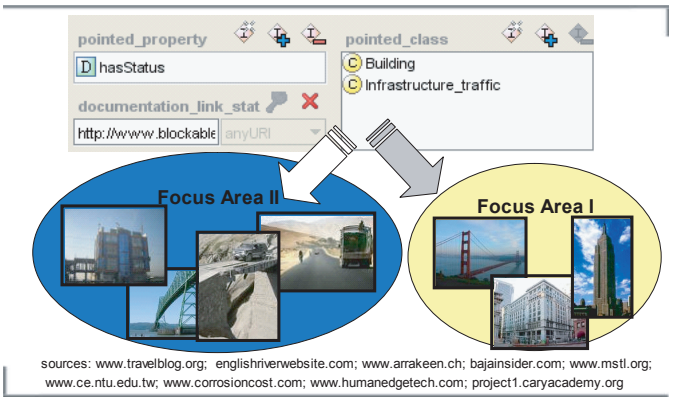


Figure 4. Abstract addressing-mechanism: The pointer-class



ObjectiveTargetChange addresses concepts by *Pointer* Objects (see 3.2). References to *EBOChange*-Objects define desired status and sets of addressed concepts. *EBOChange* itself changes a value in a relative or absolute way (defined by *ChangeType*) to (or by) a certain value. This change is executed, if all conditions are met, while a *Condition*-Object compares two sets of addressed values (see 3.2) or values.

Objectives exit within networked systems of objectives depending on each other [35]. In addition to this it is not a trivial task to define numerically defined end states or to set up references as desired values [36]. Objectives sometimes purely depend on their child-objectives in a sense that if a defined combination of child-objectives is fulfilled then the parent-objective is fulfilled itself. An example for this is given in the following table that defines A as parent-objective for B, C and D (left hand side). The requires-relation on the right hand side determines the conditions under which A is fulfilled (simplified with non-quantified relations only).

childElement(A, B)	requires(A, [B,C])
childElement(A, C)	requires(A, [C])
childElement(A, D)	requires(A, [B,D])

In order to embed single *Objectives* within such systems but keeping the structure encapsulated, the *Objective* class inherits form a class *Hierarchical_object* (see Figure 3). This class provides a special linking mechanism for its subclasses, which defines parent and child-relations as well as priority and *Formulae*. A *Formula* defines the dependencies for all child-elements in a logical expression.

The mechanisms described above are a domain-independent, and therefore exchangeable, way to formalize objectives with flexible addressing mechanism and primitive value or object-comparison mechanism.

3.2 The Advantages of Structural Definitions

One aspect to be outlined more detailed here is the addressing concept used within objective systems. The basic idea behind it is to avoid pure instance reference but instead use class references, in order to benefit from the Description Logic (DL) features within OWL. DL allows the definition of so called asserted class-structures enriched by logic statements. These statements can then, after applying reasoning tools, be resolved to new inferred class-structures [13]. Hence a Pointer-instance carries (as shown in Figure 4) a set of classes, one property, a recursive set of pointers and a set of instances to be able to refer to very important instances as well.

In the example shown above all militarily blockable concepts are addressed, which include classes of buildings and traffic- infrastructure. This mechanism is of descriptive nature only and requires an inference engine to determine results of these descriptions. As shown in [37] a class is substituted by all its direct instances and direct instances of its subclasses**.** Exclusive usage of class level concepts supports transferability and reuse of pointers within different Focus Areas.

3.3 Ontologies, Structures and Second Order Logic

If pointers use structure level concepts to address their concepts then First Order Logic does not natively suffice to do the resolution. Technically FOL can query for named predicates. What can not be solved is the question, if any predicate (with variable name) exists which fulfils a goal [38]. Assumed that each instance is transferred to a predicate named after its class and all relations are named after the relations' names and combine domain and range instances, then the predicates' names explicitly carry information about their content.

FOL Representation	SOL option
warlord(X)	concept('warlord', X)
hasInfluence(X, Y)	relation(X, 'hasInfluence', Y)

If OWL-ontologies are transformed as described in [37] all ontology-internal names become variable of a limited set of predicates. This enables SOL-like inferences including reachability analysis and reflection mechanisms based on FOL inference engines.

3.4 Example Results

The following example shows some options how the objective ontology described above can be analysed under conditions of distributed knowledge bases. One of the most important things for a planner setting up objectives is to know, if any other party within his own system has an interest in the concepts addressed by his objectives. If such situation is given, he would also like to know, what kind of dependencies between this two objectives exist. Especially competitive and complementary relations are of interest here, since conducted actions could turn out to be an – seen from the system's point of view – inefficient usage of resources.

In our example the subject to investigation is drug traffic in the Focus Area of northern Afghanistan. Two System-of-a-System-Analysis analysts [33], one on

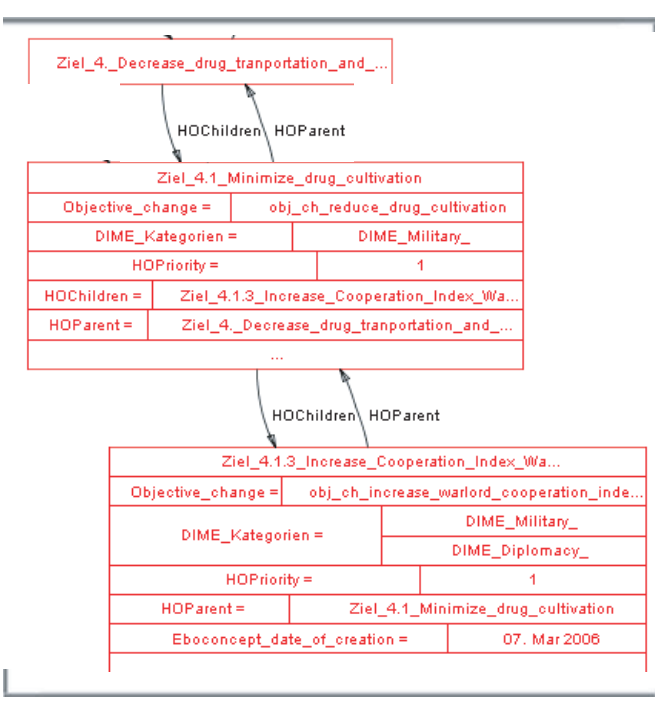
military, one on diplomatic mission are working on the effects of drug traffic on their afghan scenario. The military planner discovers some warlords' income to be generated in large portions form poppy-cultivation and opium trade. So he creates a rule to make this relation explicit, but due to lack of reliable data she/he does not quantify this information. In addition to this the analyst knows, that some warlords spend quiet a large proportion of their income on running their private militia in order to maintain control over "their" region and to stabilize or exceed their powers. Warlords of great power are considered a threat for the democratically elected afghan government since they tend to subjectively interpret state laws or decisions made by the judicative to their favour.

The diplomatic analyst objective is to increase powerful warlords' will for cooperation with the afghan government. He assumes that without the active participation of these persons, a stable government and prospering economy is far off reach. And she/he knows about the relation between actions taken about the power of warlords and their behaviour connected to the acting parties. Since warlords try to maintain their powers, their willingness to cooperate with anybody trying to weaken their influence decreases. So from the diplomatic perspective (which might be – compared to the military point of view – more far sighted in this case) it seems not recommendable to weaken warlords by aggressive means.

Both analysts now start to develop a formalized objective system to ether (in military case) decrease the income of warlords, or (in diplomatic case) to conserve the current status of the warlords. As a base for their objectives they use the Focus Area Afghanistan 2006 (distributed) KB, which offers a linked system of a large number of (mostly) compatible domain Ontologies. After loading all warlord-relevant parts of this KB to their local computers they discover after some time – indicated by a check for dependencies between their objective-system – that it seems as if somebody else addressed the warlords' income too. Figure 5 depicts a prototype for an objective analyze tool based on Stanford's Protégé-tool. Amongst other features it infers dependencies and contradictions between objectives by comparing addressed sets of concepts and their desired value. Relations such as the dependency between poppy cultivation and a warlord's income can then be inferred. Within a concrete KB these structural descriptions are then projected onto all instances collected by analysts.

Querying details about the discovered references both of them can determine the owner of these relating concepts other objective systems as their source. Now it is apparent, that their objectives are indirectly related to each other, since M wants to prevent poppy cultivation, which is a prerequisite for drug traffic – the basis for warlords' income – and D wants to keep exactly these income at a constant level. After this IT-enabled support, the procedure to resolve this conflict of interests can then be carried out on human to human level.

Figure 5. Determination of contradictious objectives



4. CONCLUSION AND OUTLOOK

The paper presented a conceptual idea on how Ontologies – here implemented in OWL in particular, can be used to mediate KB-models between different agencies. By using the decentralized approach of Ontologies at Upperlevel, Midlevel and Domainlevel dynamic KBs containing detailed expert knowledge can be assembled within a much shorter period of time. Here, alignment tools can provide great help to human analysts. Means of Second Order Logic into play enable a more powerful mechanism for querying and manipulation. Based on SOL domain independent predicates provide a framework for analyzing objective systems on dependencies and contradictions. Although this work has been implemented it has not been tested for scalability and the dynamic loading of instances from different Ontologies. While the first aspect is subject to further research, the latter one will surely be covered by Ontology editors within the near future.

REFERENCES

1. EBO_Prototyping_Team, The Multinational Effects-Based Operations Process. 2005, Washington: Joint Forces Command, Joint Experimentation Directorate.
2. Kemple, W.G., et al. Effects-Based Planning: An Empirical Examination of the Process. in 7th Command and Control Research and Technology Symposium. 2002. Monterey, CA.
3. Clausewitz, C.v., Vom Kriege. 1978, Reinbek: Rowohlt Tb.
4. Curtis, K.P. Knowledge Support for Effect-Based Operations. in CCRTS. 2006. San Diego: CCRP.
5. Smith, M.K., C. Welty, and D.L. McGuinness, OWL Web Ontology Language Guide W3C Recommendation, http://www.w3.org/TR/, 2004, accessed: 2005-09-25
6. McGuinness, D.L. and F.v. Harmelen, OWL Web Ontology Language Overview, http://www.w3.org/TR/owl-features/, 2004, accessed: 2005-11-24
7. Bärtl, C.D.M., et al., MNE 4 KBD Process Limited Objective Experiment - Final Report. 2005, Bundesministerium der Verteidigung: Munich.
8. Koide, S., J. Aasman, and S. Haflich. OWL vs. Object Orientated Programming. in International Semantic Web Conference, Workshop1: Semantic Web Enabled Software Engineering. 2005. Galway: Workshop paper.
9. Friedman-Hill, E., Jess in action. 2003, Greenwich, CT: Manning Publications Co.
10. Horrocks, I., et al., SWRL: A Semantic Web Rule Language Combining OWL and RuleML, http://www.w3.org/Submission/SWRL/, 2004, accessed: 15.10.2005
11. Knublauch, H., et al., A Semantic Web Primer for Object-Oriented Software Developers, http://www.w3.org/TR/sw-oosd-primer/, 2006, accessed: 2006-09-21
12. Bechhofer, S., et al., OWL Web Ontology Language Reference, http://www.w3.org/TR/owl-ref/, 2004, accessed: 2006-06-30
13. Baader, F., I. Horrocks, and U. Sattler, Description Logics, in Handbook on Ontologies, S. Stab and R. Studer, Editors. 2004, Springer: Berlin Heidelberg New York.
14. Ontoprise_GmbH, How to Write F-Logic Programs, http://www.ontoprise.de/documents/tutorial_flogic.pdf, 2003, accessed: 2006-08-17
15. Jacobs, B., OOP criticism and OOP problems. 2005.
16. Patel-Schneider, P.F., What is OWL (and why should I give a hoot)? http://www-db.research.bell-labs.com/user/pfps/talks/owl/all.html, 2005, accessed: 2005-10-15
17. Diestel, R., Graphentheorie. Vol. 3. 2006, Berlin: Springer.
18. Carroll, J.J., Matching RDF Graphs, http://www.hpl.hp.com/personal/jjc/tmp/matching.pdf, 2001, accessed: 2006-06-21
19. Gödel, K., Über formal unentscheidbare Sätze der Principia Mathematica und verwandter Systeme I. Monatshefte für Mathematik und Physik, 1931(38): p. 173-198.
20. Brickley, D. and R.V. Guha, RDF Vocabulary Description Language 1.0: RDF Schema, http://www.w3.org/TR/rdf-schema/, 2004, accessed: 2006-06-21
21. Foerster, H.V. and B. Poerksen, Understanding systems: conversations on epistemology and ethics. 2002, New York: Carl-Auer-Systeme.

22. Foerster, H.v., Einführung in den Konstruktivismus. 2005, München: Piper Verlag GmbH.
23. Niles, I. and A. Pease. Towards a Standard Upper Ontology. in 2nd International Conference on Formal Ontology in Information Systems (FOIS-2001). 2001. Ogunquit, Maine.
24. Ackermann, J. and e. al., Vereinheitlichte Spezifikation von Fachkomponenten. Gesellschaft für Informatik Arbeitskreis 5.10.3, 2002(Februar 2002).
25. Ševčenko, M., The KSMSA Project, http://virtual.cvut.cz:8080/ksmsaWeb/main, 2004, accessed: 2006-02-07
26. Antoniou, G. and F.v. Harmelen, Web Ontology Language, in Handbook on Ontologies, S. Staab and R. Struder, Editors. 2003, Springer: Berlin Heidelberg.
27. Szyperski, C., Component Software - Beyond Object-Orientated Programming. 2002, New York: Addison-Wesley.
28. Klein, M. Combining and relating ontologies: an analysis of problems and solutions. in IJCAI2001 Workshop on Ontologies and Information Sharing. 2001.
29. Patel-Schneider, P.F., et al., Web Ontology Language (OWL) Abstract Syntax and Semantics, http://www.w3.org/TR/2002/WD-owl-semantics-20021108/semantics-all.html, 2002, accessed: 2006-06-30
30. Bouquet, P., et al., Specification of a common framework for characterizing alignment, knowledgeweb deliverable d2.2.1v2. 2004, Universitat Karlsruhe: Karlsruhe.
31. Bruijn, J.d., et al., D4.2.1 State-of-the-art survey on Ontology Merging and Aligning V1. 2004, Digital Enterprise Research Institute, University of Innsbruck: Innsbruck. p. 99.
32. Euzénat, J., et al. Ontology Alignment with OLA. in 3rd EON Workshop, 3rd Intl. Semantic Web Conference. 2004. Hiroshima (JP).
33. USJFC, JED, and E.P. Team, The Multinational Effect-Based Operations Process, 2005, accessed: 2006-09-21
34. Hill, W., R. Fehlbaum, and P. Ulrich, Organisationslehre 1. Vol. 5. 1994, Stuttgart: UTB.
35. Keeney, R.L., Decisions with multiple objectives. 1978, New York, London, Sydney: John Wiley & Sons.
36. Gregory, G., Decision Analysis. 1988, New York: Plenum Press.
37. Lehmann, T. and A. Karcher. Logic Based Agents and Ontologies Supporting Decision Making in Effects Based Operations. in The 10th World Multi-Conference on Systemics, Cybernetics and Informatics. 2006. Orlando, Florida.
38. Huth, M. and M. Ryan, Logic in Computer Science. 2004, Cambridge: Cambridge University Press.
39. Smith, K.T. and M. Bradley, Lessons Learned in a Department of Defense -The Virtual Knowledge Base. 2006.
40. Corcho, O. and A. Gomez-Perez. A Roadmap to Ontology Specification Languages. in 12th International Conference on Knowledge Acquisition, Modeling and Management (EKAW 2000). 2000. Juan-les-Pins, France: Springer.

The Gender Pay Gap in the ICT Industry

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ABSTRACT

This paper discusses the gender pay gap in the ICT sector 30 years after Equal Pay legislation came into force in the UK. Taking a critical and feminist approach our research has highlighted contributory factors of confidence and negotiation, salary secrets, penalties for 'time-out' and issues of part-time working. We conclude with some strategies to overcome the gender pay gap and suggest that the current situation is unacceptable in the 21st century in terms of social justice and for the economy and society as a whole.

INTRODUCTION

This study explores the gender pay gap in the ICT industry throughout England. The UK labour market is dramatically changing with rapid technological innovations alongside globalisation and more than ever organisations are required to place a premium on human and intellectual capital. The demand for labour in ICT is outstripping supply. However, a recent comparative report of the IT workforce in Holland, Germany and the UK indicates women are haemorrhaging out of the IT sector (Platman and Taylor 2004). Given that presently in the UK there is an IT specialist's skills shortage of 18.4% (IER/IFF 2003) and female IT workers represent a mere 15% of ICT managers, 30% of IT operations technicians and 11% of IT strategy planning professionals (Miller et al 2004), this suggests that the ICT industry is not equipped for equality and diversity at work.

When the Equal Pat Act (1970) was enforced in 1975 the gender pay gap stood at 36% for full time and 40% for part-time. By 1981 this had decreased to 28% (Richardson 1984) and 1990 saw a further reduction to 23% (EIRO 2002). Although this data indicates a gradual reduction of the gender pay gap, in 2007 women still receive on average 18% less than that of their male counterparts in the UK and shockingly the part-time gap of 40% has remained unchanged.

Pay inequalities is an issue for all – it is unjust, unlawful and impacts on social justice, equality and economic performance (EOC 2001). Distribution and levels of pay and benefits impact on efficiency of organizations, workforce morale and productivity (ACAS 2005). In this paper we highlight some of the key issues, which contribute towards pay inequality experienced by female ICT professionals namely confidence and negotiation, salary secrets, penalties for 'time-out' and issues of part-time working. Taking a critical and feminist approach our research concludes with some strategies to tackle the gender pay gap and we suggest that gendered pay inequality is no longer acceptable in the 21st century.

THEORETICAL UNDERPINNING FOR THE PROJECT

The economic, social and political root of women's inequality in the labour market is a contested theoretical area. This section discusses theories that have informed this field and the critical and feminist approach that has shaped our research.

Neo-classical economic theory explains women's pay discrimination in two main ways. Firstly there is an 'individual' explanation suggesting that the wage paid to an individual relates to the value of the output that the individual produces. If women are paid less than men this must be because the value of what they produce is less, that is, they are less productive (Richardson 1984). Human capital theorists on the other hand, try to link women's supposedly lower human capital to their role in the family. This view suggests that women have a' free choice' and indeed choose to obtain less education and training, choosing instead the role of child rearing. If women enter the labour market this choice therefore has an impact on pay rewards.

Of course these views can be criticised for suggesting an innate and rational economic view of the labour market and family relations divorced from actual experience. The state is involved in much of the organisation of the labour market and society through education and welfare policy for example. Not all women share the same experience and choice of education and training and such theories are attributing experiences to all women regardless of whether they work or not or have children or not.

However such approaches are now finding resonance in theories of the 'information society' or 'knowledge economy' Giddens (1984) for example concurring with Beck's individual and risk society' thesis (Beck 1992), suggests that the changing situation of men and women in the family and at work must be seen in terms of individual choice: 'we live in a world in which social order of the nation state, class, ethnicity and traditional family is in decline. The ethics of individual self-fulfilment and achievement is the most powerful in modern society' (ibid 1992).

Critical approaches to women's inequality largely are rooted in Marxist or Feminist theory. Feminist theories often locate women's inequality in patriarchal gender relations within capitalist relations. Women are thus divided along class lines but share the oppression of male domination. Capitalism and patriarchy in this way continually interacts affecting women's position in the economy and family. This leads to the 'economics of male advantage' (Cockburn 1983). In Marxist analysis, women's position in the labour market depends not on market principles but arises from the organisation of production with roots in class exploitation. Inequality in the labour market is linked to women's oppression in the family. German (2003) for example explains that the family is both broken down by the effects of capitalism but also maintained and reinforced by capital as the cheapest, most convenient and most socially stable way of caring for the existing generation of workers and reproducing the next generation. The family fulfils too precious a role to be left to 'free market' individualism. In reality, three-quarters of households in the UK are still headed by two-parent families and men and women are moving closer together in terms of work and domestic life but not in circumstances of their choosing. They do so 'against a backdrop of continuing women's oppression and intensified exploitation for both men and women' (German 2003). Fitting into these roles is hard work – for women it means working for less than equal wages and for men increased unpaid childcare in the home.

Yet the family is a gendered institution and is often taken-for granted. Wharton (2005) describes how the family is viewed as 'somehow functional for society rather than a social construction and changing in relation to history and culture' and she continues to observe that though family diversity is a social fact yet this is 'obscured by a set of taken-for-granted beliefs about the family as a social institution' (Wharton 2005). These include myths of the nuclear family, the heterosexual family, women as mothers and caretakers and men as fathers and breadwinners. However it is these myths that inform the choices made including government and employment policies. As Huws (2003) suggests:

'..more than this, women's role in the domestic sphere is used to confirm and legitimate their marginal status in the labour market. The gendering of jobs cannot be reduced to a discussion of women in the domestic sphere, but must be seen as

arising from the interplay between their socially ascribed, and therefore shifting, roles in both the public and private domains' (2003:28).

So it is in this context we discuss the experiences of women in the UK ICT sector.

METHODOLOGY

The severe under-representation of women in the ICT field has received attention from academics, industry and government agencies alike. However, there has been little attention from qualitative researchers to the gender pay gap in the UK ICT industry. Existing studies are generally of a quantitative nature (e.g. ONS 2005; e-skills 2005) and provides us with overview data of ICT professionals' salary dispersions compared by gender, age, qualifications and the gender pay gap by region.

The empirical material used in this paper is drawn from data generated by the Directing Equal Pay in ICT (DEPICT) project partly funded by the European Social Fund (ESF) and completed in December 2006 The DEPICT project focussed on women in the ICT industry in England, or those working in ICT in non-ICT organisations[1]. The issue of defining the ICT[2] sector is an ongoing complexity within the Information Systems (IS) community. We used Duerden Comeau's (2003) work on defining ICT to construct the research rationale for the DEPICT project. This goes beyond a narrow view of IT as technical departments and includes for example the creative and media sectors. In framing gender within the ICT sector the research team made the assumption that the skills and expertise required from the industry are multi-disciplinary and that the work force is generated from within a diverse boundary of disciplines (Cukier et al 2002). Although we cannot solve the issue of definition, we enabled interviewees and on-line respondents to self select and define their ICT role, occupation and sector.

Our two key means of data generation were an on-line questionnaire from which we had 236 respondents and a series of 14 case study interviews. In this paper we offer a sample from both approaches. The case studies involved interviews with women from public and private organisations of all sizes and self-defined 'entrepreneurs' and the group was self selective with women contacting the research team directly if they wanted to become further involved with the study beyond completing a questionnaire. The women represent a broad spectrum of career backgrounds, unique family units and life experiences, each woman a 'pioneer in their own right' (Czarnaiwska 2005). Such an approach builds on a long tradition of feminist research which aims to take women's stories and accounts of their gendered experiences seriously, using predominately qualitative and ethnographic methods to explore their thoughts and actions (McRobbie 1997).

PROJECT FINDINGS

In these preliminary findings we highlight some of the key factors which contribute towards the continuing gender pay gap in the ICT industry.

Confidence and Negotiation

Individualized pay packages are common in the ICT industry and requires strong individual negotiation skills and a high level of confidence. Women have reported being uncomfortable with this method of pay and reward and find that masculine and aggressive organizational culture mitigates against success in such negotiation (Tattersall et al 2004). Moreover the ICT skills that women possess are often undervalued, marginalized or unrecognized regardless of achievement (Tattersall et al 2004, Woodfield 2000).

One example comes from Ann who is in her early career stage and started working for company X after graduating;

'I was happy when they offered me £23K because a lot of people I knew from uni were on starting salaries of about £20K, I have since found out that based on tests at the interview I started on £500 less than the blokes who started at the same time…….I am comfortable with my manager that I could raise it; I am not sure that I would push it. I am not sure I would say I want a pay rise or I'm walking.

This experience could be a factor behind the report from the Equal Opportunities Commission (EOC) highlighting that female graduates earn on average 15% less than their male counterparts by the age of 24 (Purcell 2002).

Many of our interviewees expressed how they were satisfied with the pay package they were offered at interview, displaying a kind of gratitude. However, by accepting initial wage offers and not negotiating a higher starting salary contributes to the gender pay gap:

'They offered me £70K and as I was on £58K in my previous job I was more than happy to accept, then when I started work I found out that the other managers (all men) were getting £80K ….. I just think they will pay what people ask for and men ask for more'.

From a total of 210 respondents 76% answered yes they found it hard to ask for a pay rise. One manager noted how everyone in her team was on £35K salaries however she said:

'Come the pay reviews in March, they are based on performance, those who perform better, I would want to pay them more….so basically it's down to whether you have got good negotiating skills and the confidence to sell yourself'.

Salary Secrets

There is a culture of 'salary secrets' in the UK IT industry and women have reported that they only find out about pay inequalities once they reach management level and have access to financial or personnel information (Tattersall 2004). In research analysing gender equality in organisational pay structures and pay practices (Neathey et al 2003), data revealed that more than 1 in 5 employers did not allow their employees to share information about pay with colleagues. Employers often demand pay levels are kept confidential and disclosing this information to colleagues can lead to disciplinary action. Our questionnaire concurs highlighting that from a total of 204 respondents, 66% identified a confidentiality culture about pay in their organisation and in the same vein from a total of 205 responses 60% were unaware of how much their colleagues earn. Delia told us how she discovered she was paid less than all other managers:

'I earned £58K and I know I was the lowest paid manager there and I was the only women manager there, I did establish that and that's one of the reason's why I went contracting because under my current contract I actually earn…well I am closer to £90 to £100K on the current rate……how I found out I was being paid lower than the other managers was, well I did some research and went to the other managers who I knew well and I said 'If you don't mind can you tell me how much you earn?' all of them with one exception told me…it was significantly more'.

In a bid to make pay systems totally transparent the EOC have introduced the Equal Pay Review, which is a toolkit to enable employers to highlight overt and covert inequality and discrimination within pay and rewards. Additionally the EOC have introduced an Equal Pay Questionnaire which allows individuals to uncover information about colleagues pay packages if they feel they are being paid less for a similar role. (Women and Equality Unit 2006)

Paying the Penalty for Time Out

According to a report by the Women and Work Commission (2006), taking time out of the labour market to have children is one of the main reasons that women earn less than men. Career breaks are set against the years of work experience that a women builds up and reduces one of the factors valued through pay by employers. The women in our study experienced discrimination in pay and promotion during and after a period of maternity leave. An on-line respondent commented that after returning from maternity leave:

'Although they say there is no change there isn't much emphasis on my career development from them'

Moreover, from a total of 50 on-line respondents 26% said that they did not return to the same status (e.g. responsibilities, working conditions) after a period of maternity leave. Another on-line respondent commented with regards to progression:

' employers are always dubious about your commitment once you have had children'.

This account highlights that direct and indirect discrimination is evident in the ICT sector penalising women for their gender 'difference'.

Part-Time Working

Many employers are failing to tap into the available talent of a part-time work force. People with or without caring responsibilities need or want to work part-time, yet this can be considered as incompatible with working in the ICT sector. Part-time working is rarely an option and part-time workers are often under-valued and lack support from inside and outside of the organisation (EOC 2005). Men perceive that part-time work can affect their career chances (Crown 2004) which may go some way to explain the low take-up of part-time work in ICT. In our study the number of women respondents who work part-time/part-time flexi-time, equates to a mere 9% (from a total of 222 respondents). Additionally, 51% (from a total 201 respondents) said that they did not feel that it would be possible to do their job working part-time hours. A report by the DTI (2004) 'Flexible Working in the IT Industry' notes that 74% of senior managers felt that conducting their job on a flexible basis would attract lower pay, diminished promotional opportunities and less interesting project work and activities. These factors are exemplified by Rose who explains how her career was put on hold whilst she worked part-time hours:

'Basically I was made P.O.1[grade] before I had my first child and 10 years later I was still on P.O.1. It was because I went part-time. It wasn't even in question with my boss, it was 'yes you can go part-time that's fine but what you will be doing will be menial, low level programming, it's your decision', so I traded, I traded for flexibility'.

Carly, a senior IT manager describes her feelings about part-time workers:

'Most people who have joined our department are aware of what it takes to get on and this is not just about women its about men too; I think a company this big can offer a number of working choices. I think the difficulty is when you have 4 or 5 women who all want to work part-time and then you have got one man left, I am in the situation where I don't have children; I will be totally honest, I want to support those women and I think its great but I don't want to work with 4 of them…I know that I am doing more work than them.'

The introduction of flexible working legislation in the UK in April 2003 has gone some way to address the rights of parents with young children under the age of six, to work part-time hours. The Maternity Alliance Group[3] conducted a survey one year after the legislation was introduced. They found that 25% of requests for flexible working are turned down. In addition many of those who were actually 'allowed' to work flexibly had to take pay cuts or have lost status within their companies. Also men are less likely to ask for flexible working hours than women. This frames the 'problem' of balancing work and family commitments as a 'female' dilemma rather than a familial and societal one.

DISCUSSION

In this paper we have established that the ICT sector in the UK is ill equipped to deal with a diverse workforce where (often blatant) pay inequality and discrimination remains a continuing problem more than three decades after the Equal Pay Act came into force. This is unacceptable in the 21st century when fairness and social inclusion are high on the political agenda - governments and organizations alike have a social responsibility to eradicate its existence. Gender difference is penalised not only in general and cultural terms but also in financial terms. Within this paper we have highlighted the gendered factors that reinforce the pay gap. These include issues relating to women's confidence and negotiation skills, the embedded culture of salary secrets, time taken out of the industry for (e.g.) a period of maternity leave and part-time working. We suggest that there needs to be a major cultural shift within the ICT industry in order to address these issues. Strategies could include the adoption of transparent pay systems with no hiding place for inequality or discrimination. In this vein we suggest legislation to enforce Equal Pay Reviews would be a positive step and in turn will contribute to removing the embedded culture of salary secrets that exists within the ICT industry. The ability of an individual to do a job should solely determine their associated pay and reward not their gender or gender difference. Flexibility is a requirement of today's ICT workforce, women (and men) want to have a career and a family. We suggest that in order to change an industry that predominantly values and rewards those who work full-time with traditional career trajectories, flexible working options and career breaks should be offered to all. Furthermore, these issues need to be taken seriously by senior management with 'buy in' to cultural change. By not utilising women's ICT talents and abilities it is not just the women themselves that lose out in terms of unequal treatment but also the economy and society as a whole.

REFERENCES

ACAS. (2005). Advisory Booklet: Pay Systems. Retrieved June 2005

Barron, R. D., Norris, G.M (Ed.). (1976). *Sexual division and the dual labour market*: British Sociological Association.

Beck, U. (1992). *Risk Society: Towards a New Modernity*. London SAGE.

Beechey, V. (Ed.). (1980). *Women and production: a critical analysis of some sociological theories* Penguin Books.

Castells, M. (1996). *The rise of the network society*. Oxford: Blackwell Publishing.

Cockburn, C. (1983). *Brothers. Male domination and technological change* Pluto Press.

Crown, S. (2004). Getting the Balance Right. *Guardian*.

Cukier, W., Shortt, D., Devine, I. (2002). Gender and Information Technology: Implications of Definitions. *SICGSE Bulletin, 34*(4), 142-148.

Czarnaiwska, B. (2005). *The thin end of the wedge*. Paper presented at the Conference Name|. Retrieved Access Date|. from URL|.

Duerden Comeau, T. (2003). Information Technology (IT) Employment: What is IT? *Workforce Ageing In The New Economy (WANE) Working Paper*, from www.wane.ca

EOC. (2001). Just Pay: Report of the Equal Pay Task Force. Retrieved June 2005, from http://www.eoc.org.uk

e-skills. (2005). *Quarterly Review of the ICT Labour Market, Quarter 2 - 2005*. London.

German, L. (2003). Women's Liberation Today. *International Socialism, 101*.

Giddens, A. (1984). *The Constitution of Society*. Cambridge: Polity Press.

Huws, U. (2003). *The making of a cybertariat. Virtual work in a real world*. London: The Merlin Press.

Institute for Employment Research. IFF Research Ltd, I. I. (2004). *National Employers Skill Survey*. Sheffield: DfES.

Kingsmill, D. (2003). The Kingsmill Review of Women's Pay and Employment. Retrieved June 2005

McRobbie, A. (Ed.). (1997). *The E's and the Anti-E's: New Questions for Feminism and Cultural Studies*. London: Sage.

Miller, L., Neathey, F., Pollard, E., Hill, D. . (2004). *Occupational Segregation, gender gaps and skills gaps*: Equal Opportunities Commission.

Neathey, F., Dench, S., Thomson, L. (2003). *Monitoring progress towards pay equality*: Equal Opportunities Commision.

O.N.S. (2003). *New Earnings Survey*. London: The Stationery Office: Office for National Statistics

O.N.S. (2005). *New Earnings Survey Q.1 2005*. London: Office for National Statistics, The Stationery Office.

On-Line, E. E. I. R. O. (2002). A comparative study on gender pay equity: The case of the UK [Electronic Version]. Retrieved 10/10/06 from http://www.eiro.eurofound.eu.int/2002/01/word/uk0110513s.doc.

Platman, K., Taylor, P. . (2004). Workforce Ageing in the New Economy: A Comparative Study of Information Technology Employment.

Richardson, H. J. (1984). *Job Evaluation and Equal Pay for Women Workers in the British Labour Market.* University of Kent at Canterbury.

Tattersall, A., Keogh, C., Richardson, H., Adam, A. (2004). *Women in North West Information Technology*: European Social Fund and University of Salford

W.A.W.C. (2006). *Women and Work Commission: Shaping a Fairer Future*. London.

Wharton, A. S. (2005). *The Sociology of Gender: An Introduction to Theory and Research*. London: Blackwell.

Woodfield, R. (2000). *Women, Work and Computing*. Cambridge: Cambridge University Press.

ENDNOTES

1 Please see the DEPICT website for further details http://www.isi.salford.ac.uk/gris/depict

2 For a detailed discussion of the difficulties of defining IT, ICT and the ICT industry please see Duerden Comeau, T. 2003, Information Technology (IT) Employment: What is IT?, Workforce Ageing In The New Economy (WANE) working paper, www.wane.ca

3 See www.maternityalliance.org.uk for further details.

Internet Adoption Decisions in Small Businesses: The Impacts of a Local Web Portal

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ABSTRACT

This article demonstrates the role played by the establishment of a UK village community web portal on the Internet adoption decisions of small businesses. The article reports on some of the findings of an ongoing study of this local community web portal, focusing specifically on those small businesses that had, prior to the launch of the web portal, made a decision not to adopt the Internet into their business operations. The barriers these non-adopting small businesses perceived to Internet adoption are identified, and the impacts their portal presence had on their subsequent choice of Internet adoption pathway are discussed.

Keywords: small business; Internet; Internet adoption; web portal; non-adoption

1. BACKGROUND

Discussions in the diffusion of innovations literature suggest that the advent of any given innovation is likely to be met by a variety of responses: some individuals and / or organisations will readily embrace and adopt the innovation, while others will probably prove less enthusiastic and thus be slower to adopt it; and still others will decide not to adopt that innovation at all (for a comprehensive discussion of innovation adoption behaviour, see Rogers 1995). The Internet adoption behaviour of enterprises in the small business sector is no exception to this: within it, there is typically a mix of rapid and enthusiastic Internet adopters, more cautious or slower Internet adopters, and those who decline to adopt the Internet altogether.

The factors that might influence small businesses' Internet adoption or non-adoption decisions are many and varied. Fillis, Johannson and Wagner (2004), in their proposed conceptual framework for Internet adoption identify factors focussed largely on the characteristics of the CEO. These include the CEO's attitudes to e-business, his/ her approach to change (or resistance to it), his / her attitude to technology, and his / her attitude towards acquiring new skills. They further suggest that financial and resource constraints within a small firm may pose barriers to Internet adoption. Elsewhere, it has been noted that Internet adoption is likely to be industry-sector dependent (see for example Poon and Swatman, 1997; Martin and Matlay, 2001). Teo and Ranganathan (2004) discuss attitudes to risk and how these influence Internet adoption decisions.

Adoption of the Internet is arguably more complex than the adoption of many other innovations. The essence of this complexity lies in the fact that the Internet comprises not simply one single application or technology, but rather a collection of applications (e.g. email, static web site, transactional web site, and so on). A small business' decision to adopt the Internet might entail simply deciding to use email for communication purposes; on the other hand, it might involve transforming the firm into a fully integrated e-business. Research to date suggests that many small firms approach Internet adoption in a series of steps, moving from the adoption of non-complex applications (such as email), through to more complex applications (such as transactional and integrated web sites) as their confidence in, and familiarity with, Internet technology grows (see for example Daniel, Wilson and Myers, 2002). It is increasingly acknowledged that such progression may include 'leapfrogging' of individual applications, rather than being a strict linear progression taking in each application in turn (see for example Rao, Metts and Monge, 2003).

Typical Internet adoption progressions discussed in the literature tend to begin with either email adoption or adoption of a basic informational web site. Some authors have, however, suggested that the first adoption level might entail having a 'basic web presence', by which they mean the company 'places an entry in a web site listing company names' (Chaffey, 2002), but does not have its own web site. The rationale for such an entry, as Chaffey goes on to explain, is essentially to 'make people aware of the existence of a company or its products'.

This 'basic web presence' stage of adoption has, to date, received little attention in empirical studies of Internet adoption by small firms. The present study was set up in order to help address that gap in the research literature by determining the role played by a local community web portal in the Internet adoption decisions and progressions of a number of small firms in a UK village. It is anticipated that the findings of the study will make a timely and relevant contribution to existing understanding of small business Internet adoption decisions and processes.

2. LOCAL COMMUNITY WEB PORTAL: OVERVIEW

The local community web portal under investigation in this study was launched towards the end of the 1990s as part of a wider community initiative in a UK village. This web portal was designed to provide a forum for community groups and charitable organisations located in the village to communicate details of their activities and / or services to the local population. In addition, through the provision of an online business directory, the portal gave businesses based in the village the opportunity to promote their products and / or services. It is this online business directory component of the local community portal that forms the focus of the study discussed in this article.

The online business directory was, it seems, included in the portal without any prior consultation or discussion with local SMEs to ascertain demand for such a facility or to determine specific requirements. It was offered to local SMEs as a marketing and promotional tool, partly in the anticipation that those SMEs that found it fruitful would be prepared to contribute to the ongoing funding and sponsorship of the portal it in the future.

The online business directory is organised thematically, including for example, sections for retail organisations, building and property maintenance enterprises, and private health and welfare providers. Each entry in the directory includes the name of the business, its postal address, other contact details (e.g. e-mail address, where available), a link to the business' own web site (if it has one), and a brief summary of what the enterprise offers by way of products and / or services. No charge is levied for local businesses to have an entry placed in the online business directory. However, local businesses, together with the local council, are encouraged to participate in providing sponsorship to cover the costs of maintaining the local community portal. Costs are kept to a minimum as the portal is managed, maintained and updated by a small team of local unpaid volunteers, with web content being supplied, as appropriate, by local individuals, community organisations and businesses.

Table 1. Small businesses participating in the study

Case	Type	Enterprise size (employees)
Case A	Plumber	4
Case B	Electrician	3
Case C	Manufacturer & distributor of electrical components	7
Case D	Manufacturer & distributor of ceramic tiles	8
Case E	Food importer & retailer	5
Case F	Outdoor/expedition equipment suppliers	8

3. RESEARCH METHOD

The investigation of the small businesses participating in the online business directory component of the local community web portal was undertaken by means of semi-structured interviews with the owner managers. Each of the 77 small businesses listed in the online business directory was contacted by telephone and invited to participate. In this article, the findings of the interviews conducted with six of these small businesses are presented. These six have been selected for discussion because the local community web portal acted as the catalyst for each of them to become Internet adopters. A summary of the participating enterprises is given in Table I below.

Interviews were conducted during 2004-05. In order to provide a framework for the interviews, an interview guide was prepared. The core topics covered in this guide were as follows:

- Background data about the small business and the owner / manager;
- Rationale for not adopting the Internet (prior to involvement with the portal);
- Motivations for portal participation;
- Benefits derived from portal participation;
- Problems encountered with portal participation;
- Impacts of portal participation on further Internet adoption;
- Future plans regarding Internet adoption.

4. SUMMARY OF FINDINGS

The enterprises participating in the study can be categorised as micro businesses, that is to say, they each have under 10 employees (Storey, 1994; Curran and Blackburn, 2001). In this section, the core findings of the study are presented, beginning with those findings relating to the CEOs' decision not to adopt the Internet.

The Non-Adoption Decision

During the interviews with the CEOs of the participating enterprises, a number of reasons were identified regarding why they had, prior to the launch of the local community web portal, decided not to adopt the Internet into their business operations. For example, Cases A and B indicated that the limited (i.e. local) geographical reach of their enterprises represented the dominant barrier to Internet adoption. These two enterprises had no plans to expand their customer bases to a wider catchment area, and were instead focusing on growing their customer base within the immediate locality of the village and surroundings. They believed the Internet to be an important medium for firms covering a wide geographical area, but not for enterprises like theirs which had only a local focus. Another reason discussed for non-adoption was the lack of external pressure to adopt, notably the lack of pressure from customers (highlighted particularly by Case C). Cases D and E felt that their existing methods of doing business, and particularly of marketing their products and / or services, were working well, and so they did not believe that any additional benefit would be gained from Internet adoption. Other reasons discussed in the interviews concerned the perceived risk of Internet adoption, particularly a concern about costs and potential for wasted investments (both financial and otherwise). Organisational readiness was also mentioned (particularly by Case F), with a dominant issue here being the enterprise's perceived lack of the necessary in-house ICT skills to handle Internet adoption.

Motivations for Involvement in the Portal Project

For each of the enterprises participating in the study, the key reason for getting involved in the online business directory component of the community web portal project was that the CEOs believed the portal presented a low-risk opportunity to experiment with having a very basic presence on the World Wide Web. This opportunity enabled them to assess whether any value could be derived from such a presence, and was made more attractive by the fact that it was available at no cost to their enterprises.

Impacts of Portal Participation

Participants in the study were asked to indicate the impacts their involvement in the online business directory component of the local community web portal had made on their Internet adoption decisions and behaviour. Two major types of impacts emerged from this part of the ongoing study, and these can be summarised as follows:

Pathway I: Portal Presence Consolidation

The CEOs of Cases A and B found their involvement with the portal project to have been a positive experience. Specifically, they noted that because the portal was focussed on the village in which their enterprises were based, the client enquiries they received via the portal tended to be from people located in that village. This helped to eliminate the problem of travelling large distances between client visits. It also, they maintained, represented a considerable advantage over existing paper-based directories in which their firms were already listed, as these more traditional resources tended to cover a much wider geographical area and so attracted a number of irrelevant and unsuitable customer enquiries which led to wasted time and effort.

Apart from exploring the possibility of setting up email accounts, these two CEOs indicated that they had no immediate plans for further Internet adoption, such as the creation of their own company web site. They both believed that their portal presence was sufficient for their needs. Particularly in view of its strong local links, which fitted well with their need to maintain a local client base.

With regard to their existing portal presence and the design of the online business directory component of the community web portal, the CEO of Case A commented that he would like to see the scope of the individual directory entries expanded. He specifically suggested that it would be useful if each firm could have capacity within its directory entry to include more detailed information about the firm's products and / or services, as well as more details about the firm itself, in order to be able to promote it better to the inhabitants of the village community.

Pathway II: Portal Presence and Beyond

Cases C, D, E and F indicated that their participation in the local community web portal project had proved a useful means for them to determine whether they could derive any value from Internet adoption. As a result of participating in the online business directory component of the community web site project, each of them believed that the Internet did, despite their earlier reservations, have something to offer them. Consequently, a number of specific actions had been taken by them. For example, Case C, D and E had each employed the services of an external organisation to design and create a basic informational web site for their respective small firms. For Case D, the motivation for this had primarily been to cut the costs of marketing and reduce the time spent on marketing activities (such as trade fairs). For Cases C and E, the motivation was related more to a desire to try a new marketing avenue. When probed about ongoing site maintenance and updating, as well as further development of their web sites beyond their initial design and creation, it was clear that some embryonic development plans were in place, with indications being given that transactional web sites might be considered in the future. In particular, Case D had some quite advanced plans for future development of the company web site.

With regard to responsibility for site development, Case F took a rather different stance from Cases C, D and E. He had seen the value of the online directory and recognised now that some form of web site was likely to be useful to his firm (at the very least, an informational web site). However, he was determined to maintain control of all his business operations and not rely on the services of outside consultants for site design and development. Therefore, he had decided to embark on some IT training courses at a local community educational establishment in order that he might develop and run his own web site.

For Case C, D, E, and F, the local community web portal proved to act as an important starting point for the development of these micro businesses towards becoming more Internet-enabled enterprises.

It is evident from the findings that involvement in the online business directory component of the local community web portal provided a means for each of the small businesses participating in the study to begin to overcome their barriers to Internet adoption and to begin to plot Internet adoption pathways appropriate to the needs of the individual businesses. The implications of these findings are discussed in the next section.

5. CONCLUDING REMARKS AND EMERGING ISSUES

This study sought to explore the role played by a local community web portal on the Internet adoption decisions and behaviour of a number of UK small businesses. The study focussed specifically on small businesses that had not adopted the Internet prior to their involvement with the local community web portal project. The findings of the study highlight the importance of such portals for small businesses. For two of the small businesses participating in the study, the web portal was important in its own right as a marketing and promotional tool for their firm's products and / or services. These two businesses had a local reach, which they wished to preserve. Typical efforts to promote the Internet and electronic commerce focus on opportunities for expanding geographical reach, and consequently these firms had ignored the Internet up until the launch of the community portal. Having participated in the portal project, they deemed the portal to be sufficient for their needs, and did not believe that further Internet adoption was warranted for their enterprises. This suggests that an initial portal presence stage of adoption constitutes an important component of Internet adoption models for small businesses. This finding was further confirmed by investigation of the other four enterprises participating in the study: for these small businesses, the portal represented an important means of setting them on a progressive Internet adoption pathway. Their initial portal presence provided a low-cost and low-risk opportunity to determine what value (if any) could be derived for them from Internet adoption.

In summary then, the key implications of this study are twofold. From a theoretical perspective, the study suggests that models of small business Internet adoption should include an early stage comprising portal presence. From a practitioner perspective, the study suggests that when considering Internet adoption, small businesses should not ignore the portal presence stage of adoption as representing a useful experimental opportunity. Equally, those advising small businesses about Internet adoption should not neglect the portal presence stage as a means of encouraging small businesses into Internet involvement. Local community web portals could be used by small business advisers and government agencies for demonstrating to small firms the value of the Internet even to those firms which traditionally see no need for the Internet in their operations, most particularly those with only a local geographical reach. In particular, there is scope here for local government initiatives to provide community portals, as a means of supporting national governments wider e-business agendas and aspirations.

As indicated at the beginning of this article, the study presented here is ongoing. In a future phase, it will be important to confirm these findings further with a larger sample of small businesses, to test their generalisability, and to provide additional evidence for the small business Internet adoption issues raised in this initial exploratory investigation.

REFERENCES

Chaffey, D. (2002) E-business and e-commerce management: strategy, implementation and practice'. Harlow: Pearson Education Ltd.

Curran, J. & Blackburn, R. A. (2001) Researching the small enterprise. London: Sage Publications Ltd.

Daniel, E., Wilson, H, & Myers, A, (2002) Adoption of E-commerce by SMEs in the UK: towards a stage model. International Small Business Journal. 20(3), 253-270

Fillis, I., Johannson, U. & Wagner, B. (2004) Factors impacting on e-business adoption and development in the smaller firm. International Journal of Entrepreneurial Behaviour and Research. 10 (3), 79-88

Martin, L., & Matlay, H., (2001) "Blanket" approaches to promoting ICT in small firms: some lessons from the DTI ladder adoption model in the UK. Internet Research: Electronic Networking, Applications and Policy. 11(5), 399-410

Poon, S. & Swatman, P. (1997) Internet-based small business communication. International Journal of Electronic Markets 7(2), 15-21

Rao, S. S., Metts, G., & Monge, C. A. M. (2003) Electronic commerce development in small and medium sized enterprises: a stage model and its implications. Business Process Management Journal. 9(1), 11-32

Rogers, E. M. (1995) Diffusion of Innovations. Fourth edition. New York: Free Press

Storey, D. J. (1994) Understanding the small business sector. London: International Thomson Business Press

Teo, T. S. H. & Ranganathan, C. (2004) Adopters and non-adopters of business-to-business electronic commerce in Singapore. Information and Management 42, 89-102

Recognition of Factors Affecting Students Trust in Virtual Universities Using Delphi Method

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ABSTRACT

At the present time in Islamic republic of Iran the virtual universities are operating beside the Non- virtual universities. The problem that virtual universities now confront is low level of students trust to these universities. The current research tries to recognition factors affecting students trust in Virtual Universities using Delphi Method. This qualitative study examined the opinions of a diverse group of participating experts in the area of information technology and virtual universities. Data were collected through a Delphi methodology during which four rounds of Delphi were administered to determine the Factors affecting students Trust in Virtual Universities.

Keywords: Virtual Universities, Information and Communication Technologies, Trust, Trust Key Factors, Delphi Method, Delphi Rounds.

INTRODUCTION

The emergence of information and communication technologies (ICTs) and their use in training of people has resulted in formation of virtual universities. Most countries with more or less similar goals have acted to establish such universities. Islamic republic of Iran too, as a developing country in Asia has taken such steps. The result of this effort up to time of writing this essay has been designing of ten virtual universities in order to satisfy the educational needs of the great number of people requesting to benefit from higher education in Iran (Sarlak and abedi jafari, 2006). At the present time virtual universities are operating beside the Non-virtual universities. The problem that virtual universities confront is low level of student trust to these universities. The current research tries to recognition factors affecting students trust in Virtual Universities using Delphi Method.

DELPHI METHOD

Delphi method (Delphi Technique) is a group decision-making process that involves circulating questionnaires on a specific problem among group members, sharing the questionnaires results with them, and then continuing to recirculate and refine individual responds until a consensus regarding the problem is reached. The formal steps followed in the Delphi method are:

Step 1- A problem is identified.
Step 2 – Group members are asked to offer solutions to the problem by providing anonymous responses to a carefully designed questionnaire.
Step 3 – Responses of all group members compiled and sent out to all group members.
Step 4 – Individual group members are asked to generate a new individual solution to the problem after they have studied the individual responses of all other group members compiled in step 3.
Step 5 – Steps 3 and 4 are repeated until a consensus problem solution is reached.

The advantages of Delphi method is that ideas can be gathered from group members who are too geographically separated or busy to meet face to face. Its disadvantages are that members are unable to ask questions of one another (Daft, 2006).

The following key characteristics of the Delphi method help the participants to focus on the issues at hand and separate Delphi from other methodologies (www.wikapedia.com):

1. Structuring of information flow
2. Regular feedback
3. Anonymity of the participants

Structuring of Information Flow

The initial contributions from the experts are collected in the form of answers to questionnaires and their comments to these answers. The panel director controls the interactions among the participants by processing the information and filtering out irrelevant content. This avoids the negative effects of face-to-face panel discussions and solves the usual problems of group dynamics.

Regular Feedback

Participants comment on their own forecasts, the responses of others and on the progress of the panel as a whole. At any moment they can revise their earlier statements. While in regular group meetings participants tend to stick to previously stated opinions and often conform too much to group leader, the Delphi method prevents it.

Table 1. Interpretation of Kendall's coefficient amounts

Kendall's Coefficient Amount	interpretation	Assuredness of Arrangement Factors
0.1	Very weak consensus	Not existing
0.3	Weak consensus	Minimal
0.5	Medium consensus	Average
0.7	Strong consensus	High
0.9	Very strong consensus	Very high

Anonymity of the Participants
Usually all participants maintain anonymity. Their identity is not revealed even after the completion of the final report. This stops them from dominating others in the process using their authority or personality, frees them to some extent from their personal biases, minimizes the "bandwagon effect" or "halo effect" allows them to freely express their opinions, encourages open critique and admitting errors by revising earlier judgments.

CONSENSUS CRITERION IN DELPHI METHOD

In this research, Kendall's Coefficient of Concordance was applied to indicate the level of consensus amongst the panel members. Table 1 explains different amounts of this coefficient (Schmidt, 1997).

RESEARCH METHODOLOGY

The present research methodology is shown in figure 1.

Research Problem
The main problem that Iran's virtual universities now confront is low level of student trust to these universities. The study sought to answer the question:

What are the effecting factors on students trust towards virtual universities?

Delphi Panel Members Selection
Delphi method uses a panel of carefully selected experts who answer a series of questionnaires.The notion is that well-informed individuals, calling on their insights and experience, are better equipped to predict the future than theoretical approaches or extrapolation of trends. In current Research 25 Experts in area of information technology and virtual universities were selected as Delphi panel members.

Literature Review
The following section provides an overview of the results of 11 empirical studies on trust in the electronic and virtual entities ranging from the year 1999 to the year 2003 (Grabner-Krauter & Kaluscha, 2003). In table 2, a brief result of eleven stated studies is shown.

According to the studies above and incorporate and eliminate same cases, factors such as Perceived Size, Perceived reputation, Disposition to trust, Social presence, Perceived ease of use, trust in e-service provider, Organizational reputation, perceived risk, Trust in e- services, Trustworthiness Of internet shopping and internet merchant, contextual factors, Perceived privacy, perceived security, satisfaction with past outcomes, Familiarity with firm, structural assurances, Enjoyment, perceived usefulness, Trust in e – retailer, are the Factors Effecting people Trust to electronic and virtual institutions.

DELPHI METHOD IMPLEMENTATION

After panel member's selection, four rounds of Delphi method were performed.

First Round Results
In round one, the questions were structured as fixed-alternative options. However, the panelists were provided the opportunity to introduce 6 new factors that not mentioned in pervious studies. In other words, in first round, the ideas of panelist about importance of trust old factors as well as trust new factors that not mentioned in pervious studies were collected. It must be noted that in the first round of Delphi method, 24 experts from 25 members of panel did participate. A Likert-type scale of 1 to 5 which includes "minimal effect: 1", "little effect: 2", "average effect: 3", "higher effect: 4" and "far higher effect: 5" made it possible to score the final list of specific first round rankings. A total score for each response ranking emerged from the statistical analysis performed.

In table 3, the panelist ideas regarding importance of trust factors mentioned in 11 pervious studies is shown. Table4 includes aspects such as number of answers for each question, average of answers, their benchmark deviation, arrangement and importance of each answer according to the average base answer, and the

Figure 1. Research methodology

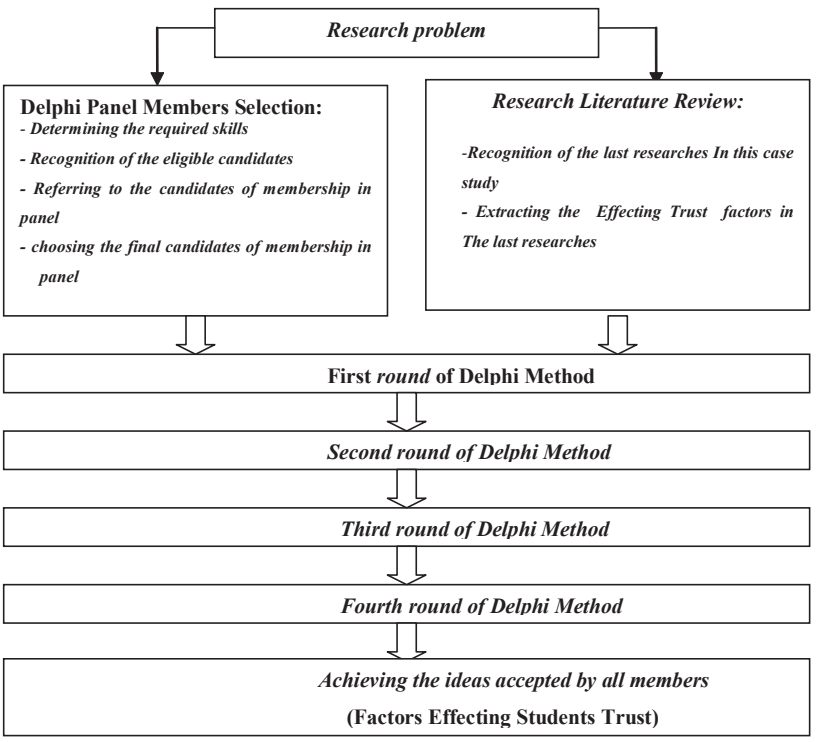

Table 2. The results of literature review

Researcher	Context	Sample Size	Theoretical Framework	Methodology	Analytic Techniques	Trust key Factors
Jarvenpaa et al. (1999, 2000)	Exploring initial trust in an Internet store and cross-cultural investigation, using online book stores and travel sites	184 students (Australia), 198 students (Israel), 115 subjects of an offline panel(Finland)	Exchange theory, balance theory, theories of reasoned action and planned behavior	Experiential survey approach, participants performed four shopping activities at on-line book-stores and on-line travel-sites; offline panel survey; cross-cultural validation of the study	Factor analyses (structural Equation modeling) and regression analyses	Perceived Size , Perceived reputation
Gefen (2000)	Exploring trust in an ecom-merce vendor, using an on-line book-store	217 students (USA)	—	Experiential survey ap-proach, participants performed product search at an on-line bookstore	Confirmatory analysis (structural equation modeling) with LISREL8	Disposition to trust
Gefen and Straub (2000)	Exploring trust in an ecom-merce vendor, using an on-line travel agency	161 students (USA)	Technology acceptance model, theory of rea-soned action	Experiential survey (free simulation experiment), participants performed search for round trip at an on-line travel agency	Confirmatory analysis with PLS, post-hoc analysis with PLS	Social presence, Perceived ease of use, trust in e-ser-vice provider
De Ruyter et al. (2001)	Exploring the antecedents of trust, relative advantage and perceived risk in the adoption of eservices	202 participants (Netherlands)	Adoption process theory, signaling theory	Experimental study, participants were presented with offline role-playing scenarios	ANOVAs (analyses of variance) and MANOVA	Organizational reputation, perceived risk, Trust in e- services
Lee and Turban (2001)	Exploring the antecedents of consumer trust in Internet shopping	405 students (China)	—	Survey	Multiple linear regression	Trustworthiness Of internet shop-ping and internet merchant, contextual factors
Pavlou and Chellappa (2001)	Exploring the antecedents of trust in electronic commerce transactions	276 students (three studies) (USA)	—	Field study with on-line questionnaire, regular survey, experimental study using manipulated Web-sites	Least-squares multiple regression analysis	Perceived privacy, perceived security, satisfaction with past outcomes
Bhattacherjee (2002)	Developing a new scale for measuring trust and testing it for the antecedents of willingness to transact with an ecom-merce company, using a bookstore	147 students, 122 online banking users (USA)	—	Experiential survey after a tour at an online bookstore, on-line survey	Confirmatory factor analyses (structural equation Modeling)	Familiarity with firm
Kim and Prabhakar (2002)	Exploring initial trust in the adoption of on-line banking	266 Internet users (196 used on-line banking) (USA)	Social network theory	On-line survey	Multiple logistic regression analysis	structural assur-ances
Koufaris and Hampton-Sosa (2002)	Exploring the antecedents of initial trust in an online company, using severable-vendors	111 students (USA)	Technology acceptance model, theory of planned behavior	Experiential survey with on-line questionnaire, participants visited an unfamiliar Web-site and performed a product search	Confirmatory factor analyses (structural equation modeling)	, Enjoyment, perceived useful-ness
Pavlou (2003)	Exploring the effect of trust in e-commerce on several factors including consumers' intention to transact	102 students, 155 Internet users (USA)	Theory of planned behavior, theory of reasoned ac-tion, technology acceptance model	Three exploratory surveys (first on predefined on-line book store, second on self-selected familiar on-line vendor, third on on-line companies in general)	Partial least squares regression analysis	Trust in e - retailer

Table 3. First round results: panelist ideas regarding importance of trust factors

Description	Numberof answers	Average of answers	Standard deviation of answers	Order of importance	Percentage of members who have determined the arrangement of factors like the arrangement of group
Perceived Reputation	24	4.88	0.33	1	87.5
Perceived Size	24	4.58	0.7	2	66.7
Previous familiarity with firm	23	3.91	0.83	3	43.4
Reliability of e- services	24	3.88	1.01	4	50
Structural assurance	23	3.83	0.87	5	39.1
Social and cyberspace presence	23	3.78	0.98	6	56.5
Satisfaction with past outcomes	23	3.78	1.1	7	47.8
Perceived risk	22	3.77	0.95	8	36.3
Easy to use	23	3.74	1.07	9	52.1
Perceived quality	24	3.21	1.12	10	70.8
Perceived security	21	2.52	1.05	11	76.1
Perceived privacy	21	2.43	0.9	12	71.4

percentage of members which arranged each factor like arrangement of group have been indicated and shown.

The second part of the questionnaire of Delphi method in first round was assigned to trust influential factors, which didn't exist in the first list. But from the point of view of those who answered, this was an important key factor. In this part, it was requested from each those who were answering to give six successful factors along with brief explanation.. In the Table4, panelist's new ideas regarding the Factors affecting Students Trust in Virtual universities are shown.

Table 4. Panelist's new ideas' regarding the factors effecting students trust to virtual universities

No.	Title	Number of iteration
1	Honesty	1
2	Sense of accepting critics	1
3	Virtue of intention	1
4	Eligibility	1
5	Stability	1
6	Loyalty	1
7	Administrative efficacy	7
8	openness	1
9	Confidentiality	1
10	Accomplishing commitments	1
11	Economical nature of studies	6
12	Predictability	1
13	Suitable environmental conditions for activities of virtual universities	5
14	Fairness& Justice	1
15	Flexibility	1

Second Round Results

In round two, the questions were structured as fixed-alternative options. It must be noted that in the second round of Delphi method, 23 experts from 25 members of panel did participate. All those who answered in this round did participate in the previous round. A Likert-type scale of 1 to 5 which includes "minimal effect: 1", "little effect: 2", "average effect: 3", "higher effect: 4" and "far higher effect: 5" made it possible to score the final list of specific first round rankings.

In second rounds questionnaires, a new list was introduced in which participants in the first round mentioned the influential factors of students' trust towards virtual universities in Iran. In this section, the respondent had to declare his/her opinion on the level of influence of each of them and the students' trust towards the virtual universities in Iran, with choosing from the existing selection. These selections are in the form of LIKRET Scale and contain " very little influence 1", " little influence 2", " average influence 3", " great influence 4", " greater influence 5". In the Table 5 results of the second round of Delphi method contains aspects such as number of answer for each question, average response, deviation of their benchmark, importance of each factor according to the average response and percentage of member who indicated, issued and arranged each factor like a continuous group is shown.

Third Round Results

In round three, the questions were structured as fixed-alternative options. It must be noted that in the third round of Delphi method, 22 experts from 25 members of panel did participate. All those who answered in this round did participate in the previous round. A Likert-type scale of 1 to 5 which includes "minimal effect: 1", "little effect: 2", "average effect: 3", "higher effect: 4" and "far higher effect: 5" made it possible to score the final list of specific first round rankings.

In the first part of the questionnaire of the third round of Delphi method, ensemble of factors were introduced which participants in the first and the second rounds did recognize those as a key and influential factor of students' trust upon the virtual universities in Iran. Only those responses receiving a median score of 4 or higher remained for the third round (Linstone & Turoff, 1975). In table6 the results of third round is shown.

In this round, Kendal's Coefficient of Concordance is 0.711.

Table 5. Second round results

Description	Number of answers	Average of answers	Standard deviation of answers	Order of importance	Percentage of members who have determined the arrangement of factors like the arrangement of group
Universities Administrative efficacy	23	3.43	0.73	1	60.8
Economical nature of studies	22	4.23	0.92	3	50
Suitable environmental conditions for activities of virtual universities	23	4.17	0.65	5	43.4
Accomplishing commitment	23	3.96	0.71	10	43.4
Fairness& Justice	23	3.91	1.20	11	65.2
Flexibility	23	3.87	0.92	12	47.8
Predictability	23	3.87	0.97	13	52.1
openness	23	3.74	0.81	14	39.1
Confidentiality	22	3.73	0.88	15	31.8
Honesty	22	3.64	0.95	16	40.9
Sense of accepting critics	23	3.52	0.95	17	47.8
Virtue of intention	21	3.48	1.03	18	57.1
Eligibility	22	3.32	0.78	19	63.6
Stability	23	2.96	0.77	20	78.2
Loyalty	21	2.90	1.04	21	100

Table 6. Third round results

Description	Number of answers	Average of answers	Standard deviation of answers	Order of importance	Percentage of members who have determined the arrangement of factors like the arrangement of group
Academic perceived Reputation	22	4.86	0.35	1	86.3
Administrative efficacy	22	4.69	0.48	2	68.1
university Perceived Size	21	4.50	0.91	3	69.4
Suitable environmental conditions for activities of virtual universities	22	4.23	0.69	4	52.3
Economical nature of studies	22	4.18	0.66	5	63.6

Fourth Round Results

In round four, the questions were structured as fixed-alternative options. It must be noted that in the fourth round of Delphi method, only 20 experts from 25 members of panel did participate. All those who answered in this round did participate in the previous round. A Likert-type scale of 1 to 5 which includes "minimal effect: 1", "little effect: 2", "average effect: 3", "higher effect: 4" and "far higher effect: 5" made it possible to score the final list of specific first round rankings.

In fourth round questionnaire, a number of factors were introduced which the participants in the first and second rounds did recognize as an influential key factor on student' trust towards virtual universities. The median scores of this factors was 4 or higher("a lot" and "a lot more)". In this round, the respondent must again give his/her opinion by choosing one of the existing items about the influential level of each factor, which influence on students trust towards virtual universities. In table 7 the results of fourth round is shown.

The brief results of Delphi fourth round are shown in Table 8.

In fourth round, Kendal's Coefficient of Concordance is 0.734, compared to the third round coefficient (0.711) was increased up to 2.3 percent.

CONCLUSION

The results of four rounds of Delphi shows that according to the following reasons, consensus amongst the panel members was obtained and can terminate the repetition of rounds:

Table 7. Fourth round results

Description	Number of answers	Average of answers	Standard deviation of answers	Order of importance	Percentage of members who have determined the arrangement of factors like the arrangement of group
Academic perceived Reputation	20	4.88	0.32	1	85.00
Administrative efficacy	20	4.65	0.50	2	65.00
University perceived Size	19	4.62	0.84	3	70.00
Economical nature of studies	20	4.26	0.73	4	63.10
Suitable environmental conditions for activities of virtual universities	20	4.20	0.60	5	70.00

Table 8. The brief results of Delphi fourth round

Description	Arrangement of factors importance based on the fourth round answers
Academic perceived Reputation	1
Administrative efficacy	2
University perceived Size	3
Economical nature of studies	4
Suitable environmental conditions for activities of virtual universities	5

Table 9. The standard deviation of panelist answers

Description	First and second rounds k1=24 , k2=23		Third round k3=22		Forth round k4=20	
	Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation
Academic perceived Reputation	4.88	0.33	4.86	0.35	4.88	0.32
Administrative efficacy	4.58	0.70	4.50	0.91	4.52	0.84
University perceived Size	4.43	0.73	4.69	0.48	4.65	0.50
Economical nature of studies	4.23	0.92	4.18	0.66	4.26	0.73
Suitable environmental conditions for activities of virtual universities	4.17	0.65	4.23	0.69	4.20	0.60
Average of Standard Deviations		**0.666**		**0.618**		**0.598**

1. According to Table7, More than 50 Percentage of members have determined the arrangement of factors like the arrangement of group.
2. According to the Table 9, the standard deviation of panelist answers regarding the importance of trust factors has decreased from 0.666 in the first and second round to 0.598 in the fourth round.
3. The Kendal's Coefficient of Concordance for the panelist answers regarding the arrangement and importance of student trust factors in the fourth round is 0.734. With attention to the number of panelist, which is more than 10 people, this level of Kendal's Coefficient is significantly meaningful (Schmitt 1997). The Kendal's Coefficient of Concordance for the arrangement of success factors in the fourth round (0.734) in comparison to the third round (0.711) is just increased up to 0.023. This coefficient or the level of unanimity amongst the panel members did not grow much between two continuous rounds (Schmitt 1997).

STUDY IMPLICATIONS

The study findings indicate that factors effecting students trust in virtual universities are Academic perceived Reputation, Administrative efficacy of virtual university, virtual University perceived Size, Economical nature of Study in virtual university and Suitable environmental conditions for activities of virtual universities**.**

The implication for virtual and on– line universities is that the trust building to these universities requires recognition factors effecting student trust.

REFERENCES

Bhattacherjee, A., 2002. Individual trust in online firms: scale development and initial trust. Journal of Management Information Systems 19 (1), 213–243.

De Ruyter, K., Wetzels, M., Kleijnen, M., 2001. Customer adoption of e-services: an experimental study, International Journal of Service Industry Management 12 (2), 184–207.

Gefen, D., 2000. E-commerce: the role of familiarity and trust. Omega: The International Journal of Management Science 28, 725–737.

Gefen, D., Straub, D., 2000. Managing User Trust in B2C e-Services. e-Services Quarterly, 1,1. Electronic publication, URL: http://www.lebow.drexel.edu/gefen/eServiceJournal2001.pdf, last access: 31 October 2002.

Grabner-Krauter, S . And Kaluscha., 2003. Empirical research in online trust: a review and critical assessment .international Journal of human – computer studies.58.783-812.

Jarvenpaa, S., Tractinsky, N., Saarinen, L., Vitale, M., 1999. Consumer trust in an Internet store: a cross cultural validation. Journal of Computer-Mediated Communication, 5, 2. Electronic publication, URL: http://www.ascusc.org/jcmc/vol5/issue2/jarvenpaa.html, last access: 31 October 2002.

Jarvenpaa, S., Tractinsky, N., Vitale, M., 2000. Consumer trust in an Internet store. Information Technology and Management 1 (1–2), 45–71.

Kim, K.K., Prabhakar, B., 2002. Initial trust and the adoption of B2C e-commerce: the case of Internet banking. The DATA BASE for Advances in Information Systems.

Koufaris, M., Hampton-Sosa, W., 2002. Customer trust online: examining the role of the experience with the Web-site. CIS Working Paper Series, Zicklin School of Business , Baruch College, New York, NY. Electronic publication, URL: http://cisnet.baruch.cuny.edu/papers/cis200205.pdf, last access: 31 October 2002.

Lee, M.K.O., Turban, E., 2001. A trust model for consumer Internet shopping . International Journal of Electronic Commerce 6 (1), 75–91.

Pavlou, P.A., 2003. Consumer acceptance of electronic commerce—integrating trust and risk with the technology acceptance model. International Journal of Electronic Commerce 7 (3), 69–103.

Pavlou, P.A., Chellappa, R.K., 2001. The role of perceived privacy and perceived security in the development of trust in electronic commerce transactions . Submitted to the Special Issue of ISR on ''Electronic Commerce Metrics''. Electronic publication, URL: http://www-scf.usc.edu/Btis/eBizLab/Papers/secpriv-isr.pdf, last access: 31 October 2002

Richard L.Daft.2006.The new area of management .Thomson – South Western . USA

Sarlak,M and Abedi Jafari , H.2006. Designing and Explaining the trust model of students applying to virtual universities, IRMA 2006 International conference proceedings, USA, Idea Group publishing.(www.idea-group.com)

Schmidt, Roy C. 1997. Managing Delphi surveys using nonparametric statistical techniques. *Decision Sciences* 28 (3): 763-773.

Improving Project Management Through Collaboration-Aware Risk Management Practices

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ABSTRACT

Collaborative software development spanning national, language and cultural boundaries, raises new challenges and risks, which interfere with the success of software projects even when all traditional risk factors are being controlled. Software project management for such collaborative projects must address these concerns. In this paper, we outline a collaborative risk management approach and recommend policies and management processes for its support.

Keywords: Collaborative risk management, Software project management, Collaborative Risk Management Plan (CRMP), Risk Monitoring, Mitigation and Management (RMMM), inter-organizational collaboration, management contingency processes.

1. INTRODUCTION

The globalization of markets, business relationships and technology has given rise to an increasing number of less centralized, collaborative efforts and partnerships for inter-organizational software development. Collaborative relationships, including third party development, outsourcing, off-shoring, and peer-to-peer alliances, require changes to management, technical and support activities, processes, and policies. In particular the following should be considered: (1) appropriate modifications of internal organizational practices to support collaborative relationships and communication, (2) enhancements and integration of project management activities including risk monitoring, mitigation and management (RMMM), and (3) creation or adaptation of management policies and processes to guide and support the above activities.

The complexity of collaborative software development and the need for extensive cooperation and clear technical and management communication intensify the demand for steady flow of information, enhanced handling of risk, and better coordination among partners. These, together with the need to coordinate management policies between participating organizations, implies that collaborative software project management requires more flexibility, yet simultaneously more thorough process and project monitoring (Mohtashami 2006).

Risk management is an essential project management activity. It deals with anticipating, preventing, and mitigating problems related to software products, projects or processes, including difficulties in personnel, communication, and coordination. Traditional risk management has been defined and practiced with varying success in the context of a single organization and its relationships with clients and subcontractors. Risk management in a collaborative setting becomes more complex and critical as issues such as differences in organizational cultures and goals, software development and documentation practices, intellectual property, security, and management conflicts, become more prominent. Detection and mitigation are also complicated by the distributed nature of the problems, and often by the lack of a central business authority[4].

The problems faced in "traditional" project management settings[5] and these additional Collaborative Software Development (CSD) challenges necessitate a broader and more comprehensive approach to project management in general and to risk management in particular. In response, this paper outlines a collaborative risk management framework in which early and ongoing planning, clear policies, and mature collaboration-aware management contingency processes play a critical role.

The rest of this paper is organized as follows. Section 2 briefly outlines critical attributes of collaborative software development. Section 3 discusses risk management in traditional and collaborative software development. Section 4 highlights new principles for collaborative risk management, and Section 5 offers a layered framework for effective risk management in CSD derived from the attributes of CSD and those principles. Section 6 then introduces important aspects of management contingency processes required to support the framework. Finally, Section 7 briefly discusses related work, and Section 8 provides conclusions and suggests future directions.

2. COLLABORATIVE SOFTWARE DEVELOPMENT

Collaborative software development is of ever increasing importance due to the globalization of business, markets and enterprises, cost reduction and expertise utilization efforts, and more. Some significant differences between traditional software development and CSD are highlighted in Table 1[6]. CSD projects are typically characterized with no clear central authority, multiple teams, locations, and management structures, often crossing national, cultural, and language boundaries. A CSD project requires a common product vision and architecture, extensive idea and knowledge exchange, continuous communication, and active use of consultation, approval and consensus [(Higuera 1994), (Gorton, Motwani 1996), (Crampton 2002), (Niederman, Beise 1999)], although limited by intellectual property, privacy, and security considerations. This in turn mandates a detailed early analysis of technological, business and social issues and early planning for risk management. To accommodate all of the above CSD initiatives have to establish and exploit extensive channels of communication and an integrated operational environment.

While not all collaborative development projects will exhibit all of the characteristics displayed in Table 1, each will share some of these attributes and challenges, and can benefit from the proposed risk management framework, suitably adapted to individual project needs.

3. RISK MANAGEMENT IN TRADITIONAL AND COLLABORATIVE SOFTWARE DEVELOPMENT ENVIRONMENTS

Traditional software engineering practices were developed to support project teams formed by functional sub-teams or cross-functional teams operating under a single business authority. Traditional risk management is defined and used in this context.

Major risk management activities include identification and categorization of risk types, and planning for how to avoid risks where possible, and otherwise how

Table 1. Differences between traditional SD and inter-organizational collaborative SD

Perspective	Traditional SD	Inter-organizational Collaborative SD
Organizational culture		
Stakeholders	Stakeholders standard & well-known	Heterogeneous stakeholders with varying roles
Organizational culture and business practices	Homogeneous organizational culture Single set of business practices	Diverse organizational cultures Multiple sets of business practices
Organizational goal	Single organizational goal	Differing organizational goals
Peer support	Internal support and corporate loyalty	Power struggle among participants, Possible lack of support by some individuals or teams
Trust and awareness	Higher degree of trust More sure of procedures and people	Lower level of trust Higher degree of uncertainty
Management		
Management cohesiveness	Unified management	Autonomous organizations, distributed management Multiple management models
Management structure	Clear management hierarchy	No clear central authority
Communication structure	Management communication follows established business practices	Communication between peers across new channels Requires high level of cooperation & communication
Technical platform & development team		
SD practices	One set of SD methodologies	Multiple heterogeneous systems, SD standards, tools and libraries
Technological Communication	Technical communication across established and trusted channels	High volume of technical communication across new & untrusted channels
SD/technical Resources	Single set of resources	One set of resources per partner plus shared resources
Risk Management plan	Single risk management plan with clear management	Multiple risk management plans No central authority for risk mitigation
Work Practices	Known set of organizational and professional standards	Some variation in organizational and professional standards
Social and cultural issues		
Social Culture	Uniform and known social practices, norms and standards	Heterogeneous social practices, norms, and standards partly unknown to other partners
Language and idiom	A single language and idiom	Multiple languages and idioms
Cultural related work norms	Uniform cultural standard for work performance	Differing standards for work performance

to detect, mitigate and recover from problems as they occur. The key risk management functions are outlined in Table 2 below. The last two functions—Risk Communication and RMMM Review—are Supporting Activities integrated throughout the process.

Most of the activities in Table 2 are broadly discussed and applicable to more traditional as well as to CSD projects. Risk Identification and Analysis function warrants some further discussion as its scope and complexity change in CSD. Traditional risk analysis categorizes each risk along several dimensions, using historical data, industry experience, and organizational theory [(Barki, Rivard, Talbot 2001), (Boehm 1989), (Nidumolu 1996)]. The dimensions reflect the origin of the risk (nature and cause), the definiteness (from near-certain to highly unlikely), the anticipated consequences (degree of risk), and the aspects affected. Following the literature (Pressman 2005) and based on our studies (Mohtashami 2006), risk dimensions have been grouped and summarized as shown in Table 3. The last group–Collaborative Impact–is specific to collaborative software development, and is discussed in more detail below.

Collaborative software development entails a comprehensive change in the software engineering practices, from business case and product vision through development processes to management policies. Cooperation and communication issues are significantly different, both in level and kind. CSD depends on shared understanding of product vision, architecture, and implementation strategy, and hence requires extensive and continues exchange of ideas, design decisions and change information. The distributed nature of CSD teams and the diversity of work practices, cultures and regulations, skills and training levels make cooperation and communication more critical yet simultaneously more challenging. Risk management in such an environment must therefore address these new challenges. Detection and mitigation are complicated by the distributed nature of problems, and by the lack of central authority. More importantly, risk management must guard ongoing relationships between partners, rather than just the success of a single product or project.

This overarching concern for collaboration and ongoing relationships led to the introduction of the two new risk dimensions (and a new dimension group)—the degree to which the effects of a risk extend beyond organizational/team boundaries (contagion), and the degree to which the ongoing relationship between partners may be affected (trust). For our extended classification structure see Table 3.

Collaborative software development affects all aspects of risk management, and introduces changes to the traditional dimensions of Table 3, including:

Table 2. Risk management functions

Risk Management Phases	**Risk Identification and Analysis**	Elicit, identify, and classify (as below) major project and process risks. Process risk data into decision-making information. Determine the values of impact, likelihood, and timeframe [SEI/team].
	Risk Planning	Translate risk information into decisions and actions (both present and future) and implement those actions.
	Risk Avoidance	Where possible, modify to minimize likelihood/impact of particular risk type.
	Risk Monitoring	Track risk indicators and mitigation actions. Anticipate increasing likelihood of particular risks. Detect (impending/actual) occurrence where possible.
	Risk Mitigation	If a problem occurs, take steps to limit its scope and impact. In particular, try to prevent cascade of related problems.
	Risk Management, Recovery and Control	Once problem has occurred, take steps to get project/ product back on track. Correct for deviations from the planned risk actions.
Support Activities	**Risk Communication**	Provide information and feedback internal and external to the project on the risk activities, current risks, and emerging risks.
	RMMM Review	Review and update risk management strategies, plans, and activities, based on current and past feedback and environmental changes.

- **Form, View, and Source:** Additional perspectives, reflecting the CSD specifics (e.g., language barriers) must be considered; also resources to mitigate associated problems must be allocated
- **Level, Impact, and Scope:** Change in likelihood and effect can be observed—certain kinds of risks and effects become more likely and significant; others less significant.
- **Source, Driver, and Type**: Risks are likely to arise at interfaces between collaborating partners, rather than entirely within a single organization, and these new problems must be identified and classified.
- **Definiteness**: An advantage in collaboration-aware risk management is that some previously predictable risks become known risks, and can be avoided. Likewise, some previously unpredictable/unknown risks become predictable and a specific strategy for addressing them can be developed (Mohtashami, et al. 2006a).

The new dimensions must also be considered carefully:

- **Contagion and risk confinement**: Many risks, even within a single organization, may have wider effects. A risk that cannot be confined to a single organization must be addressed collaboratively.

Table 3. Dimensions for classifying risk

	Dimension Group	Dimension	Key question	Categories
Classical Dimensions	Nature and cause of risk	Form	What factor is stressed?	Resource, technical, business, environmental, platform
		View	In which aspect of the process will the problem occur?	Project[1], technical/product[2], business[3]
		Source	Which activities or constraints causes the problem?	Product definition, business impact/environment, process definition, development environment, innovation, staff skills/training, legal/regulatory
	Definiteness	Definiteness	Known in advance?	Known, predictable, unpredictable, unknowable
	Degree of risk	Level	How likely to arise?	Estimated probability range
		Impact	How serious if occurs?	Negligible to significant to catastrophic
		Scope	How much affected?	Isolated component to subsystem to entire system
	Location of effects	Driver	What business aspects are most affected?	Market, performance, support environment, cost, schedule, deployment, relationships
		Type	How does it manifest?	Functional specification/ expectation Performance or other extra-functional requirements Schedule, budget, process compliance
New Dimension	Collaborative impact	Contagion	Where are the effects?	Intra-organizational, interface, global
		Trust	How is ongoing cooperation/trust affected?	Unaffected, recoverable, damaged, unrecoverable

- **Trust**: Once collaboration has deteriorated, it is difficult or impossible to restore a good working relationship. Each risk must be examined for its potential effects on existing relationships.

In addition, collaborative software development further stresses the support activities in Table 2 that is, Risk Communication and Risk Planning, and RMMM Review. Appropriate planning, risk management strategy, and well-structured comprehensive risk plans are needed to address each of the above problems effectively. A collaboration-aware risk management plan thus becomes a critical binding and facilitation tool supporting collaboration and project management activities. Monitoring, mitigation, and recovery are specialized for an individual risk or a *risk class*, depending on the probability and potential effects of that risk (Table 3). Serious risks with high likelihood receive a dedicated specialized "*risk control plan"* (SPMN 2005) for monitoring, mitigation, and control, while less likely, less catastrophic, or more generic groups of similar risks can be handled together (Mohtashami, Marlowe, Kirova, Deek 2006a).

4. PRINCIPLES OF COLLABORATIVE RISK MANAGEMENT

Successful collaboration requires collaboration-aware management, intra- and inter-organizationally, and collaboration-aware risk management, which must extend traditional risk management [(Higuera1994), (Higuera1994a)] with means for handling the specifics of collaborative software development efforts—although standard risks, and existing management policies and practices, must still be addressed and considered.

The importance of communication, both generally and as specifically related to risk management, has long been recognized: "In the continuing application of the risk management process to large software development programs, the most dramatic effect has been in opening the communication channels for dialogues within organizations relating to risk and risk management" (Higuera 1994a). Collaborative risk management extends this need across institutional boundaries, calling for new management approaches to inter-organizational information exchange and to risk management activities themselves. This has an additional benefit in establishing trust and handling cultural and language problems. (Cultural familiarity and trust are consistently identified among the top four important success factors for collaboration (Powell, Piccoli, Ives 2004).) In CSD, project management and its risk management function must be supplemented and enhanced with new communication protocols, standards, policies and strategy, in order to:

- Help with establishment and growth of trust
- Evaluate the suitability and adequacy of management and IT processes for support of technical and social aspects of inter-organizational communication
- Address organizational, social, cultural, linguistic, and legal/regulatory differences
- Manage or at least monitor disagreements over power and responsibility among organizations
- Decrease conflict and define norms
- Let information flow effortlessly, precisely, and in a timely way
- Select metrics and tools for monitoring and measuring the success of collaborative communication and risk management

These considerations have led us to extend existing risk management principles with new principles for CSD, see (Mohtashami et al. 2006a). They augment the traditional and team-based risk management principles (SEI 2005) with collaboration-aware guidelines focused on:

- Building effective collaboration through establishment of trust, cultural sensitivity, and open communication channels, and
- Institutionalization of effective management processes, including aligned management support and responsibility for risk management–building trust, shared product vision, and consensus among partners.

Collaborative risk management provides support for addressing risk in CSD, including risks triggered by CSD-specific or intensified risk drivers and sources: cultural differences (both social and organizational), the quality of trust, communication, and IT support, and difficulties with project and risk management themselves. These principles form the basis for the layered risk-management framework sketched in the next section.

5. A LAYERED APPROACH TO RISK MANAGEMENT FOR CSD

An effective Risk Management framework for CSD should be based on collaborative-risk management principles, discussed above, and provide clear definition of decisions, actions, and responsibilities related to risk management functions. A key means in implementing the framework is a collaboration-aware RM plan, which must (1) address traditional intra-organization risk identification and management in collaborating agencies, (2) handle risks identified as introduced or intensified by CSD, including single-organization risks, resulting from interfaces, communication and collaboration, (3) handle collaborative risks not well-managed intra-organizationally, (4) drive incremental modification of policies, processes, and activities as needed, and (5) support negotiation to resolve conflicts and to assign responsibilities for risk management, while still addressing traditional concerns.

In (Mohtashami, et al. 2006a), we introduced a layered structure partitioning risk classes with minimal overlap into those best monitored and managed internally, and those requiring inter-organizational, collaborative oversight. The resulting layered Collaborative Risk Management Plan (CRMP) has three components:

1. Modified and enhanced individual, intra-organizational risk management plans incorporating collaborative risks.
2. A shared inter-organizational plan to address risks likely to be missed inside individual organizations, or which affect multiple organizations in different ways, or seriously affect cooperation and collaboration.
3. Establishment of a structure for administration and management of the shared plan, and (perhaps separately) for conflict resolution, to mediate/arbitrate conflicting organizational interests.

Thus, our collaborative RM framework has three major components: modified internal plans—one per partner, a shared inter-organizational plan (with both traditional and collaboration-specific features), and a structure for mediation and resolution. This layered approach can only be successful if accompanied by effective project management practices, including a collaboration-aware RMMM Review process.

It is not sufficient, however, to simply change the risk management functions. Changes in management contingency processes and policies are necessary, to support collaborative risk management, to reduce risk, and otherwise to conduct effective collaboration-aware management and development.

6. CONTINGENCY PROCESSES FOR CSD

To support CSD and collaborative RM effectively, project management depends on management contingency processes and policies, constituting a collaboration-aware management contingency profile (MCP). The MCP, the continuous, iterative, and interactive communication, particularly across organizational boundaries, and the creation of shared knowledge and awareness are the keys to effective collaborative project management. In addition to the typical objectives of a management contingency profile [(Piccoli, Ives 2000), (Powell, et al. 2004)], a collaboration-aware MCP must guide and support management efforts in addressing the CSD challenges discussed earlier.

CSD projects require more management involvement, plus management processes that permit a higher level of dynamic behavior than may be customary (Piccoli, et al. 2000). Moreover, the nature of the development process, and the required level of formality, must be determined with care. Although high-risk complex (but non-safety-critical) projects ordinarily benefit from a more dynamic, less formal management profile, Cohen (Cohen, Levinthal 1990) and Piccoli (Piccoli, et al. 2000) suggest that management intervention may nonetheless be beneficial. Barki (Barki et al. 2001) in fact argues that formal planning is important, particularly when cost management is at least as important as system quality. Not only management profile, but also the development process must allow for some flexibility, particularly at boundaries between collaborators.

The major risks, and thus the major focus of management processes and policies, fall into four primary categories: (1) technical risks, (2) risks arising from com-

munication, trust, and culture, (3) integration and planning risks, and finally (4) risks arising from risk management itself (risk reflection).

Technical risks–tools, product and process: Technical risks arise from difficulties with development platforms and tools, challenges with process coordination and design methodology alignment, or from problems with product compatibility, functionality and dependability (performance, reliability, scalability, etc.). These risks are exacerbated by strong process interdependence or complexity, by high rates of changes in requirements or development environment, and by lack of availability or clarity of information (Barki, et al. 2001).

Problems such as poor inter-institutional planning, or lack of effective inter-institutional risk management strategy, further increase these risks. CSD is also vulnerable to management resistance to cross-institutional technical integration, or to unification of protocols and communication modes/standards, and also to poorly specified inter-institutional technical interfaces.

Inter-organizational and inter-cultural communication and trust: The key factors in this category—trust, cultural differences and miscommunication—are mutually reinforcing. Our studies (Mohtashami 2006) indicate that, with risk management and management contingency profile, these factors contribute significantly to CSD product and process success.

Toffolon (Toffolon, Dakhili 2000) emphasizes the importance of management of communication and coordination for effective collaborative software development. Social communication at both management and technical levels is also important in building familiarity, trust, and employee morale. Policies for promoting communication and trust are discussed in (Mohtashami et al. 2006a).

Cross-organizational integration and planning: Cross-organizational integration of functions, as well as platform and information, should be defined and managed from both organizational and software development perspectives. Organizational integration deals with linking resources across physical boundaries, so that scattered organizations and teams can share and exchange information seamlessly. Two important aspects are (1) sharing and broadcasting information, and (2) collective decision making, planning and scheduling. Software development integration relies on compatibility of tools and methodology. Finally, technical platform integration is important primarily insofar as it supports these activities.

In general, CSD calls for formal planning activities, management intervention, and integration [(Barki et al 2001), (Bogia, Tolone, Kaplan, de la Tribouille 1993)]. Because of the scope, impact and contagion of many risk factors, formal planning must nonetheless support dynamic management of collaborative activities. Therefore, CSD requires a project management profile that supports high levels of planning, adaptability and integration of management approaches. Formal control effectively contains the complexity of CSD, while adaptability controls unexpected variation—the challenge is remaining flexible enough to adapt to CSD's chaotic nature.

Risk reflection: The increased complexity of risk identification, classification, and management, as well as complexities introduced by cooperative decision-making for risk mitigation, may lead to additional complications. New risks can arise from bad, inappropriate, or overly constrictive RMMM plans and policies. While this paper does not address the issue further, RMMM planning, review and evolution is an essential requirement for a successful collaborative project management.

The contingency processes, required to address the above added complexity and challenges, include behavioral control management policy (rules and procedures), collaborative management policies, and management of differences in institutional practices; risk management overlaps each of these categories. These aspects of management profile are responsible for initiating or effectively controlling the following activities: management of organizational behavior, management of processes, policies for integration, policies for IT support, and policies for risk identification and management.

Management of organizational behavior deals primarily with social and technical training, and with establishment of a cooperative culture. It includes creation of inter-organizational trust, recognition of and adaptation to cultural differences, establishment of training programs, and demonstration of senior management support for the collaborative effort.

Management of processes includes establishment of a proper fit between project risk and management profile, enhancing task clarity (clear specification of global requirements, partner responsibilities, and interfaces), and establishment of communication protocols and standards, as well as tool and development process standardization.

Policies for IT support need to respond to the high uncertainty of CSD. They should address provision of tools to support and manage non-routine activities (such as event-driven group conferencing). They must deal with increased needs for security and integrity, as well as protection of privacy and intellectual property. In addition, they must support tool and process integration, and sharing of a wide variety of software and management artifacts.

Policies related to risk identification and management require definition and institutionalization of a collaborative RM framework, institutionalization of collaboration-aware risk identification and analysis, monitoring of risk arising from inter-organizational communication and interfaces, and cross-organizational sharing of risk-related information, events, and changes. These activities are essential to CSD, and are discussed in detail in (Mohtashami et al. 2006a).

7. RELATED WORK

Related work falls primarily into the following areas: risk management and software project management, distributed software development (SD) and software teams, collaborative software development and cultural differences and sensitivity.

Extended discussions of project management, traditional risk management, and RMMM planning, can be found, for example, in [(Pressman 2005), (Sommerville 2006)], in publications focused on software project management [(Tsui 2004), (Royce 1998)], or in the publications of the Software Engineering Institute (SEI 2005) and the Project Management Institutes (PMI 2006). Ranky (Ranky 2006) offers a practical introduction to collaborative project management, and Fang (Fang, Nunamaker, Romano, Briggs 2003) examines the problems associated with traditional project management approaches given business globalization and information technology advances, and highlights the benefits of collaborative project management.

Distributed software development and its risk management are addressed in [(Barki et al. 2001), (Gotterbarn 2005), (Higuera 1994), (Lee, DeLone, Espinosa 2006)]. Good analysis of virtual teams management and collaborative software development issues can be found in [(Chopra, Meindl 2001), (Beranek, Broder, Romano, Reinig 2005), (Cantu 1997)]. Selection of software process models for distributed and collaborative software development is also a subject of ongoing discussion (see for example (Ramesh, **Cao, Mohan., Xu** 2006)).

Risk management for distributed SD, particularly focused on customer-supplier relationships and team-work (Team RM) is addressed in [(Beranek, et al. 2005), (Higuera 1994), (Higuera 1994a), (SEI 2005)]. The Team RM approach emphasizes collaboration, teamwork, as well as negotiation and use of shared team risk management plans. However, it does not consider such issues as lack of a single authoritative decision-making entity or cultural differences, which are specific to CSD and are addressed in the collaborative risk management framework presented in this paper.

8. CONCLUSIONS, IMPLICATIONS AND FUTURE WORK

We have introduced an enhancement of current risk management practices and policies to handle complications arising in large, multi-organizational/multi-enterprise, collaborative software development projects.

In support of collaborative project management and collaborative RM, in particular, we have introduced the concept of a layered risk management plan as a critical means of collaborative risk management. The effective execution of such a layered plan requires appropriate management and mediation policies and processes. Understanding the role these play in CSD, and augmenting the CRMPs with effective collaboration-aware management contingency profiles, further adds the dynamic control and flexibility needed for successful CSD projects.

As a preliminary study, this work leaves many open questions, which we (and we hope others) will explore in the future. Important areas of future work include:

- Further exploration of risk classification and risk management issues for collaborative software development (Mohtashami et al. 2006a).
- Exploration of approaches to develop specific recommendations for management contingency processes and policies
- Investigation of strategies for reconciling mitigation actions taken by different authorities (e.g., in multi-company CSD projects) and the changes needed in MCPs to support these strategies

- Consideration of the impact of Software Development Lifecycle process models on the success of CSD projects and their management
- Investigation of the interactions between collaborative risk management, management contingency processes and policies, and overall software project management activities.

The range of open questions, and the difficulty in collecting solid statistics on the experience of on-going collaborative efforts, makes full validation of this proposal challenging. Nonetheless, we expect that practitioners will be able to use the preliminary results and ideas presented in this and prior papers in developing more effective, collaboration-aware risk management plans and management contingency policies for their specific efforts, resulting in improved CSD project management practices.

REFERENCES

Barki, H., Rivard, S., Talbot, J. (2001). An integrative contingency model of software project risk management. *Journal of Management Information Systems*. Spring 2001. 17 (4). 37-69.

Beranek, P. M., Broder, J., Romano, N., Reinig, B. (2005). Management of virtual project teams: Guidelines for team leaders. *Communications of the Association for Information Systems*, 16(10), 247−259, 2005.

Boehm, Barry W. (1989). Software Risk Management. *IEEE Computer Society Press*. Los Alamitos, CA.1989

Bogia, D. P., Tolone, W, J. Kaplan, S. M., de la Tribouille, E. (1993). Supporting Dynamic Interdependencies among Collaborative Activities, *Proceedings of the Conference on Organizational Computing Systems***.** 108-118, 1993.

Cantu, C. (1997). CSWT Papers, Virtual Teams, Centre for the Study of Work Teams, University of North Texas, Available at: http://www.workteams.unt.edu/reports/Cantu.html, 1997.

Chopra, S., Meindl, P. (2001). Supply Chain Management, Strategy, Planning and Operation, *Prentice-Hall Inc*, Upper Saddle River, New Jersey, 2001.

Cohen, G. W. M., Levinthal, D. A. (1990). *Absorptive Capacity: A New Perspective on Learning and Innovation*. Administration Science Quarterly, Vol. 35, 128 –152, 1990.

Crampton, C. D. (2002). Finding Common Ground in Dispersed Collaboration. *Organizational Dynamics*. 39(4). 356-367. 2002.

Fang C., Nunamaker, J.F., Jr., Romano, N.C., Jr., Briggs, R.O. (2003). A collaborative project management architecture, *Proceedings of the 36th Annual Hawaii International Conference on System Sciences*, 2003.

Gorton, I, Motwani, S. (1996). Issues in co-operative software engineering using globally distributed teams. *Information and Software Technology*. 38 (10). 647−656, 1996.

Gotterbarn, R. (2005). Responsible Risk Analysis for Software Development: Creating the Software Development Impact Statement, *Communications of the Association for Information Systems*, 15, 730−750, 2005.

Higuera, R. P. (1994). Introduction to Team Risk Management, *Special Report CMU/SEI-94-SR-1*, May 1994,

Higuera, R. P. (1994a). Team Risk Management: A New Model for Customer-Supplier Relationship, *Special Report CMU/SEI-94-SR-5*, July 1994, http://www.sei.cmu.edu/pub/documents/94.reports/pdf/sr05.94.pdf.

Lee, G. DeLone, W., Espinosa J. A. (2006). Ambidextrous coping strategies in globally distributed software development projects. *Communications of the ACM*. SPECIAL ISSUE: Flexible and distributed software processes: old petunias in new bowls? Volume 49, Issue 10, P: 35 - 40 ISSN:0001-0782 October 2006.

Mohtashami, M. (2006) The Antecedents and Impacts of Information Processing Effectiveness in Inter-Organizational Collaborative Software Development, PhD Thesis, Rutgers University – School of Management, June 2006.

(Mohtashami 2006a) Mohtashami, M., Marlowe, T., Kirova, V., Deek, F.P. (2006a) Risk Management for Collaborative Software Development*, Information Systems Management*, 23(4), 20-30, Fall 2006).

Niederman, F., Beise, C. M. (1999). Defining the Virtualness of Groups, Teams, and meetings. *Proceedings of the 1999 ACM SIGCPR Conference on Computer Personnel Research*. 14-18, 1999.

Nidumolu, S. R. (1996). A Comparison of the Structural Contingency and Risk-Based Perspectives on Coordination in Software-Development Projects. *Journal of Management Information Systems,* 13 (2), 77–113., 1996.

Piccoli, G., Ives, B., (2000). Virtual teams: Managerial behavior control's impact on team effectiveness, *Proceedings of the twenty-first international conference on information systems*. Brisbane, Queensland, Australia**.** 575- 580, 2000.

Powell, A., Piccoli, G., Ives, B. (2004). Virtual Teams: A review of Current Literature and Directions for Future Research. *The DATA BASE for Advances in Information Systems*, *35 (1)*, 2004.

(Pressman, R. S. (2005). Software Engineering: A practitioner's approach. *6th edition. McGrawHill,. ISBN 0-07-301933-X*, 2005.

PMI 2006 (2006). Project Leadership: A Practical Guide to Communication, Influence and Collaboration, http://www.pmi.org/prod/groups/public/documents/info/pdc_sw_td_projleader07.asp

Ranky, P. G. (2006). Collaborative Project Management Methods, Tools & Technologies with USA & International . Examples in Engineering, IT, Management and Service Industries, *CIM ware USA, Inc.* March 5, 2006

Ramesh B., Cao, L., Mohan, K., Xu, P. (2006). Can distributed software development be agile? *Communications of the ACM***,** SPECIAL ISSUE: Flexible and distributed software processes: old petunias in new bowls? Volume 49 (10), 41 - 46 ISSN:0001-0782, October 2006.

Royce, W. (1998). Software Project Management: A Unified Framework, *Addison-Wesley Professional*, 1998.

Sommerville, I. (2006). Software Engineering, Addison-Wesley, England, 8th Edition, 2006.

Standish (2004-2005) The Standish Group. *The Chaos report.* West Yarmouth, MA:, 2004/2005.

SPMN 2005: 16 Critical software practices for performance-based management, Software Program Managers Network, 2005. http://www.spmn.com/16CSP.html.

Toffolon, C., Dakhili, S. (2000). A framework for studying coordination process in software engineering. *Proceedings of the 2000 ACM Symposium Applied Computing*, 851– 857, March 2000.

Tsui, F. (2004). Managing Software Projects, Jones and Bartlett Publishers, Inc., March 2004.

ENDNOTES

1. Project includes process, resources (including personnel), communication, and systems analysis.
2. Product requirements and technical environment.
3. Corporate health, business case, senior management support, etc.
4. Clear project management structure does not necessarily entail authority to make process changes across organizational boundaries required to reduce or handle risk. Such changes depend on organizational decisions and require the involvement and support of business management, whose span of control is restricted by the organizational boundaries.
5. The failure rates of contemporary projects (Standish 2004-2005), indicate problems even with in-house project development despite the existence of developmental methodologies, frameworks and risk management practices. Given such problems – with time, cost, functionality and quality—development in a dispersed or virtual setting is even more challenging.
6. The comparison is based on extremes – a simple case of traditional software development is compared with a complex CSD effort – in order to identify as many potential areas of new or intensified risk as possible. There is a spectrum from "fully local" to "fully distributed/fully collaborative" efforts, and many of the factors we identify affect single-enterprise projects in the middle of this spectrum.

Pull and Push Business Functions in an Experimental Text Processing System

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ABSTRACT

We observe an unprecedented growth in the volume of unstructured data. Active use of business information contained in large volumes of unstructured data is becoming one of the biggest challenges now. In this paper, we examine an automated mechanism for pull and push functions for business documents. The pull function allows users to access the information contained in documents. The push function alerts users to the presence of information contained in new documents which is consistent or inconsistent with the background information. To implement these functions, documents are annotated using XML tags, and then, XML query processing techniques are used. Our approach is to use a limited context defined by an ontology or set of well established background documents for the guidance in identification and annotation of basic concepts and relationships in new business documents. The described text mining system is a highly modular and parametric, giving the human a tool to adjust quickly in a dynamically changing environment. The indirect goal of this paper is to provide a foundation for a new self-tunable text mining system that can adjust to new environment by itself.

1. INTRODUCTION

The abundance of business documents makes it increasingly likely that the precise information the user needs or wants is available. At the same time, however, retrieval of this information is much more challenging. Fortunately, this trend has been accompanied by unprecedented progress in technologies for content-based access to text documents. Using these technologies is crucial for achieving competitive advantage for our businesses.

Current information extraction techniques are either keyword/category based, such as Google, AltaVista [1] or Yahoo [8, 13], or structure dependent such as Rapper [10] and XWrap [9]. Our approach to text mining is to use the combination of qualitative and quantitative techniques for identification of relevant concepts and relationships. The selected concepts and relationships are extracted in the process guided by ontologies and by background documents for the domain of interest.

In this paper we address the problem of simultaneous text mining of two distinct groups of documents, background documents and new documents, as shown in Fig.1. The documents will be also referred as text corpora. We examine an automated mechanism for pull and push functions for business documents. The pull function allows users to access the information contained in the documents. The push function alerts users to the presence of information contained in new documents which is consistent or inconsistent with the background information. To implement these functions, documents are annotated using XML tags, and then, XML query processing techniques are used.

The described system is highly modular and parametric giving the human a tool to adjust quickly to text mining in a dynamically changing environment. The indirect goal of this paper is to provide a foundation for a new self-tunable text mining system that can adjust to new environment by itself.

Our approach assumes multi-stage document processing. These stages include ontology processing, background document annotations, queries for ontology and background documents, new document annotations, comparative queries for new and background documents, and generation of alerts when the information in new documents does not match information the background documents.

XML was chosen as a language for our annotations [4, 12] for several reasons: (1) XML provides a simple, standard, self-describing way of storing and exchanging text and data, (2) XML-based retrieval systems are relatively simple and can retrieve XML information quickly without linguistic analysis of text documents during the query time, (3) XML notation is very convenient as an internal representation because it allows for incremental annotations that represent explicitly the various phases of information extraction (knowledge discovery process), (4) XML can provide many annotation types and XML-based query systems can retrieve only those types of information that are requested, (5) XML annotations can be inserted/deleted/modified in the future responding to dynamically changing needs, (6) XML annotated text is open to further processing beyond annotations, and (7) XML texts can be integrated with other structured data.

The results of our project represent an integration of various text processing technologies and have immediate application for pull and push functions as shown in Fig.1. These results generalize beyond our application and will be important wherever concept-based information retrieval through XML-capable search engines or query systems is desirable.

The "Pull" functional requirement is the ability of the system to answer queries for new or background documents. The "Push" functional requirement needs more discussion. In the business world we often have to deal with new events described in new documents that need to be reflected directly in the "knowledge base" of our corporation. The text processing system can help us identify such documents to be included in the set of background documents. We refer to such function of text processing system as a push function.

The system described in this report is being designed to support military medical documents; however, such a system, because of its general nature, can be successfully used in other business environments. It provides integrated concept-based access and awareness of unstructured data. The system is capable of querying unstructured data sources and continuous monitoring of event patterns in new documents.

2. FLEXIBLE ARCHITECTURE OF EXPERIMENTAL TEXT PROCESSING SYSTEM

Our experimental text processing system is flexible in the sense that it can be constructed from various available modules. Each module is highly parametric allowing the human to adjust parameters for the existing needs.

The architecture of our experimental text processing system is shown in Fig 2. It is constructed from relatively independent modules: Ontology Processing Module, Text Annotation Module, and Pull and Push Modules.

Figure 1. An overview of pull and push functions

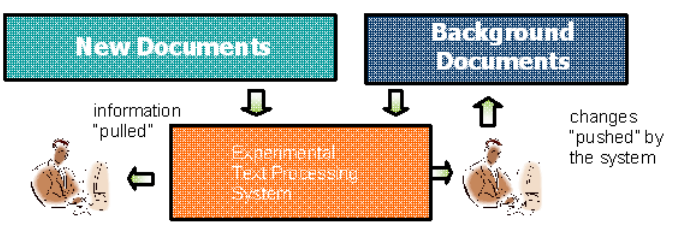
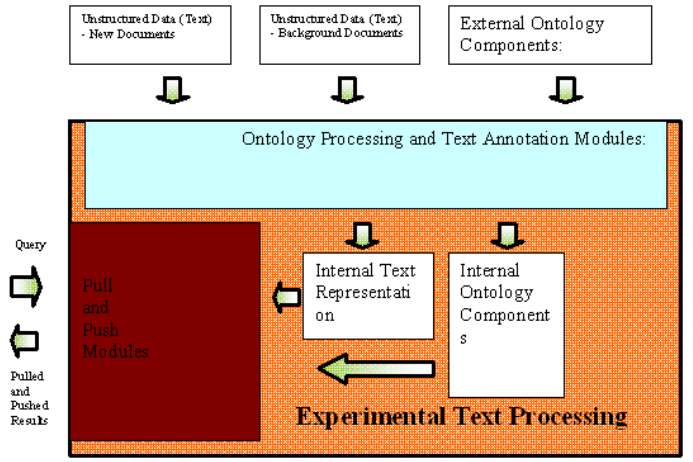


Figure 2. An overview of a flexible system architecture of an experimental text processing system



Text annotation can involve concepts hierarchy of concepts and concepts relationships. For each annotation level we can apply various statistical processing types, for example frequencies of words, direct collocations, and distant collocations. For each pair of annotation level and processing type, we can use various ontology components: simple and compound concepts, relationships, word stems, synonyms, antonyms, stop words, stop modifiers, etc. Not all combinations of system parameter values are important to consider. Some combinations of parameter values are useful in specific situations only, and some combinations of parameter values can result in either contradicting functionality of the modules.

Based on internal representation, the query can be issued or alerts generated. The query can be:(a) keyword search, (b) hierarchy and relationship search, or (c) comparative.

The internal text annotation is done using XML. XML allows us to annotate important concepts, hierarchy of concepts and relationships between them. These annotations are done using tags ***<concept>*** and ***<relationship>*** and various tag properties e.g. ***type, source,*** etc.

Document processing is done in several stages. In the first stage, the internal ontology is created by using components of external ontology (if available) and statistical processing of primary background but also new documents as shown in Fig. 3. In the second stage, relevant concepts, hierarchy of concepts and relationships between concepts are identified in background documents and annotated using XML as shown in Fig.4. In the third stage, the query is processed to verify the consistency of knowledge contained in ontology and background documents. In the fourth stage, the relevant concepts, hierarchy of concepts and relationships between concepts are identified in new documents and annotated using XML as shown in Fig.5. In the fifth stage, the alerts are generated if the consistency of knowledge contained in new documents and background documents is violated.

The flexibility of the architecture of the text processing system is of crucial importance for success in business automatic information extraction from text. So

Figure 3. Stage 1of text processing

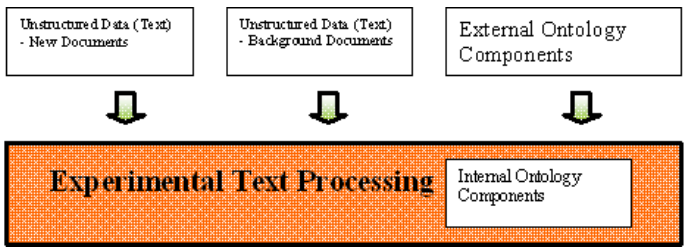


Figure 4. Stages 2 and 3 of text processing

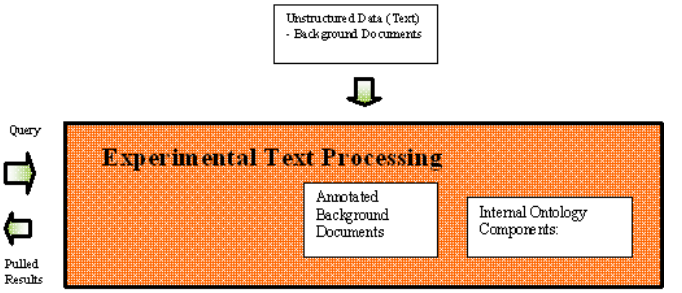
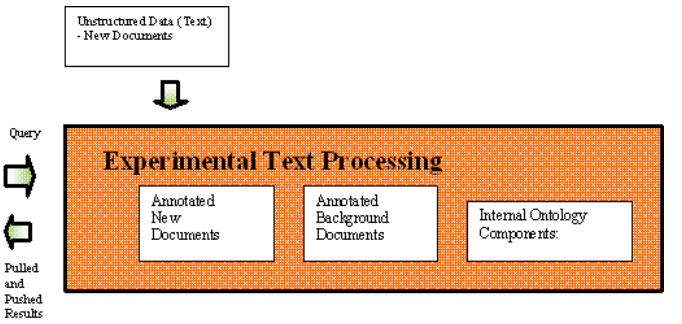


Figure 5. Stages 4 and 5 of text processing



far there are no black box solutions that are good for text processing for a broad range of styles of business documents. Our experience suggests that in order to succeed in a complex business environment with a text processing system it is necessary to use an iterative approach in terms of both domain and complexity of analysis to tailor the system to business needs. We suggest proceeding concurrently with experiments in these two directions.

3. ONTOLOGY PROCESSING

Whenever we humans process an individual document (text) we view it in a broad context of facts and rules acquired throughout our life. Let us refer to this context as a background knowledge. The background knowledge can be in various forms. It can be in the form of background documents that we remember or studied and can recall quickly. In can be also in the form of more digested information such as dictionaries. Let us refer to "digested" knowledge as an ontology. In general, the ontology can contain not only the list of concepts as in simple dictionary but also explicit concept hierarchy and relationships between concepts.

Our understanding of a new document very much depends on the "scope" of our background knowledge. Obviously, there are various scopes of background knowledge and "quality" of background knowledge can be different for different areas. Let us, in this section, concentrate on a "digested" knowledge – ontology. When we refer to an ontology, we can mean a general ontology or more often, an ontology for the specific area of interest e.g. medical, technical.

One of the measures of ontology "quality" is ontology completeness levels. To compute a concept completeness level for an ontology with respect to a set of documents, we first compute the number of all concepts in ontology that are found in a set of documents and divide it by a number of all concepts in a set of documents. Similarly, we can define concept hierarchy completeness level and relationship completeness level. By completeness level, we can mean overall completeness level or completeness level with respect to a subset of documents or even a completeness level with respect to single document or its fragment. This is an important measure how "good" ontology is for the specific set of documents. When several distinct sets are processed e.g. new and background documents the completeness measure for each subset may need to be calculated.

3.1 Concepts in Ontology

There are different requirement for ontologies depending on text recognition levels. For the lexical text recognition level, the ontology should contain the list of concepts, their possible representations and the methods to identify them. Specifically, an ontology for lexical recognition can contain: (a) list of concepts represented by primary names, alternative names, stem words, and synonyms, (b) list of stop words, and if applicable (c) list of misspellings. For the list of concepts, we assume that each concept is represented by a unique primary name, e.g. "**organization",** that we call *name*. Each concept *name* is associated with a list of alternative names, e.g. "**organizations,"** to allow for alternative forms, singular and plural, etc. The list of alternative words can be also generated from the stem words, e.g. assuming a stem word "**organization,"** the alternative name "**organizations"** can be generated by appending the "s" to the stem word. In general, both generated and stored alternative words can be used. Each concept has a list of synonyms, e.g. "**corporation"** for the concept "**organization."** Each concept can have a list of misspelled words, e.g. "**corporation."** The list of misspelling words can be also generated from the alternative names by using some rule e.g. removing one character, replacing one letter by another letter. In general, both generated and stored misspelled words can be used.

3.2 Creating Ontology with Concepts

Internal ontology can be built from a variety of external resources. In the medical area, there are many existing external ontologies e.g. Mesh, UMLS, SNOWMED. Some of the external ontologies are very large e.g. UMLS, so that they need to be appropriately processed (restricted in size) to be useful for text recognition purposes. Sometimes, for a narrow area of interest, the internal ontology can be created from the specific set of documents (text corpora). This process is called ontology extraction from text corpora. For our project text corpora can contain both background documents and new documents.

Ontology extraction is based on finding statistically important words in documents. The words in the document are also referred as tokens. It is easy to see that ontology extraction, guided only by global statistical computations, may not be reliable, especially when we deal with a small number of documents or groups of documents with significantly different presentation features. Therefore, statistical techniques should take into consideration a diversity of documents. In summary, when an ontology is not available, there is a potential increase in the number of generated errors, in terms of false positives, but human interaction can make this process much more reliable.

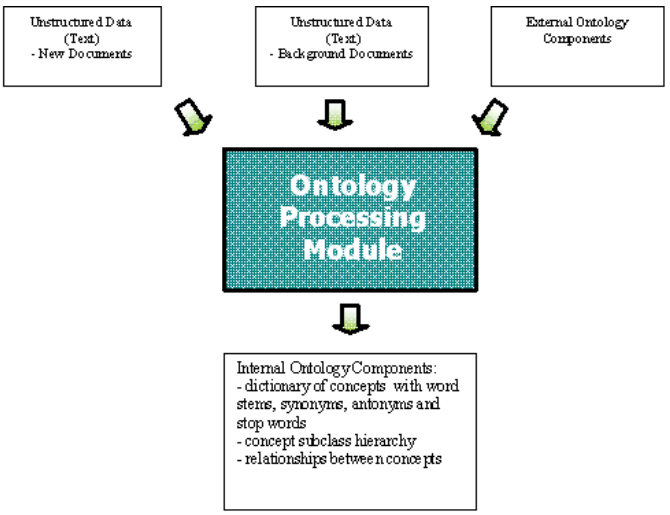
In general, the external ontology components can be used together with internally created ontology for lexical text recognition. More specifically, the optimal use of ontology might require appropriate combining of external and internal components so that they will provide both effective and efficient support for the text recognition.

Let us discuss briefly the process of creating the internal ontology from the documents (text corpora) as shown in Fig. 6. As we discussed before, there is need to construct such internal ontology when the external ontology does not exist for a given area, or when external ontology needs to be enhanced by knowledge from the given area (an external ontology has a low completeness level with respect to text corpora). The process of constructing internal ontology is multi-phased. First, it involves finding the frequency of all tokens in text corpora. Second, we eliminate some tokens of no semantic value e.g. "a", "the", and create a stop list from them. Third, we choose mainly nouns that can be potentially relevant concepts. Next, we need to group tokens representing the same concept together and assign to the group a unique identifier i.e. typically *primary name*. Last, we choose some frequency threshold to eliminate irrelevant concepts. An enhanced version of this multi-phase process will also involve computing frequencies for collocated tokens.

Let us also discuss some specifics about combining of external and internal components so that they will provide both effective and efficient support of text recognition. We can enhance the multi-phase process of creating internal ontology, described above, by investigating frequency of co-occurrence of external ontology concepts with text corpora concepts to identify new concepts with multi-component names.

In summary, the ontology processing module creates internal ontology components from modified external ontologies and from components obtained by ontology extraction process from text corpora. Actually, this process is much more complicated than described above. Let us mention the aspect of ontology

Figure 6. Ontology processing



self-modification. After the internal ontology is used for text recognition, it should self-adjust automatically e.g. re-arrange, expand and possibly shrink. This self-adjusting mechanism, together with zooming techniques, will allow ontology to respond to dynamically changing text environment.

At this stage let us assume that the example internal ontology is available and it contains the following concepts: "**organization,"** "**disease**," "**rate**," and "**study**." The concept "**organizations,**" has an alternative name "**organizations**" and the synonym "**corporation."** Similarly, alternative name for **"rate"** is **"rates,"** and for **"injury"** is **"injuries"** etc**.**

3.3 Multi-Component, Compound, and Derived Concepts

So far we were discussing simple concepts whose primary name or its equivalent textual representations contain one word. There are also concepts whose primary name or one of its equivalent textual representations contain several words (components). We will refer to such concepts as *multi-component* concepts. If at least one of the components corresponds to another concept, then the *multi-component* concept becomes *compound* concept. If all components of *multi-component* concept match some other ontology concepts we will call it a *derived* concept.

Let us consider a sample ontology from Section 3.2. If is enhanced by a new concept, "injury rate," that concept would be classified as *compound* since "rate" is already a valid concept. If we add another new concept "injury," then the *compound* concept "injury rate" would become also *derived*. It is important to notice that as ontology changes the properties of concepts can also change. In a well designed system all changes need to propagate appropriately.

The *multi-component* concepts can be stored and processed in the ontology as simple concepts. The *compound* and *derived* concepts can be also stored as *simple* concepts but then some additional ontology processing is necessary to discover relationships between then. Alternative notations are described in the next subsections.

3.4 Hierarchy of Concepts

Multi-component concepts are candidates for building traditional type hierarchy for concepts. For example, "injury rate" is a subtype of the concept, "rate." This classification can be explicitly specified in the ontology or can be computed.

In general, there are also other candidates for building traditional type hierarchy e.g. "flu" is a subtype of "disease." Such a hierarchy can not be simply discovered by collocation of words but need to be extracted using more sophisticated analysis.

3.5 Relationships Between Concepts

An ontology can also contain relationships between concepts. The relationship can be unique for some concepts but very often they are classified into some classes called relationship types. For example, let us consider two important types of relationships: "***is-a,***" and "***has.***" The first relationship type represents an alternative notation for a hierarchy of concepts as described in the previous section. In our example instead of concept hierarchy can be described by the following relationships: "injury rate ***is_a*** rate" and "flu ***is_a*** disease." The second relationship type "***has***" is used to describe a strong association between concepts including ownership, main activity or components. Let us assume that for our ontology example, we have a relationship "CASS ***has*** study." From the existing relationships new concepts and relationships can be derived. They will be also called derived concepts or derived relationships. From the "***has***" relationship, we can create a derived concept such as "CASS study". There are also derived relationships obtained by so called inheritance operation.

4. TEXT ANNOTATION

Typical documents include a wide variety of concepts from physical objects to events and states of affairs. The text recognition process will extract this information. The first step in identifying and annotating all important information in documents is to recognize basic concepts. This process can be extended to identify and annotate the concept hierarchy and relationships between concepts as shown in Fig. 7. This process establishes the mapping between words in the text, also referred as tokens, and concepts (i.e. ontology concepts), concept hierarchies, and relationships. Once a word is mapped to the ontology concept, it is called a text corpora concept or simply text concept. The same applies to concept hierarchy and relationships between concepts. There are many ways to describe this mapping. One very convenient, technique is to annotate such words inside the text e.g. using appropriate XML tags. This annotation technique is used in our paper.

4.1 Annotation of Concepts Using Ontology

The concept text annotation sub-module is based on lexical analysis of text, i.e. it scans the text, extracts each word, and annotates the words matching the concepts in ontology with appropriate tags. The annotated words become text concepts. In the initial phase, a set of text concepts is simply a subset of ontology concepts.

Let us consider an example of a sample fragment of a document:

Our CASS organization is involved in a variety of studies. Disease rates are CASS main study.

The system can process the text with concepts properly annotated shown below. The lines without tags are not annotated. The characters in bold constitute the original text. The annotated text fragment is shown in Fig. 8.

Figure 7. Text annotation

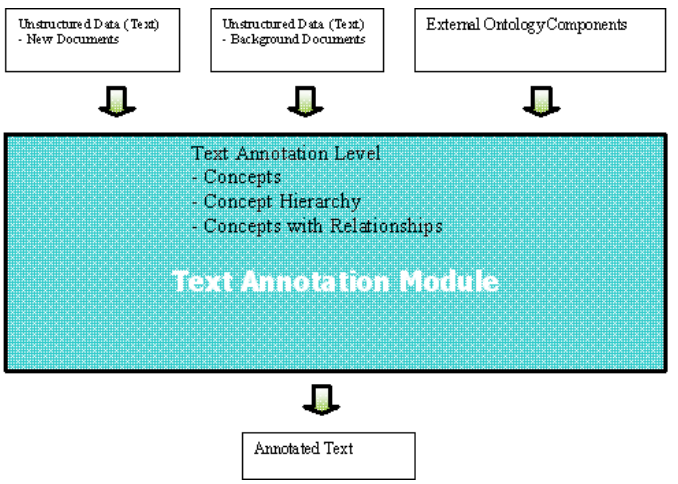


Figure 8. Document fragment with concepts annotated

```
1.  Our CASS
2.   <concept name="organization" >Organization </concept>
3.  is involved in a variety of
4.  <concept name="study"> studies </concept>
5.  .
6.  <concept name=" disease" > Disease </concept>
7.  <concept name=" rate" > rates </concept>
8.  are CASS main
9.  < concept name="study""> studies </concept>
10. .
```

Let us discuss annotations in Fig. 4 resulting from lexical text recognition process. In this process all words (tokens) matching an ontology concept are annotated as "concept" as shown in line 2, 4, 6, 7, 9 and 11. We assume that ontology contains all information necessary for an extended matching sub-process. Such a sub-process needs to take into consideration synonyms, misspellings, and alternative forms (e.g. singular and plural) resulting in a unique assignment of a word (token) to the concept. In actual implementation, the concept primary name can be a word stem but for the readability purposes we will use a meaningful name.

4.2 Annotation of Compound Concepts Using Statistical Computations

In the case the when ontology completeness level is low the process described in Section 4.1 can be augmented by finding words (tokens) with high frequency and treating them as concepts (text concepts) even though they are not present in ontology. We want include these concepts especially if they are collocated with the discovered ontology concepts.

The text annotation process for compound concepts can be performed together or after annotation of simple concepts in text. In the currently described process, all non-matching words are considered. First, we treat all existing ontology concepts in the text as a "hook." A word in the text with statistically supported collocations with the ontology concept is grouped together with the ontology concept itself to establish a new compound concept as shown in line 2-3 of Fig. 9. Such compound concepts are annotated as "compound". It is important to note that statistically supported collocations can return false positives in the sense that some unneeded components are attached to the beginning or to the end of the concept from the ontology.

In this process we want to make a more precise determination about concepts including compound concepts. We explicitly specify each concept property with the values: "simple," "compound," or "derived." Also, we can annotate the concepts by stating their source: they can be located in "ontology," or only in the "text" as shown in Fig. 9.

In our example, the concepts in text are annotated as the "simple" concept as shown in line 3 and 4 and as the "compound" concept as shown in line 2. The source of concept can be "ontology" as shown in line 2 and 4, and "text" as shown in line 3.

4.3 Annotation of Concept Hierarchy Using Ontology

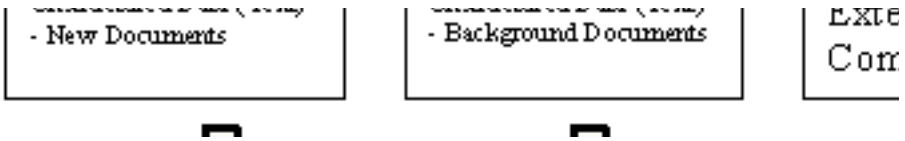
In the case when ontology contains concept hierarchy, that information can be used in the annotation process of a document. Let us assume that "CASS organization" is recorded in the ontology as a sub-concept of "organization." Then the process of annotation can include this information as shown in Fig. 10.

In our example, the concept "organization" has the property *hierarchy* with the value "super-concept" indicating that "CASS organization" is recorded in ontology as a sub-concept of "organization."

Figure 9. Annotations of compound concepts

```
1.  Our
2.  <concept name="CASS organization" type=" compound "  source= " text ">
3.          < concept name="CASS"  type="simple"  source=" text"> > CASS </concept>
4.          < concept name=" organization"  type="simple" source= " ontology " >organization </concept></concept>
```

Figure 10. Annotations of concept hierarchy



4.4 Annotation of Concept Hierarchy Using Statistical Computation

If an ontology with concept hierarchy is available, then concept hierarchies in documents can be identified and matched with ontology concept hierarchy. The problem is that many hierarchies in the document can be very complicated and they are only partially reflected in the ontology. There are different methods to deal with this problem. One method is to use syntactical text recognition by applying Parts of Speech (POS) analysis. If the document is written using strictly grammatical use POS analysis can be very helpful. In the document, however, that is not well structured, there may be an excessive number of modifiers since the parser could mistakenly cluster some other words together. In any case, POS can give us only some guidance but not precise results. Therefore, statistical computation (quantitative analysis) is required to obtain the relevant hierarchies. Typically, such annotation process is based on elimination rather than expansion. Statistically supported collocations are investigated as they serve the purpose of eliminating some irrelevant noun modifiers. In our case, for example, the modifier "our" is eliminated but the modifier "main" is included in the concept hierarchy as shown in Fig. 11.

4.5 Annotation of Relationships Based on Ontology

If an ontology with concept relationships is available, then the relationships can be identified and matched with ontology relationships. This process can be improved if a phrase structure parser is also available. Structure rules can refer directly to concept annotations. Let us discuss one of the rules: if the verb is 'is,' 'are,' etc., then name is 'is_a'; if the verb is 'announces,' 'has introduced,' etc. then name = 'has'; if it is 'includes,' exhibits,', etc., then type = 'capability,' and so on. In our example the verb 'are' is classified as 'is_a' type.

A relationship in the document can relate to the ontology in numerous ways giving several patterns for relationship identification. These patterns correspond to different sets of matching rules. There are many of these patterns. Let us discuss some of them. The first pattern is when the exact relationship type and concepts already exist in the ontology. For our example, the first pattern would be applicable if the relationship "disease rate ***is_a*** main study" exists in ontology. Another pattern would identify relationship type in the document if only one concept of relationship type can be matched.

4.6 Annotation of Relationships Based on Statistical Computations

There are many relationships used in different contexts and, therefore, the strict ontology structure may not be sufficient to retrieve the relevant relationships. The statistical matching rules can be used in such situations. If the statistical rule indicates a close association of concepts, then the relationship between the concepts is identified and annotated as generic "association" as shown in Fig. 13.

5. PULL FUNCTION

It is important to notice that our system allows the user to get the information directly without referring to any text. Practically, it means that we have several modes for results: text referring results and data returning results. The latter mode works like data retrieval in a database system. The user can specify a concept or a concept with relationships. Our system can return several types of results: text, text fragment(s) containing the concept or frequency of occurrence of the concept in the text.

Figure 11. Another example of annotations of concept hierarchy

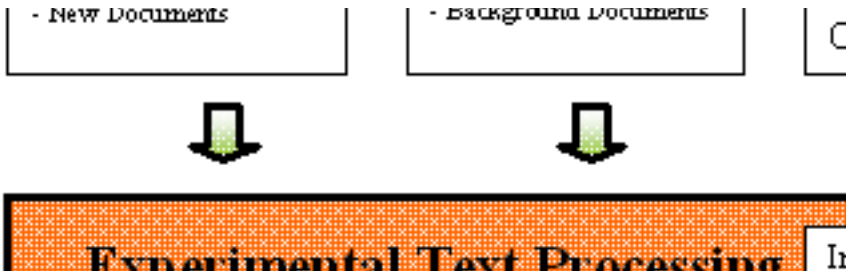


Figure 12. Annotation of relationships

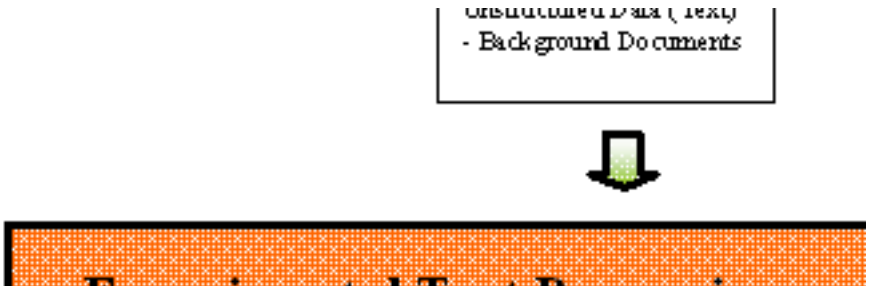


Figure 13. Document with relationships annotated

1. **Our**
2. <concept name="CASS organization" type=" compound " source= " ontology ">
3. < concept name="CASS" type="simple" source=" text"> > **CASS** </concept>
4. < concept name=" organization" type="simple" source= " ontology " hierarchy=" super-concept" >**Organization** </concept></concept>
5. < relationship name="association" type="simple" source="text" > **is involved in a variety of** </ relationship>
6. < concept name="study" source="ontology" type="simple"" source= " ontology " > **studies** </concept>
7. **.**

5.1 Keyword Search

Most of the existing text retrieval system have this feature implemented. Here the queries are based on simple keywords or any logical combinations using OR, AND, and NOT operators. Typically the documents are ranked based on these keywords and the most relevant documents are returned. Some text processing system also contain a text mining module that can cluster documents based on concepts.

5.2 Queries Involving Concept Hierarchy and Concept Relationships

Concept hierarchy and relationship annotations allow the user to issue specific data queries e.g. "Give me the names for the projects done by CASS" for a set of documents. For our example, the result would be "disease rates". A document fragment also could be displayed to show this information. Some statistical ranking and clustering can be improved when text is annotated with concept hierarchies and relationships.

6. PUSH FUNCTION

After the new document is processed, there are three types of information that can be "pushed" by the system: (a) "new document is consistent with background document," (b) "new document is inconsistent with background document," or (c) "new document is disjointed with the background document".

For the military medical documents, the most important situation is to identify the case when "new document is inconsistent with background document." Therefore, our experimental system should trigger some action, in this case, e.g.: alert subject matter expert, about the situation who make the makes the final decision such as review and updates the background document. For other business applications, when "new document disjoint with the background document," it may also be important to trigger some action.

The push function requires comparison of documents: the new document with background documents. The background documents indirectly provide the list of concepts of interest. There are many levels of operation for the Push module. At the first level, it compares concepts. This is very similar to the pull function operated at the simplest mode.

6.1 Push Function Based on Concepts

There are many levels of operation for the Push module. At the first level, it compares concepts. This is very similar to the pull function operated at the simplest mode. In this case, our system returns several types of results, e.g. pairs of text fragment(s) containing the same concept or pairs of frequencies of occurrence of the concept in the new and background text. It is possible to add keyword restriction if necessary. There is a need to experiment with the system and to tune it to satisfy the requirements. For example, it is possible by specifying the general constraints between concept frequency matrices (including collocated concept matrices). In general, however, that level may be appropriate to find disjointed documents but may be insufficient for "similar" documents. It typically would cluster together both "consistent" and "inconsistent" documents. Therefore, for our purpose, we need to include concept hierarchy and/or relationships in document comparison.

6.2 Push Function Based on Hierarchies and Relationships

Let us consider the following document fragment as a new document.

Battle injury (BI) rates are the main topic of CASS studies.

Figure 14. Pull and push module

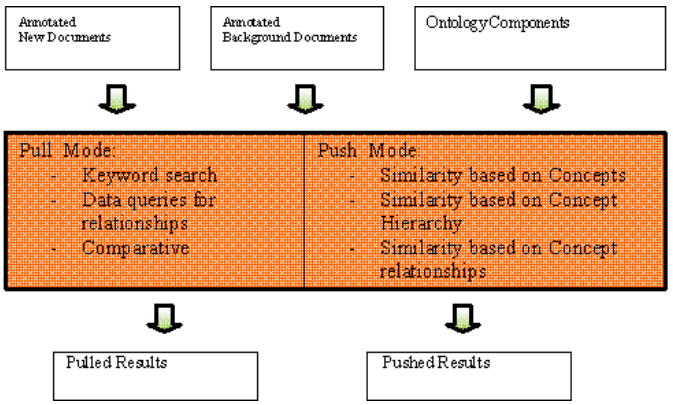


Figure 15. New document with concepts and relationships annotated

1. < concept name=" BI rate" type="compound" source="text" >
2. < concept name="BI" " type="compound" source="text" >
3. < concept name=" battle" " type="simple" source="text" > **Battle** </concept>
4. < concept name=" injury" " type="simple" source="ontology" " hierarchy=" super-concept" > **injury** </concept> **(BI)** </concept>
5. < concept name=" rate" " type="simple" source="ontology" " hierarchy=" super-concept" > **rates** </concept></concept>
6. < relationship name="association" type="simple" source="text" > **are the main topic of** </ relationship>
7. <concept name="CASS study" type=" compound " source= " ontology ">
8. < concept name="CASS" type="simple" source=" text"> > **CASS** </concept>
9. < concept name=" study" type="simple" source= " ontology " hierarchy=" super-concept" > **studies** </concept></concept>**.**

Let us also assume that the previous text fragment given in Section 4.1 constitutes the background document. The provided above new document fragment can be processed by Text Annotation Module resulting in the document annotations as shown in Fig. 15.

Comparison of the concept hierarchies in new and background document would reveal the semantic differences much more precisely. We can automatically discover inconsistencies between the background information that claims that "CASS main study is disease rates" and the new document that claims that "CASS main study is battle injury rate" (please note the role of word *main* in the analysis).

There are many parameters that can be specified for hierarchy comparison functions that are used in the Push Module. For example, a comparison function can take into account the inheritance of relationships, e.g. if the background document contains "CASS main study is injury rates," then the new document "CASS main study is battle injury rates," would be accepted as "consistent" with the background document. The same comparison function can perform matching at various hierarchy levels.

In addition, hierarchy comparison functions or relationship comparison function can use equivalence transformation between "is_a" relationship and "super-concept."

In general, the use of a combination of matching functions may be required. Then we either need to define their priority, or establish some global measure of "inconsistency" based on measures of individual functions.

7. SUMMARY

The goal of this project is to provide an experimental processing system for unstructured data in the dynamically changing environment of new and background documents. The project allows for automatic generation of XML annotations and their use in retrieval systems. Our approach in this project is to use a combination of qualitative and quantitative technique of identification of basic concepts and relationships with respect to the domain of interest represented by a well established ontology. The immediate use of these techniques are for pull and push business functions.

NOTE

The views expressed in this article are those of the authors and do not reflect the views of the Army Medical Department, Department of the Army, or Department of Defense.

REFERENCES

[1] AltaVista Search Engine, http://www.altavista.com

[2] R. Bayardo et al. InfoSleuth: Agent-based Semantic Integration of Information in Open and Dynamic Environments. *In Proceedings of the ACM SIGMOD*, pages 195-206. ACM Press, 6 1997.

[3] E. Brill. Transformation-based Error-driven Learning and Natural Language Processing: A Case Study in Part-of-Speech Tagging. *Computational Linguistics*, vol. 21 pages 543-565, 1995

[4] B. D. Czejdo, and C. Sobaniec. Using a Semantic Model and XML for Document Annotation. To appear in *Proceedings of IEA/AIE-2000, Lecture Notes in Computer Science*, Springer-Verlag, 2000.

[5] J. Dinsmore. Layout, A Road Map for Information Extraction. Technical Report INSL-094-00, MCC, 1999

[6] J. Dinsmore. The Next Generation of Information Extractors. Technical Report SRI-068-99, MCC, 1999

[7] C. H. Hwang. Incompletely and Imprecisely Speaking: Using Dynamic Ontologies for Representing and Retrieving Information. Technical Report INSL-043-99, MCC, 1999

[8] Y. Labrou and T. Finin. Yahoo! As an Ontology – Using Yahoo! Categories to Describe Documents. *In Processing of CIKM*, pages 180-187, Kansas City MO 1999

[9] L. Liu et al. An XML-based Wrapper Generator for Web Information Extraction. *In Proceeding ACM SIGMOD*, pages 540-543. Philadelphia PA, 1999

[10] D. Mattox, L. Seligman, and K. Smith. Rapper: A Wrapper Generator with Linguistic Knowledge. *In Proceeding of WIDM*, pages 6-11. Kansas City MO, 1999

[11] M. Nodine et al. Active Information Gathering in InfoSleuth. *International Journal of Cooperative Information Systems*, 5(1/2), 2000

[12] World Wide Web Consortium, XML Home Page, http://www.w3.org/XML

[13] Yahoo, http://www.yahoo.com

The Experiential Marketing on Blogs

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ABSTRACT

There has been a revolution in marketing, especially using new media, such as blogs. The purpose of this study is to determine how different types of information on the Internet can affect customers' motivation to take a vacation in a particular place. The analysis suggests that information provided in blogs can help customers experience a feeling about a particular place and influence their choice of vacation. The analysis also confirms two moderating relationships: (1) customers who browse travel information from blogs will have stronger purchase intentions than if they browse information about travel packages provide by tour operators; and (2) customers who browse travel information in blogs experience stronger feelings than if they browse information in travel packages.

1. INTRODUCTION

E-commerce web-site owners hope customers will become locked into on-line shopping malls [1][4]. Unfortunately, they do not really understand customers' needs, especially psychological factors, like their feelings, thoughts, and senses, or how customers choose an unfamiliar product or service. Traditional marketing research assumes that a consumer acts as a rational decision-maker. According to this concept, if consumers buy products or services from suppliers, they focus on the products' functions and effects that maximize their value. E-commerce researchers also follow this assumption, and their research results suggest that the owners of web sites should provide many kinds of products and services for customers.

The 1998-2000 marketing research priorities of the Marketing Science Institute set the goal of understanding customer experience as one of two important research topics [32]. Reber [22] defines experience, as any feelings that people have while they encounter events and activities in their daily lives. Holbrook & Hirschman [19] consider consumption as a primarily subjective state of consciousness with various symbolic meanings, hedonic responses, and esthetic criteria. Consumption experience, for example, could be behavior like pursuing fantasies and feelings and having fun. Experience is considered as a service and companies can create or even customize experiences to meet customers' individual needs. Although many studies in the literature focus on the real world, few focus on the virtual world.

In the list of 2006~2008 marketing research priorities [31], measurement of the impact of new media is one of top tier topics. A blog is the most famous new medium on the Web. Clyde [10] defines a blog as a web page that has brief and chronologically arranged items of information. Since a blog often combines text, photographs, videos and/or audio, and links to other blogs, it is a fluid and dynamic medium. Vuorinen [27] lists five features of a blog: it is written fairly frequently; it is free form and brief; it follows a reverse-chronological order; it is personal; and it links to other blogs. To date, very little research has been conducted on blogs. In fact, most of the literature consists of reports and essays on concepts and user behavior, and does not address the use of blogs for business purposes.

Schmitt [26] suggested that there has been a revolution in marketing, which he calls experiential marketing. According to Schmitt, we must change our deeply ingrained marketing ideas in favor of providing valuable experiences for customers. Experiential Marketing can satisfy customers' needs and desires and encourage them to become immersed in on-line shopping malls.

Can a blog be for an experiential web application? According to Gartner Research's [30] report about blog users' behavior, 52% of users are able to express themselves creatively, 37% can document personal experiences or share them with others, and 29% can motivate other people to action. Thus, a blog can be as an experiential application.

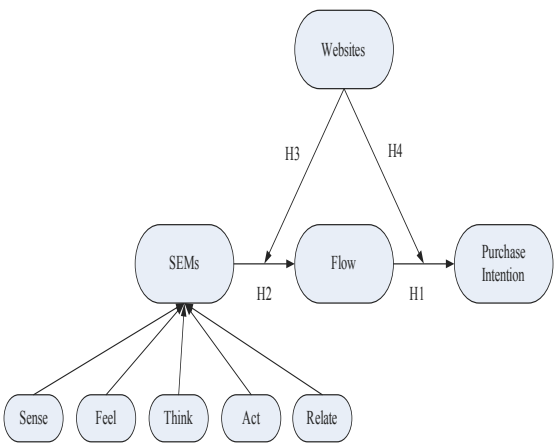
The blog has become an important experience for users for two reasons. First, an increasing number of people are writing blogs [24]. The Hong Kong Blogger Survey Report [18] found that bloggers want to express and even share their feelings and creativeness, so blogs are rich in content. Second, since blogs allow users to explain their feelings willingly and freely, people are attracted to this new medium.

In this paper, our purpose to investigate how blogs can be used as experiential web applications. We select two travel web sites: Realtravel in the U.S and ezTravel in Taiwan. The main difference between the web sites is that Realtravel has a lot of travel blogs written by tourists, whereas ezTravel only provides on-line ticketing and travel packages.

2. CONCEPTUAL FRAMEWORK AND HYPOTHESIS DEVELOPMENT

Based on experiential marketing and consumer behavior literature, we develop a conceptual framework of experiential marketing, as shown in Figure 1. We believe

Figure 1. Our research model



that consumer purchase intentions with respect to travel services are guided by a flow experience, such that users become immersed in playfulness and involvement, which triggers a new exploratory experience [17].

2.1. Flow Theory

According to Flow Theory, flow is a process of optimal experiences that are intrinsically enjoyable [11][7]. Flow is a temporary and subjective experience, and it is also the reason that people want to participate in particular activities [11].

Webster et al.'s [28] study of human-computer interaction established that flow is a subjective experience of human-computer interaction that is characterized by playfulness and exploratory behavior. When people interact with computers, they feel playful and involved, which triggers a new exploratory experience for them.

Hoffman & Novak [17] proposed a model of network navigation for hypermedia that involves two kinds of browsing experience: goal-directed behavior and experiential behavior. When users' behavior is goal-directed, they have a specific goal and make an optimal decision about browsing for information. On the other hand, when users' behavior is experiential, they focus on processes, not on a specific goal. According to Hoffman & Novak's model, four consequences flow from network navigation, namely, increased learning, increased perceived behavioral control, increased exploratory and participatory behavior, and positive subjective experiences. Hoffman & Novak also posited that increased exploration can derive better information, especially when making purchasing decisions. We believe that the same concept can be applied to the use of blogs because they motivate people to search for more information. Thus, we propose the following hypothesis:

H1: Flow experiences positively influence purchase intentions.

2.2. Experiential Marketing

Pine and Gilmore [25] advanced the concept of experience economy, and divided the progression of economic value into four stages: commodities, goods, services, and experience. Experience economy means that enterprises must regard service as a stage and create an attractive consumption situation that immerses the consumer in a consumption experience. Traditional marketing and business concepts offer hardly any guidance on how to capitalize on the emerging experiential economy, because such concepts were developed in response to the industrial age, not today's information, branding, and communications revolution [26].

Schmitt [26] takes issue with the features and benefits approach of traditional marketing. In the traditional model, consumers are thought to go through a considered decision-making process, where each feature or characteristic of a particular product or service is seen to convey certain benefits, and these are all assessed by the potential purchaser (either consciously or unconsciously). However, for Schmitt, this is far too limited a way of viewing purchase decisions, with its excessive emphasis on the rational and logical elements of the decision, and not enough (or any) on the emotional and irrational aspects involved in the purchase. The alternative framework that Schmitt proposes is based on two elements: strategic experience modules (SEMs), which are different types of experiences, and ExPros (short for experience producers), which are the various agencies that deliver these experiences. Experiential marketing is the discipline of creating products and services that consider all elements of this framework.

Since blogs aggregate people who have similar interests, blogging portals give readers the opportunity to interact with other bloggers [27]. Schmitt [26] identifies five different types of experience, which we use to describe the features of blogging behavior. Here, we briefly consider Schmitt's five SEMs in terms of blogging.

(1) SENSE: Sense experiences help motivate potential consumers and immediately creating a sense of value in their minds. In addition to the sense of sight aroused by travel pictures, bloggers can also set regional music to touch off the readers' sense of hearing.
(2) FEEL: When trying to influence the purchase intentions of consumers, their feelings toward a product should not be ignored. By considering the abundant pictures usually shown in travel blogs and the accompanying literary compositions, it is possible to understand the feelings of the travelers more easily.
(3) THINK: Thinking experiences can persuade consumers to engage in creative thinking, which may prompt them to re-evaluate a product. The mechanisms of blogs, such as blog scroll, backtracking, and comments, help users search for more innovative and diversified travel information outside their own small, closed social network [13][14][5].
(4) ACT: Active experiences focus on changing the long-term behavior and habits of consumers toward a particular product. When influenced by other bloggers' travel ideas, an individual may decide he/she wants to travel to the same place.
(5) RELATE: People tend to relate to a broader social or cultural context. In reality, social ties in blogs are shown by hyperlinks, which can help an individual get in touch with numerous travelers and join an extensive community of like-minded people who are interested in traveling.

Furthermore, Hoffman & Novak [17] suggested that focused attention is one of the four primary antecedents that motivate users so that the flow experience can occur. Schmitt's five types of experience can motivate users to focus their attention. Therefore, we advance the following hypothesis:

H2: The experiences defined by Schmitt's SEMs positively influence flow experiences.

2.3. The Difference Between Travel Websites

We consider two travel websites, Realtravel and ezTravel. Realtravel is actually a blog website that provides information to people who wish to travel, so people can compose some travel journals, share experiences, communicate via blogs with people who have common interests all over the world, and even form a community. On the strength of tourist blogs in Realtravel, people can search for more information about traveling, including the descriptions of places and photographs. In addition, Realtravel offers information about tickets, hotels, and transportation so that a consumer can arrange a trip that correlates with a blog immediately.

EzTravel is the leading on-line travel service provider in Taiwan with 1.7 million members. The company offers package trips, including group trips, backpacker trips, and train, bus and flight bookings. Consumers can just browse the webpage of EzTravel when they want to plan a trip.

It is claimed that the presentation format of information display boards affects decision-making [6][23]. A recent study by Widing and Talarzyk [29] tested these theories in the on-line environment. The results support their hypotheses that the information display capabilities of these new services alter users' decision-making processes. Given this conclusion, we put forward the following hypotheses:

H3: The relationship between Schmitt's SEMs and flow experience is stronger in travel blogs than in travel packages.

H4: The relationship between flow experience and purchase intention is stronger in travel blogs than in travel packages.

3. METHODOLOGY

We designed our study to gather information about two kinds of travel decisions. Our focus is on students who want to arrange a package for their graduation trip. In this section, we describe sample and data collection, and instrument development.

3.1. Sample & Data Collection

The study was conducted at a large public university in Taiwan. Students of two classes volunteered to choose a journey for their graduation trip. They chose a trip to Phuket, and browsed for information about the trip in two ways: one was a travel package provided by ezTravel and the other was Realtravel, which contained blogs provided by people who had traveled to Phuket. To avoid browsing bias, we provided three travel blogs and one trip, which were selected by six graduate students. After the students had browsed the travel websites, they answered two questionnaires on the differences between the two travel website providers. A total of 52 surveys were distributed, and we received 50 useable responses (96 percent).

3.2. Variable Measurement

The dependent variable of intention to purchase has been employed in previous TAM research (e.g., [12]) and in marketing studies of user behavior (e.g., [3]).

Each experience under Schmitt's SEMs was developed and validated as part of this research. Schmitt's five experiential activities were consistent with perceived intrinsic motivation [26]. We adopt the Flow scale developed by Luna et al. [20] and Hoffman & Novak [17]. To ensure that the English and Chinese versions of the questionnaires were consistent in meaning, all the scales used in this study were examined by experts to ensure that the items were comprehensible and unambivalent to Chinese respondents. The respondents assessed all the items via a 7-point scale ranging from strongly disagree to strongly agree.

4. DATA ANALYSIS AND RESULTS

We used PLS (partial least squares), which is considered an appropriate analytical approach, to (1) model latent constructs as either formative or reflective, and (2) assess the psychometric properties of the constructs (the measurement model) within a theoretical context (the structural model) [21]. Unlike other structural equation modeling techniques, PLS uses a relatively lean sample size to validate a model [8][9]. A sample size of 30 would be a reasonable starting point for the three-construct model [9]. Following Anderson and Gerbing [2] and Hair et al. [16], the models were tested with a two-stage structural equation model. First, we conducted Confirmatory Factor Analysis (CFA) to assess the constructs' validity in terms of convergent and discriminant validity. Second, we performed structural equation model analysis to test the research hypotheses empirically.

4.1. Measurement Model

The model contains one second-order variable (SEMs). We also created a second-order construct using the factor scores from the first-order construct.

With respect to the quality of the measurement model for the full sample, three types of validity were assessed: content validity, convergent validity, and discriminant validity. We assessed the convergent validity by examining the average variance extracted (AVE), since each construct has an AVE of at least 0.7 [8]. Finally, we verified the discriminant validity by examining the value of the square root of the AVE to determine whether it was consistently greater than the off-diagonal correlations [15]. As shown in Table 1, the composite reliability values range from 0.928 to 0.972, which are above the acceptability value; the average variance extracted by our measure ranges from 0.722 to 0.896, which is also above the acceptability value of convergent validity; and the square root of the average variance extracted for each construct is greater than the off-diagonal correlations. All our multi-item constructs meet these criteria, thus confirming the constructs' validity.

4.2. Assessing the Structural Model

To test the moderating effect of the type of travel website, we used three structural models in the PLS-Graph: the full sample, the sub-sample of the Realtravel website, and the sup-sample of the ezTravel website. We also tested for differences between all three models by using a bootstrapping technique to derive the path estimates and t-value, which were used to test the hypotheses. The results of the structural model test are shown in Table 2.

Hypothesis 1 suggests that flow experiences positively influence purchase intention. From the structural equation modeling results and standardized path coefficient (SPC) of 0.67 ($p < 0.001$), this contention is strongly supported. Our analysis of the results also shows that SEMs positively influence flow experience (SPC = 0.734, $p<0.001$), providing support for H2. Hypotheses 3 and 4 propose that travel blogs and travel packages moderate the relationship between flow experience and purchase intention and between SEMs and flow experience. The result shows that the standardized path coefficient of the Realtravel website is greater than that of the ezTravel website, thus proving that proving that travel blogs can strengthen the intention to purchase.

5. DISCUSSION AND CONCLUSION

The objectives of the study are twofold: (1) to verify that customers' experiences strengthen purchase intentions; and (2) to examine two types of travel website to determine how they affect users' purchase intentions.

Our results suggest that users who obtain information about travel packages from blogs may have positive experiences so that they become immersed in the flow scenario. This results in increased purchase intentions, no matter whether the sample is a full sample or one of the two sub-samples, which is the same as the result based on information search theory. In the travel industry, travel websites should provide more information and combine more types of media about trips, which would increase customers' intention to purchase.

The analysis also confirms two moderating relationships: (1) customers who browse travel information in blogs will have stronger purchase intentions than if they browse travel packages provided by tour operator; and (2) customers who browse travel information in blogs have deeper experiences than those who browse travel packages. Therefore, customers who browse information in blogs have more experiences and stronger purchase intentions.

Our study has two potential limitations. First, the sampling was limited to students of an undergraduate class. Hence, there exists the possibility of sampling bias. Second, the sample sizes were about 50, which may be considered small; however, as noted earlier, PLS uses a sample size of 30 as a reasonable starting point [9].

In summary, blogs represent a fundamentally different on-line environment for marketing activities compared to travel package websites. The results of this study suggests that consumers can obtain richer information from blogs. The opportunity for customers to browse for information on the Internet can be realized in numerous ways and website owners should therefore provide new media to lock in their customers.

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REFERENCES

y1 z Allen, N. J., & Meyer, J. P. (1990). The measurement and antecedents of affective, continuance and normative commitment to the organization. *Journal of Occupational Psychology*, 63, 1–18.

y2 z Anderson, J. C., and Gerbing, D.W. (1988). Structural equation modeling in practice: A review and recommended two-step approach. *Psychological Bulletin*, 103, 411–423.

y3 z Bansal, H. S., Irving, P. G., & Taylor, S. F. (2004). A three-component model of customer commitment to service providers. *Journal of the Academy of Marketing Science*, 32, 234–250.

y4 z Bendapudi, N., & Berry, L. L. (1997). Customers' motivations for maintaining relationships with service providers. *Journal of Retailing*, 73, 15–37.

y5 z Brady, M. (2005). Blogging: personal participation in public knowledge building on the web. From http://www.essex.ac.uk/chimera/content/pubs/wps/CWP-2005-02-Blogging-in-the-Knowledge-Society-MB.pdf.

y6 z Brucks, M. (1985). The Effects of Product Class Knowledge on Information Search Behavior. *Journal of Consumer Research,* 12, 1-16.

y7 z Chen, H., Wigand, T. R., & Nilan, S. M. (1999). Optimal experience of web activities. *Computers in Human Behavior*, 15(5), 585-608.

y8 z Chin, W. W. (1998). The Partial Least Squares Approach to Structural Equation Modeling. in *Modern Methods for Business Research*, G. A. Marcoulides (Ed.), Lawrence Erlbaum, Mahway, NJ, 295-336.

y9 z Chin W. W., Marcolin Barbara L., & Newsted Peter R. (2003). A Partial Least Squares Latent Variable Modeling Approach for Measuring Interaction Effects: Results from a Monte Carlo Simulation Study and an Electronic-Mail Emotion/ Adoption Study. *Information Systems Research,* 14(2), 189-217.

y10 z Clyde A. (2002). Shall We Blog?. *Teacher Librarian* H.W. Wilson - EDUC , 30(1), 44-47.

y11 z Csikszentmihalyi, M. (1990). *Flow: The psychology of optimal experience,* New York: Harper Collins.

y12 z Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly*, 13(3), 319-339.

y13 z Efimova, L. (2004). Discovering the iceberg of knowledge work: A weblog case. from https://doc.telin.nl/dscgi/ds.py/Get/File-34786/OKLC_Efimova.pdf.

y14 z Efimova, L., Hendrick, S., & Anjewierden, A. (2005). Finding the life between buildings: An approach for defining a weblog community from http://staff.science.uva.nl/~anjo/aoir_2005.pdf.

y15 z Fornell, C. & Larcker D. F. (1981). Evaluating Structural Equation Models with Unobservable Variables and Measurement Error. *Journal of Marketing Research* 18, 39-50.

y16 z Hair, Joseph F., Anderson Rolph E., Tatham Ronald L. & Black William C. (1998). *Multivariate Data Analysis*, 5th ed. Upper Saddle River, New Jersey: Prentice-Hall, Inc..

y17 z Hoffman Donna L. & Novak Thomas P. (1996). Marketing in Hypermedia Computer-Mediated Environments: conceptual foundations. *Journal of Marketing*, 60, 50-68.

y18 z Hong Kong Blogger Survey Report, http://blog-you.com/?survey

y19 z Holbrook, Morris B. & Hirschman, Elizabeth C. (1982). The Experiential Aspects of Consumption: Consumer Fantasies, Feelings, and Fun. *Journal of consumer Research*, 9(2), 132-141.

y20 z Luna David, Peracchio Laura A., & Juan Maria D de. (2002). Cross-cultural and cognitive aspects of Web site navigation. *Academy of Marketing Science*, 30(4), 2002, 397-410.

y21 z Patnayakuni Ravi, Cynthia P Ruppel, & Arun Rai. (2006). Managing the Complementarity of Knowledge Integration and Process Formalization for Systems Development Performance. *Journal of the Association for Information Systems*, 7(8), 545-567.

y22 z Reber, Arthur S. (1985). *The Penguin Dictionary of Psychology*, Harmondsworth, Middlesex, England; New York: Penguin Books.

y23 z Petty, Richard E., Unnava, Rao, & Strathman, Alan. (1991). *Theories of Attitude Change in Handbook of Consumer Behavior*, Thomas S. Robertson and Harold H. Kassarbab, eds., Prentice-Hall, Engle-wood Chiffs, NJ.

y24 z Pew Research Center, http://www.pewinternet.org/

y25 z Pine, B. Joseph, & Glimore, James H. (1998). Welcome to the experience economy. *Harvard Business Review,* 76(4), 97-105.

y26 z Schmitt, B. H. (1999). *Experiential Marketing: how to get customers to sense, feel, think, act, and relate to your company and brand*, The Free Press, New York.

y27 z Vuorinen, Kimmo. (2005) *Using weblogs for discussion*, University Interactive Technology Master's Thesis.

y28 z Webster, J., Trevino, K. L., & Ryan, L. (1993). The dimensionality and correlates of flow in human-computer interactions. *Computers in Human Behavior*, 9(4), 411-426.

y29 z Widing II, Robert E., & Talarzyk, W. Wayne. (1993). Electronic Information Systems for Consumers: An Evaluation of Computer-Assisted Formats in Multiple Decision Environments. *Journal of Marketing Research*, 125-141.

y30 z http://www.gartner.com/

y31 z http://www.msi.org/msi/rp0608.cfm

y32 z http://www.msi.org/msi/rp-djr.cfm

y33 z www.eztravel.com.tw

y34 z www.realtravel.com

(IT) Management in the Organization of the Developing Countries

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1. ABSTRACT

At the present century (IT) plays major role in the international development programs. Those countries which have been well educated or specialized in this subject have taken the best advantage in every aspect of today's human kind activities. Information is the lifeblood of any system. It is the essential ingredient for a successful business. if the resources of the information are not reliable or the mismanagement of the technological information exists in the organization, it is clear that the destructive decisions will lead the organization towards the bankruptcy or dark end .in most of the developing countries the organizational activities are not goal oriented and communication system, and also circulation of the information are not well organized. In this paper difficulties encountered whit the management of (IT) in the developing countries are discussed and for effective use of (IT) in this countries constructive suggestions are made.

Keywords: Management – Technology – E. Collaboration – Development.

2. (IT) STRATEGY IN DEVELOPING COUNTRIES:

At the present time it can be noticed that, from telecommunications to super computers, from semiconductors to multimedia technology is probably the single most important factor driving the evolution global competition. Where are developing countries in this global market? The debate about the competitive need of these countries technological growth – and local government's role in improving it is increasingly becoming the focus of the debate of formulating technology policy. This debate centers on the question of whether government can or should play an active role in stimulating commercial technological innovation. For example in Iran at a time when companies are steadily gaining ground in the industrial sector because of the privatization and the formation of the capital market , government support for R&D on critical technologies is absolutely essential . However , not by owning and controlling the industry but by being an active partner with the private sector , linking industry with universities , by providing generous funding of basic research at universities and major investment on the part of related ministries such as heavy industry , oil , and energy in technology development . Critics may counter – argue that however painful the formation of private industry and loss of business might be any government remedy would be worth than the disease. There is the question of whether, on general developing countries need technology policy? If so, what is the role of local governments in shaping this policy and what are the appropriate domestic technologies for these countries for producing? Learning from other countries like Japan, U.S, and Singapore in forming their technologies is the matter which could be focused upon it.

3. HOW THE PROGRESS SHOULD BE MADE?

In order to have a society capable of growth, there are other issues to be resolved. If one believes that the foundation of society have been established for growth, then the next question becomes who makes progress happens? Is it people or government, or, combination of both? Is it external forces or is it the internal need of a country that makes progress happens. If we consider, the U.S. and Singapore, one could ask, what was the role of people in making these countries the way they are presently? For example In the case of Iran as a developing country, also Iranian government, by virtue of its nature which is Islamic, has been making efforts to create an atmosphere for progress. Nevertheless, in many areas, the progress is not adequate to create an environment that promotes citizens to participate in building the country to its potential. Perhaps a fundamental question is how the government can integrate the power people and the institutional systems that bring civil justice and at the same time provide principles for growth. Many Arab countries are moving in this direction.

Much as they fear the fundamentalists, the Arab governments are still under pressure to reform. They know that they have to manage the process carefully, but they can not stop it. The challenge for the governments, there fore, is to maintain some momentum towards greater freedom and democracy, enough to give their people a feeling of gradual improvement. (1)

Iran is also moving toward democracy. However the collaboration between government and the people is not enough. There fore, the next step is to integrate efforts of the government and the people conceivably, another major revelation in Iranian thinking is quintessential to take the country many steps farther than where it presently is.

This revelation lays on collaboration between people and government. A type of magical unity that a nation craves to take that quantum leap in terms of progress

Looking to this subject from different angles, reveals that, what need the nation of a developing country to achieve in order to create the condition for technology policy to mold itself in a meaningful direction? However , in general if there is infrastructure for progress and the society share justice , people and government are flexible , then the governments of developing countries can look at people as it resources not as an adversarial camp that requires support on a constant basis. In the case of Iran, majority of people look at their government as source of their income. However, if these vision changes, which means, Iranians become skilled resources for their government or their country, then Iranian government can focus on creating technology policy, however, before technology policy can succeed, the privatization of major industry has to be completed. The reason is because government can not be in direct competition with citizens. The first step towards allowing a government of facilitate growth is to privatize. However, privatization is not without its problems. Some studies indicated that , the privatization and liberalization programs either failed outright in the so called market economics of Saudi Arabia and the United Arab Emirates or were blocked in the so called socialist countries of Syria , Libya , and Algeria through the concerted efforts of labor , party members , and bureaucrats (2) .

Considering that most of these issues are some what the same for Iran, then Iran presently is experiencing some the same problems shared with its Arab neighbor. There has been no study about the process of privatization conducted in Iran yet. There fore, many of the questions can not be answered yet. Under the privatization plan of the Islamic republic of Iran, a number of companies have been privatized.

Iran has suffered tremendously for lack of an infrastructure. As a nation, Iranians have to think twice when they demand modernization, state of the art technologies, and the latest and greatest of the western products. They have to stop and think about what makes them deserve to have the best but contribute very little in building their country. There fore, once they become honest in their thinking, then as a nation, thinking about how to build the economy, is possible. So they have to participate in building the infrastructure and then will start to appreciate what it takes to have a technologically advanced country. The participation process takes times but if and only if this participation happens, the formation of a technology policy is possible (3).

4. (IT) MANAGEMENT IN THE ORGANIZATIONS OF THE DEVELOPING COUNTRIES:

Information technology is the fastest – growing industry in the world. In a way Iran has to absorb the technologies from other countries just like what Japan did after war II. In the process of strengthening ability to borrow and adapt U.S. technology, Japan has also created the intellectual talent to generate new technology on

its own. Iran and also other developing countries should focus on the absorption and application of existing ideas. The most important task currently facing the policy community is not how to create a new series of recommendations but how to systematically implement an existing set of ideas.

Because of the dynamics of technology fusion , established technologies in any industry constantly run the risk of being displaced by radically different technologies coming from outside . As a result, traditional distinctions between High – tech and Low – tech industries are fast disappearing. In effect, every business is, or should be, High – tech. Thinking in Global scale nations should create an international research and education network (IREN) that could expand internet to serve universities, governments, and industries. (IREN) could be important because it will greatly increase the capacity for collaboration by many geographically dispersed companies and institutions.

Now a days knowledge has proven so vital to organizational success that a new organizational form – knowledge based firms has emerged. With a slow down in the world economy, the bursting of the technology bubble and tighter budgets, the importance of leveraging existing knowledge and expertise has reached new highs. Knowledge management will remain in a critical success factor for organizations as the economy recovers. In most of the developing countries knowledge management is a critical issue and especial attention should be focused upon it. In the organizations there are formal knowledge and informal knowledge networks so management of both should be taken in to consideration. Effective use of information for economy and technological development is needed. For sustainable development and protection of environment and saving of our planet for future generations, transfer of knowledge, information and experience among all nations is an essential factor, which it should be considered seriously. In this paper especial attention has been focused on e-collaboration. Collaboration is a process by which individuals and/or groups work together on a practical endeavor. Collaborative work is a fundamental feature of organizations and is increasingly being supported by technology. The advent of (ICT) or information and communication technologies in network for nation and support has enabled collaboration to take place on a virtual dimension regardless of time and location. This form of working relationship through the electronic network is known as electronic collaboration. The development of these technological capabilities and e – collaboration initiatives is changing the way individuals and groups perform and interact. As well as the scope of traditional processes and work flow. E-collaboration offers an unprecedented way for organizations to share information and knowledge, and to better integrate business, work or learning processes.

For solving the existing problems of the developing countries and for the best management of (IT), for above mentioned reasons e-collaboration could be the right choice. If we believe that for the better future and comfort of all nations, we need to share in resources and technological achievements, in this case we have to help each other in order to achieve the mutual targets. Hence to achieve sustainable development, close cooperation between organizations in international scale is needed. It has been shown 4, 5, 6, 7, 8 due to the lack of proper circulation of scientific information between developed and developing countries accelerated depletion of energy resources and un repairable environmental damages have been occurred. It is believed that through e-collaboration and exchange of knowledge and technical achievements the human being can solve most of existing problems and create better life for future generations.

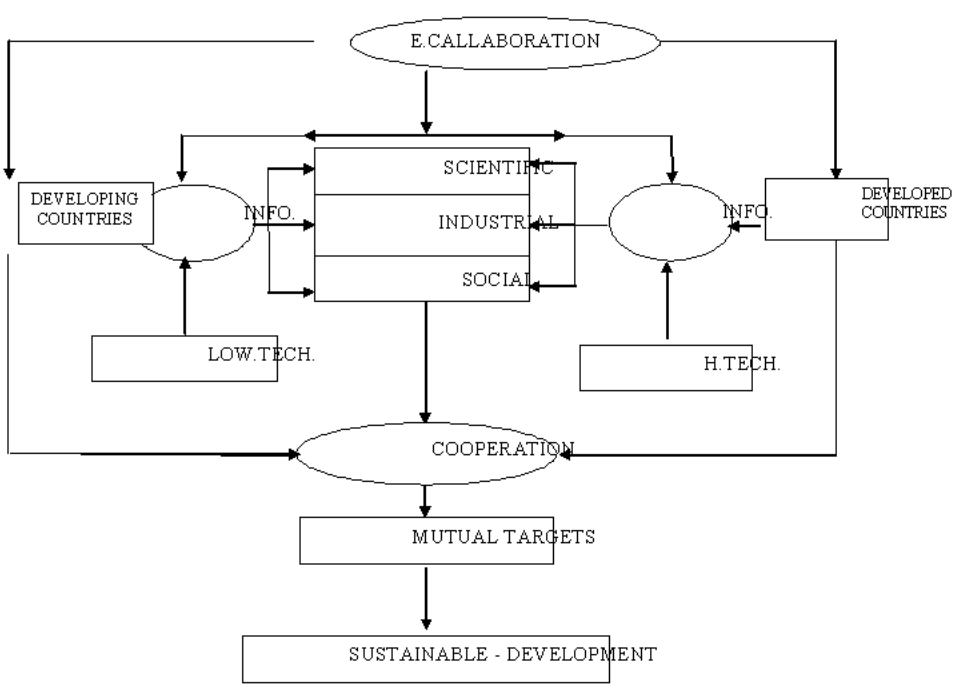
In Fig1with e-collaboration the High – tech and Low tech. information's flows in both directions from developed and undeveloped countries in different fields of scientific , industrial and social fields in order to exchange ideas, knowledge and experiences to solve existing problems and for gaining the mutual targets and benefits.

As could be seen from fig 1 the e – collaboration could have essential role in achieving targets which finally could end to the sustainable development.

5. CONCLUSIONS AND RECOMMENDATIONS:

- Information technology increasingly gaining importance in the world today. Information and Communications technologies are pervading all aspects of life at work, university, and home.
- In order to succeed in our complex world, a variety of people require (IT) education.
- Management of (IT) in developing countries is an essential factor which should be taken into consideration.
- For solving scientific, industrial and social problems of developing countries, e. collaboration could have major role which in Fig 1 has been shown.

Figure 1.



- In order to have better life for whole nations and to protect environment and planet for the future generations , the transfer of ideas , experience , knowledge in the, international scale is necessary and gaining benefit from (IT) in whole aspects should have the first priority .
- Paying especial attention to the international research and education network (IREN) is highly recommended.

6. REFERENCES

1) Michael field, Inside the Arab world, 1994, P. 272.
2) Kiren Aziz chaudhry , Economic liberalization in Oil – Exporting Countries: Iraq and Saudi Arabia. ED. Lliya , Harik and Denis. J. Sullivan, privatization and liberalization in the Middle East, 1992, pp 145 – 147.
3) Nateghian Faramarz , Prospect of Technology Policy for Iran ,(IT) Strategy .
4) R. M. Musayev , Problems of Energy Saving in Azerbaijan, sixth Baku International Congress Energy Ecology Economy 2002 P. 120.
5) I. S. Ahmadov , R . I. Khalilov, Ozone Depletion and Increased UV – B radiation, Six Baku International Congress, Energy, Ecology, Economy, 2002, P. 257.
6): M. G. Mamedov , D . B. Shirinova, E. M. Mamedov , A . F. Ahmedova, Sources of Atmospheric Pollution during Oil Production and Treatment, Six Baku International Congress Energy, Ecology Economy, 2002, P. 236 – 237.
7): M. Massarrat , Iran's Energy Policy Current Dilemmas and Perspective for a Sustainable Energy Policy, Iranian Journal of Energy vol. 9 / no. 22 May, 2005 P. 2 – 3.
8) Azim – Sahatimehr, Management Effects on Solving Energy Crisis, WREC- IX, Florence, Italy, 19-25 August 2006.

Modeling Organizational Competencies for Business Process Description and Alignment

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ABSTRACT

Business activities are performed by human or automated actors. For the organization to adapt to changes it must be able to understand how and why actors are related to and assigned to processes. This requires a consistent representation of the services required by the organization's processes and those provided by its actors. This paper focuses on defining the concepts that allow to structurally align human actors and business processes through the description of the organizational competencies required to perform processes' activities. These structures are used within a marketplace-based model, supporting the management of actors and activities according to the supply and demand of competencies.

1. INTRODUCTION

Competency-based management is becoming an object of growing interest as its importance is recognized from a strategic perspective. It aims leveraging the competitive advantage of knowledge-based organizations by observing individuals as strategic assets and explicitly integrating them into the organization's business strategy and processes. This approach has led to the development of several methods and systems (Woodruffe, 1993; Stone, 1995; Hamel & Prahalad, 1990; Fletcher, 1995).

Competency-based management provides individuals with a set of task definitions and objectives, linking organizational and personal objectives. It facilitates process analysis and standardization inside and outside the organization's boundaries, making recruitment and compensation systems fairer and more open. However, competency related information is prone to become obsolete due to organizational changes, so it can become expensive and time consuming to keep this information updated (Chartered Institute of Personnel and Development UK, 1995). Competency management support systems play a role in different organizational activities, such as expert finding, personnel recruitment and project management. These activities customarily involve human judgment to classify the skills held by workers, to evaluate the degree of competency and keeping up-to-date profiles. To facilitate the management of competencies and to minimize the subjectivity of human evaluation, several approaches put forward the use of information technologies to facilitate tasks such as contextualizing the communication between actors (Yimam, 2000), managing skills and activities within teams (Gronau & Uslar, 1994) and using groupware to support information sharing (Johansen et al, 1991).

Nevertheless, these solutions focus on supporting the operational phases of a business process and few assist the identification and selection of actors before the actual commitment to carry out its activities. This operational focus also means that skill management systems often do not relate the skill information pertaining to the actors to the activities' requirements as derived from the organization's process models. Consequently, information on the organization's competencies cannot be directly traced to its business processes. This hinders skill management from a process perspective and promotes the existence of mismatches within the enterprise architecture description.

This paper outlines a framework to overcome these issues by extending previous work on business process and actor modeling (Caetano, Zacarias, Rito Silva, & Tribolet, 2005; Neves, Caetano, Vasconcelos, & Tribolet, 2001; Spencer, Spencer, & Signe, 1993; Zacarias, Caetano, Pinto, & Tribolet, 2005) with a set of concepts that allow representing and evaluating actors and competencies in the context of a business process. The remainder of this paper is structured as follows: section 3 describes our proposal on competency modeling, section 4 describes how to integrate this model into an organization using the concept of competency marketplace and section 5 sets out the conclusions and describes future work.

2. RELATED WORK

Despite the research on competency-based management, representation of competencies is not fully addressed in nearly all business process modeling standards. IDEFØ (Scheer, 1999) is a method of modeling organizational decisions and activities through functions, inputs and outputs but it does not provide the means to represent how activities are performed by actors. BPMN (Business Process Management Initiative, 2004) is a notation that focuses on describing business process flows. Participation in a process is represented through swimlanes that relate activities to its performer, thus mapping responsibilities at a high level of abstraction. There is no means to specify the requirements an actor must fulfill to execute an activity. Other approaches, such as IDEF3 (Mayer et al, 1995) and RADs (Ould, 1995) focus on describing process flow but overlook the specification of actor competencies as well as activity requirements.

There is a large amount of research on competency modeling outside the scope of business process modeling. The "competency movement", credited to McClelland (1973), uses the concept of competency to classify human actors and to relate them with the ability of performing a task. Spencer (1993) defines competency as a characteristic of an individual that is causally related to effective and/or superior performance in a situation. *Underlying characteristic* means the competency is part of a person and can be used to deduce behavior, being part of what Davenport (1997) classifies as tacit knowledge. *Causally related* means that a competency causes or predicts behavior. *Criterion referenced* means it is possible to quantify the performance of a competency and implies a causal relation between purpose and result.

Defining the granularity of competency representation is equally important as a high-level representation will not provide enough information, while if it is too detailed, the entire representation process may become compromised, as it is effort and time-consuming (CIPD UK, 2005). Competencies are usually represented as hierarchical structures or competency trees. An example is the "body of knowledge", in which competencies are classified according to specific areas of knowledge, such as IEEE's Software Engineering Body of Knowledge (Abran & Moore, 2004). Lang and Pigneur (1999) also propose using a hierarchical structure to represent competencies since it simplifies processing when compared to the mining of textual descriptions. It is also easier for people to identify competencies, the expectations of the organization and possible gaps. Pigneur proposes four competency categories as starting points: Enabling Technologies, Field Experience, Knowledge and Personal Traits. However, the semantics associated with these hierarchies is static by design, relying on a specific functional domain classification to describe the competencies.

A pragmatic approach is found at CommOnCV (Harzallah & Lecrère, 2002), which models *curricula vitae* during the recruitment process. Competencies are represented as annotations derived from each *curriculum* and are represented using RDF (Brickley et al, 2000) or DAML+OIL (Euzenat, 2002). The annotations are based on a particular competency model, created within a specific knowledge area.

Competency trees present problems related to flexibility and reusability. These trees are usually deep, with the functional categorization specified in its upper levels; the description of a competency is not easily decomposable, leading to the dispersion of concepts between nodes. As a result, inference is limited as the concepts are not structured and connected to each competency as individual components. Reusing competencies in different contexts is hindered as functional categorization is embedded at the tree's upper levels.

3. COMPETENCY MODELING

The approach relies on defining the structure of competencies so they can be aggregated or composed at design time. This structure can be instantiated at run time enabling inference and analysis. These three phases separate the definition of individual competencies from their hierarchy as well as from the runtime information that will instantiate the structures.

The rationale behind separating the definition of a competency from its hierarchy is that it is not possible to anticipate the needs of an organization in terms of its competency categorization. If the definition and the corresponding hierarchy were entwined, then the competency would be defined in the scope of a single organizational context, making difficult specifying the same competency across multiple contexts. This is often the case where different organizational units use different classification schemes for the same competency. Thus, this separation aims at maximizing the reusability and flexibility of the structure.

3.1 Competency Definition

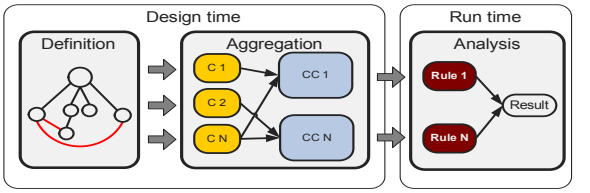
Defining a competency requires specifying or reusing the concepts that are necessary for its description and, second, specifying the structure that will hold these concepts and their relationships. Creating a structure to relate competencies is complex since it not straightforward to model a potential large set of disparate individual features that influence the performance of a given task, such as knowledge, practical experience, psychological and social factors, context and motivation.

Before detailing how competencies are defined, it is important to disambiguate some fundamental concepts. A *skill* is the ability to perform a particular activity, while *knowledge* is related to the information needed for enabling the skill. As an example, while there are skills needed to carry out network troubleshooting, there must be knowledge about physical media and network protocols for that skill to be available. The improvement of skills and knowledge through experience, training or education leads to *occupational competency* (Jones & Bearly 2006). This means a single competency may encompass multiple skills. A *competency* relates to the behavior that individuals must perform as input into a situation while achieving some level of performance. It represents the association of knowledge and action. This means, on the one hand, that competencies are based on knowledge, and, on the other, that for a competency to be recognized as such, it is necessary to demonstrate the capability of giving use to that knowledge through an action that brings value to the task.

A competency is an expression defined through the aggregation of elementary *nouns* and *verbs* (e.g. "coding a search algorithm in Lisp", "coding a web service in C#"). The concepts may be related or dependent (e.g. Lisp and C# are programming languages with different programming paradigms). To deal with the representation of such features, we define a set of layered hierarchic structures that specify the competency's concepts regardless of their usage context. This type of structure allows concepts to be reused while defining isolated competencies.

Actors and activities relate to competencies whose meaning depends on their usage context. These competencies may also be structurally related. To cope with this, competencies are aggregated as coherent groups comprising individual competencies. Separating the aggregation of competencies from their definition enables their rearrangement according to usage context without disrupting the corresponding definition. Groups of aggregated competencies can be bound to actors and activities, specifying supply and demand of competencies.

Figure 1. Design-time and run-time modeling phases



3.2 Structuring Competencies

Competencies are often structured hierarchically. As previously discussed, such an approach offsets representation simplicity and expressiveness. However, most approaches rely on static classification schemes that prove difficult to adjust to the organization dynamics and its environment. Furthermore, hierarchical representations are defined in the scope of some functional context, so it is not straightforward to detach a structure from its context and keep its semantics. Therefore, as it is not reasonable to assume that functional contexts are shared throughout the organization, the representation structure must be able to separate competency definition from its categorization.

To overcome these issues and those identified in section 2, we propose using a multi-dimensional tree structure, where each dimension relates the element with its usage context. This allows multiple views on the same object while keeping its uniqueness. Such structure can be perceived as a regular hierarchical tree where a number of contextual layers can be superimposed.

Nodes in the same dimension or layer are connected using intra-level links allowing relating elementary concepts. Inter-level links associate nodes from different dimensions allowing the specification of complex concepts. The semantics of this type of link is defined by ontological relations, such as "belong-to", "uses" or "enables".

The diagram in Fig. 2 depicts three layers (A, B, C), each defining elementary concepts in a given context. Using inter-level links (depicted as dotted arcs) to associate a number of elementary concept nodes in different contexts enables a competency defined as {⟨A1, B1⟩, ⟨A1, C1⟩, ⟨B2, C1⟩} to be specified.

As an example, Fig. 3 shows a number of elementary competencies related to software development.

Fig. 3 specifies the following set of competencies:

- Develop Software in the Banking Business Domain
- Software Design using both Imperative and Object Oriented Paradigms
- Code Software both in C# and Lisp Programming Languages
- Know Java Programming Language
- Administer Linux Operating System
- Use any Operating System
- Use the Visual Studio IDE

3.3 Competency Aggregation

Competency aggregation allows specifying multiple contexts through the specification of viewpoints. After being defined, competencies can be composed so they can be handled as a unit. The meaning of the competency "programming" can change according to the perspective. One definition could be the knowledge of a given programming language. Nevertheless, it can also mean the knowledge

Figure 2. Elementary concept structure (left). Competency definition (right)

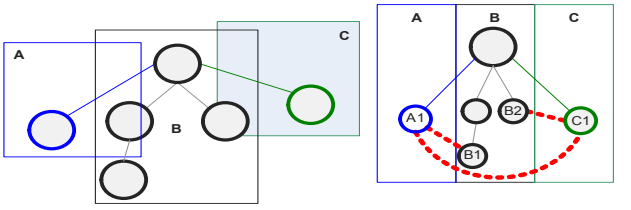
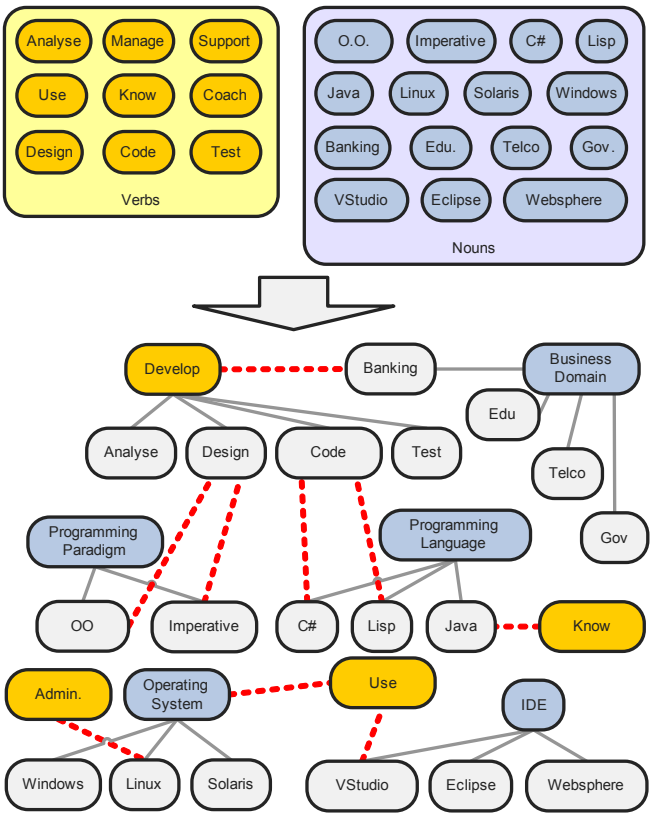


Figure 3. Elementary concepts and competency definition



in programming paradigms and programming languages. These two contexts can be specified as distinct viewpoints.

Different observations can be taken from the value of a competency element by changing the hierarchy while using the same inputs. It becomes necessary to ensure the independence between the viewpoint and the competencies themselves. The latter cannot be dependent on the categorization chosen by the organizational unit: they are part of the individual and exist regardless of context. Therefore, we propose using two layers: one featuring objective information on the competencies and other with their classification and context information. Thus, the upper level hierarchy corresponds to categorization and views, allowing the creation of structures that can reuse previously defined components. This approach is flexible since it enables the creation of a semantic level above elementary competencies by separating both and making individual's competencies context invariant.

Other aspect has to do with granularity: a monolithic structure is inadequate to representing competencies, so it is useful to create smaller trees, particularly in the case of relationships between nodes that arise from their own definition as concepts. As an example, take imperative, object-oriented and functional while programming paradigms. This classification can be considered context insensitive. These smaller trees are also known as "concept islands" (Lau & Sure, 2002), self-contained concept groups from sub-domains of a larger domain. Since these islands are interlaced, it makes sense to include them into multiple trees, which implies a complex network of node relationships. One approach is combining the concept islands into a single tree. This introduces complexity at ontology design time. Worse, it limits the expressiveness and flexibility of the structure. Therefore, we propose representing the concept island as multiple trees and keeping them separately in a repository. This approach enables these structures to be used as modular building blocks when composing larger trees. It also supports the flexible rearrangement of blocks, without breaking existing connections, i.e., maintaining the connections traceable from runtime back to the atomic elements that form a competency.

To illustrate the competency aggregation step, Fig.4 shows the result of competency composition. The original structure does not require revision. Aggregated competencies defined in this step may also be used to map roles to competencies.

3.4 Competency Analysis

The main goal of this phase is instantiating the competency structures according to the competencies provided by the organization's human actors. While the first two phases are enacted during design time, this phase relates activities and actors at run time, allowing the assessment of competency supply and demand.

Competency analysis requires a set of propagation rules to be defined between different hierarchy levels. Both the rules and the hierarchy itself are part of the classification scheme used by an organizational unit and should not be mistaken for the definition of the competencies. The latter should be independent of the analysis phase as otherwise competencies will not be able to cross-organizational boundaries.

Propagation rules describe how a node's information can be computed from its child nodes. They are defined bottom-up and are related to non-leaf nodes. Leaf nodes are instantiated with values that are propagated up to the root node using the rules on each intermediate node. A rule can include operations, such as logical expressions, weighted averages and threshold definitions. This enables real-time propagation of values, as opposed to static assignment where the connection to the original structure is lost from the moment that the first values are obtained.

When matching competency supply and demand there are important questions about the abstraction level or granularity used on both sides of the negotiation. If the supply is specified in more detail than the demand, simple bottom-up derivation is sufficient to match both sides. However, in the opposite case, it is necessary to request a further specification to the entity responsible for the offer. The updated specification will be included in the existing model as a supplementary layer.

While the most visible aspect of inference is performed at competency level, its application in that case is straightforward. The following example focuses on the application of rules to the relationships between elementary competency concepts. Fig. 5 depicts a scenario where a programming competency depends 60% on programming language knowledge and 40% on programming paradigms. As the programming paradigm is not a leaf node, another rule must specify how

Figure 4. Competency aggregation

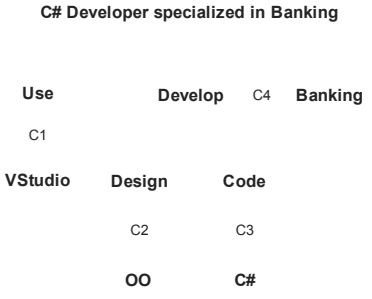
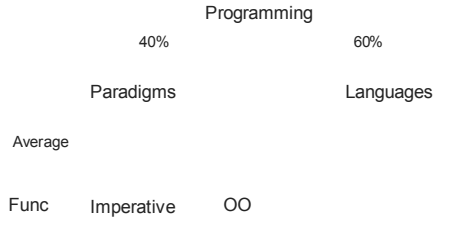


Figure 5. Example of propagation rules



to compute its value. In this case, a non-weighted average of its descendents has been used.

A fundamental aspect of the proposed framework is the traceability across the three phases. It enables the identification of a specific atomic element that composes an aggregate competency instantiated at runtime. In turn, low-level syntactic translation mechanisms create the conditions to analyze competency elements that would otherwise be obscured by their macro description. The competencies are expandable down to leaf-level, therefore representing the most objective information possible about the organization's human actors. So, competencies can become as independent as desirable from their organizational classification and activity-specific arrangements. As a result, competency movement across different units implies ontological agreement only at the lowest hierarchical level.

4. THE COMPETENCY MARKETPLACE

The primary goal of representing competency supply and demand is allowing an organization to find, schedule and manage suitable teams of actors to perform activities. Our approach follows the paradigm of a marketplace transaction. This facilitates the management and tracking of competencies from an organizational perspective while promoting actors to develop their own competencies. It also facilitates correcting the gaps between the actual requirements of an activity and those specified in the process models through market rules. It is important that all parties in the marketplace share a common vocabulary and semantic model to make the negotiation possible. Such shared knowledge should be iteratively built and continuously updated. The market dynamics enables the runtime evaluation of the negotiated work, thus offering feedback for process improvement.

The implementation of a competency marketplace involves a specific process, which goes through the stages of Information, Negotiation and Settlement (Lang & Pigneur, 1999). The Information stage consists in representing actual supply and demand. This is specified at design time during the Definition and Aggregation phases of the framework. The next step is finding the best candidate that fulfills the requirement of an activity. This is accomplished by searching the supply-side representations using inference and propagation mechanisms on the hierarchical structures, instantiated with the proficiency values associated with each actor. The result is a set of actors and the corresponding evaluations computed from the similarity level between the required and provided competencies.

After identifying a potential group of actors able to perform the task, the results must be categorized according to existing work scheduling plans that limit their availability. The results also need to consider business rules that may constrain the process (e.g. actor B and C can not participate in the same activity instance) and the type of results (e.g. the result must be a team of two people). The information resulting from this step can be used to facilitate team formation.

Team formation corresponds to the negotiation between the transaction participants. Each individual actor, the team as a whole and the activity owner settle the contract details, making explicit the assignment and scheduling terms. A contract is defined after the negotiation phase is complete, specifying the details, thus binding actors to an activity through their competencies along the settlement step.

Implementing the contract means performing the activity's tasks. The execution phase can be evaluated during its performance or *a posteriori* using metrics whose goals are measuring how the contract was carried out.

This approach promotes an actor to be actively involved in the management of her own competencies. This influences her evaluation criteria and, as a result, how management observes her performance. It is in the best interest of the actor to be properly represented in the model, since an accurate description will facilitate her scheduling to the tasks included on her competency pool. It will also enable the identification of gaps inhibiting good performance, calling for specific training.

5. CONCLUSIONS AND FUTURE WORK

The concept of competency is fundamental to align actors and activities within business processes. It enables an organization to understand and evaluate what is required by its processes and what is provided by its actors. It also provides a means to make competencies visible to all process stakeholders, including its performers, designers and owners, allowing mismatches to be identified and continually adjusted. Provided the different stakeholders see the benefit of accurately representing the competencies they are responsible for, the marketplace will converge to a state that represents the actual supply and demand of competencies within the organization.

To validate this approach, we have developed a web-based system that implements the concepts outlined in this paper, which is currently being evaluated in real organizations. It allows employees advertise their competencies and process owners and designers to specify activity requirements and evaluate the performance of actors. The system supports the dynamic aspects of actor scheduling, allowing the search of competencies, assisting the process of team formation and evaluating the scheduling results.

The establishment of trust relationships is crucial and the integration into the Semantic Web will enable the creation of shared repositories of services. The unification between competencies and technological services is subject of our future work. We are currently extending the framework to include the representation of the services provided by information systems and other business process support systems. This will enable defining alignment metrics between the organization's service providers and its processes.

REFERENCES

Abran, A., & Moore, J. (2004). Guide to the Software Engineering Body of Knowledge, IEEE.

Brickley, D., et al. (2000). RDFS: Resource Description Framework Schema Specification 1.0.

Business Process Management Initiative. (2004). Business Process Modeling Notation (Version 1.0).

Caetano, A., Zacarias, M., Rito Silva, A., & Tribolet, J. (2005). A Role-Based Framework for Business Process Modeling. In HICSS 38, IEEE.

Chartered Institute of Personnel and Development, UK (2005). Competency and competency frameworks.

Davenport, T., & Prusak, L. (1997). Working Knowledge: How Organizations Manage What They Know. Harvard Business School Press: Boston.

Euzenat, J. (2002). Research challenges and perspectives of the semantic web. EU-NSF Strategic Workshop.

Fletcher, S. (1997). Competence-based assessment techniques. Kogan Page, London.

Gronau, N., & Uslar, M. (2004). Integrating knowledge management and human resources via skill management. In Proceedings IKNOW '04.

Hamel, G., & Prahalad, C. (1990). The core competency of the corporation. Harvard Business Review.

Harzallah, M., & Lecrère, M. (2002). CommOnCV: Modelling the Competencies Underlying a Curriculum Vitae. SEKE'02.

Johansen, R., et al. (1991). Leading Business teams: How Teams Can Use Technology and Group Process Tools to Enhance Performance. Addison-Wesley.

Jones, J., & Bearley, W. (2006). Developing 360º Leadership-Feedback Instruments. Organizational Universe Systems.

Lang, A., & Pigneur, Y. (1999). Digital Trade of Human Competencies, Proc. HICSS-32.

Lau, T., & Sure, Y. (2002). Introducing ontology-based skills man-agement at a large insurance company. In Proceedings of the Modellierung 2002.

Mayer, R. et al. (1995). IDEF3 Process Description Capture Method Report. Knowledge Based Systems Inc.

McClelland, D. (1973). Testing for competence rather than for intelligence. American Psychologist,. Jan;28(1):1-14.

Neves, J., Caetano, A., Vasconcelos, A., & Tribolet, J. (2001). Integrating Knowledge Into Business Processes. ICEIS 2001.

Ould, M. (1995). Business Processes, Modeling and Analysis for Reengineering and Improvement. John Wiley & Sons.

Scheer, A. W. (1999). Business Process Modeling. Springer Verlag.

Spencer, L., Spencer, S., & Signe, M. (1993) Competency at work: models for superior performance. John Wiley & Sons, Inc, New York.

Stone, F. (1995). New Definition of Corporate Competencies. Management Review, vol. 84, no. 6.

Woodruffe, C. (1993). What is meant by a competency? Leadership & Organization Development Journal, vol. 14, no. 1.

Yimam, D. (2000). Expert finding systems for organizations: Domain analysis and the demoir approach. In Beyond Knowledge Management: Sharing Expertise. MIT Press.

Zacarias, M., Caetano, A., Pinto, S., & Tribolet, J. (2005). Modeling Contexts for Business Process Oriented Knowledge Support. In Knowledge Management for Distributed Agile Processes, Springer-Verlag.

Palm OS and Programming for Mobile Commerce

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ABSTRACT

Mobile commerce or m-commerce, defined as the exchange or buying and selling of commodities, services, or information on the Internet through the use of Internet-enabled mobile handheld devices, is a coming milestone after electronic commerce blossoming in the late 1990's. Mobile handheld devices provide convenience and portable access to the huge information on the Internet for mobile users from anywhere and at anytime. However, most software engineers are not familiar with programming for handheld devices. Handheld computing is the programming for handheld devices such as smart cellular phones and PDAs (Personal Digital Assistants). It consists of two kinds of programming: client- and server- side programming. This paper introduces handheld computing and gives a detailed description of Palm OS programming, client-side handheld programming. Other related issues such as mobile commerce systems and handheld devices will be discussed also.

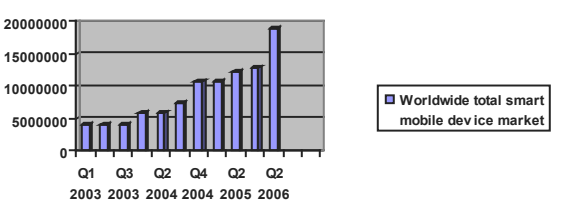
INTRODUCTION

Mobile commerce is a coming milestone after electronic commerce blossoming in the late 1990's. Figure 1 shows the growth in demand for smart mobile devices including handhelds, wireless handhelds, and smart cellular phones through 2006, as estimated by the research firm Canalys (2006). However, it is also commonly admitted that the development in this field is constrained. There are still considerable barriers waiting to be overcome. One of the barriers is most software engineers are not familiar with handheld programming. Handheld computing is the programming for handheld devices such as smart cellular phones and PDAs. This paper gives a study of handheld computing to help software engineers better understand this subject. It includes three major topics:

- *Mobile commerce systems*: The system structure includes six components: (i) mobile commerce applications, (ii) mobile handheld devices, (iii) mobile middleware, (iv) wireless networks, (v) wired networks, and (vi) host computers.
- *Handheld computing*: It consists of two kinds of programming: client- and server- side programming.
- *Palm OS and programming*: The Palm OS Developer Suite is used to develop applications for Palm devices by handheld programmers.

This paper focuses on Palm OS programming by giving a step-by-step procedure of a Palm application development. Other client-side handheld computing is also discussed.

Figure 1. Worldwide total smart mobile device market

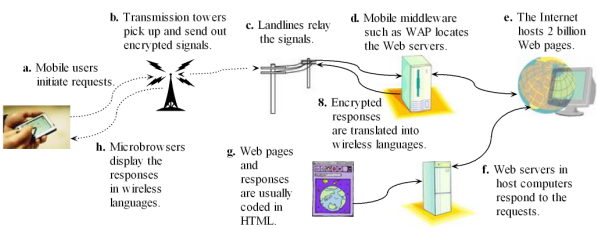


BACKGROUND

With the introduction of the World Wide Web, electronic commerce has revolutionized traditional commerce and boosted sales and exchanges of merchandise and information. Recently, the emergence of wireless and mobile networks has made possible the extension of electronic commerce to a new application and research area: mobile commerce, which is defined as the exchange or buying and selling of commodities, services, or information on the Internet through the use of mobile handheld devices. In just a few years, mobile commerce has emerged from nowhere to become the hottest new trend in business transactions. To explain how the mobile commerce components work together, Figure 2 shows a flowchart of how a user request is processed by the components in a mobile commerce system, along with brief descriptions of how each component processes the request (Hu, et al, 2004):

1. *Mobile commerce applications*: Electronic commerce applications are numerous, including auctions, banking, marketplaces and exchanges, news, recruiting, and retailing, to name but a few. Mobile commerce applications not only cover the electronic commerce applications, but also include new applications, which can be performed at any time and from anywhere by using mobile computing technology, for example, mobile inventory tracking.
2. *Mobile handheld devices*: An Internet-enabled mobile handheld device is a small general-purpose, programmable, battery-powered computer that is capable of handling the front end of mobile commerce applications and can be operated comfortably while being held in one hand. It is the device with which mobile users interact directly with mobile commerce applications.
3. *Mobile middleware*: The term middleware refers to the software layer between the operating system and the distributed applications that interact via the networks. The primary mission of a middleware layer is to hide the underlying networked environment's complexity by insulating applications from explicit protocols that handle disjoint memories, data replication, network faults, and parallelism (Geihs, 2001). The major task of mobile middleware is to seamlessly and transparently map Internet contents to mobile stations that support a wide variety of operating systems, markup languages, microbrowsers, and protocols. WAP and i-mode are the two major kinds of mobile middleware.
4. *Wireless and wired networks*: Wireless communication capability supports mobility for end users in mobile commerce systems. Wireless LAN, MAN,

Figure 2. A flowchart of a user request processed in a mobile commerce system



and WAN are the major components used to provide radio communication channels so that mobile service is possible. In the WLAN category, the Wi-Fi standard with 11 Mbps throughput dominates the current market. However, it is expected that standards with much higher transmission speeds, such as IEEE 802.11a and 802.11g, will replace Wi-Fi in the near future. Compared to WLANs, cellular systems can provide longer transmission distances and greater radio coverage, but suffer from the drawback of much lower bandwidth (less than 1 Mbps). In the latest trend for cellular systems, 3G standards supporting wireless multimedia and high-bandwidth services are beginning to be deployed.

5. *Host computers*: A user request such as database access or updating is actually processed at a host computer, which contains three major kinds of software: (i) web servers, (ii) database servers, and (iii) application programs and support software.

HANDHELD COMPUTING

Handheld computing is a fairly new computing area and a formal definition of it is not found yet. Nevertheless, the author defines it as follows:

Handheld computing is to use handheld devices such as smart cellular phones and PDAs (Personal Digital Assistants) to perform wireless, mobile, handheld operations such as personal data management and making phone calls.

Again, handheld computing includes two kinds of computing: server- and client-side handheld computing, which are defined as follows:

- *Server-side handheld computing*: It is to use handheld devices to perform wireless, mobile, handheld operations, which require the supports of server-side computing. Examples of its applications include (a) instant messages, (b) mobile Web contents, (c) online video games, and (d) wireless telephony.
- *Client-side handheld computing*: It is to use handheld devices to perform handheld operations, which do not need the supports of server-side computing. Examples of its applications include (a) address books, (b) standalone video games, (c) note pads, and (d) to-do-list.

The terms of computing and programming are sometimes confusing and misused. The handheld programming, defined as programming for handheld devices, is different from handheld computing and includes two kinds of programming too:

- *Server-side handheld programming*: It is design and development of handheld software such as CGI programs that reside on the servers.
- *Client-side handheld programming*: It is design and development of handheld software such as J2ME programs that reside on the handheld devices.

Client-Side Handheld Computing

Some popular mobile environments/languages for client-side handheld programming are listed below:

- *BREW (Binary Runtime Environment for Wireless)*: It is an application development platform created by Qualcomm Inc. for CDMA-based mobile phones (Qualcomm Inc., 2003).
- *J2ME (Java 2 Platform, Micro Edition)*: J2ME, developed by Sun Microsystems Inc., provides an environment for applications running on consumer devices, such as mobile phones, PDAs, and TV set-top boxes, as well as a broad range of embedded devices (Sun Microsystem Inc., 2002).
- *Palm OS*: Palm OS, developed by Palm Source Inc., is a fully ARM-native, 32-bit operating system running on handheld devices. Using Palm OS to build handheld applications will be introduced later.
- *Symbian*: Symbian Ltd. is a software licensing company that develops and supplies the advanced, open, standard operating system—Symbian OS—for data-enabled mobile phones (Symbian Ltd., 2005).
- *Windows Mobile*: Windows Mobile is a compact operating system for mobile devices based on the Microsoft Win32 API. It is designed to be similar to desktop versions of Windows (Microsoft Corp., 2005).

Figure 3. A generalized client-side handheld computing development cycle

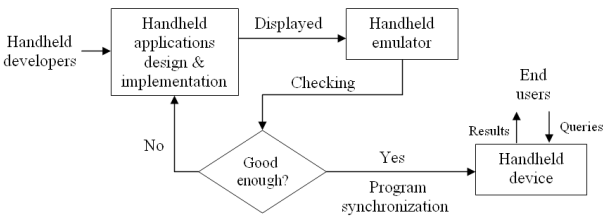


Table 1. A comparison among five handheld-computing languages/environments

	BREW	J2ME	Palm OS	Symbian OS	Windows Mobile
Creator	Qualcomm	Sun Microsystems	PalmSource	Symbian	Microsoft
Language/ Environment	Envir.	Language	Envir.	Envir.	Envir.
Market Share (PDA) as of 2005	N/A	N/A	3rd	4th	1st
Market Share (Smartphone) as of 2006	?	N/A	4th	1st	5th
Primary Host Language	C/C++	Java	C/C++	C++	C/C++
Target Devices	Phones	PDAs & phones	PDAs	Phones	PDAs & phones

They apply different approaches to accomplishing the development of mobile applications. Figure 3 shows a generalized development cycle applied by them and Table 1 gives a comparison among the five languages/environments. The second half of this article is devoted to the details of Palm OS and programming.

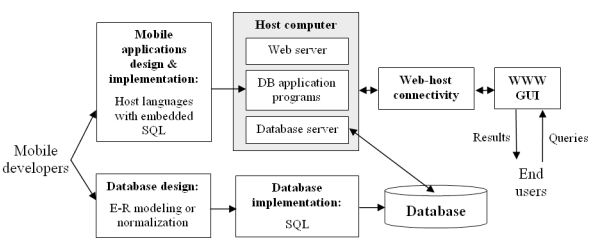
Server-Side Handheld Computing

Most applications created by this kind of programming such as instant messaging require network programming such as TCP/IP programming, which will not be covered in this paper. The most popular application of server-side handheld computing is database-driven mobile web sites, whose structure is shown in Figure 4. A database-driven mobile web site is often implemented by using a `three-tiered client/server architecture` consisting of three layers:

A database-driven mobile web site is often implemented by using a `three-tiered client/server architecture` consisting of three layers:

1. *User interface*: It runs on a handheld device (the client) and uses a standard graphical user interface (GUI).
2. *Functional module*: This level actually processes data. It may consist of one or more separate modules running on a workstation or application server. This tier may be multi-tiered itself.

Figure 4. A generalized system structure of a database-driven mobile web site



3. *Database management system (DBMS)*: A DBMS on a host computer stores the data required by the middle tier.

The three-tier design has many advantages over traditional two-tier or single-tier designs, the chief one being: The added modularity makes it easier to modify or replace one tier without affecting the other tiers.

PALM OS AND PROGRAMMING

Palm OS is a fully ARM-native, 32-bit operating system designed for used on Palm handhelds and other third-party devices. Palm OS runs on almost two out of every three PDAs. Its popularity can be attributed to its many advantages, such as its long battery life, support for a wide variety of wireless standards, and the abundant software available. The plain design of the Palm OS has resulted in a long battery life, approximately twice that of its rivals. It supports many important wireless standards, including Bluetooth and 802.11b local wireless and GSM, Mo-bitex, and CDMA wide-area wireless networks (PalmSource Inc., 2002). Two major versions of Palm OS are currently under development:

- *Palm OS Garnet*: It is an enhanced version of Palm OS 5 and provides features such as dynamic input area, improved network communication, and support for a broad range of screen resolutions including QVGA.
- *Palm OS Cobalt*: It is Palm OS 6, which focuses on enabling faster and more efficient development of smartphones and integrated wireless (WiFi/Bluetooth) handhelds.

Palm OS Programming

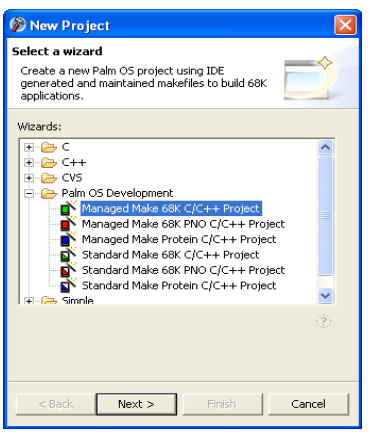
The Palm OS Developer Suite, which is the official development environment and tool chain from PalmSource, is intended for software developers at all levels. It is a complete IDE (Integrated Development Environment) for

- Protein applications (all ARM-native code) for Palm OS Cobalt and
- 68K applications for all shipping versions of the Palm OS.

The following steps show how to develop a Palm OS application, a simple "Hello, Mobile world!" program, under Microsoft Windows XP:

Figure 5. A screenshot of the Palm OS Developer Suite

Figure 6: A screenshot showing Palm OS application and make types



1. Download *Palm OS Developer Suite* at http://www.palmos.com/dev/tools/dev_suite.html .
2. Activate the Eclipse Workbench IDE as shown in Figure 5 under the Windows environment by selecting the following commands

```
Start ► All Programs ► PalmSource ►
     Palm OS Developer Suite
```

   May select a default workspace at "C:\Program Files\PalmSource\Palm OS Developer Suite\workspace."
3. Create a new project by selecting a wizard: There are three Palm OS application types as shown in Figure 6:
   - *Palm OS 68K Application*,
   - *Palm OS 68K Application with PACE Native Objects*, and
   - *Palm OS Protein Application*.

   There are also two kinds of *make files*:
   - *Standard make*: It provides a generic set of makefiles that you can modify and tailor for your specific application build.
   - *Managed make*: It dynamically generates your makefile based on the contents of your project folders.
4. Create a Palm OS C/C++ program and put it in the directory "C:\Program Files\PalmSource\Palm OS Developer Suite\workspace\Hello\." Program 1 gives a Palm example, which displays the text "Hello, Mobile world!," an image, and a button "OK."

Program 1. An example of a Palm OS program HelloWorld.c

C:\Program Files\PalmSource\Palm OS Developer Suite\workspace\Hello\HelloWorld.c

```
#include  <PalmOS.h>
#define   Form1  1000
#define   OK     1003

UInt32  PilotMain( UInt16 cmd, void *cmdPBP, UInt16 launchFlags ) {
 short      err;
 EventType  e;
 FormType   *pfrm;

 if ( cmd == sysAppLaunchCmdNormalLaunch ) {
  FrmGotoForm( Form1 );
  while( 1 ) {
   EvtGetEvent( &e, 100 );
   if ( SysHandleEvent( &e ) )  continue;
   if ( MenuHandleEvent( (void *) 0, &e, &err ) )  continue;
    switch ( e.eType ) {
     case ctlSelectEvent:
      if ( e.data.ctlSelect.controlID == OK )
       goto  _quit;
       break;
     case frmLoadEvent:
      FrmSetActiveForm( FrmInitForm( e.data.frmLoad.formID ) );
      break;
     case frmOpenEvent:
      pfrm = FrmGetActiveForm( );
      FrmDrawForm( pfrm );
      break;
     case menuEvent:
      break;
     case appStopEvent:
      goto  _quit;
      break;
     default:
      if ( FrmGetActiveForm( ) )
       FrmHandleEvent( FrmGetActiveForm( ), &e );
      break;
    }
   }
_quit:
  FrmCloseAllForms( );
 }
 return 0;
}
```

Figure 7. A screenshot of the Palm OS Developer Suite after the project Hellow-World is created

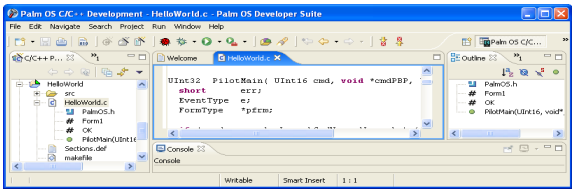


Figure 8. A screenshot of the Palm OS Resource Editor

For how to create Palm OS applications, check Palm OS Developer Documentation at http://www.palmos.com/dev/support/docs/. In order to display the current status on the Eclipse, may need to constantly `refresh` the project *`HelloWorld`* by right clicking on the mouse on the project name as shown in Figure 7.

If the project includes resources (`.xrd`) such as buttons and images, the Palm OS Resource Editor at

```
Start ▶ All Programs ▶ PalmSource ▶
  Tools ▶ Palm OS Resource Editor
```

could be used to create the resources as shown in Figure 8.

5. Build the project *HelloWorld*.
6. Activate a Palm OS emulator by selecting

```
Start ▶ All Programs ▶ PalmSource ▶
   Tools ▶ Palm OS Emulator
```

7. Drag the icon of *`Hello.prc`* (Palm Application file) at "`C:\Program Files\PalmSource\Palm OS Developer Suite\workspace\Hello5\Debug\Hello.prc`" to the Palm OS emulator. Figure 9 shows the execution result of the project *`HelloWorld`*.

Figure 9. A screenshot of the execution results of the project HelloWorld

Table 2. Palm OS programmer's API reference

Function	Descriptions
User Interface	User interface APIs include events, notifications, attention, control, dialogs, forms, lists, menus, scroll bars, etc.
System Management	Provides largest number of functions such as alarm, debug, file streaming, graffiti, I/O, memory, pen, sound, time, windows, etc. for system management.
System Management	Provides largest number of functions such as alarm, debug, file streaming, graffiti, I/O, memory, pen, sound, time, windows, etc. for system management.
Libraries	Include miscellaneous libraries such as Internet, Bluetooth, cryptography, etc.

8. If the application is finalized, synchronize the application to handheld devices by selecting

```
Start ▶ All Programs ▶ Palm Desktop ▶
    Palm Desktop
```

after downloading the Palm Desktop at http://www.palmos.com/dev/tools/desktop/.

Palm OS Programmer's API Reference

Table 2 gives the Palm OS programmer's API reference of Palm OS 68K SDK (PalmSource Inc., n.d.). It includes four major sections (i) user interface, (ii) system management, (iii) communications, and (iv) libraries.

CONCLUSION

Using Internet-enabled mobile handheld devices to access the World Wide Web is a promising addition to the Web and traditional e-commerce. Mobile handheld devices provide convenience and portable access to the huge information on the Internet for mobile users from anywhere and at anytime. However, most software engineers are not familiar with programming for handheld devices. Handheld computing is the programming for handheld devices such as smart cellular phones and PDAs. This paper gives a study of handheld computing and includes three major topics:

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2. *Handheld computing*: It consists of two kinds of programming:
   - Client-side programming: It is the programming for handheld devices and it does not need the supports from server-side programs.
   - Server-side programming: It is the programming for wireless mobile handheld devices and it needs the supports from server-side programs.
3. *Palm OS programming*: Two major versions of Palm OS are currently under development:
   - *Palm OS Garnet*: It is an enhanced version of Palm OS.
   - *Palm OS Cobalt*: It is the Palm OS 6.

This article focuses on Palm OS programming by giving a step-by-step procedure of a Palm application development. The Palm OS Developer Suite is used to develop applications for Palm devices by handheld programmers.

REFERENCES

Canalys. (2006). *Smart Mobile Device Market Growth Remains Steady at 55%.* Retrieved December 3, 2006, from: http://www.canalys.com/pr/2006/r2006071.pdf.

Geihs, K. (2001). Middleware challenges ahead. *IEEE Computer*, 34(6), 24-31.

Hu, W.-C., Lee, C.-w., & Yeh, J.-h. (2004). Mobile commerce systems. Shi Nansi, editor, *Mobile Commerce Applications*, pages 1-23, Idea Group Publishing.

Microsoft Corp. (2005). *What's New for Developers in Windows Mobile 5.0?* Retrieved May 29, 2006, from: http://msdn.microsoft.com/mobility/windowsmobile/howto/documentation/default.aspx?pull=/library/en-us/dnppcgen/html/whatsnew_wm5.asp.

NTT-DoCoMo. (n.d.). *i-mode*. Retrieved January 2, 2006, from http://www.nttdocomo.com/

PalmSource Inc. (2002). *Why PalmOS?* Retrieved June 23, 2006, from: http://www.palmsource.com/palmos/Advantage/index_files/v3_document.htm.

PalmSource Inc. (n.d.). *Palm OS Programmer's API Reference*. Retrieved August 15, 2006, from: http://www.palmos.com/dev/support/docs/palmos/PalmOSReference/ReferenceTOC.html.

Qualcomm Inc. (2003). *BREW and J2ME—A Complete Wireless Solution for Operators Committed to Java*. Retrieved February 12, 2006, from: http://brew.qualcomm.com/brew/en/img/about/pdf/brew_j2me.pdf.

Sun Microsystem Inc. (2002). *Java 2 Platform, Micro Edition*. Retrieved January 12, 2006, from: http://java.sun.com/j2me/docs/j2me-ds.pdf.

Symbian Ltd. (2005). *Symbain OS Version 9.2*. Retrieved May 20, 2006, from: http://www.symbian.com/technology/symbianOSv9.2_ds_0905.pdf.

Symbian Ltd. (2006). *Fast Facts*. Retrieved August 12, 2006, from: http://www.symbian.com/about/fastfacts/fastfacts.html.

Wireless Application Protocol Forum Ltd. (n.d.). *WAP (Wireless Application Protocol)*. Retrieved July 21, 2006, from: http://www.wapforum.org/.

Integrating Formal Methods with Reuse Techniques

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ABSTRACT

It is widely accepted by software community that formal methods increase software quality and reliability, and even though their industrial use is still limited it has steadily been growing. A well-known formal method is the RAISE Method [4,5] based on the idea that software development is a stepwise. Originally designed to be applied at different levels of abstraction as well as stages of development, RAISE is successfully applied to different domains obtaining high precise specifications of components. However, there is no explicit reference to the specification reusability in the process. Feature models have received much attention in the software engineering community who see the Domain Analysis [7] as a prerequisite in a successful reuse, for example FODA [8], FORM [9] and Featured Reuse-driven Software Engineering Business (FeatuRSEB) [6]. This paper presents a brief overview of feature modeling and the integration into RAISE. Some key relations between features are formalized using RAISE specification language [3]. Such integration allows to take advantage of formal methods in the context of software reuse.

INTRODUCTION

Formal methods have come into use for the construction of real systems, as they help to increase software quality and reliability, and even though their industrial use is still limited it has steadily been growing. A well-known formal method is the RAISE Method, which has been used on several real developments. By using formal methods early in the software development process, ambiguities, incompleteness, inconsistencies, errors or misunderstandings can be detected, avoiding their discovery during costly testing and debugging phases.

In particular, there are two main activities in the RAISE method: writing an initial specification, and developing it towards something that can be implemented in a programming language. Writing the initial specification is the most critical task in software development. If it is wrong, i.e. if it fails to meet the requirements, the following work will be largely wasted. It is well known that mistakes made in the life-cycle are considerably more expensive to fix than those made later.

Our goal is to work with reuse in the confines of the domain engineering, where there is no reference in RAISE process. Therefore, the introduction of a Domain Analysis method into RAISE is a crucial task considering the possibility of reusing the specifications in the future.

Examples of more relevant Domain Analysis methods include FODA, FORM and Featured Reuse-driven Software Engineering Business (FeatuRSEB). They support the notion of feature-oriented. This is a concept based on the emphasis this method places on finding the features or functionalities usually expected in applications for a given domain.

In a reuse strategy, domain analysis must be maintained over many systems, and the repository should contain domain models that form the basis of subsequent development activities. Domain analysis is essential to formalize reuse. However, it is missing from most software development methods. Reuse engineering extends information engineering by adding this new stage, to provide a place in the life cycle where the most valuable reusable components for the domains of the enterprise can be identified and a library containing these components can be created. At this stage of the software development, working with formal methods (or formal specification languages, specifically) implies to provide a means of unambiguously stating the requirements of a system, or of a system component. In this way, formally specified system components that meet the requirements of components of the new system can be easily identified. Thus, components that have been formally specified and sufficiently well documented can be identified, reused and combined to form components of the new system.

Nevertheless, the main problem is that we may not understand the requirements. Specially, when the requirements are written in a natural language the result is likely to be ambiguous. The aim of the initial specification is to capture the requirements in a precise way applying a reusability model.

Based on this paradigm, our work consists in the incorporation of the feature model into a RAISE formal method, filling the gap between requirements and the RSL (RAISE specification language) specifications. In this work we suggest introduce the phase -reusable domain analysis- using a feature model and expressing the relationships among them in RSL language. Thus, we can combine domain analysis notions with a formal language in early phases of development process. Particularly, we use the feature model proposed by FORM method, briefly described in section 2.

The remainder of the paper is organized as follows. In section 3, we briefly introduce the Raise method. Section 4 presents the integration of Domain analysis into RAISE. In section 5 we give a formalization of the relation in a feature model in RSL language. Section 6 concludes the paper and describes future work.

2. THE FORM METHOD

FORM product line engineering consists of two major processes: asset development and product development. Asset development consists of analyzing a product line (domain analysis, feature modeling) and developing architectures and reusable components based on analysis results. Product development includes analyzing requirements, selecting features, selecting and adopting architecture, and adapting components and generating code for the product.

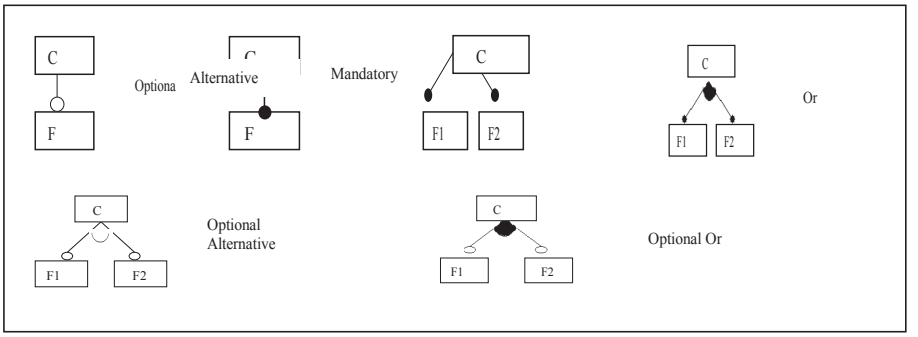
The FORM (Feature-Oriented Reuse Method) method comes as a concretization of the FODA (Feature-Oriented Domain Analysis) processes and has been recently extended by Feature Oriented Product Line Software Engineering (FOPLE) [10,11]. It provides guidelines for the creation of the feature model, design and implementation phases. FORM performs an analysis of domain´s features and attempts to provide a mapping between features and architectural components. This method follows all principles of modern software, being flexible, extendible and maintainable.

The use of features is motivated by the fact that users and developers often speak of product characteristics in terms of "features the product has and/or delivers". That is, services provided, and techniques used in applications are abstracted as features, and they are used by domain experts to communicate their ideas, needs, and problems.

To create coherent models, feature analysis involves tasks for identifying, classifying, and organizing product features as models. Feature models are a well accepted means for expressing requirements in a domain on an abstract level, and it resides between the requirements model and the system design model.

As potential features are identified, they are classified according to the types of information they represent. For example, users are concerned with functions provided by the systems (i.e. service features); analysts and designers are concerned about domain technologies, and developers are concerned about implementation techniques.

Figure 1. Types of features



FORM separates features into four different feature categories:

- *Capability features* are distinct services, operations, or non-functional aspects. Features of this category are end-user visible and are selected by the customer to specify the desired system.
- *Operating environment features* address the hardware and software components used by the family. All the components of a system with their interfaces and protocols are part of this category.
- *Domain technology features* are domain specific technologies and problem solutions, used by domain experts.
- *Implementation technique features* are general problem solutions, which may be used in different domains.

A feature model should cover all four categories of features for a domain. To make it possible, FORM uses the following constructs:

A *feature diagram*: a graphical AND/OR hierarchy of features, capturing the logical relationships (composition / generalization) among features. Three types of relationships are represented in this diagram: "composed-of", "generalization/ specialization", and "implemented-by". Features themselves may be "mandatory" (unless specified otherwise), "optional" (denoted with a circle), or "alternative" (denoted with an arc) [Figure 1]. A mandatory feature is neccesary for general users, and an optional feature is neccesary for partial users. Czarnecki [1] introduced the notion of sets of features.

Using the optional, mandatory and alternative criteria for features, it is possible to define subsets with constraints for minimum and maximum number of features to be taken out of this set.

Composition rules that supplement the feature diagram with mutual dependency and mutual exclusion relationships.

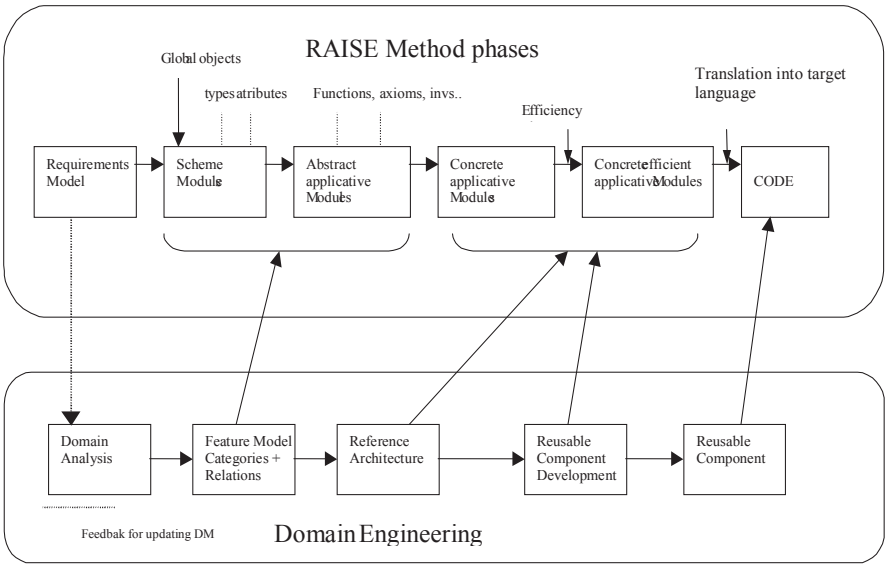
Depending on the domain, it is possible that AND/OR diagram tends to become complex. The AND/OR diagram was used to show the relationships among selected features.

Features are considered following the four level feature hierarchy, since the hierarchy reflects step-wise refinement in the reference architecture. These concepts are strongly connected with the style of development in RAISE, where the separate and step-wise are the basis to build a solid specification of an infrastructure.

3. RAISE OVERVIEW

RAISE method provides guidelines to hierarchically structure a specification, aiming at encouraging separate development and step-wise development. A development in RAISE begins with an abstract specification and gradually evolves into concrete

Figure 2. RAISE phases and DE



implementations. RAISE proposes to structure modules hierarchically in order to get a particular component over by reference only to it and its suppliers, to limit the effects of changes of a module to it and its clients, and to limit the properties of a module to it and its suppliers. It is an object-oriented method and covers a large portion of systems development phases.

Moreover, the RAISE method permits the abstract specification of sequential as well as concurrent systems, modular operations for decomposing large systems into subsystems and composing subsystems into a more complex system.

4. INTEGRATING DOMAIN ANALYSIS INTO RAISE

In this section we present the integration of domain analysis into RAISE method. The underlying idea is to specify and design a family of systems to produce qualitative application in a domain, as we can see in the lower part of figure 2, promoting early reuse and reducing development costs.

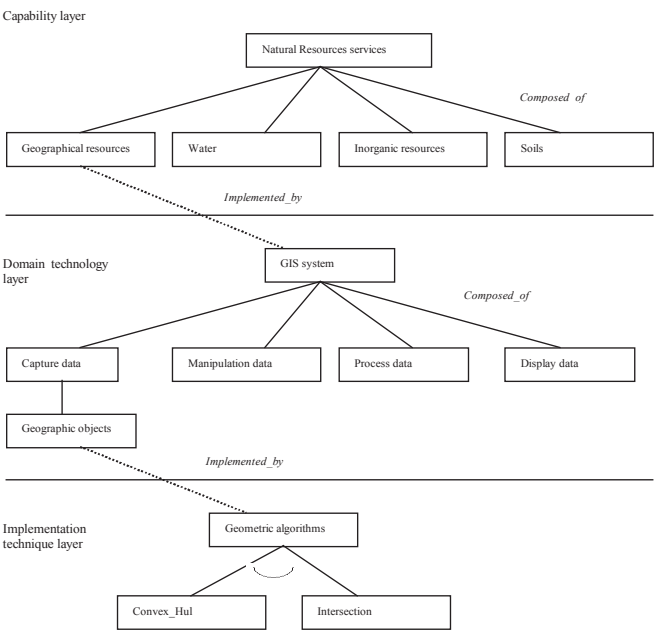
Domain engineering gives a set of guidelines that can be used to derive domain products from the feature model. The objective of domain engineering is to establish a mapping between the decision space (Feature model) and the artifact space (Reference Architecture). Each feature with the corresponding relations in the decision space somehow constrains the selection of the final reference model considering differences in types of features following the four level hierarchy. Feature model gives a set of guidelines that can be used to derive domain products from it and it is considered as an intermediate step between analysis and design models.

4.1 The Feature Model and RSL Modules

The objective of a feature model is to capture commonalities and variabilities of a family. There is a trace from the requirements to the feature model, and there are relations within the feature model. Categories help to elaborate features, but feature relations do not have a rigorous definition and we need the precise usage of relations for modeling.

Given the example of [12] in Figure 3 (Feature Model of Agriculture system domain), next section deals with some relations among features, and we show them described in a way we can automatically check the feature model for consistency. "Agriculture system" is an information system whose objective is a model which will help deciders to identify problems with the management and the access to resources for several purposes. Following, we discuss how the feature model serves as a guideline to identify RSL reusable modules.

Figure 3. Agriculture System partial feature model



In the partial example illustrated in Figure 3, Natural Resources service can be mapped respectively, into Natural Resources RSL module, performing a set of operations with its specific role. Once a feature is mapped into a module, the sub-features of the feature such as Geographical Resources, Water, Inorganic resources, Soils can be modules that are part of Natural Resources following the same type of relationships in the feature model (e.g., generalization, aggregation).

Moreover, operations can be mapped as internal functions to provide services, and they are a collection of types and values without type of interest. On the other hand, non-functional features include end-user visible application characteristics that cannot be identified in terms of services or operations, like quality attribute, cost, etc. So, they can not be mapped into any RSL constructions.

With respect to the model operating environment features, the RSL specifications are independent from the operating environment. These features can be mapped into the subsidiary RSL modules, which are less important from the point of view of development.

Model domain technology features such as GIS systems will be considered by the RSL system modules and they will be expected to be finally implemented as software modules. In object-oriented terms they will form the objects of the software system.

Modules derived from implementation technique features are generally used to implement or to derive concrete applicative specifications derived from capability or domain technology features. Geometric Algorithms would be part of a module called "Algorithms". This module will be defined as a generic module, i.e. a module we expect to instantiate more than once with different parameter, being the sub-features (Convex_Hull or Intersection) the possible instantiations. Each RSL module derived would be later refined and completed with the definition of functions. Once the RSL modules are derived from the feature model, they need to be organized into a model in order to represent how they are related to each other and what the contexts for their use are.

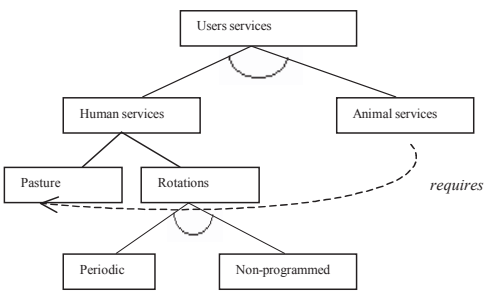
This simple heuristic is very useful in providing a good first reference architecture that will be the basis to specify the Concrete applicative RSL modules.

4.2 Dependencies in a Feature Model

To complete the feature model, we give an overview of dependencies used not only in FORM but also in FOPLE and FeatureRSEB. "Composed of" relation is used when a parent feature consists of a set of child features. "Generalization/specialization" relation connects very general features with concrete ones. "Implemented by" relation represents a connection between user-visible features and their implementation strategy, used in the specific domain. In Figure 3 we have taken a subset out of all the features of the Agriculture system. We show features of Natural Resources services: the features "Geographical resources", "Water", "Inorganic resources" and "Soils" are so-called mandatory features, and are part of the instance by definition.

The Capability layer is used to represent the details of the family required to further develop the system design, while Domain technology layer are specific technologies and problem solutions linked with the sub-feature Geographical resources. The Implementation technique layer are the 'solutions' used by domain experts (Example: Geographic objects are "implemented by" Geometric algorithms). "Requires" dependency (uni-directional) is used to describe if one feature needs another (e.g. Animal services "requires" Pasture, figure 4). "Exclude" depen-

Figure 4. "Requires" relation



dency (bi-directional) is used when one feature conflicts with another. “Hints” dependency is used to express that the choice of another feature increases the system usage. “Mathematical” dependency describes the relative impact from one feature to another.

5. FORMALIZING THE RELATIONS OF THE FEATURE MODEL IN RSL

RSL is one of the most versatile and comprehensive languages for formal specification, design and development of software. A significant advantage of using RSL is that it combines both algebraic and coalgebraic specification techniques in one specification language.

Different features in a feature model are related by different kinds of relations. Generalization, requires, excludes and implemented_by are considered binary relationships. Each relation in a feature model must be well formed. Next, the structure for each type of relation is defined as follows:

```
type
  Rel={|r:Rel1 • well_formed (r ) |},
  Rel1=
     Generalization | Implemented_by | Composed_of | Requires |
     Excludes ….
type
  Generalization::
       subfeature: Feature
       superfeature: Feature,
  Composed_of::
         has-part: Feature
         Part-of: Feature-set,
  Implemented_by::
       source: Feature
       target: Feature,
  Requires::
       source: Feature
       target: Feature,
  Excludes::
       source: Feature
       target: Feature,
   ……..
```

Below, we give the boolean function “well_formed” used to define well-formed relationships. Each relation has different properties. For example, the “generalization” relation must satisfy the following: a subfeature can not be root; the superfeature can not be leaf and the subfeature can not redefine the attributes of their superclasses. The “requires” relation describes that the binding of one variant implies the need of another variant (required variant). “Excludes” defines a feature relation that the selection of one feature excludes the selection of the other (see below).

Also, as relations are described in RSL language, all the concepts involved in the feature model can be specified in RSL. Multiplicity for features and parameters for features [1] in a graphical notation way may result ambiguous. It is neccesary to give clear semantics. The need to consider the complete set of relations has been identified by the feature modelling community, and approaches to formalizing them are defined in several formal languages [2, 14].

6. CONCLUSIONS

The use of formal methods in system development can help to overcome inconsistencies, and should aid the promotion of software reuse in early stages of software development. In this paper we present a first approach to integrate a feature model into RAISE methods to be used in the context of software reuse. The feature model enables to work with the identification of commonalties and variabilities among related applications creating a feature model of a specific domain. More precisely, a feature model has been developed for the “Agriculture system” being the basis to the specifications of the RAISE reusable component. In this work we identified basic features relations, i.e. Generalization, Requires and Exclude, among the features in a domain context. Our contribution is not only to define features, categories and relations in RSL; but also to give an approach to a rigorous reasoning of feature models. We are currently extending the work by taking feature interaction [13]. Feature interaction occurs when one feature modifies the operations of another. Also, we are working towards a reference architecture in the RAISE method framework.

REFERENCES

[1] Czarnecki, K. “ Generative Programming”. Dissertation TU-Ilmenau, 1998.

[2] Detlef Streifert, Matthias Riebisch, I. Philippow; Formal Details of Relations in Feature Models; In:Proceedings 10th IEEE Symposium and Workshops on Engineering of Computer-Based Systems. USA April 2003.

[3] George, C., Haff, P., Havelund, K., Haxthausen, A., Milne, R., Nielsen, C., Prehn, S. and Ritter, K. The RAISE Specification Language, Prentice Hall, UK, 2002.

[4] George, C. RAISE Tools User Guide. (Technical report No.227) Retrieved from http:// www.iist.unu.edu, 2001.

[5] George, C., Haxthausen, A., Hughes, S., Milne, R., Prehn, S. and Pedersen, J., The RAISE Development Method, Prentice Hall, UK, 1995.

[6] Griss, D.; Allen, R. And d´Alessandro, M.: “Integrating Feature Modelling with the RSEB”. In Proceedings of the 5th International Conference of Software Reuse (ICSR-5), 1998.

[7] Hess, J; Novack, W; Carrol, P; Cohen, S; Holibaugh, R; Kang, K; and Peterson, A. “A domain analysis bibliography”. SEI-90-SR-3 Software Engineering Institute, Carnegie Mellon University, Pittsburgh, PA, 1990.

[8] Kang, K., et al. Feature-Oriented Domain Analysis (FODA) Feasibility Study (CMU/SEI-90-TR-21, ADA235785). Pittsburgh, PA: Software Engineering Institute, Carnegie Mellon University, 1990.


```
value
  well_formedGen: Feature x Feature-> Bool
  well_formed Gen (subfeature, superfeature) ≡
   ~is_root(subfeature) ^
   ~is_leaf(superfeature)^
   (∀at1,at2: Attribute •
       (at1∈ attributes(subfeature)^ at2 ∈
          attributes(superfeature))⇒
          name(at1)≠ name(at2)
```

“*Generalization*” RSL construct

```
value
  well_formedReq: Feature x Feature-> Bool
  well_formedReq (requester, supplier) ≡
    is_selected(requester) ⇒ is_selected (supplier)
```

“*Requires*” RSL construct

```
value
  well_formedExc: Feature x Feature-> Bool
  well_formedExc (source, target) ≡
    is_selected(target) ⇒ ~is_selected (source) ^
    is_selected(source) ⇒ ~is_selected (target)
```

“*Excludes*” RSL construct

[9] Kang, K; Kim, S, Lee, J and Kim, K "FORM: A Feature-Oriented Reuse Method with Domain-Specific Reference Architectures". Annals of Software Engineering, 5, pp: 143-268.

[10] Kang, K; Kim, S, Lee, J and Kim, K "Feature-Oriented Product Line Software Engineering: Principles and Guidelines. In: Domain Oriented Systems Development: Practices and Perspectives". Taylor & Francis, 2003, pp: 19-36.

[11] Lee, K; Kang, K; Chae, W and Choi B. "Feature-based approach to object-oriented engineering of applications for reuse". In Software -Practice and Experience 2000:3. J.Wiley &Sons Ltd, pp: 1025-1046.

[12] Riesco, D; Felice, L; Debnath, N and Montejano, G (2005). Using a feature model for RAISE specification reusability. In Proceedings of the 2005 IEEE International Conference on Information Reuse and Integration, IRI – 2005. Las Vegas, NV USA. (pp: 306-311).

[13] Zave, P. Feature interactions and formal specifications in telecommunications. IEEE Computer. 1993.

[14] Zhang, Hongyu; Jing Sun and Hai Wang, Formalizing and Analyzing Feature Models in Alloy, RMIT CS Technical Report TR-04-2, March 2004.

The Value of Communities of Practice (CoPs) Within Knowledge Management (KM)

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ABSTRACT

This paper focuses on Communities of Practice (CoPs) as one vehicle for managing knowledge in an international organisation, with core business areas in civil and defence aerospace, as well as industrial and marine power. The study aims to characterise the nature of CoPs in terms of the value they provide. 21 CoPs were sampled using a range of data collection methods, and thematic analysis resulted in the following four categories of value: re-use and transfer of knowledge; connecting and strengthening of networks; motives and rewards for participation; and gaining management support and organisational credibility. It is argued that the multi-dimensional value of CoPs implementations can be conceptualised as reducing costs, and/or adding benefits at various levels. Effective CoPs operate like a lens to draw in disconnected people, practices and knowledge, and then focus on relevant issues at personal, community and organisational levels. CoPs can be a powerful component of a holistic KM strategy, when the strengths of people's tendency to seek social interaction and share informal knowledge are balanced with addressing formal, business needs and demonstrating organisational value.

INTRODUCTION

This paper focuses on Communities of Practice (CoPs) as one vehicle for managing knowledge in the workplace. The research investigates 21 CoPs operating in an international organisation, with core business areas in civil and defence aerospace, as well as industrial and marine power. A review of the relevant literature on CoPs is used to inform the rationale and objectives for the present study. The research context and methods are then described, before presenting and discussing the main findings, and drawing preliminary conclusions.

LITERATURE REVIEW

Despite claims made by theorists and practitioners that Knowledge Management (KM) can be a primary opportunity for improved organisational effectiveness and gains in competitive advantage, the empirical evidence remains sparse (Scarborough, 2003). A consideration of the literature reveals a polarization between what may be classified as technology-based approaches and more social/people orientations to KM (McDermott, 1999; Wenger et al, 2002). Both technological and social solutions should be accommodated if an organisation is to manage knowledge resources effectively (Bhatt, 2001).

Bechy (2003) highlights the transfer of knowledge across boundaries as a major KM challenge, and the potential role of occupational CoPs. Indeed, CoPs have been forwarded as central to many KM strategies, particularly those aimed at facilitating knowledge sharing and exchange between geographically, socially and organisationally distributed workgroups (Brown & Duguid, 1991; Lave & Wenger, 1991; Orr, 1990). Ali (2001) further supports the importance of cultivating CoPs to promote the more creative and implicit features of knowledge activities. There is a significant interest in how to effectively capitalise on the organic, informal and resilient nature of CoPs, in order to cultivate and nuture them as more formal organisational knowledge assets (McDermott, 2000). From this standpoint, CoPs can help span boundaries created by typical hierarchical and bureaucratic organisational structures (Scarbrough, 2003). The emphasis is on encouraging the free and open sharing of experiences among CoP members about work, and facilitating this through trust and reciprocity with little direct management (Swan & Newell, 2000). However, the notion of cultivating CoPs and increasing the level of management and control means that some return on investment becomes a priority.

For CoPs, like many KM activities, this goal of demonstrating value is difficult to meet. Essentially, there is a recognition that it is easier for organisations to adopt, accept and justify technological KM solutions. However, guidance on nurturing these often fragile organisational units has been recently outlined (Gonglo & Rizzuto, 2001; Wenger et al, 2002.). Typically, this advice describes ideal lifecycle models of development, and offers suggestions on how to facilitate the CoPs through various stages to reach maturity and demonstrate value at the organisational level (Skyrme, 2002). Despite these advances, there is scope for empirical work on what the value of CoPs means in organisational reality.

Research Objectives

The reported successes of CoPs are limited to a relatively few number of organisations and small-scale case studies (Breu & Hemingway, 2002). With this in mind, the current study has the following objectives:

- to characterise the nature of the CoPs
- to categorise the value that CoPs can provide

Research Context

The research was carried out in a large global company providing power for land, sea and air, which has core business areas in civil and defence aerospace, as well as industrial and marine power. At this time, CoPs were being promoted and supported as one element of a company-wide KM initiative. Within this investigation, 21 CoPs were sampled using a range of data collection and analysis methods, which served to triangulate the findings and strengthen the overall claims. The CoPs covered a wide range of issues and topics including: parts and components (e.g. bearings, compressors, and control systems); analysis techniques (e.g. automatic and thermo-mechanical); engineering design (e.g. computational fluid dynamics and whole engine modelling); IT (e.g. computer-aided design and intranet development); and organisational strategy (e.g. business intelligence and knowledge management).

METHODOLOGY

The multi-method case study approach provided a comprehensive account of CoPs, and permitted the perspectives of the main stakeholders (i.e. facilitators, members and researcher) to be acknowledged and investigated. Both planned and opportunistic methods of data collection were used, with each technique offering particular insights. A qualitative survey and semi-structured interviews constituted the main methods of data collection, while the researcher also participated in workshops, meetings, and informal discussions. All data were analysed for qualitative themes.

Questionnaire

Initially, a short self-assessment questionnaire was developed collaboratively by the researcher and key contacts within the host organisation. This instrument was designed to elicit the views and opinions members had of their CoP, together with any future aspirations. It can be seen as a health-check mechanism or a method of

taking the temperature of a CoP (Adams & Freeman, 2000). The survey focused attention on CoP issues such as; objectives, activities, problems and successes, and was either administered at meetings or circulated electronically to the appropriate distribution lists. Anonymity was guaranteed and 52 responses were received.

Interviews

Ten interviews with facilitators and members of various CoPs were also conducted in the early stages of the case study. These allowed the researcher to become familiar with the specific groups under investigation, and started the process of gathering data about indicators of value. Subsequently a further 15 interviews were undertaken with facilitators and members. All interviews were audio-recorded and in order to retain a degree of informality and flexibility, a semi-structured interview guide was used to cover a set of issues (e.g. goals and objectives; roles and activities; problems and obstacles; successes and achievements)

Meetings and Workshops

The researcher also participated in meetings and workshops (n=15), which were centred on providing feedback to, and eliciting further views from CoP members. Several of these face-to-face events were used for more specific purposes, such as, gathering and documenting success stories and failures as useful lessons. In conjunction with the more formal methods of collecting data, informal discussions were also held with several of the CoP facilitators (n=5).

Thematic Data Analysis

The recorded interviews were fully transcribed, while detailed field-notes from meetings, workshops and informal discussions were also written up. As the survey responses were also in written format, the analysis was mainly qualitative and focused on developing themes to address each of the research objectives.

RESULTS

Key features of the CoPs are briefly described before outlining the main findings from overall analyses of value (see Table 1 for representative examples of the CoPs investigated).

Nature of CoPs

Although the CoPs initiative formed part of a larger KM programme within the organisation, two clear patterns of emergence can be distinguished. Most of the CoPs were initially informal interest groups, while a minority were set up in the wake of a disbanding project team. Typical objectives for these groups are to facilitate different types of KM processes, namely; solve problems (know-what), share good practices (know-how), and link people (know-who). Face-to-face meetings and workshops were common at start-up and then to review progress and plan next steps at regular intervals. Email, discussion lists and intranet websites allow on-going updates and news provision for members. In terms of organisation, some CoPs have become hierarchical and evolved sub-units with dedicated functions. There are also examples of CoP roles being distributed by company site location or across key individuals.

Value of CoPs

The study reveals the following four categories of value attributable to the CoPs initiative: re-use and transfer of knowledge; connecting and strengthening of networks; motives and rewards for participation; and gaining management support and organisational credibility. These factors are inter-related and within each there are several sub-components and characteristics of interest.

Re-Use and Transfer of Knowledge

A prominent aspect of this value indicator is re-using up-to-date knowledge to solve similar problems. This process was demonstrated within the Thermo Mechanical Analysis CoP, where a request for information on windage in oil dominated sumps was raised by an analyst based in Canada. Another expert in this type of analysis was able to provide an answer, because a similar problem had been encountered and successfully solved at his own UK site. Specifically, the solution was contained in test rig data, which were located and transferred between these individual members of the CoP. Within the same CoP, a second instance saw an enquiry for carbon seals information posed by a German member. This led to the name of a colleague based in USA being suggested by a UK member of the CoP. Overall, the international links within the CoP facilitated the feedback of advice and test data, about heat generation, and wear and tear on carbon seals, to the original questioner in Germany.

The development of good working practices is assessed as another valuable knowledge transfer contribution made by CoPs. The Facilitators CoP is a key player in co-ordinating efforts to learn lessons from both positive and negative experiences, and to draw upon wider KM resources and experts where appropriate. One tangible outcome is the documentation of this knowledge, which is shared among all the CoPs, through both electronic and face-to-face forums. This collaboratively developed material also serves to promote the CoPs initiative to the rest of the organisation. A member of the Computer Aided Design CoP articulates one part of a vision about how this KM system might function, in which for example, relevant knowledge concerning the rationale for design modifications could be incorporated into a website as an entry on a prompt list, a lesson learnt or a working practice.

Lastly, knowledge transfer can increase efficiency and reduce unnecessary repetition. For instance, the Manufacturing Laboratories Managers CoP conducts up-front work to obtain opinions on any proposed amendments to specifications, so that they are correct when formally issued. Such time and cost savings are also shown within the Computational Fluid Dynamics CoP, where requests from an out-lying group resulted in the retrieval of test data. The general consensus is that without the CoP, this data either would not have been found (i.e. cost of re-doing the test) or would have taken a long time and effort to discover (i.e. cost of individuals time). Subsequently, this episode influenced when and why expensive testing procedures should be conducted in the future.

Table 1. Example communities of practice

Nature of CoP	Core objectives	Main functions	Key activities	Example value
Group of CoP Facilitators	Help members to cultivate their own CoPs	Sharing similar experiences	Meetings aimed at picking up successful lessons	Agreed set of guidelines for setting up a CoP
Topic of Knowledge Management	Sharing latest ideas on KM – strategies, practices and technologies	Linking people with KM interests and pointing to new opportunities for collaboration	Themed/focused meetings rotating around company locations	Shift from focus on technology to holistic view of KM. Assist with internal innovative KM applications
Engineering Analysis Technique	Inter-project sharing	Problem solving across boundaries	Moderated discussion group	Time and money savings
Computer Aided Design Tool	Sharing best practice about this package	Learning	Website with hints, tips and Frequently Asked Questions	Faster lead user group (experts) development

Connecting and Strengthening Networks

CoPs in this study combat the disconnectedness of both geographically remote, and those less experienced members of the company. UK-based members of Whole Engine Modelling CoP admitted a lack of knowledge about what their US counterparts were doing. This has now improved to such an extent that they can locate and identify who, for example, has previous experience with specific measurement techniques and instruments. Likewise, the Combustion Cost Reduction CoP actively encouraged a *'know-who'* functionality by inviting nominations for membership, so providing access to the people who are judged favourably by their peers and managers. Other CoPs, such as the Bearings, also see expert identification and location as a key feature, especially for inexperienced members and those further away from the core activity. To launch the Bearings CoP, all group members provided a mini CV, which was then published as a who's who on their website. As a result, members have direct communication links to experts who are located in different domains, such as in-service and product-support.

The development and enhancement of such networks through boundary spanning also plays a critical role in the formation and development of a CoP identity. Within the Computational Fluid Dynamics CoP for example, membership has widened to include sub-contractors, who had previously reported a sense of isolation. These new members of the CoP now feel part of user group, and are excited at being invited to the quarterly meetings, where problems are addressed and best practice shared. Furthermore, spanning boundaries through sabbatical visits between Canadian and UK members of the Whole Engine Modelling CoP have been used to encourage a two-way exchange of experience between sites with strengths in different modelling methods.

Motives and Rewards for Participation

For many members, participation in a CoP is internally motivated to some degree, as the communal activity was seen as inherently valuable. It is also clear that ensuring participants get positive feedback from their investments of time, effort and knowledge is critical. This form of outcome is encouraged through a feedback cycle of making the experience useful (e.g. learning something new or seeing the outcomes of a contribution), so that members became more likely to participate in the future. Likewise, a more vibrant and active CoP also tends to increase the chances that participants would enjoy a positive and valuable experience. Findings from several CoPs, most notably the KM, indicate the importance of a non-judgmental arena and the development of trust to motivate and encourage involvement.

Gaining Management Support and Organisational Credibility

The final mode of value exhibited in this study concerns the challenge faced by CoPs to acquire a sufficient level of organisational support while retaining a degree of self-ownership and direction. Several of the CoPs were able to help projects and other formal groups accomplish their tasks more efficiently. This greatly enhanced their credibility and focused their efforts on relevant issues for the organisation. Generally, management support and recognition helps to give credibility to the CoP and indicates that it is seen as valuable. A reciprocal relationship, which requires on-going negotiation between CoP members and the organisation as a business, is also regarded as another feature helping survival. In the Web Editors case, retaining sufficient organisational support, while adhering to a self-management philosophy helped to manage the transition from a project team to a CoP. To date, most value for the company has been delivered through knowledge exchange between business units and in cultivating innovative and holistic KM practices and thinking.

DISCUSSION

The foremost value indicator comprises the core elements of knowledge management espoused in much of the literature, namely building on and re-using previous experience, while also generating new systems for creating, sharing and transferring knowledge (Kakabadse et al, 2003). CoPs not only provide contexts for sharing expertise (Breu & Hemingway, 2002), but also help develop expertise quicker by giving members the opportunity to become recognised as experts in a particular topic or domain (Archichvili et al, 2003). The Web Editors CoP is a good example of a "learning CoP", where novices gain knowledge about building and publishing intranet sites from experienced members.

Findings are consistent with Archichvili et al (2003), who report that CoPs can help reduce the duplication of activities, through timeliness and efficiency in acquiring information. In line with the existing investigation, they also found that CoPs could operate as a general encyclopaedic problem-solving tool, as an expertise identifier, and as a way of keeping informed and up-to-date about developments in their profession (Archichvili et al, 2003). Having access to best practices and lessons learnt via the CoPs was key to bringing about this multi-functionality.

The current research supports earlier work by Scarbrough (2003), who concludes that one major benefit of CoPs is integrating previously weakly or non-related individuals and professional groups within any organisation. On a related theme, Boland and Tenkasi (1995) highlight the role played by information and communication technologies in fostering a shared or community identity across dispersed employees. It can be argued that as members become connected to people they would not have had a chance to without the CoP, the social capital of the organisation is strengthened (Archichvili et al, 2003). Furthermore, the capability of the CoPs in this study to moderate the fragmentation of people and knowledge may be very useful in providing continuity during times of change and uncertainty (Breu & Hemingway, 2002).

In terms of encouraging CoP participation, Breu & Hemingway (2002) present a similar "success breeds success" argument, in which members can test out their ideas in a risk-free environment without many negative consequences. Motivating factors highlighted within the current investigation include; the role of relevant professional interests, together with satisfactory prior experiences, the integrity of the organisation, and the competence of members to encourage active engagement in CoPs (also see Archichvili et al, 2003).

Although the shift from informal interest groups to CoPs can be seen as part of the company's wider KM initiative, it also exhibits a sense of legitimisation (Wenger, 1998) and an element of sponsorship (Nickols, 2000). Previous studies tend to position CoPs as pre-cursors to generating value at the organisational level. For instance, the creative and innovative nature of CoPs can be cultivated to focus on formal project work with unambiguous and observable organisational deliverables (Breu & Hemingway, 2002). Similarly, Von Krogh et al (2001) emphasise the role of CoPs in making knowledge explicit, with subsequent strategic application towards business goals, both within the organisation and to external partners. They offer a phased description of how these should be managed and outline a raft of organisational benefits, including better decisions on investments and collaboration across geographical and functional company boundaries. Similar findings are exhibited in the current study, although the Web Editors evolution from a project team to a CoP is an interesting exception to the typical pattern of development.

CONCLUSIONS

This paper has explored Communities of Practice (CoPs) as one form of Knowledge Management (KM) enacted within the engineering context of two aerospace organisations. The current research argues that the value of CoPs implementations are multi-dimensional and can be usefully conceptualised as reducing costs, and/or adding benefits at various levels. CoPs should be inherently rewarding at the personal level in order to capitalise on individual motivations. At the group level, the value is in connecting people and their expertise. The re-use and transfer of both explicit and implicit knowledge through social and technical mechanisms is a defining feature of this form of value. While it is advocated that members should control and negotiate what they do and how they do things in the CoP, there should also be some clarity about the benefits offered to the organisation.

Successful and effective CoPs can best be depicted as operating like a lens to draw in disconnected people, practices and knowledge, and then focussing on problems and issues of relevance at personal, community and organisational levels. Accommodating these multiple requirements pose questions for managers, researchers, and practitioners alike. In terms of recommended ways forward, sub-groups could be used to consolidate the depth of core knowledge within the CoP, while recruiting new members may help to widen its scope. Overall, combining the strengths of people's tendency to seek social interaction and share informal knowledge, with the organisational benefit of addressing more formal, business needs, CoPs can be a powerful component of a holistic KM strategy.

REFERENCES

Adams, E.C. & Freeman, C. (2000). Communities of practice building technology and knowledge assessment. Journal of Knowledge Management, 4(1), 38-44.

Ali, Y. (2001). The intranet and the management of making and using skills. Journal of Knowledge Management, 5(4), 338-348.

Ardichvili, A., Page, V. & Wentling, T. (2003). Motivation and barriers to participation in virtual knowledge-sharing communities of practice. Journal of Knowledge Management, 7(1), 64-77.

Bechky, B. (2003). Sharing meaning across occupational communities: the transformation of understanding on a production floor. Organization Science, 14(3), 312-330.

Bhatt.G.D. (2001). Knowledge management in organizations: examining the interaction between technologies, techniques, and people. Journal of Knowledge Management, 5(1), 68-75.

Boland, R. & Tenkasi, R.V. (1995). Perspective making and perspective taking in communities of knowing. Organization Science, 6(4), 350-372.

Breu, K. & Hemingway, C. (2002). Collaboration processes and knowledge creation in communities-of-practice. Creativity and Innovation Management, 11(3), 147-153.

Brown, J. S. & Duguid, P. (1991). Organizational learning and communities of practice: toward a unified view of working, learning and innovation. Organization Science, 2(1), 40-57.

Gonglo, P. & Rizzuto, C.R. (2001). Evolving communities of practice: IBM Global Services experience. IBM Systems Journal, 40(4), 842-862.

Kakabadse, N.K., Kakabadse, A. & Kouzmin, A. (2003). Reviewing the knowledge management literature: towards a taxonomy. Journal of Knowledge Management, 7(4), 75-91.

Lave, J. & Wenger, E.C. (1991). Situated learning: legitimate peripheral participation, New York: Cambridge University Press.

McDermott, R. (1999). Why information technology inspired but cannot deliver knowledge management. California Management Review, 41(4), 103-117.

McDermott, R. (2000). Community development as a natural step. Knowledge Management Review, 3(5), 16-19.

Nickols, F. (2000). Communities of practice: definition, indicators & identifying characteristics, URL: http://home.att.net/~discon/KM/CoPCharacteristics.htm

Orr, J. (1990). Sharing knowledge, celebrating identity: war stories and community memory in a service culture. In D. Middleton & D. Edwards (Eds). Collective Remembering: Memory in Society. Beverly Hills, CA: Sage Publications.

Scarborough, H. (2003). Knowledge management. In D. Holman, T.D. Wall, C. Clegg, P. Sparrow, & A. Howard (Eds.), The New Workplace. Chichester: Wiley.

Skyrme, D. (2002). Creating successful communities, K-Guide: insights and practical guidance for the knowledge professional. Available from David Skyrme Associates. URL: http://www.skyrme.com/kshop/kguides.htm#CoP

Swan, J. & Newell, S. (2000). Linking knowledge management and innovation. In H.R. Hansen, M. Bichler, & H. Maher (Eds). Proceedings of the 8th European Conference on Information Systems, Vienna University of Economics and Business Administration, 591-598.

Von Krogh, G., Nonaka, I. & Aben, M. (2001). Making the most of your company's knowledge: a strategic framework. Long Range Planning, 34, 421-439.

Wenger, E.C. (1998) Communities of Practice: Learning, Meaning and Identity. New York: Cambridge University Press.

Wenger, E.C. & Snyder. W.M. (2000). Communities of practice: the organizational frontier. Harvard Business Review, Jan-Feb, 39-145.

Wenger, E.C., McDermott, R. & Snyder, W.M. (2002). Cultivating Communities of Practice: A Guide to Managing Knowledge. Cambridge: Harvard Business School Press.

Call-Graph Based Program Analysis with .Net

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ABSTRACT

Software development is a complex business, whether maintaining or extending existing legacy systems, or whether developing new systems. Another challenge faced by programmers, is determining whether sufficiently rigorous unit- and integration-testing is employed to give confidence that a system is behaving as intended. One approach to help address such challenges is to use automated program analysis tools and techniques, where the programmer will use a software tool to gain an insight into some aspect of the system they're working on. One particular type of static program analysis technique, call-graph analysis, focuses on the calling relationships that exist in a program. One of the common problems with this and other static analysis techniques is that they tend to be source language based and are therefore often limited in terms of applicability, especially in multi-language/module systems. In this research we investigate call-graph analysis on the .Net platform that sidesteps these common limitations and allows analysis of programs regardless of source language, and regardless of the number of modules/assemblies in the program. We demonstrate the soundness and usefulness of the approach by demonstrating the analysis of a multi-module application that is written in several different source languages from 2 different vendors.

Keywords: Call-graph analysis, .Net, Program analysis, Integration testing

1. INTRODUCTION

Key challenges faced by programmers today include the difficulty of understanding complex codebases while performing maintenance and ensuring that test-suites sufficiently cover the code in question. Software maintenance particularly often involves many difficulties, including gaining an understanding of the system being modified or analyzing an existing system as a whole. Understanding a system is often complicated by documentation which is either out of date, limited or in some cases even non-existent, and analyzing a system is complicated when it spans over several languages, implementation modules, and/or process boundaries. By 1990, the amount of legacy code being maintained was already estimated at 120 billion lines of code (Sommerville 2001, p. 623.) Today, this is estimated to be in excess of 250 billion lines of code! (Losch 2005) With a legacy codebase of this size being maintained, the argument for re-engineering systems instead of outright replacement becomes quite compelling.

These challenges are typically addressed through suitable program comprehension and -coverage analysis tools. A key data structure used by both these types of program analysis tools is the program call-graph. Call-graph analysis focuses on the particular calling relationships that exist in a program, and the results of such a tool are very useful in determining the call relationships used to track errors and design suitable test data for unit and integration testing. However, conventional program call-graph analysis often relies on program source code parsing techniques, which limit it to that particular source language. Thus, if the system consists of multiple modules written in multiple languages then it follows that it would be extremely difficult at best to do a full-program analysis, unless you have analysis tool(s) that can read all the source languages and can inter-operate when generating the call graph. An alternative approach that addresses both these limitations is to perform analysis on .NET Common Intermediate Language (CIL) instead of the program source language. In this research we develop a simple software framework and a prototype call-graph analysis tool using CIL, thus in principle demonstrating the feasibility of this approach in practice.

The contribution of this paper is in the development of the prototype model mentioned which provides a usable foundation from which further work may be conducted, on the .Net platform and CIL. Details of the model are given in Section 3, followed by a short discussion and outline for future work.

2. BRIEF LITERATURE REVIEW

While we've had program development, there seems to be renewed interest in many types of such tools. This interest is driven by several factors, including the increased capacity for analysis on today's machines, the increasing ability for analysis as a result of software platform advances, and the changing focus of the industry with respect to software development and maintenance. Ultimately however all of these things can be largely drawn back to the problem of software maintenance and software change. If a system was not that well designed to begin with, or if it's been modified in less than ideal ways and accumulated a substantial so called "code debt" (Fowler 2000, pg. 66), gaining an understanding of the codebase, clarifying its original design intentions and developing meaningful test suites are crucial (for which such tools are very useful.)

Call Graph Analysis

Olin Shivers' provides a succinct description of the call graph analysis problem: "*For each call site c in program P, what is the set F(c), that c could be a call to?*" (Shivers 1988):

Call Graph analysis is the process of generating a program call multi-graph (call-graph) for a program. It's a directed graph where nodes represent procedure, function or method names, and edges represent calling relationships (Aiken 2005). A program call graph is therefore a control flow representational construct at the inter-procedural level (therefore not showing detail inside procedures/methods.) A call graph may also be described in textual form by enumerating all the nodes) together with the set of edges between them. Note however that this description actually encompasses several possible meanings, for example:

method m_i invokes method m_j

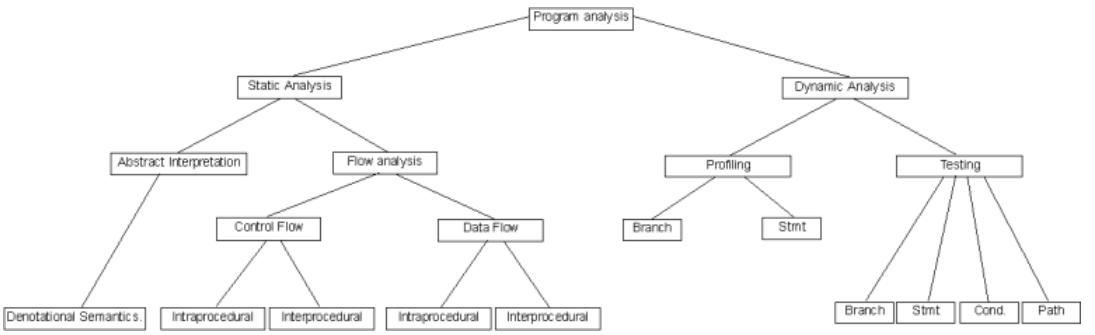
call site c_k inside mi invokes m_j

call site c_k inside mi invokes m_j on an instance of X (Rountev, Kagan & Gibas 2004)

Figure 1 below shows a taxonomic breakdown of program analysis in general, serving to place call-graph analysis into the broader program analysis context:

Call graphs are central to various types of compiler optimizations, including both inter-procedural optimization (where the effects of callers and callee's are summarized into the call graph) as well as intra-procedural optimization (for example where the included receiver class sets may allow method invocation to be bound statically instead of dynamically). Call graphs are also central to several other types of analysis such as call-chain analysis and call-tree coverage analysis, and is also useful in various types of developer tools, such as test tools, debug tools and program understanding tools.

Figure 1. Taxonomic breakdown of program analysis (Losch 2005)



Call graph generation in first order languages such as FORTRAN is very easy: It can be performed by firstly generating the nodes by finding all functions in the program, followed by insertion of edges for each function call that exists in the program. That is, for each call to function *b()* in arbitrary method *a()*, you insert an edge (a,b) (Lakhotia 1993, pg. 273).

In higher order languages things are unfortunately substantially less simple, due to the requirement to estimate the receiver classes at call-sites prior to call-graph construction. The problem is more or less as follows: In order to perform Inter-procedural data flow analysis (a process whereby you compute summaries of the effects of callers and callee's at function/procedure entry points and call-sites respectively, which may be consulted during optimization (Grove 2001, pg. 686)), you need to have already constructed a call graph that may be traversed during this analysis. As mentioned, in first-order languages there is no problem as the the target function is directly and unambiguously evident from the call site. However, with object-oriented languages with dynamic dispatch mechanisms, the actual target of a call site is usually dependent on the data flow(s) to that point in the program (in particular, the actual class type of the object variable on which the method call is performed), which implies that you need to have already performed some form of data flow analysis in order to discover the actual receiver classes for a call site (ibid)! Thus there occurs a seemingly paradoxical situation.

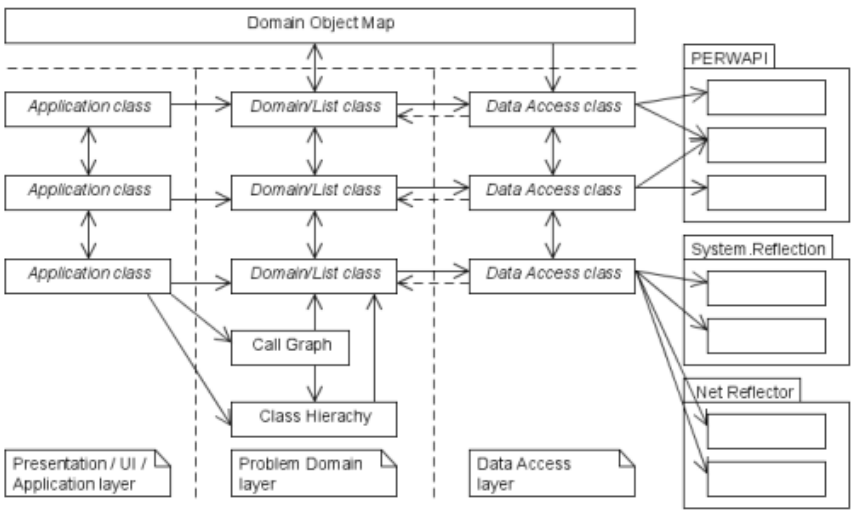
Typical solutions include performing the two steps in parallel (to be precise to interleave them), or to make suitable assumptions (whether optimistic or pessimistic) for one of the three entities involved (call-graph, receiver class sets or inter-procedural analysis) in order to break the deadlock and then iterating the solution to a suitable solution point (ibid). Dean compares and contrasts several techniques for the construction of call-graphs in the presence of "higher-order" functions and goes on to evaluate them in terms of three properties, namely: Precision; Time complexity; Supported Language features (Dean 1997, pg. 2).

Grove & Chambers present a fairly comprehensive evaluation of existing call-graph construction algorithms in (Grove 2001). They implement the evaluation via a generic parameterized call-graph construction algorithm implemented in the context of an optimizing compiler infrastructure. This approach allows them to validly compare different call-graph algorithms on a "level playing field."

Call Graph Analysis at Intermediate Code Level

While some research has been done with respect to program analysis in general and call-graph construction in particular using VM's and intermediate languages, most of this work is Java based. For example, Lance presents work where the unmodified bytecode output by a Java compiler was analyzed to produce "end-product program analysis information" and utilized a prototype to prove the concept (Lance 1999). Another work by Maggi & Sisto demonstrates the feasibility of performing data flow analysis against Java bytecode to infer type information (Maggi 2001). On the other hand, Zhao demonstrates the viability of performing intra-procedural dependence analysis using Java bytecodes in their work (Zhao 2000). Other work such as that by Arnold (2005) examines the idea of using dynamically collected profiling information, collected via the virtual machine itself to generate high-accuracy call-graphs.

Figure 2. Analyzer architecture layout



Finally, Searle presents a tool called "DUCT" (for Define Use Chain Tool) which focuses on "relative debugging" and the following of "define-use" chains in program code. DUCT, unlike most other research focusing at the intermediate level (and very much like this research) leverages .Net CIL to allow it to operate on "a wide variety of languages without modification." (Searle 2003) Additionally, it should be noted that DUCT uses an incremental approach and mostly avoids traditional global program analysis (although like other incremental algorithms it also does require an initial full analysis to start with). DUCT's implementation uses essentially 3 analysis data structures, namely a Control Flow Graph, a Class Hierarchy Graph, and a Call Graph.

3. CALL GRAPH ANALYZER IMPLEMENTATION

A layered architecture, typical of many systems and particularly 3-tier business systems was used, as initially there was some uncertainty with respect to exactly how the .Net files would be interacted with (i.e. it was uncertain which back-end library or combination of libraries would be used to read the IL assemblies.) The analysis framework along with all algorithms and logic it contained was therefore to be well separated from the mechanics of actually retrieving the information, thus making it possible to easily change the data-access aspect without affecting the rest of the analyzer too much (hence the similarity to how a tiered business app might use an object persistence framework to insulate itself from database platform changes.) The particular architecture was inspired by an example object-persistence framework by Philip Brown (2000). The original architectural layout is shown in Figure 2 below. The idea was to contain the "analysis domain" logic in the middle layer, keeping separate all assembly data access concerns in data access classes in the right-had layer. These in turn delegate to one or more underlying reflection libraries to get their work done. Lastly, user interface and other application logic are kept in the application layer on the left.

Since most domain classes would have a common need/requirement in terms of having to be populated/loaded from the back-end API's by the data access classes, having this functionality common to a base domain class seemed sensible. Similarly, common data access behavior could be put in a base class for all data access classes.

The implementation used C# as primary implementation language, but also used all of the other languages available in Visual Studio 2005 (Beta 2) namely C++, VB.Net and J#, as well as Borland Delphi, as an alternative vendor's language. Small test libraries or assemblies were constructed in each of these languages, some with multiple links, as test cases for the analysis. For example, there's a C# test application that calls on a J# library, that in turn calls on a C++ library.

Other tools used include the Nunit unit testing framework for .Net as well as TestDriven.Net (a plug-in for Visual Studio that make Nunit testing available from within the VS IDE.) Note that Visual Studio 2005 (however, only the high end Team Suite edition) now has built-in Unit testing support (which is clearly closely modeled on Nunit's approach). It also includes other code analysis support functions, such as unit-test coverage analysis. For version control Subversion was used, together with the TortoiseSVN plug-in for Windows Explorer.

4. PRELIMINARY RESULTS

We now demonstrate and evaluates the .Net CIL based analyzer in actual use, firstly using an "Animal Taxonomy" example inspired by a somewhat similar example using the usual Shape/ Square/ Rectangle hierarchy in the Java language, by Rayside (2001). The main assembly listing is shown in Table 1 below. The components were compiled into .Net executables files and then run through the analyzer. Then the analyzer is evaluated and demonstrated to operate on a multi-assembly application where one assembly was constructed using a compiler from another vendor.

Firstly, the analyzer was run without Class Hierarchy Analysis, and as would be expected, this was processed extremely quickly, but also incorrectly includes an edge between AnimalInheritance.doATrick(Mamal) and Mamal.rollOverAndPlayDead(). Class Hierarchy Analysis (CHA) can be described as the process of the calculation of a program's inheritance hierarchy (Dean et al. 1995, pg. 1). Performing Class Hierarchy Analysis produces some form of Class Hierarchy Graph (whether explicit or implicit). This structure describes all the inheritance relationships between the classes in the program, as well as the methods that each class contains, particularly virtual and overridden methods and which ones are abstract (Bairagi 1997, pg. 2). In this case, the runtime was on the order of 47ms

Table 1. Animal taxonomy main listing (written in C#)

```
 1: namespace AnimalInheritance {
 2:   abstract class Mamal { public abstract void rollOverAndPlayDead (); }
 3:
 4:   class Cat     : Mamal { public override void rollOverAndPlayDead() { } }
 5:   class Hamster : Mamal { public override void rollOverAndPlayDead () { } }
 6:   class Dog     : Mamal { public override void rollOverAndPlayDead () { } }
 7:   class Terrier : Dog { }
 8:
 9:   class AnimalInheritance {
10:     static void doATrick ( Mamal m ) {
11:       m.rollOverAndPlayDead();
12:     }
13:
14:     static void Main ( string[] args ) {
15:       doATrick( new Terrier() );
16:     }
17:   }
18: }
```

in this case. This value appeared quite stable and repeated runs did not alter this value appreciably. The results of a particular run can be viewed in Figure 3.

Following these experiments, the analyzer was run with the aid of Class Hierarchy Analysis, but using a conventional full-program scan to build the class hierarchy. The results for this can be seen in Figure 4. As expected this was several orders

Figure 3. Execution of call graph analyzer without class hierarchy analysis

```
(Classes seen during traversal/in object map: No = 5)
(Methods seen during traversal/in object map: No = 6)

Call Graph:
Nodes: (No = 7)
    [AnimalInheritance.Main(String[]) : Void]
    [Terrier..ctor() : Void]
    [Dog..ctor() : Void]
    [Mamal..ctor() : Void]
    [Object..ctor() : Void]
    [AnimalInheritance.doATrick(Mamal) : Void]
    [Mamal.rollOverAndPlayDead() : Void]

Edges: (No = 6)
    [AnimalInheritance.Main(String[]) : Void] ------->[Terrier..ctor() : Void]
    [Terrier..ctor() : Void] ------->[Dog..ctor() : Void]
    [Dog..ctor() : Void] ------->[Mamal..ctor() : Void]
    [Mamal..ctor() : Void] ------->[Object..ctor() : Void]
    [AnimalInheritance.Main(String[]) : Void] ------->[AnimalInheritance.doATrick(Mamal) : Void]
    [AnimalInheritance.doATrick(Mamal) : Void] ------->[Mamal.rollOverAndPlayDead() : Void]

Time taken: 47 ms.
```

Figure 4. Execution of call graph analyzer with class hierarchy analysis

```
(Classes seen during traversal/in object map: No = 1983)
(Methods seen during traversal/in object map: No = 20042)

Call Graph:
Nodes: (No = 9)
    [AnimalInheritance.Main(String[]) : Void]
    [Terrier..ctor() : Void]
    [Dog..ctor() : Void]
    [Mamal..ctor() : Void]
    [Object..ctor() : Void]
    [AnimalInheritance.doATrick(Mamal) : Void]
    [Cat.rollOverAndPlayDead() : Void]
    [Hamster.rollOverAndPlayDead() : Void]
    [Dog.rollOverAndPlayDead() : Void]

Edges: (No = 8)
    [AnimalInheritance.Main(String[]) : Void] ------->[Terrier..ctor() : Void]
    [Terrier..ctor() : Void] ------->[Dog..ctor() : Void]
    [Dog..ctor() : Void] ------->[Mamal..ctor() : Void]
    [Mamal..ctor() : Void] ------->[Object..ctor() : Void]
    [AnimalInheritance.Main(String[]) : Void] ------->[AnimalInheritance.doATrick(Mamal) : Void]
    [AnimalInheritance.doATrick(Mamal) : Void] ------->[Cat.rollOverAndPlayDead() : Void]
    [AnimalInheritance.doATrick(Mamal) : Void] ------->[Hamster.rollOverAndPlayDead() : Void]
    [AnimalInheritance.doATrick(Mamal) : Void] ------->[Dog.rollOverAndPlayDead() : Void]

Time taken: 7953 ms.
```

Figure 5. Execution of call graph analyzer for reachable types

```
(Classes seen during traversal/in object map: No = 5)
(Methods seen during traversal/in object map: No = 8)

Call Graph:
Nodes: (No = 7)
     [AnimalInheritance.Main(String[]) : Void]
     [Terrier..ctor() : Void]
     [Dog..ctor() : Void]
     [Mamal..ctor() : Void]
     [Object..ctor() : Void]
     [AnimalInheritance.doATrick(Mamal) : Void]
     [Dog.rollOverAndPlayDead() : Void]

Edges: (No = 6)
     [AnimalInheritance.Main(String[]) : Void] ------->[Terrier..ctor() : Void]
     [Terrier..ctor() : Void] ------->[Dog..ctor() : Void]
     [Dog..ctor() : Void] ------->[Mamal..ctor() : Void]
     [Mamal..ctor() : Void] ------->[Object..ctor() : Void]
     [AnimalInheritance.Main(String[]) : Void] ------->[AnimalInheritance.doATrick(Mamal) : Void]
     [AnimalInheritance.doATrick(Mamal) : Void] ------->[Dog.rollOverAndPlayDead() : Void]

Time taken: 47 ms.
```

Figure 6. Call graph analyzer multi-module example

```
(Classes seen during traversal/in object map: No = 4)
(Methods seen during traversal/in object map: No = 6)

Call Graph:
Nodes: (No = 6)
     [CSAppRefDelphiLib.Main(String[]) : Void]
     [TFact..ctor() : Void]
     [Object..ctor() : Void]
     [TFact.Fact(Int32) : Int32]
     [Environment.Exit(Int32) : Void]
     [Environment.ExitNative(Int32) : Void]

Edges: (No = 6)
     [CSAppRefDelphiLib.Main(String[]) : Void] ------->[TFact..ctor() : Void]
     [TFact..ctor() : Void] ------->[Object..ctor() : Void]
     [CSAppRefDelphiLib.Main(String[]) : Void] ------->[TFact.Fact(Int32) : Int32]
     [TFact.Fact(Int32) : Int32] ------->[TFact.Fact(Int32) : Int32]
     [CSAppRefDelphiLib.Main(String[]) : Void] ------->[Environment.Exit(Int32) : Void]
     [Environment.Exit(Int32) : Void] ------->[Environment.ExitNative(Int32) : Void]

Time taken: 187 ms.
```

of magnitude slower, both in space and time required, comparing the number of classes and methods processed and the time taken to the previous run. Time taken was approximately 7593ms (with an estimated variance of about 200ms based on observing repeated runs). This is at least 2 orders of magnitude larger than before. The discrepancy between the storage requirements here and previously is even more staggering: approximately 2,000 classes processed versus just 5 before and about 20,000 methods seen versus just 6 before.

Here we can see the analyzer now being very conservative, by now including all three of Cat, Hamster and Dog classes as being receiver classes of the rollOverAndPlayDead method call (together with also including for safety, all visible types in all referenced assemblies. Finally, we show an example where the analyzer was run to strictly include only the reachable types when building the *Class Hierarchy Graph* (CHG). (This is in terms of processing result much like that of the *RTA* algorithm by Bacon and Sweeney (1996), however the actual algorithm is rather different.): The output was as follows:

The performance is markedly improved, evidently back to where it was in the beginning in terms of time, with the class count also being the same as the first experiment and the method count being marginally higher. More importantly, the result is also a lot more accurate, thanks to the extra intelligence employed. Clearly the cost of blindly traversing all of the "visible" program code, without analyzing whether it is in fact reachable from the main entry point is enormous.

One of the key goals of this research was to prove that it was possible to do multi-language/multi-module full-program analysis. We therefore also tested the analyzer with several multi-language scenarios, including this one where a C# application calls on a Borland Delphi library. The source for the both functions are given in Table 2.

Table 2. Call graph analyzer multi-module example: Program code

C# Main Program Code

```
using System;
using System.Collections.Generic;
using System.Text;
using DelphiLib;

namespace CSAppRefDelphiLib {
  class CSAppRefDelphiLib {
    static void Main ( string[] args ) {
      TFact fact = new TFact();
      System.Environment.Exit( fact.Fact( 5 ) );
    }
  }
}
```

Delphi Library Code

```
library DelphiLib;
 type
   TFact = class
   public
     function Fact (n : integer) : Integer;
   end;

function TFact.Fact( n : Integer) : Integer;
begin
  if n = 0 then
    result := 1
  else
    result := n * Fact(n -1 );
end;

begin
end.
```

These two programs were compiled by completely different compilers written by completely different vendors. The main program was fed into the analyzer as input. The output is shown below in Figure 6.

As can be seen, the analyzer had no problem with the fact that the library was originally written in another source language, as should be expected. It can be inferred that a different language was used through visual inspection from the type names, but that is all. There are no other obvious differences. It would be interesting to re-run some of these tests against/on the Mono platform.

5. BRIEF DISCUSSION

Most conventional program analysis approaches employ source based approaches, either simple text I/O or actual scanning and parsing techniques. In some cases byte-code analysis is also used, although this (with a few exceptions) focuses on Java bytecode rather than .Net CIL. While a detailed quantitative comparison of techniques is outside the scope of this research, it is nevertheless useful to try and establish qualitatively the relative strengths of the various approaches, so as to establish whether the .Net CIL based approach is comparable, better or poorer than conventional techniques. There does not appear to exist any comparative study in the literature that compares both source and bytecode based approaches as part of the one study. Murphy (1998) presents an empirical study of static call-graph constructors and states that "four choices of input format are available for the developer of an extractor for a system implemented in C: unprocessed source, preprocessed source, object code with symbol table information, and executable code with symbol table information." Unfortunately they also state that their focus was on source based processing in their study and that object-code based analysis was thus out of scope.

The first observation to make is that .Net CIL files tend to be very compact. The IL assembler language is actually quite simple, and while op-code's can be multiple bytes, most of them (90%) are in fact single bytes. To be precise, there is at present only 250 op-codes, 225 of which occupy a single byte, the remainder occupying 2 bytes (Lidin 2002, pp 422 - 428). Roughly speaking, based on estimates observing the ratios of source code to binary size of the Analyzer code, test case libraries and example libraries produced as part of this research, it would appear that the ratio of IL binary size vs. Original Source code size would be about 2:3. More investigation would be needed to establish whether this observation is borne out in larger systems. But in any case, in terms of I/O overheads, it can therefore be argued that IL will probably be as easy or easier to deal with than text based source code.

Of course, on today's machines, I/O throughput is unlikely to be a significant bottleneck during program analysis. However, as can be observed by trying to analyze even trivial programs with the analyzer while employing a naive approach to what is read as "potentially callable," it is quite possible to have the analyzer consume several hundred megabytes of memory and take several minutes of processing time. So the real problem lies with managing the intermediate in memory representation, and with the algorithms employed during analysis. Here the IL

based approach will suffer the same challenges faced by text based approaches – there is essentially no advantage to either approach from this point of view.

Comparing Java bytecode based analysis to .Net bytecode based analysis, it appears that some of the Java bytecode approaches suffer somewhat partly because of weaker reflection support (whether third party libraries or in the platform.) Lance (1999, pg. 5) presents their "JAristotle" bytecode based Java program analyzer. He remarks that the development of the bytecode based prototype required the writing of (only) 13,700 lines of Java code, and contrast this with the prior "Aristotle" based front-end (which was source based) and required modification to some 30,000 lines of an existing C parser to implement. While probably not directly comparable (since that analyzer computes intra-procedural flow-graphs, not call-graphs) it is nevertheless instructive to note that the .Net CGAnalyzer source code consist of approximately only 1500 lines of C# code, and this includes more than one approach to the analysis as well. This appears to be due in part to to the stronger reflection and introspection support in the .Net platform which enabled us to avoid writing code to directly deal with IL bytecode. This advantage is in addition to and apart from the implied advantages of being able to analyze whatever language target the .Net platform.

6. CONCLUSION AND FUTURE WORK

This research project investigated the possibility of leveraging .Net's CIL bytecode together with reflection support as a vehicle for static program analysis, in particular call-graph analysis, and successfully implemented a prototype to prove the concept. Like Lance (1999) this approach has the benefit of sidestepping the usual lexical and syntax analysis that is associated with conventional source based analyzers, with a consequent lowering of the amount of effort required to get a working analyzer going. Unlike Lance (1999) our approach focuses on .Net, a platform that is deliberately multi-language, and one that is likely to be increasingly used as a platform for legacy migration. In this way, this work therefore will ultimately contribute towards easing the maintenance burden for legacy systems.

The focus on .Net has also made the entry to program analysis easier in other ways. There are a number of API's and libraries available to choose from that can shield one from having to even deal with the bytecode oneself. All of this is reflected in the number of lines of code that was required to effectively implement a protoype analyzer with several analysis features, including a form of Class Hierarchy Analysis and an RTA-like call-graph generation algorithm (that uses a "reachable types only" approach to limit the amount of analysis work done.)

There are clearly many potentially interesting areas for future work: This research project was originally started with a view to call-chain analysis. Having now developed a basic call-graph one could now go directly forward and add some form of call-chain analysis. Call-chain analysis is sometimes used in the context of integration test coverage analysis (see for example (Rountev 2004b)), which requires dynamic analysis support as well to measure the actual chains occurring at runtime. As such, another avenue of work may be to investigate dynamic analysis support on the .Net platform with a view to fully supporting call-chain analysis as part of integration test coverage.

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REFERENCES

Aiken (2005) Call Graphs in Higher-Order Languages (Lecture 14) <http://www.cs.berkeley.edu/~aiken/cs264_02/lectures/lecture14.ppt>. (7/9/2005)

Bacon, D.F. Sweeney, P.F. (1996) 'Fast static analysis of C++ virtual function calls.' ACM SIGPLAN Not. 31, 10 (October)., pp. 324–341

Bairagi, D. & Agrawal, Dharma P. & Kumar, Sandeep (1997) 'Precise Call Graph Construction for OO Programs in the Presence of Virtual Functions,' 1997 International Conference on Parallel Processing (ICPP '97) p. 412, IEEE , <http://doi.ieeecomputersociety.org/10.1109/ICPP.1997.622674> (15/09/2005)

Brown, P. (2000) An Object-Oriented Persistence Layer Design ,: <http://cc.borland.com/Item.aspx?id=15511> (24/1/2006)

Dean, J & Grove, D & Chambers C (1995) 'Optimization of Object-Oriented Programs using Static Class Hierarchy Analysis', ECOOP, <http://www.cs.ucla.edu/~palsberg/tba/papers/dean-grove-chambers-ecoop95.pdf>. (05/09/2005)

Dean, J (1997) Call Graph Analysis in the Presence of Higher-Order Functions , <http://citeseer.ifi.unizh.ch/20731.html>. (6/9/2005)

Fowler, M., (2000) Refactoring: Improving the design of existing code, Upper Saddle River, New Jersey: Addison Wesley

Grove, D., Chambers, C., (2001) 'A framework for call graph construction algorithms' ACM Transactions on Programming Languages and Systems (TOPLAS) v.23 n.6, pp. 685-746, November

Lakhotia A., (1993) 'Constructing call multigraphs using dependence graphs.' Proceedings of the Conference Record of the Twentieth ACM SIGPLAN-SIGACT Symposium on Principles of Programming Languages. ACM, New York, NY, pp. 273–284.

Lance D., Untch R. H., Wahl (1999) 'Bytecode-based Java program analysis.' Proceedings of the 37th Annual Southeast Regional Conference (Cd-Rom) ACM-SE 37. ACM Press, New York, NY, 14.

Lidin Serge (2002) Inside Microsoft .Net CIL Assembler Redmond, Washington, Microsoft Press, pp 421- 428

Losch F, (2005) Instrumentation of Java Program Code for ControlFlow Analysis , <http://elib.uni-stuttgart.de/opus/volltexte/2005/2256/pdf/DIP_2258.pdf>.(5/1/2006)

Maggi P., Sisto R., (2001) 'Using Data Flow Analysis to Infer Type Information in Java Bytecode' FirstIEEE International Workshop on Source Code Analysis and Manipulation, p. 213

Murphy G., (1998) 'An Empirical Study of Static Call Graph Extractors' ACM Transactions on Software Engineering and Methodology, Vol 7, No. 2, April, pp 158-191

Rayside D. (2001) A Generic Worklist Algorithm For Graph Reachability Problems in Program Analysis Waterloo MSc Thesis, Ontario, Canada: University of Waterloo

Rountev A, Kagan S, Gibas M (2004b) 'Static And Dynamic Analysis of Call Chains in Java' Software Engineering Notes Vol. 29(4), p. 1

Searle A., Gough J., Abramson D., (2003a) 'DUCT: An interactive Define-Use Chain Navigation tool for relative debugging' Fifth Int. Workshop on Automated and Algorithmic Debugging [Internet]

Shivers O., (1988) 'Control flow analysis in Scheme' Proceedings of the ACM SIGPLAN 1988 Conference on Programming Language Design and Implementation, vol. 23(7) New York: ACM Press, July, pp 164-174,

Sommerville I., (2001) Software Engineering (6th edition), Upper Saddle River, New Jersey: Addison Wesley, p. 623

Zhao J., (2000) 'Dependence Analysis of Java Bytecode.' 24th international Computer Software and Applications Conference pp. 486-491, October

Applying Domestication: How the Internet Found Its Place in the Home

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ABSTRACT

The concept of the domestication of media technologies has been developed to describe and analyse the processes of technology's acceptance, rejection and use. The concept is both theoretical and conceptual but proves to be valuable when applied to everyday life scenarios. This paper employs the Silverstone model of domestication (1989, 1992) as a structural and analytical framework to achieve an empirical understanding of domestication from the viewpoint of the domestic user of the internet. A model of re-domestication is offered to comprehend the process of domestication through the eyes of everyday users.

INTRODUCTION AND BACKGROUND

The field of technology acceptance and adoption has its roots in information systems and in systems of innovation disciplines. Everett Rogers' S curve adoption model (1995) and the TAM are widely used by researchers wishing to predict user acceptance of information technologies. With such technology focused treatments of the process of adoption and use very little is known about how the user experiences the social processes through which technologies undergo in order to become accepted and used in everyday life. In order to bridge this knowledge gap, this paper will present findings from a study of domestic internet users on their personal experiences of how internet technologies become part of their everyday life – in other words, how technologies are domesticated.

The dominant technology-led models (Negroponte, 1996, Kelly 1999) provide an inadequate explanation of how ICTs are incorporated into the household. In fact, these technological determinist accounts completely ignore the role of the user in the process. Such models suggest that ICTs come into the household as completed or self-contained artefacts, with fixed interpretations and meanings. This ignores the role of users in shaping or reshaping technologies in many important respects. Users of technology are generally (and too easily) conceptualised as relatively passive end users and are thus overlooked or taken for granted. Technological artefacts are treated as 'black boxes', and users are denied agency to choose, use and experience them in different and varying ways. This, in turn, denies them a role in the active construction of meaning.

This paper will focus on the human side of the relationship between users and computers/internet. The domestication process is essentially about how relationships between humans and technologies are constructed, maintained and modified. Domestication is, above all, sensitive to the social factors (age, gender, class to name but a few) that are central to how both the user and the technology are mutually shaped in this process. Domestication is one of the more accepted conceptual frameworks used to analyse ICT users and their relationship to technologies they use. Domestication was deemed more suitable than alternative adoption of technology models (for instance, Rogers 1995) as it signifies the ability of individuals, families, households and other institutions to make new technologies and services their own; to integrate them into everyday lives. In a dialectical process, skills and practices interact with and underpin the construction of meaning around the use of ICTs.

The concept of domestication was first formulated to deal with the appropriation and use of mature media technologies, such as television (Silverstone *et al*., 1992). This produced a 4-stage model of domestication aimed at making sense of the process whereby people come into possession of a new technology, for whatever reason, and where they subject the technology to social processes in order to 'tame' or 'integrate' the technology into their lives, and into the moral economy of the household.

The domestication concept, as expressed and employed here, is very much a European construct. First developed in the UK by researchers at Brunel University to explore the relationship between media and households (Silverstone *et al*., 1989, 1992), it was later applied by Norwegian researchers and other technologies such as cars and smart houses (Lie & Sørensen 1996, Berg 1999). Domestication more recently has been extended and applied to organisational contexts (Pierson, 2006) and to educational contexts (Hynes & Rommes, 2006) where humans seek to eke out a place for technology in their daily routines of both learning and work.

In this paper, domestication will be applied as a tool which helps in analyzing the process through which the user makes the technology 'one's own', a process in which both the technology and its user are changed. This process takes place through various phases or dimensions in which the artefact is fitted into the routines and practices of the everyday life of its user (Silverstone et al., 1992; Lie and Sørensen, 1996; Aune, 1996; Mansell and Silverstone, 1996; Frissen, 1997; Mackay, 1997). The product of the application of domestication in this way provides an ethnography of how users themselves experienced the process of how the internet became a part of their everyday lives.

THE FOUR PHASES OF DOMESTICATION

n the **appropriation** phase, possession and ownership are central. The acquisition of the technology is the main activity or concern. A technology gets appropriated as it is sold and then owned or possessed by a household. That is the point at which a commodity crosses the threshold between public and private, beginning its new life as a domestic object. **Objectification** tries to capture how values, tastes or styles are expressed through the display of the new technology. It involves both a spatial aspect (where it is placed in the house), and a temporal aspect (how it is fitted in the time structure). However, the spatial aspect is more central in this phase, '…physical artefacts, in their arrangement and display, as well as…in the creation of the environment for their display, provide an objectification of the values, the aesthetic and…cognitive universe, of those who feel comfortable or identify with them' (Silverstone *et al*., 1992:22–23). The **incorporation** phase emphasises how ICTs are used, and the temporal aspect is more central in this phase. Silverstone *et al*. (1992) suggest that for an artefact to be incorporated it has to be actively used, such as in the performance of a task. The **conversion** phase is concerned with the relations between the households' internal affairs and the public domain or outside world. This phase is also concerned with how users speak and articulate their relationship with technology.

This model, however, is posited as a paradigmatic process with abstract phases relating to user experiences. The Silverstone approach, in some ways, lacks a real sense of *user* experiences. In some respects, it can also appear rigid in the ways phases are entered into – these become blurred when applied to new media technologies (especially the computer and internet). The challenge of this paper, then, is to empirically apply the Silverstone domestication model and assess whether this process can be transferable to new ICTs.

METHODS AND APPLICATION

The empirical dataset is drawn from small-scale qualitative study of 16 households as part of a wider doctoral research analysing the use and consumption of new media technologies in the household setting in Dublin, Ireland (Hynes, 2005). The households were drawn from middle class and working class suburban areas and were of varied composition. Instead of a survey of a representative sample of the population to provide a package of easily managed figures and statistics,

this paper will strive to eliminate objectivity in order to achieve subjectivity. Subjectivity, in this case, represents individual domestication experiences and narratives of user's internet consumption.

A number of research techniques were carried out to provide a rich picture of the nature of internet consumption. In-depth interviewing formed the main research instrument. To complement the interviews, the respondents were asked to complete a time-use diary describing their overall media use in order to gain a complete picture of how the internet fitted into their portfolio of media use. A small amount of participant observation was also employed.

To understand the domestication process from the viewpoint of the user, I shall present a version of domestication gained through an analysis of the empirical data. The 4-stage approach proposed by Silverstone *et al.* (1989) underpinned my study, providing a theoretical framework and a tool by which to analyse the process of domestication. However, it became apparent that the user's *own* interpretation of how and why they consumed the technologies was not adequately described by the Silverstone approach. In fact, the results and findings from my study might be understood as the *product* of the application of Silverstone's model which evolved into an alternative 3-stage model. This alternative model aims to advance the concept of domestication, in order to portray the lived realities of domestic users as they experience domestication of internet technologies in their own homes.

RESULTS

In carrying out this research, I have applied the domestication process as offered and developed by Silverstone *et al.* (1989, 1992). In a sense, I have used Silverstone's concept as an 'ideal model', through which the findings were filtered about the domestic consumption practices and experiences of the users. Silverstone's model has both informed the way I gathered the data and the way I have interpreted the data, essentially meaning that the domestication concept has provided me with an analytical tool. The Silverstone version proved to be more appropriate than the competing, alternative theories and concepts of ICT integration into everyday life (Lie & Sørensen, 1996) or even diffusion models of uptake (Rogers, 1995). The Silverstone model proved useful in the ways it highlighted certain phases or aspects of the social processes through which domestic users experience a level of meaning and significance, embedding the artefact into 'everyday life' and the household.

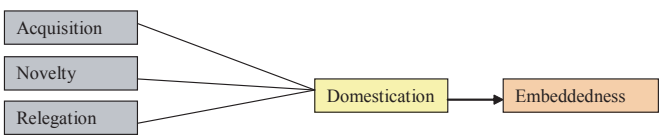
However, despite my extensive use of Silverstone's domestication concept, it should only be thought of as a theoretical apparatus, or empirical check-list employed to make sense of the experiences of users. While I have retained the terminology offered by the Silverstone's approach to domestication, my analysis of domestic use suggests that the process of domestication can be understood in another way, one which stems from my rich, in-depth research of domestic users.

I propose a user-based model which makes sense of users' experiences. These processes are not fixed or linear, but can be experienced at different stages during use. The 3-stage model below describes the processes that occur *before* the actual acquisition of the technology to the changes the user and technology undergo during subsequent social processes (Figure 1). Although this schema begins with 'acquisition', I propose that the processes that occur before the technology actually enters the home form a crucial element of the acquisition phase.

ACQUISITION PHASE: THE HOME'S NEW ARRIVAL

The Silverstone 4-stage model suggests domestication begins when the technology enters the home; however, my empirical analysis suggests that users experience earlier stages/aspects *before* the technology even reaches the home or even before it is used in any real meaningful way in the domestic domain.

Figure 1. 3-stage model



The findings indicate the following phases of acquisition:

- First/previous encounter(s) sets the scene/shape of use
- Interest, motivation and skills
- Justification for purchase
- Research
- Actual purchase experience
- Entrance of the technology
- Location in the household
- Early use
- Learning, training, and teaching skills to other family members.

My findings suggest that what goes on before the entrance of the technologies to the home is just as important as what goes on once they have entered the domestic space. In this study, the users or 'informed' non-users shape their experiences typically on their first encounters with the technology – such as in a school, university and college or work – and this shapes the way users approach the acquisition of the technology.

Interest, motivation and skills also prove to be crucial factors in the ways respondents shape their experiences when coming into possession of the technology. Respondents see skills and abilities to operate the technology as crucial to the type of machine acquired, how they perceive the technology, and where this technology is to be located. If the technology is seen as another part of the entertainment network and used mainly for entertainment or communication purposes, it tended to be located in the communal living space. When the technology is seen as an information resource, in the same way as a set of encyclopaedias, it tended to be located in a bedroom or study location.

The justification for purchase, and the research that the respondents conducted prior to the purchase of the actual equipment, was associated with a high level of significance for respondents. This sub-phase of acquisition was important in that it informed what kind of technology was best suited to their needs and financial status.

The technology then enters the home and remains in the acquisition stage whilst the user realises the actuality of consumption. Once the technology achieves a level of familiarity, and the user overcomes the difficult stage of becoming acquainted with it and its functions, the process enters the next stage.

NOVELTY PHASE: 'I COULDN'T TURN IT OFF!'

The second phase, which I have termed the novelty phase, is experienced after the early stages of meaning association and value attribution have assigned a certain level of significance to the technology. This phase is concerned with meaning and use. All respondents testify to experiencing this stage during their domestic use. For example, a female respondent explains how she experienced the 'novelty phase':

It took a couple of nights, when we had it first, we had it on all the time - the novelty of it - just surfing through it, finding out how things worked, what goes where, and what you can do with it. It was a bit of a buzz at first, but it soon wears off. (Female, 38)

This phase has an unfixed timeframe and is entirely dependent on the individual user. The time it takes for the 'freshness' or novelty to abate is determined by what functions the users themselves have discovered. Significantly, it is also possible to re-experience this phase, along with the acquisition phase, throughout the process as a whole, as new uses and functions are constantly discovered and the technology is reshaped, and as new items of hardware and software are added. Once this happens, the user will undergo the process again and experience yet another novelty phase.

RELEGATION PHASE: HOW THE TECHNOLOGY LOST ITS CHARM

The third phase in this empirical model is the relegation phase. Once the period of novelty has abated users' patterns of use change as the technology fits into the everyday routines of their lifestyles. After the initial acquisition and novelty periods, the attraction of the technology begins to dissipate and the technology

slowly begins to achieve a level of embeddedness and integration. The technology comes to be regarded as just 'being there', relegated to just 'another machine for the home', in the same sense as the television, radio or telephone. The testimonies below illustrate how the technology loses its charm:

Even though when you buy something, within weeks – because you have worked for it and you have bought it and are delighted with it. Suddenly it loses its novelty like everything does. I found the computer still lost the novelty of being a wonderful thing (Female 33).

When I first got it, I would have considered it a special type of machine. I was very much careful because it was so expensive, so it was packaged and only taken out if I wanted to do something specific. But now, because I have it for so long, it is part of the home. I'd come in and put on the television and computer (internet) automatically (Female 24).

No, to us it is part and parcel of the household like the television (Female 48).

However, as stated before, even though the technology may appear to be in the relegation phase, if new functions or uses are discovered, the user re-enters the two initial phases. The model I propose should not be considered as a linear process, because overlapping and entwining of all stages is possible, unlike the Silverstone model.

CONCLUSIONS

This paper argues that when the Silverstone model is applied to the domestication of the internet, several issues become problematic. First, the process needs to become more fluid and dynamic than the initial conception of the model, due to the increased functionality of new media technologies. It is rarely the case that new media technologies are dedicated to one purpose or function; instead they can converge with or assume the role of mature media uses. Closure of meaning becomes problematic because of the increased functionality and utility of new media, in the ways that the internet can mean different things to different users, sometimes simultaneously (as an information resource, communication medium, or entertainment station).

Transfer of meaning and interest across the different functions of new media may also occur. This multiplicity of functions brings with it an added problem of new skills and practices required to operate the technology and make use of it to its fullest capacity. Renegotiations of meanings and uses are possible and common in relation to new media technologies. For instance, meanings are renegotiated when novel aspects of new technologies are discovered by users. This ensures the process of domestication of new media technologies is not harmonious, linear, or complete, but is in constant flux and transformation, resulting in heterogeneous and unfixed outcomes of domestication. Some of the factors making domestication problematic when applied to new media technologies are:

New Technologies

Users experience the domestication process, more often than not, when the technology is newly acquired, or when it is first encountered in external environments. However, in the case of new media technologies, peripheral devices are often bought to complement the existing artefact (printers, scanners, digital cameras etc). This brings about a new domestication experience, and sometimes a relocation of the artefact, which further enhances the user's experience of the technology. New technologies and peripheral devices open new negotiations in ways not possible with mature or traditional media.

Software

Users can explore and discover new aspects to the technology brought about by new software. New software also carries baggage in the shape of new skills required to negotiate and navigate the new experience.

Shift of Focus

When users discover alternative uses and functions of the technology, their experience is again enhanced. For instance, if the primary function of the internet was to surf for information, but the user discovers email, chat-rooms and/or message boards, their interest, skills and conception of the artefact is developed and extended. This brings about a re-negotiation of meaning and significance of the technology in their everyday life.

While the model I propose gives an understanding of the lived reality and user experience of the domestication process, it is essential to place it within the context of my sample, as a working application of Silverstone's model. It must be viewed as an empirical, rather than a theoretical model. It is only through practical application that such a model can further our understanding of the complex processes of domestication, that is the ways users acquire, use and consume and make sense of the technologies within their own 'everyday' reality.

REFERENCES

Aune, M. (1996) The Computer in Everyday Life: Patterns of Domestication of a New Technology, in Lie, M and Sørensen (eds) (1996) Making Technologies Our Own? Domesticating Technology into Everyday Life, Scandinavian University Press, Oslo

Berg, AJ. (1999) *A gendered socio-technical construction: the smart house* in MacKenzie, D. & Wajcman eds (1999) *The Social Shaping of Technology* 2nd eds. Open University Press

Frissen, V. (1997) *ICTs in the Rush Hour of Life* Cost A4 workshop paper, 27-29 June, 1997 Edinburgh, Scotland.

Hynes (2005) Digital Multimedia Use and Consumption in the Household Setting, Dublin City University, Unpublished PhD

Hynes, D & Rommes, E. (2005) *Fitting the internet into our lives: what IT courses have to do with It* in Berker, T. Hartmann, M. Punie, Y. Ward. K (2005) *Rethinking Domestication*, Open University Press.

Kelly, K. (1999) New Rules for the New Economy: 10 Ways the Network is changing everything London: Fourth Estate

Lie, M. & Sørenson, K. H. (1996) *Making technology our own: Domesticating technology into everyday life*. In Lie, M. and Sørensen, K. H. (Eds.), *Making Technology Our Own*. Oslo: Scandinavian University Press.

Mackay, H. (1997) *Consumption and Everyday life* Sage and Open University.

Mansell, R. & Silverstone, R. (1996) Communication by Design: The Politics of Information and Communication Technologies, Oxford University Press

Negroponte, N. (1995) *Being Digital,* London, Hoddler & Stoughton

Pierson, J (2005) *Domestication at work in small businesses* in Berker, T. Hartmann, M. Punie, Y. Ward. K (2005) *Rethinking Domestication*, Open University Press.

Rogers, E M. (1995) *Diffusion of Innovation*s. 4th edition New York: The Free Press.

Silverstone, R. *et al.* (1989) *Families, Technologies and Consumption: the household and information and communication technologies,* Uxbridge, Middlesex: Centre for Research into Innovation, Culture and Technology, CRICT discussion paper.

Silverstone, R and Hirsch, E [eds.] (1992) Consuming Technologies: Media and Information in Domestic Spaces, London: Routledge

Silverstone, R.; Hirsch, E. and Morley, D. (1992) Information and communication technologies and the moral economy of the household, in R. Silverstone and E.Hirsch (eds.) Consuming Technologies. Media and information in domestic spaces. London and New York: Routledge.

Knowledge Integration: A Public Goods Approach Under Asymmetric Information

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ABSTRACT

Knowledge integration is one of the keys to e-business which have more competitive advantage than traditional organizations. However, building knowledge management system from technology-oriented and user viewpoint is insufficient. Because of the effect of free-riding, the benefit of knowledge integration can't be linked to group size in direct proportion. This paper examines how the total effective level of effort persons exert vary with individual belief about knowledge level, group size, and their cost-knowledge level ratios. This study discusses the relation among these factors and proposes solutions to vanish the effect of free-riding under asymmetric information.

Keywords: Knowledge integration, public goods, asymmetric information

1. INTRODUCTION

In the past few years, knowledge management had mushroomed all over the industrials. According to the framework addressed by Alavi et al. (2001), "knowledge process" is classified into four fundamental elements: (1) construction, (2) storage/retrieval, (3) transfer, and (4) application. One research question they proposed is how to implement effectively knowledge transfer. In recent work, Lin et al. (2005) have proposed a sender-receiver framework for investigating knowledge transfer under asymmetric information. They view knowledge as goods traded in a knowledge market and one of their most significant research contributions is to apply a signaling mechanism to overcome 'adverse selection problem', which is a common phenomenon arising in knowledge sharing that means inability manager is unable to differentiate between the qualities of knowledge under incomplete-information.

Successful knowledge management can be attributed to ability, motivation, and opportunity (Argote et al. 2003). Ability is a talent but can be enhanced by training (Nadler et al. 2003). The position of ability should be identified so as to make it more valuable. Thus, opportunity, such as an organization or informal networks, establishes an invisible multidirectional channel to save acquiring and search cost by reducing distance (Borgatti and Cross 2003, Hansen 1999, McEvily and Zaheer 1999, Reagans and Zuckerman 2001, Uzzi and Lancaster 2003). However, knowledge transfer will be inefficient if members of the organization utilize internal knowledge without any reward. (Menon and Pfeffer 2003). Hence, in addition to ability and opportunity, the organization should provide members with motivation to take part in the knowledge management process (Argote et al. 2003).

Another major research question is what incentive makes persons contribute and share their knowledge truthfully. Although organizational knowledge can be conveniently stored in various component forms, including electronic documentation, database, and even expert system (Tan et al. 1998), many factors limit the success of knowledge storage. One of the barriers is that employees lack time to transform their knowledge into reusable component forms (Cranfield University 1998; KPMG 1998b; Glazer 1998). Another barrier is their organizational culture without a rewarded mechanism for exerting such effort (Brown and Duguid 1998; Cranfield University 1998; KPMG 1998b).

Because knowledge sharing is one of the most important aims in most knowledge management projects, many managers seek an efficient way to make their employees contribute their knowledge without reservation, not hiding what they had learned. In d'Aspremont et al. (1998), knowledge is treated as public goods for studying sharing knowledge and development efforts on R&D agreements and research joint ventures. They have considered a situation where one cannot identify a 'most knowledgeable' partner and proposed a balanced contract arrangement based on a two stage game which leads the cooperative activities to a first best solution.

"Free-riding" is a common effect when a group carries out knowledge sharing and all participants could consume the public benefit. This is because the provision of public goods generates an externality that all participants benefit from others who provide public goods. Hence, individuals' behaviors may tend to reserve their effort, resulting in the decrease of the level of the public good. The concept of public goods is also conveniently applied to other disciplines characterized by non-rivalness and non-excludability, such as peer-to-peer system, information security, and so on. Varian (2004) examined how system reliability varied with three prototypical cases: total effort, weakest link, and best shot. In the case of total effort under complete-information, his research result shows that system reliability is determined by the agent with the highest benefit-cost ratio. This result is similar to the work of Bhattacharya et al. (1992) which suggests that the most intelligent agent's knowledge is the only useful input for efficient development effort when individual knowledge levels are revealed.

To help employees share their best findings and management experiences, a large number of companies put themselves to the great expense of hiring consultants to set up IT-based applications, gathering and retrieving their useful knowledge. Ba et al. (2001), however, point out that building knowledge management system from software engineering and user acceptance perspectives is insufficient. Under circumstances without incentive, a manager is difficult to entice her peers and subordinates to contribute their individual knowledge into the knowledge management system.

As in Antoniadis et al (2004), we consider knowledge a cumulative public goods like files their work handles. Because our model treats in this paper the case where there are only two types of knowledge, this distinction makes ours less complicated to yield analytical solution under incomplete-information. The heart of this study is to establish an incentive mechanism depended on different knowledge types under incomplete-information, also known as screening, or truth telling. We present the model in section 2 and enhance this model by adding incomplete-information in section 3. A screening mechanism is introduced and detailed in section 4. Finally, we give a numerical example and conclude this paper in section 5 and 6.

2. A MODEL OF KNOWLEDGE INTEGRATION

Consider a knowledge integration model for n participants. These participants want to cooperate to get certain epistemic work done efficiently and share the public benefit, such as product development, technology innovation, or knowledge sharing. In order to simplify analysis process, Lin et al. (2005) denote the expected value of a participant's knowledge as either K_H (high level) or K_L (low level), where $K_H > K_L > 0$. We follow the same notations and call a person with high knowledge level a high type participant, and one with low knowledge level a low type participant. Similarly, we define C_H and C_L as the cost of exerting effort to a high type participant and low type one, respectively. We assume $C_H < C_L$ for a high type participant is efficient than low type one. This assumption means that the cost is an increasing linear function, the argument of which is the level of effort, and knowledge of higher level can reduce more expenses than that of inferior level under exerting the same effort.

In this model of complete-information version, each participant decides on x_i, the quantity of effort she exerts, where $x_i \geq 0$. In this paper we assume that each participant is risk neutral and effort is an observable variable, such as work hours, the frequency of proposals, or the cited rate of individual submitted report. The total effective level of effort and cooperative benefit is respectively defined as $Q = \sum K_i x_i$ and $f(Q)$, where the cooperative benefit function $f(.) \geq 0$ is assumed to be continuously differentiable, increasing, and concave in its argument. Then, the payoff of participant i is $f(Q) - c_i x_i$. For participant i, solving the first-order condition for participant i's payoff and defining $G(.)$ as an inverse function of $f'(.)$ yields:

$$x_i^* = \max\left\{\frac{1}{K_i} G\left(\frac{c_i}{K_i}\right) - \frac{1}{K_i}\sum_{j\neq i} K_j x_j^*, 0\right\}. \quad (1)$$

Each participant's strategy shows that when marginal public benefit is not greater than marginal private cost, they will free ride on the others. Thus, participants with highest knowledge-cost ratio determine a Nash equilibrium and the others free ride on the participants. This also means that when the number of participants with highest knowledge-cost ratio is greater than one, the number of Nash equilibrium outcomes will be infinite. Because concentrating on the total effective effort, we use asymmetric Nash equilibrium outcome directly for convenient.

$$\frac{1}{mK_H} G\left(\frac{c_H}{K_H}\right),$$

therefore, is the symmetric Nash equilibrium outcome we derive from (1) if there exists at least one high type participant in the group, where m is the number of high type participants. By considering a situation where all participants are low type ones, we have

total effective effort

$$Q^* = \begin{cases} G\left(\frac{c_H}{K_H}\right) & \text{if } \exists K_i \neq K_L \\ G\left(\frac{c_L}{K_L}\right) & \text{if } K_i = K_L, \forall i \end{cases}. \quad (2)$$

Our first proposition summarizes the above observations.

Proposition 1. In complete-information case (the knowledge type of each participant is public information),

(a) the low type participants always free ride on the high type participants, and
(b) for any group size, overall knowledge integration level, i.e., Q^*, is the same except that all participants are low type ones.

If nature determines the probability that $K_i = K_H$ is θ, in complete-information case the expected total effective level of effort they exert under given condition is

$$E\left[Q^*\right] = (1-\theta)^n G\left(\frac{c_L}{K_L}\right) + \left(1-(1-\theta)^n\right) G\left(\frac{c_H}{K_H}\right). \quad (3)$$

We now consider a scenario where knowledge integration is initiated by an all-powerful leader who has complete and perfect information about all participants' parameters. The leader, therefore, can stipulate the effort each participant should exert to maximize the social welfare:

$$\underset{x_1, x_2, \ldots, x_n}{Maximize} \quad W = \sum_{i=1}^{n} f(Q) - c_i x_i. \quad (4)$$

By first-order condition, this program would be optimal allocation if $\frac{\partial W}{\partial x_i} = nK_i f'(Q) - c_i \leq 0$ holds for each participant i. These inequalities mean that individual contribution levels have to maximize the total value of the group less the total cost incurred by the participants. Thus, from $f'(Q) \leq \frac{c_i}{nK_i}$ and $\frac{K_H}{c_H} > \frac{K_L}{c_L}$, we derive the socially optimal total effective level of effort:

$$Q_s^* = \begin{cases} G\left(\frac{c_H}{nK_H}\right) & \text{if } \exists K_i \neq K_L \\ G\left(\frac{c_L}{nK_L}\right) & \text{if } K_i = K_L, \forall i \end{cases}. \quad (5)$$

The above observations suggest that based on the viewpoint of arbitrary, a compulsive policy should force participants carry out $x^*(K_H) = \frac{1}{mK_H} G\left(\frac{c_H}{nK_H}\right)$ and $x^*(K_L) = 0$ if given m high type participants, where $m \geq 1$; otherwise, $x^*(K_L) = \frac{1}{nK_L} G\left(\frac{c_L}{nK_L}\right)$.

Proposition 2. In complete-information, the achievement of social welfare implies that

(a) socially total effort is absorbed by all high type participants if there exists at least one high type participant in the group, and
(b) low type participants' selfish shirking behaviors are allowable due to lacking of competitive advantage, unless all persons are low type participants.

Furthermore, we consider a situation where each participant can determine whether to join the group or not. In fact, a high type participant might receive a negative payoff under the arrangement of social welfare. If a high type participant's payoff is negative and the cooperative activity is devoid of a reasonable compensation mechanism, she will leave the group. Hence, the compensation mechanism is necessary for the achievement of social welfare if all participants have liberty to determine whether to join or leave.

Because social welfare, $W = \sum_{i=1}^{n}\left(f(Q) - c_i x_i\right)$, can be decomposed into $f(Q) - c_i x_i$ and $\sum_{j\neq i}^{n}\left(f(Q) - c_j x_j\right)$, we could derive $\frac{\partial}{\partial x_i}\left(f(Q) - c_i x_i\right)$ and $\frac{\partial}{\partial x_i}\sum_{j\neq i}^{n}\left(f(Q) - c_j x_j\right)$ after differentiating both expressions with respect to x_i. Hence, differentiating social welfare with respect to x_i yields:

$$\frac{\partial W}{\partial x_i} = \frac{\partial}{\partial x_i}\left(f(Q) - c_i x_i\right) + \frac{\partial}{\partial x_i}\sum_{j\neq i}^{n}\left(f(Q)\right) \quad (6)$$

Because each participant's individual payoff is to maximize $f(Q) - c_i x_i$, $\frac{\partial}{\partial x_i}\left(f(Q) - c_i x_i\right) = 0$ is the first-order condition to this problem which is the same as the former part of $\frac{\partial W}{\partial x_i}$. Hence, the externalities can be measured by $\frac{\partial}{\partial x_i}\sum_{j\neq i}^{n}\left(f(Q)\right)$ for participant i. Solving it yields:

$$\frac{\partial}{\partial x_i}\sum_{j\neq i}^{n}\left(f(Q)\right) = (n-1) f'(Q) K_i \quad (7)$$

Thus, the appropriate socially optimal compensation paid for a high type participant is:

$$p_H = (n-1) f'\left(Q_s^*\right) K_H = \left(\frac{n-1}{n}\right) c_H. \quad (8)$$

Since low type participants free ride on social welfare unless all persons are low type participants, the appropriate socially optimal compensation for them is:

$$p_L = \begin{cases} 0 & \text{if } \exists K_i \neq K_L \\ \left(\frac{n-1}{n}\right)c_L & \text{if } K_i = K_L, \forall i \end{cases} \quad (9)$$

Because in social welfare the externalities increase with the group size, the subsidy paid to participants also increases with the number of attendants.

Proposition 3. In the complete-information case, if all participants are paid p_H or p_L based on their types, Nash equilibrium outcomes achieve the socially optimal level of effort.

3. KNOWLEDGE INTEGRATION UNDER ASYMMETRIC INFORMATION

In this section we consider this model of incomplete-information version. Assuming each participant has private information about her knowledge type and all participants' knowledge types are independent. Let $x_i^*(K_H)$ and $x_i^*(K_L)$ denote participant *i*'s effort as a function of her knowledge level. Each participant knows that her coworkers' knowledge level is high with probability θ and anticipates that their effort would be $x_i^*(K_H)$ or $x_i^*(K_L)$, depending on their knowledge level. This implies that each participant's expected effective level of effort is:

$$\theta K_H x_j^*(K_H) + (1-\theta) K_L x_j^*(K_L). \quad (10)$$

Thus, based on individual knowledge level, participant *i* chooses $x_i^*(K_i)$ to maximize her payoff as follows:

$$\max_{x_i(K_i)} U_i(K_i) = f\left(K_i x_i + \sum_{j\neq i} \theta K_H x_j^*(K_H) + (1-\theta) K_L x_j^*(K_L)\right) - c_i x_i. \quad (11)$$

Solving the first-order condition for (10) yields:

$$x_i^*(K_H) = \frac{1}{K_H} G\left(\frac{c_H}{K_H}\right) - \sum_{j\neq i} \theta x_j^*(K_H) - (1-\theta)\frac{K_L}{K_H} x_j^*(K_L) \quad (12)$$

and

$$x_i^*(K_L) = \frac{1}{K_L} G\left(\frac{c_L}{K_L}\right) - \sum_{j\neq i} \theta \frac{K_H}{K_L} x_j^*(K_H) - (1-\theta) x_j^*(K_L). \quad (13)$$

In a separating strategy, we let $x_i^*(K_H) = x_j^*(K_H)$ and $x_i^*(K_L) = x_j^*(K_L)$ where $i \neq j$; it yields:

$$x_i^*(K_H) = \frac{\frac{1}{K_H} G\left(\frac{c_H}{K_H}\right) - (n-1)(1-\theta)\frac{K_L}{K_H} x_j^*(K_L)}{1+(n-1)\theta} \quad (14)$$

and

$$x_i^*(K_L) = \frac{\frac{1}{K_L} G\left(\frac{c_L}{K_L}\right) - (n-1)\theta \frac{K_H}{K_L} x_j^*(K_H)}{1+(n-1)(1-\theta)}. \quad (15)$$

Since a high type participant's work efficiency is higher than low type one's, i.e., $\frac{K_H}{c_H} > \frac{K_L}{c_L}$, persons with higher knowledge level always contribute their effort in this model. On the other hand, assuming that all low type participants don't work at all, i.e., $x_i^*(K_L) = 0$, the necessary and sufficient condition for a low type participant to free ride on the others is $G\left(\frac{c_L}{K_L}\right) \leq \frac{(n-1)\theta}{1+(n-1)\theta} G\left(\frac{c_H}{K_H}\right)$. This also implies that when information is rife that most of persons are low type participants, i.e., $\theta < G\left(\frac{c_L}{K_L}\right) \Big/ \left((n-1)\left(G\left(\frac{c_H}{K_H}\right) - G\left(\frac{c_L}{K_L}\right)\right)\right)$, low type participants prefer to contribute their effort rather than shrinking. $G\left(\frac{c_L}{K_L}\right) \Big/ \left((n-1)\left(G\left(\frac{c_H}{K_H}\right) - G\left(\frac{c_L}{K_L}\right)\right)\right)$ is denoted as $\hat{\theta}$ for conciseness. Each participant based her private type has two strategies relying on whether θ is less than $\hat{\theta}$ or not. Hence, given $\theta < \hat{\theta}$, solving (14) and (15) simultaneously yields $x_i^*(K_H)$ and $x_i^*(K_L)$. Given $\theta \geq \hat{\theta}$, plugging $x_i^*(K_L) = 0$ into (14) yields new $x_i^*(K_H)$. We list the results as follows:

$$x_i^*(K_H) = \begin{cases} \frac{1}{nK_H}\left(G\left(\frac{c_H}{K_H}\right) + (n-1)(1-\theta)\left(G\left(\frac{c_H}{K_H}\right) - G\left(\frac{c_L}{K_L}\right)\right)\right) & \text{if } \theta < \hat{\theta} \\ G\left(\frac{c_H}{K_H}\right)\left((1+(n-1)\theta)K_H\right)^{-1}. & \text{if } \theta \geq \hat{\theta} \end{cases} \quad (16)$$

and

$$x_i^*(K_L) = \begin{cases} \frac{1}{nK_L}\left(G\left(\frac{c_L}{K_L}\right) - (n-1)\theta\left(G\left(\frac{c_H}{K_H}\right) - G\left(\frac{c_L}{K_L}\right)\right)\right) & \text{if } \theta < \hat{\theta} \\ 0 & \text{if } \theta \geq \hat{\theta}. \end{cases} \quad (17)$$

Thus, the expected total effective level of effort under asymmetric information is

$$E[Q] = \sum_{i=0}^{n} \binom{n}{i} \theta^i (1-\theta)^{n-i} \left(i \cdot K_H x_i^*(K_H) + (n-i)\cdot K_L x_i^*(K_L)\right) = n\left(\theta K_H x_i^*(K_H) + (1-\theta) K_L x_i^*(K_L)\right)$$

which implies

$$E[Q] = \begin{cases} \frac{n\theta}{1+(n-1)\theta} G\left(\frac{c_H}{K_H}\right) & , \text{if } \theta \geq \hat{\theta} \\ \theta G\left(\frac{c_H}{K_H}\right) + (1-\theta) G\left(\frac{c_L}{K_L}\right) & , \text{if } \theta < \hat{\theta}. \end{cases} \quad (18)$$

Although low type participants free ride on high type ones when $\theta \geq \hat{\theta}$, the expected total effective level of effort increases with θ. Low type participants prefer to shrink rather than exert effort when the expected total effective level of effort is greater than $\frac{n}{n-1} G\left(\frac{c_L}{K_L}\right)$.

Proposition 4 In the incomplete-information case (the knowledge type of each participant is private information),

(a) although high type participants are still pivotal contributors, the expected total effective level of effort under incomplete-information is less than that under complete- information unless θ approaches one,
(b) the more the number of attendants, the more the motivation for low type participants to free ride, and
(c) when the number of attendants is 'mild' and knowledge-cost ratio of high type participants is close to that of low type participants, participants of both types would exert the effort.

4. INCENTIVE-COMPATIBLE INCENTIVE MECHANISM (SCREENING, TRUTH REVELATION)

Since participants' types are unknown, in this section we consider whether there exists a payment mechanism, or a contract, such that each participant, based on maximizing individual benefit, truthfully reveals her type to achieve social optimum. This contract can be described as $[P_H, x_H]$ and $[P_L, x_L]$; that is, each

participant feels free to pick one of the two options, and then achieves the stated workload and receives the deserved subsidy. Under this architecture, P_H and P_L is the subsidy paid to participants who report their ability for high type or low type, respectively.

Hence, under this mechanism we must have two incentive-rationality (*IR*) constraints; that is; no matter what contract each participant signs, she earns a nonnegative payoff after ending the activity. We denote these two constraints as (*IRH*) and (*IRL*) where '*H*' and '*L*' represent a participant's type. In order to let each participant all truthfully reveal her type, we must have another two incentive-compatibility (*IC*) constraints; that is; because each participant can't earn more payoff by mimicking the behavior of the other type, they sign contracts based on their individual type. These two constraints are denoted as (*ICH*) and (*ICL*). Thus, this framework can be described as

$$\max_{x_H, x_L} \quad W = nf\left(n\bar{K}\right) - n\bar{c}$$

subject to

$$f\left(K_H x_H + (n-1)\bar{K}\right) - c_H x_H + P_H \geq f\left(K_H x_L + (n-1)\bar{K}\right) - c_H x_L + P_L \qquad (ICH)$$

$$f\left(K_L x_L + (n-1)\bar{K}\right) - c_L x_L + P_L \geq f\left(K_L x_H + (n-1)\bar{K}\right) - c_L x_H + P_H \qquad (ICL)$$

$$f\left(K_H x_H + (n-1)\bar{K}\right) - c_H x_H + P_H \geq 0 \qquad (IRH)$$

$$f\left(K_L x_L + (n-1)\bar{K}\right) - c_L x_L + P_L \geq 0 \qquad (IRL)$$

where $\bar{K} = \theta K_H x_H + (1-\theta) K_L x_L$, and $\bar{c} = \theta c_H x_H + (1-\theta) c_L x_L$.

Our approach to this problem is to relax it by delete all constraints, solve the relaxed problem, and check whether there exists P_H and P_L to satisfy these omitted incentive constraints. The following proposition shows that there exists a payment mechanism based on the expected number of high type participants, i.e., $n\theta$, to maximize the program.

Proposition 5 Assume $\theta > 0$. Let the contracts be:

$$\left[P_H = c_H x_H^*, x_H^* = \frac{1}{n\theta K_H} G\left(\frac{c_H}{nK_H}\right)\right],$$

$$\left[P_L = f\left(K_H x_H^* + (n-1)\bar{K}\right) - f\left((n-1)\bar{K}\right), x_L^* = 0\right].$$

Then, all participants truthfully reveal their type and exert the assigned effort. (See Appendix A)

Thus, the expected total effective level of effort under screening is $E[Q] = G\left(\frac{c_H}{nK_H}\right)$, which is the same as the socially optimal total effective level of effort under complete information in a situation where there exists at least one high type participant in the group. The proposition 5 suggests two things: first, to make high type participants act as pivotal contributors, the function of P_H is to exempt high type participants from the cost of exerting effort. Because the cost of exerting effort to a low type participant is higher than that to high type one, a low type participant has no incentive to deviate from accepting P_H if P_L is 'large enough'. Second, to make low type participants truthfully report their ability, a fixed fee based on the number of attendants is necessary to entice low type participants to be honest. However, the price of P_L must be commonplace so as to prevent high type participants from envying low type ones, even if they not only free ride on the high type participants but also earn extra payments.

5. NUMERICAL EXAMPLE

We apply a specific form, $f(x) = x^{\alpha}$ (where $0 < \alpha < 1$), to examine the behavior of participants under asymmetric information without incentive mechanisms. Given $\alpha = \{0.45, 0.5, 0.55\}$, $n = 10$, $c_H = 5$, $K_H = 55$, $c_L = 5.5$, and $K_L = 50$, the expected total effective level of effort, $E[f(Q)]$, varies depending on θ and α as shown in

Figure 1

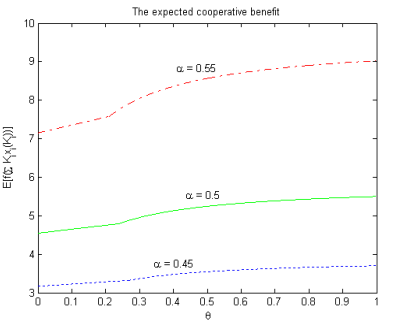

Figure 2

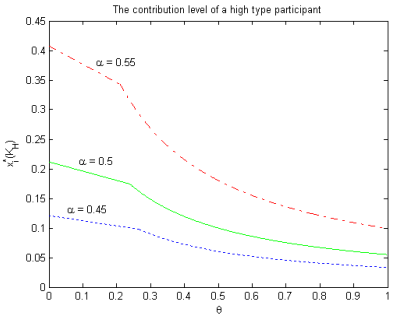

Figure 3

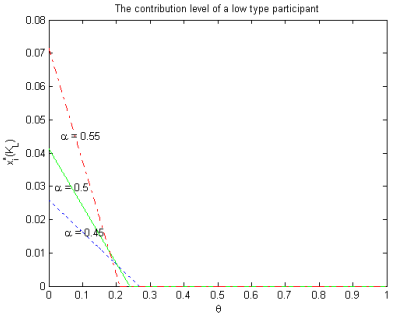

Figure 1. The contribution level of a high type participant and one of a low type participant are shown in Figure 2 and Figure 3, respectively.

First, these figures reveal that although the efforts of participants are decreasing with θ, the expected knowledge integration level still increases as θ. Second, when knowledge value is greater than production cost, the effort exerted by high and low type participants will increase as α, the degree of concavity (see figure 2 and figure 3).

Second, the cooperative benefit under complete-information is always greater than the expected one under incomplete-information. However, unlike the complete-information case, low type participants exert their effort when θ and n are sufficient small. All observations suggest that an incentive mechanism is an essential dimension to knowledge integration, especially in the society full of uncertain contingency.

6. CONCLUSION

Knowledge integration is one of the keys to e-business which has more competitive advantage than traditional organizations. However, under a situation without incentive, everyone treats this issue from her personal viewpoint, such that technology fails to operate well. Thus, if we develop a knowledge management system only based on software engineering and user acceptance perspectives, the benefit of establishing the application is hard to achieve an anticipative level. Because of the effect of free-riding, the real value of a research team can't be measured only by the group size. Hence, to maximize the benefit of human resources, our belief is to make the best possible use of men/women. That is, we allocate high ability persons to core departments, and free or lighten their cost. For low ability persons, we should support a smaller reward to compensate their behavior for telling the truth. This research can be further extended to a multiple stages game to analysis the long-time performance of knowledge integration.

REFERENCES

1. Alavi, M., and Leidner, D. E. "Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues," *MIS Quarterly* (25:1), 2001, pp. 107-136.
2. Antoniadis, P., Courcoubetis, C., and Mason, R. "Comparing Economic Incentives in Peer-to-Peer Networks," Computer Networks (46), 2004, pp. 133-146.
3. Argote, L., McEvily, B., and Reagans, R. "Managing knowledge in organizations: an integrative framework and review of emerging themes," *Management Science* (49:4), 2003, pp. 571-582.
4. Ba, S., Stallaert, J., Whinston, A. B. "Research Commentary: Introducing a Third Dimension in Information System Design—The Case for Incentive Alignment", Information System Research (12:3), 2001, pp. 225-239.
5. Bhattacharya, S., Glazer, J., and Sappington, D. "Licensing and the Sharing of Knowledge in Research Joint Ventures," *Journal of Economic Theory* (56), 1992, pp. 43-69.
6. Borgatti, S. P., and Cross, R. "A Relational View of Information Seeking and Learning in Social Networks," *Management Science* (49:4), 2003, pp. 432-445.
7. Brown, J., and Duguid, P. "Organizing Knowledge," *California Management Review* (40:3), 1998, pp. 90-111.
8. Cranfield University. "The Cranfield/Information Strategy Knowledge Survey: Europe's State of the Art in Knowledge Management," *The Economist Group*, 1998.
9. d' Aspremont, C., Bhattacharya, S., and Gérard-Varet, L. "Knowledge as a Public Good: Efficient Sharing and Incentives for Development Effort," *Journal of Mathematical Economics* (30), 1998, pp. 389-404.
10. Glazer, R. "Measuring the Knower: Towards a Theory of Knowledge Equity," *California Management Review* (40:3), 1998, pp. 175-194.
11. Hansen, M. "The Search-Transfer Problem: The Role of Weak Ties in Sharing Knowledge across Organization Subunits," *Administrative Science Quarterly* (44), 1999, pp. 82-111.
12. KPMG Management Consulting. *Knowledge Management*: *Research Report*, 1998b.
13. Lin., L., Geng, X., and Whinston, A. B. "A Sender- Receiver Framework for Knowledge Transfer," *MIS Quarterly* (29:2), 2005, pp. 197-219.
14. McEvily, B., and Zaheer, A. "Bridging Ties: A Source of Firm Heterogeneity in Competitive Capabilities," *Strategic Management Journal* (20), 1999, pp. 1133-1156.
15. Menon, T., and Pfeffer, J. "Valuing Internal versus External Knowledge," *Management Science* (49:4), 2003, pp. 497-513.
16. Nadler, J., Thompson, L., and Van Boven, L. "Learning Negotiation Skills: Four Models of Knowledge Creation and Transfer," *Management Science* (49:4), 2003, pp. 529-540.
17. Reagans, R., and Zuckerman, E. W. "Networks, Diversity and Performance: The Social Capital of R&D Units," *Organization Science* (12), 2001, pp. 502-517.
18. Tan, S. S., Teo, H. H., Tan, B. C., and Wei, K. K. "Developing a Preliminary Framework for Knowledge Management in Organizations," in *Proceedings of the Fourth Americas Conference on Information Systems*, E. Hoadley and I. Benbasat (eds.), Baltimore, MD, August 1998, pp. 629-631.
19. Uzzi, B., and Lancaster, R. "The Role of Relationships in Interfirm Knowledge Transfer and Learning: The Case of Corporate Debt Markets," *Management Science* (49:4), 2003, pp. 383-399.
20. Varian, H. R. "System Reliability and Free Riding," *http://www.ischool. berkeley. edu/~hal/people/hal/papers.html*, 2004.

APPENDIX A. PROOF OF PROPOSITION 5

Given the unconstrained mathematical program, by first-order condition, the following inequalities must be satisfied:

$$nf'\left(n\bar{K}\right)n\mathrm{q}K_H \le n\mathrm{q}c_H \qquad (A1)$$

$$nf'\left(n\bar{K}\right)n\left(1-\mathrm{q}\right)K_L \le n\left(1-\mathrm{q}\right)c_L \qquad (A2)$$

Because of $\frac{K_H}{c_H} > \frac{K_L}{c_L}$, $(A1)$ will bind at the optimum so as to $\bar{K} = \frac{1}{n}G\left(\frac{c_H}{nK_H}\right)$. Thus, $x_H^* = \frac{1}{n\mathrm{q}K_H}G\left(\frac{c_H}{nK_H}\right)$ and $x_L^* = 0$ will satisfy $\bar{K} = \frac{1}{n}G\left(\frac{c_H}{nK_H}\right)$ if given $\mathrm{q} > 0$. Furthermore, let $P_H = c_H x_H^*$, $P_L = f\left(K_H x_H^* + (n-1)\bar{K}\right) - f\left((n-1)\bar{K}\right)$ and check all incentive constraints as follows:

$$f\left(K_H x_H^* + (n-1)\bar{K}\right) - c_H x_H^* + P_H = f\left(K_H x_H^* + (n-1)\bar{K}\right) \ge 0 \qquad \text{(IRH)}$$

$$f\left(K_L x_L^* + (n-1)\bar{K}\right) - c_L x_L^* + P_L = f\left(K_H x_H^* + (n-1)\bar{K}\right) \ge 0 \qquad \text{(IRL)}$$

$$f\left(K_H x_L^* + (n-1)\bar{K}\right) - c_H x_L^* + P_L = f\left(K_H x_H^* + (n-1)\bar{K}\right) = f\left(K_H x_H^* + (n-1)\bar{K}\right) - c_H x_H^* + P_H \qquad \text{(ICH)}$$

$$f\left(K_L x_H^* + (n-1)\bar{K}\right) - c_L x_H^* + P_H = f\left(K_L x_H^* + (n-1)\bar{K}\right) + x_H^*\left(c_H - c_L\right) \le f\left(K_L x_L^* + (n-1)\bar{K}\right) - c_L x_L^* + P_L \qquad \text{(ICL)}$$

Teaching Online: Using Moodle for a Blended Course

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ABSTRACT

The purpose of this paper is to articulate the use of a server-based software package designed to allow educators to provide collaborative activities and learning resources to online students, as well as supporting face-to-face learning. After providing a discussion on the course management systems and Moodle, the author describes the rationale why Moodle has been selected to be integrated into a blended research course at an American Pacific island university. This is a pilot implementation of mixing e-learning with face-to-face classroom learning in the graduate education program. Based on the qualitative data (self-reported perceptions of students about online experience), the author discusses the use of Moodle mainly from students' point of view, and concludes by setting future directions for design research in the online course based on constructivist perspectives.

INTRODUCTION

In 1993, there was no World Wide Web. Today, it seems as if it is everywhere…. Is it any wonder that so many instructors are both anxious and apprehensive as they try to make sense of this new phenomenon? There are so many questions to answer: What is the difference between teaching "on the ground" and teaching online? What are the fundamental techniques? What kind of equipment or software do you use? How do you assess how effective you are? (Ko & Rossen, 2004, p. xv)

"Teaching online" means conducting a course—partially or entirely—through the Internet; what makes teaching online unique is that it uses the Internet, especially the World Wide Web, as the primary means of communication (Ko & Rossen, 2004). Using new media technology and the Internet offers possibilities to enhance Web-based learning (also known as "e-learning"), which is currently one of the major applications of the Internet. Due to the rapid development of Web-based technologies, increasing bandwidth, decreasing costs, and widening access, online versions of education programs are becoming increasingly popular teaching strategies for universities to adopt (Townsend & Wheeler, 2004). In classroom learning, face-to-face contact can help motivate and involve students in active learning, but in online learning via the new teaching and learning technologies makes materials available anytime and anywhere; in practice, both face-to-face and online programs often rely on transmissionist, teacher-centered provision of information rather than on student-centered construction of knowledge (Wonacott, 2002): "Students may end up receiving passively both online and in the classroom. Two themes, nevertheless, clearly emerge as the most frequently cited strengths—thus the *personal contact* allowed by face-to-face classroom learning and the *flexibility* allowed by online learning" (¶ 2).

The new educational technologies can be classified in two broad categories: (1) communication technologies are broken down into synchronous (online chat, audio-graphics, whiteboard, online video-conferencing, and live Web-casting) and asynchronous (e-mail, bulletin board, listserv, and computer conferencing) technologies, whereas (2) resources technologies are divided into four levels (Fox, 2005): Level 1 (Web sites, online databases, and online journals); Level 2 (online materials created by teachers, such as notes, syllabi and references); Level 3 (online multimedia courseware packages that include text, graphics, animation, audio, and video); and Level 4 (intelligent tutoring systems, expert systems, online simulations, and virtual reality environment). Fox further notes that because of their prevalence, it is useful to examine where virtual learning environments (WebCT, Blackboard, and Moodle) fit into the above classification.

This paper purports to articulate the use of a server-based software package designed to allow educators to provide collaborative activities, critical reflection, and learning resources to online students, as well as supplementing face-to-face learning. After providing a discussion on the course management systems (CMSs) and the CMS Moodle (Modular Object-Oriented Dynamic Learning Environment), the author describes the rationale why Moodle has been selected to be integrated into a "blended" course. One frequent question asked when one hears about blended learning (BL) is "What is being blended? Therefore, BL is clearly defined. Based on the student reflection papers on their online experience and their perception about BL, the author discusses the use of Moodle mainly from students' point of view, and concludes by setting future directions for design research in the online course based on constructivist perspectives.

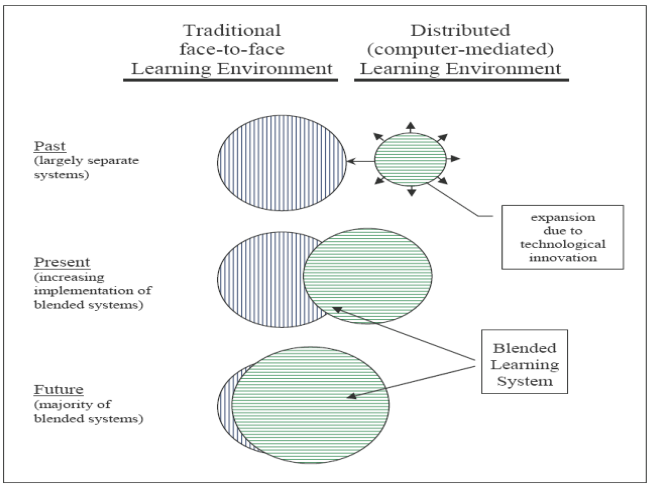
WHAT IS BEING BLENDED?

The term BL is being used with increased frequency in both academic and corporate circles (Graham, 2004): "In 2003, the American Society for Training and Development identified BL as one of the top ten trends to emerge in the knowledge delivery industry (cited by Rooney, 2003)" (p. 1). While there are a variety of responses to this question ("What is being blended?"), Graham has identified three most commonly documented definitions: (1) combining instructional modalities (or delivery media); (2) combining instructional methods; and (3) combining online and face-to-face instruction. The first two positions above reflect the debate on the influences of media versus method on learning, whereas the third position more accurately reflects the historical emergence of BL systems. BL emphasizes the central role of computer-based technologies in BL as depicted in Figure 1.

COURSE MANAGEMENT SYSTEMS

Learning software systems, such as CMSs or learning management systems (LMSs), provide the platform for online learning by enabling the management, delivery, and tracking of learning. CMSs, which are often viewed as being the

Figure 1. Progressive convergence of traditional face-to-face and distributed environments allowing development of blended learning systems (Source: Graham, 2004, p. 28)



starting point of any online learning program (Cavus, Uzunboylu, & Ibrahim, 2005), have the unique capacity to capture significant amounts of information about *how* students use the system, *how* they access online activities, and *how* they interact with other students in synchronous and asynchronous modes (Ullman, Peters, & Reimann, 2005).

The rising costs of education often lead to the call for a change from the traditional, space-and-time bound institutions to ones that offer increasingly cost-effective, technologically enhanced programs; as institutions of higher education turn to technology, primarily Internet-based, to address these challenges, the use of "open source" CMSs is dramatically increasing (Minielli & Ferris, 2005). Open source is "viable and significant in the commercial Internet and enterprise …[but] this new development is less than ten years old and may face significant legal and/or business challenges ahead" (Abel, 2005, pp. 3-4). Some of the best known commercially available CMS systems are Blackboard, WebCT, and Desire2Learn; there are also many open source software and free CMS systems, such as Moodle, Segue, Interact, CourseWork, Atutor, and KEWL (Cavus, et al., 2005). Additionally, "The terms 'free software' and 'open-source software' are sometimes used interchangeably in the discussion of software.…but free software is not 'free' as 'free' in the monetary sense, but users of the software should have the *freedom* to run, modify, adapt, customize and share without charge" (Kennedy, 2005, p. 327).

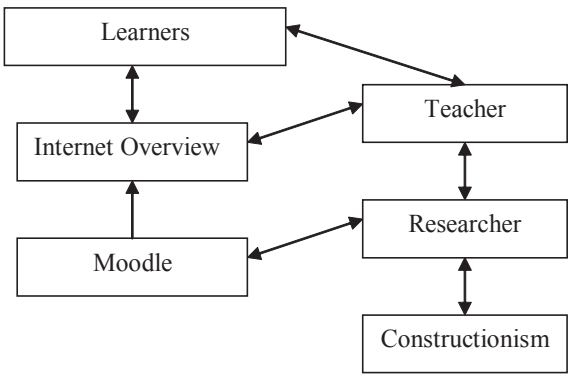
Blackboard—a commercial product produced by Blackboard Inc.—is a mature CMS with a large number of features that support learning and the most dominant CMS provider, whereas Moodle was first released in 2002 and was developed as an educationally sound alternative to Blackboard by Martin Dougiamas of Curtin University (Corich, 2005). Moodle provides many of the tools available within Blackboard, but the user interface is more primitive and the online help is minimal in comparison. According to Corich, the majority of early e-learning adopters in New Zealand decided to use mature CMSs like Blackboard and WebCT but, more recently, many institutes have been looking to the open source community to provide a less expensive and there are a growing number of the institutes looking towards Moodle. Compared with Blackboard, in Corich's research, students found Moodle easy to use and appreciated the way that Moodle presented materials week by week. In fact, Moodle is one of the popular CMSs, and it has a very large user base with 12,165 registered sites in 155 countries with 4,021,531 users in 376,565 courses as of May 30, 2006 ("Moolde," 2006).

THE CMS MOODLE

Dougiamas (2000) implemented using a prototype of a new Web course (titled "Internet Overview") development tool called "Moodle" that used constructionist referents to model engagement of the participants with course content and each other. Dougiamas notes:

I was inspired to create a new Web-based tool I could use to implement, modify, and experiment with an interactive internet-based course as easily and as flexibly as possible. I called this tool Moodle…. As a researcher using constructionism as a referent, I needed to develop Moodle to a usable state, then use Moodle itself to develop Internet Overview from a teacher's perspective. Through interaction with students and the course, I intended to develop new insights as a researcher and perhaps the nature of constructionism (see Figure 2). (¶ 24)

Figure 2. Diagram of affective relationships between the instructor's roles as teacher and researcher, course software, the course and students (Source: Dougiamas, 2000)



The system of Moodle is grounded in situated cognition and cognitive flexibility theory that provide the opportunity for an instructor to create a constructivist and constructionist environment to enhance teaching and learning; the abilities to design "student-centered" learning are embedded in Moodle and its modules, but it is ultimately the responsibility of the instructor to make good use of them (Antonenko, Toy, & Niederhauser, 2004). A constructivist perspective, as Dougiamas (1998) describes, does view learners as actively engaged in making meaning, and teaching with that approach looks for what students can *analyse*, *investigate*, *collaborate*, *share*, *build,* and *generate* based on what they already know, rather than what facts, skills, and processes they can parrot. As seen in Figure 2, to do this effectively, a teacher needs to be a learner and a researcher, and at the same time to strive for greater awareness of the environments and the participants in a given teaching situation in order to continually adjust their actions to engage students in learning, using constructivism as a referent.

Free open-source is becoming a serious competition to the CMS vendors, but the advantage of open-source solutions goes beyond cost savings as listed below (Yordanova, et al., 2003):

- Moodle allows to be adapted for many operating systems (Windows, Linux, Sun, and UNIX) and software environment (Mysql, Postgresql, MS-SQL Server, Oracle, and Access).
- Moodle can be installed at an institutional server and allows establishment and maintaining of courses from different categories kept in a catalog at a portal page.
- Moodle supports more services than others concerning course activities; the teacher arranges the activity modules in order the students will use them; and editing is possible in any time.
- Course formats give the templates for course settings facilitating the teacher design work.
- There are opportunities for uploading files of various formats that allow usage of materials from previous ordinary courses and easy extension of existing courses.
- Moodle supports many different languages with opportunities to add extra ones.

Moodle provides a range of functionality using such 'building blocks' as *Forums*, *Journals*, *Resources*, *Choices*, *Surveys*, and *Assignments*. Students can upload their assignments (any file format) to the server, which are then date-stamped. Instructors can keep track of student involvement as well as monitor and get reports on the aspects of the student's learning. Focusing on how Moodle has been implemented in a hybrid business English course at Kyoto Sangyo University, Baskerville and Robb (2005) describe the following unique components of Moodle:

- *Submission and retrieval system*: There is a common area for students to submit files ('To Teacher') in the administration block, and to retrieve files from the teacher ('From Teacher').
- *Attendance*: This feature logs the time of initial access to a course area; the instructor can view the attendance for the entire semester and download the results as an Excel file.
- *Class resources*: This feature provides data that students need to complete an assignment.
- *Class quizzes*: Moodle allows the teacher to set when students may begin a quiz and how long they have to complete the quiz.
- *Class activities*: Activities are to reinforce what students have been learning and to help them with current assignments.
- *Calendar*: Notes can be posted to the calendar to remind students of assignment due dates.
- *Participants*: Students and teachers in the course are shown on this page along with how much time has elapsed since they last accessed this page.
- *Forums*: This area allows communication among students or between students and teachers.
- *Logs*: The feature is flexible enough to report the results of all activities for all students down to checking one particular activity of an individual student.

Table 1. Moodle features and activities in the blended research course

Categories	Learning activities	Moodle 'building blocks'
Instructor Presentation	This includes lectures, simulations, charts, and graphs, as well as computer assisted presentations using tools like PowerPoint.	*News Forum* – Instructor's welcome message *Resources* -- PowerPoint slides for each week's lecture
Discussion	Guided discussion sections are common format for discussion. In seminars, instructor presentation and discussion are often combined.	*Forum* – Students participate in a weekly online discussion and a weekly online exercise
Group-oriented and individual projects	Collaborative activities are included here, in addition to group and independent projects presented to the entire class.	*Assignment*: Students upload weekly assignments, and submit online
Research	Research may be conducted either by individuals or in groups (e.g., practical applications, fieldwork and interviews).	Students develop their research proposal and submit online (but present it orally in class)
Assessment	This involves exams, essays, and projects; portfolios that combine different types of work; and evaluation for participation.	Scoring guidelines and rubrics are used, in addition to student participation in Moodle activities

Adapted from Ko & Rossen, 2004, p. 48

USING MOODLE FOR A BLENDED COURSE

The School of Education at an American Pacific island university has been the early adopter of Moodle, and training has been offered with small-groups assistance to provide faculty the skills needed to prepare course materials for online learning. The author of the present paper is one of those trained and has taught a blended graduate research course (titled "Introduction to Research Methods") using Moodle in the fall of 2006. This is the first implementation of mixing e-learning with face-to-face classroom learning in the teacher education program. The course is scheduled to teach entirely online in the future. Moodle has been selected for the implementation because of its *flexibility*, *efficiency*, and *cost-effectiveness*, as previously discussed in this paper.

This research course provides an overview of the concepts and applications used in educational research, with a focus on knowledge of research methods necessary to obtain valid and reliable outcomes as solutions to educational problems. The detailed course syllabus indicates the instructor's planned learning outcomes, and student practice, as well as how mastery is assessed. Student work is evaluated based on scoring guidelines and scoring rubrics. Incorporating an active learner model ('constructivist' approach), it is hoped that the instructor sends the message effectively so that students feel satisfied with their online experience. It is also hoped that the likelihood of faculty-student interactions may increase by timely feedback. Eventually, various strategies will be experimented to enhance content interaction, including animations, short video segments and interactive activities embedded right into the lecture material. Student surveys (or reflection papers) are conducted at the end of the semester to improve the course constantly.

The activities in most college courses can probably be divided into a few large categories (Ko & Rossen, 2004); the building blocks of Moodle are used in the course as summarized in Table 1.

HOW DOES STUDENT LEARNING EXPERIENCE BENEFIT FROM BL?

The aforementioned course was offered in a blended modality (up to 50% online)—thus in-class meetings (50%), and online activities (50%). A total of 19 students enrolled in the course and all of them completed the course. Students submitted all the assignments electronically creating 'files.' Students also participated in a weekly online discussion and a weekly online exercise. At the end of the semester, students developed a one-page reflection paper (their perceptions about BL, including their online experience). Typical reflection statements are as follows:

- BL is convenient for the full-time graduate student who is also a full-time employee, simply because it provides a great opportunity for students to work at their own pace.
- Online learning encourages student interaction and electronic contact with the professor beyond the confines of the classroom.
- This virtual platform provides students with the flexibility to complete and submit assignments virtually anywhere.
- Incorporating technology with traditional lecture formats has a positive, synergistic effect on the learning environment for graduate students.
- BL teaches students how to manage time and to be more responsible by setting proper due dates of assignments and other learning activities.

Several students expressed as follows: "the best part of BL is that students not only attend classes, meeting face-to-face with each other and their instructors, but they also can communicate electronically outside of class meetings using Moodle," supporting the characteristic of blended instruction (thus the *personal contact* allowed by face-to-face classroom learning and the *flexibility* by e-learning) pointed out by Wonacott (2002). Regarding communication, face-to face communication seems to be better for tasks for which students need immediate clarification and explanation, but face-to-face communication appears to be preferable when students need to generate new ideas.

Many of the students in the course are full-time school teachers or administrators. It also should be emphasized that students at the graduate level are responsible enough to study on their own. In this situation, the BL system works very well; accordingly, student reflection papers show that students have satisfied with their online experience. Furthermore, students in the course found that Moodle easy to use and appreciated the way that Moodle presented materials week by week, just as found in the research study by Corich (2005).

Nevertheless, several students pointed out the inconveniences, including inaccessibility to the website, the occasional power outage, and network downtime. The power surges, brownouts, and blackouts people experience in this Pacific island promote more than the usual amount of wear and tear than equipment normally receives, even with proper protection. In addition, lack of adequate air conditioning can allow damage due to moisture, heat, mold, and even insects. Maintenance and replacement parts can be difficult to come by and are expensive.

CONCLUSION AND FUTURE RESEARCH

The widespread adoption and availability of digital learning technologies has led to increased levels of integration of computer-mediated instructional elements into the traditional face-to-face learning experience. Students' perceptions of using the CMS Moodle are important, however:

Our focus should be teaching and learning….We must remember that our goals as educators include engaging students in higher order learning, facilitating the exercise of critical thinking skills, and ensuring students' mastery of conceptual, analytical, and theoretical knowledge as well as rather than solely developing students' ability and comfort with the use of technologies. (Minielli & Ferris, 2004, p. 17)

To effectively utilize open-source CMSs, educators not only need to be aware of terminology, functions, and uses of the most popular types of electronic

courseware, but also they need to develop and critique pedagogically based on research; therefore, "design research" is very important to maximize student learning (Reeves, Herington, & Oliver, 2005). "Design" really means the *shape* and *direction* the instructor wants the course to take, and the instructor has to keep in mind two design principles (Ko & Rossen, 2004): "to make sure that (1) your course objectives are defined in terms of the learning outcomes that you want students to be able to demonstrate and that (2) you align all activities, assignments, and assessments with those expected learning outcomes" (p. 46). Course designs are also very important to maximize student *online* learning; design research "has grown in importance since it was first conceptualized in the early 1990s…but many researchers continue to conduct studies that principally seek to determine the effectiveness of the delivery medium, rather than the instructional strategies and tasks" (Reeves et al., 2005, p. 96). Design research requires that faculty members should:

- define pedagogical outcomes and create learning environments that address them;
- emphasize content and pedagogy rather than technology;
- give special attention to supporting human interactions and nurturing learning communities;
- modify the learning environments until the pedagogical outcomes are reached; and
- reflect on the process to reveal design principles that can inform other instructors and researchers, and future development projects. (Reeves et al., 2005, pp. 109-110)

Blended instruction is becoming more commonplace in higher education. Through the pilot implementation described in the present paper, it is clear that the requirements noted by Reeves et al. are the necessary steps to enhance the quality and usefulness of design research in the use of the CMS Moodle for a blended course: apply theory to course design, put design into practice, collect and analyse data, and use the results to revise and modify the design. In order to enhance and maintain high quality *blended* or *online* instructional practices, it is essential for instructors to develop and implement specific assessments to evaluate the effectiveness of the teaching-learning process. That is, future studies should examine actual student performance with concrete learning tasks—not perceptions or preferences—in order to see whether these are consistent with teaching and learning effectiveness in the use of course management tools such as Moodle.

REFERENCES

Abel, R. (2005). Will open software become an important institutional strategy in higher education? Retrieved July 28, 2006, from http://www.a-hec.org

Antonenko, P., Toy, S., & Niederhauser, D. (2004). Modular object-oriented dynamic learning environment. (ERIC Database #ED485088)

Baskerville, B., & Robb, T. (2005). Using Moodle for teaching business English in a CALL environment. *PacCALL Journal, 1*(1), 138-151.

Cavus, N., Uzunboylu, H., & Ibrahim, D. (2005). Near east university learning management systems based distant education. (ED491480)

Corich, S. (2005). Is it time to Moodle? Retrieved July 29, 2006, from http://www.naccq.ac.nz/conference05/proceedings_05/concise/corich_moodle.pdf

Dougiamas, M. (1998). A journey into constructivism. Retrieved July 31, 2006, from http://dougiamas.com/writing/constructivism.html

Dougiamas, M. (2000). Improving the effectiveness of tools for Internet based education. Retrieved August 1, 2006, from http://dougiamas.com/writing/tlf2000/

Fox, S. (2005). Reflections of the benefits of the use of the new learning technologies in higher distance education through the prism of a case study. Paper presented at the 11th Cambridge International Conference on Open and Distance Learning, September 2005.

Graham, C. R. (2004). Blended learning systems: Definition, current trends, and future directions. C. J. Bonk, & C. R. Graham. (Eds.). *Handbook of blended learning: Global Perspectives,* local designs. San Francisco, CA: Pfeiffer Publishing. Retrieved December 7, 2006,from www.uab.edu/it/instructional/technology/docs/blended_learning_systems.pdf

Kennedy, D. M. (2005). Challenges in evaluating Hong Kong students' perceptions of Moodle. Retrieved July 28, 2006, from www.ascilite.org.au/conferences/brisbane05/blogs/proceedings/38_Kennedy.pdf

Ko, S., & Rossen, S. (2004). *Teaching online: A practical guide*. Boston, MA: Houghton Mifflin.

Minielli, M. C., & Ferris, S. P. (2005). Electronic courseware in higher education. *First Monday,10*(9). Retrieved July 29, 2006, from http://firstmonday.org/issues/issue10_9/minielli/index.html

Moodle. (2006). In *Wikipedia, The Free Encyclopedia*. Retrieved July 29, 2006, form http://en.wikipedia.org/wiki/Moodle

Reeves, T. C., Herrington, J., & Oliver, R. (2005). Design research: A socially responsible approach to instructional technology research in higher education. *Journal of Computing in Higher Education, 16*(2), 97-116.

Rooney, J. E. (2003). Blending learning opportunities to enhance educational programming and meetings. *Association Managment, 55*(5), 26-32.

Townsend, M., & Wheeler, S. (2004). Is there anybody out there? *The Quarterly Review of Distance Education, 5*(2), 127-138.

Ullman, A., Peters, D., & Reimann, P. (2005). Developing a research supportive Web-based learning systems. Retrieved August 2, 2006, from http://www.citeulike.org/user/kate_waxlyrical/article/621106

Wonacott, M. E. (2002). Blending face-to-face and distance learning methods in adult and career-technical education. *Practice Application Brief, 23* (ERIC Clearinghouse on Adult, Career, and Vocational Education).

Yordanova, L., et al. (2003). Development of a Web-based course on informatics via open-source software package Moodle. Retrieved August 3, 2006, from http://ecet.ecs.ru.acad.bg/cst/Docs/proceddings/S4/IV-15.pdf

Assessing the Knowledge Sharing Environment Within a Multi-National Pharmaceutical Company

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1. ABSTRACT

This paper has taken the key concepts taken from Andreas Riege's (Riege 2005) work to construct a questionnaire that was used within the drug development department of a large multi-national pharmaceutical organisation. The questionnaire assesses the department's culture to sharing knowledge which will aid in the development and deployment of a new Knowledge Management Decision Capturing Tool. The overall aim of the research is to increase the chance of the tool succeeding within the organisation by better understanding the cultural issues. This paper details how the questionnaire was formulated, analyses the results and draws conclusions form what can be learnt from such research projects.

2. INTRODUCTION

Nowadays we live in a knowledge economy that relies on the knowledge of employees. This is particularly relevant to the Pharmaceutical industry that develops and sells drugs and medications. Yet what they are really purveying is the knowledge and creativity of the researchers who develop these products, obtain approval, and get them to market. Knowledge Management has emerged as a popular and important area of academic and practitioner research, the principal reason behind the rise in popularity, is that authors such as (Drucker 1993)have assigned a value to the knowledge within an organisation. The sharing of knowledge between employees in an organisation has been shown to be of great benefit and provide competitive advantage (Argote, Ingram 2000). Argot and Ingram (Argote, Ingram 2000) stated that 'The ability to transfer knowledge from one unit to another has been found to contribute to the organizational performance of firms in both the manufacturing and service sectors'. Due to these factors, organisations are becoming increasingly aware of the need to actively manage the knowledge of their employees and knowledge repositories, as their operating strategies are driven into distributed models by the advent of modern cross functional and cross team working practices (Argote, McEvily & Reagans 2003). For example, typically, only one out of 30 new projects results in marketable medication in the pharmaceutical industry (Myers 1991) and the knowledge the researchers carry from project to project therefore has a direct bearing on profits. A company that can improve the ratio to one in 28 through more rapid and efficient development has a competitive advantage (Myers 1991)

Attempts to address the issues of information and knowledge extraction within the initial discovery stages of drug development have met with mixed results. Scarce Knowledge Management based literature exists on the subject, indeed Schweizer (Schweizer 2005) questions the ability of the acquiring pharmaceutical company to 'absorb' the knowledge of the biotech company, concluding that in many cases the pharmaceutical company may prefer to outsource its R&D activities to these companies and instead concentrate upon its core competencies of late stage clinical trials, regulatory affairs and marketing activities.

The research detailed within this paper is part of a larger three year research programme into how the multi-national pharmaceutical company can increase their competitive advantage through the careful development, education, deployment and training of staff around a specific Knowledge Management and Decision Capturing Tool (KM-DCT) that will aid their employees to:

- Record and structure their knowledge and decisions.
- Make informed decisions through interrogating the stored knowledge and decisions.
- Provide considered and concise strategic options for internal customers, thus saving them time and above all providing a higher level of scientific accuracy.
- Use a tool that is seamlessly part of their working habitat, integrated with their everyday process.

This paper details the results of stage one of the research which involves assessing the environment (employees and culture) within the drug development department of the pharmaceutical company with regards to knowledge sharing and capturing.

This research has been based on the paper "Three-dozen knowledge-sharing barriers managers must consider" (Riege 2005) which presents a number of barriers and problems that must be considered. The key concepts of that paper have been used to develop a questionnaire that was used within the drug development department of the multi-national pharmaceutical to assess the department's culture to sharing knowledge and determine how the suggestions fit this organisation. The results of the questionnaire will be used to feed into the development of the KM-DCT, with the overall aim of the research to increase the chance of KM-DCT succeeding.

A practitioner aims to create an environment conducive to knowledge sharing and is largely reliant upon the implementation of technology to support such knowledge interaction (Richardson 2001). On the other hand, the academic arena approaches Knowledge Management from a conceptual angle, seeking to analyse the underlying basis of knowledge and create an environment conducive to knowledge sharing without the emphasis upon technology (Sullivan 2000)(Nomura 2002).

In order to gain a competitive advantage through the development, education, deployment and training of staff on the KM-DCT, three main areas will be addressed to ensure that the three year research programme is successful. Research will address the following three main areas as a holistic approach:

- Employees (culture)
- Process integration
- Technology

Employees, because only human beings can generate knowledge from information and re-use it in a different context. Processes, because the transmission of knowledge from person to person requires rules and procedures in order to make use of knowledge or take action on it. Technology is necessary to store, retrieve, and organise vast quantities of information and make it digestible by human beings so that new knowledge can be discovered. Note that technology was not first on this list. Without detailed consideration of the employees and processes technological systems will undoubtedly fail.

3. METHODOLOGY

3.1. Research Methods

It was decided that the most efficient way to capture the information required would be to use a questionnaire. The ability to distribute the questionnaires to a wide geographical area was vital as a number of employees were based at different locations throughout the United Kingdom. Surveys also allow a greater number of variables to be studied than some other experimental methods (Galliers 1992).

It was also important to be aware of some of the pitfalls related to using questionnaires. Using a questionnaire takes a snapshot of the persons view at a particular point in time. They may also allow bias to be introduced because the person completing the survey chooses the answer they give. This may of course not reflect their true belief or their true state. Questions are also open to interpretation of the respondent. They may also not show the full picture as to why the respondent gives the answer they do. These are all issues to bear in mind whilst analysing and interpreting the results.

3.2. Questionnaire Sections

Three key areas of knowledge management have been addressed within the questionnaire and are namely:

- Technology
- Culture
- Process

Whilst technology and culture can be addressed by questions in the questionnaire, the daily process of an employee must also be taken into consideration. For this reason a number of questions were asked surrounding the user's daily process. It was important to see if we could establish a way of introducing the toolset into their work whilst minimising disruption to their daily process and causing unnecessary stress or complication.

In addition to these widely recognised areas another section was created. This focused on reward. In preliminary discussions it was apparent that many employees felt that they couldn't make time to focus on knowledge sharing because of the lack of reward that would be received and perhaps even the negative impact it would have on their job. They felt that there was no system to reward them for knowledge sharing or encourage them to share. Any knowledge sharing was being done 'off their own backs' in the hope that it would improve their skills and job performance. There was also no way to record the fact they had spent time sharing knowledge in their time-sheets leading to unexplainable holes in their work schedule. Given the preliminary discussions it was important to discover if these feelings were shared throughout the organisation.

3.3. Question Types

A number of questions where presented as multiple choice answers. In the majority of these scenarios they were in answer to a question that asked about the frequency something occurred. Most of these multiple choice questions were presented with an even scale, meaning that they had and even number of possible answers. There were generally 4 or 6 options. This was done to prevent employees from giving just a neutral answer and forced them to make a clear decision about the side of the argument they agreed with.

There were also a number of open text fields available. It was felt that although no statistical analysis can be easily achieved with these fields they would provide and excellent insight into the views of those questioned and enables them to expand on the answers that they give. This allows a greater view into their thoughts and hopefully leads to less interpretation being required to alleviate some of the issues mentioned previously.

3.4. Deployment

The questionnaire was delivered as an online survey within the target organisation. This was done for a number of reasons.

The first and foremost reason was that anonymity was required. The questionnaire asks a number of questions which may be considered quite sensitive and their answers may be perceived by the employees as a threat to their job security should they offend anyone. It is also obviously important that truthful answers were received. In order to ensure that a unique reference to the employee was available without compromising their privacy, windows login id's were first encrypted using a cryptographic hashing algorithm which is very difficult to reverse (the system actually uses the SHA-1 algorithm).

Secondly, to ensure that recipients answered within their normal working environments to minimise the disruption caused and maximise the probability that responses would be received. It also increased the benefits of the questionnaire technique for obtaining results from highly geographically dispersed recipients.

The questionnaire contained many questions that related to IT and systems that the IT department delivers, thus it was important to get their agreement. The Human Resources department also ensured that they were acceptable to the members of staff.

The survey contained 60 questions divided into the previously discussed categories and was distributed to employees in one geographically dispersed department. Employees were asked to participate via and email and of the 100 asked to participate, at the time of writing, 65 responses had been received.

4. RESULTS AND ANALYSIS

Like the questionnaire the results have been divided into four sections, Technology, Culture, Daily Process and Reward and Recognition Schemes.

4.1. Technology

The first key indicator area has been used to determine the ability of the employees to use technology and to understand their current concerns with the existing systems that they use.

It is interesting to note that two thirds of the participants stated they were experienced as a computer user. Whilst 20% said that they had some experience and 12% said that they were experts. Only one person rated themselves as a novice. The employees' opinions of their experience with technology in general, followed a similar pattern. However slightly more employees felt they only had some experience.

Reluctance to use IT systems due to a lack of familiarity or experience with them is an issue for some employers, however, in a company where the majority of employees feel that they have experience with computers one might expect that this would not be a problem. What is quite positive is that 50% of the participants actually became excited about the prospect of something new.

Employees were also generally happy with the amount of training they had received to perform tasks associated with their daily work. However, over 50% felt training is inadequate. What this may indicate is that a system of clear communication is necessary to allow those who are perhaps slower at picking up the new technology or do not feel comfortable with the training, to obtain more references or training, whilst allowing those who are content to bypass this.

Another key issue mentioned by Riege (Riege 2005) is that not demonstrating all of the advantages of a new system over an old can cause negativity towards a system. This has also been identified as a problem within the target organization with 6% saying that benefits are rarely explained and 66% saying that they are only sometimes made clear.

Almost two-thirds of employees felt that sufficient technical support was available which is a positive outcome. It is worth investigating the reasons behind why one-third did not feel that technical support is available.

There was also a feeling that IS tools and business processes are not very well integrated with 61% saying that only sometimes are they well integrated. This lack of perceived integration will obviously impair sharing and coupled with the previous point shows an area that must be investigated.

4.2. Daily Process

As mentioned earlier in the paper, for a new system to be a success it needs to be embedded within current daily processes, which includes the systems they use on a regular basis. The second key indicator determines the applications the employees use on a daily basis and what activities they undertake. Through understanding these it will be possible to determine the most suitable place for the KM-DCT to be embedded.

One of the most obvious options is to make the tool a web based system on the company intranet. When asked how often employees made use of the internet for work, 30% said all the time and 17% said hourly, this left 39% saying they

used it once or twice per day. Only seven employees said they used it just once or twice per week. This reinforces the fact that the web is a great location for a new system.

Several questions were asked about the sites that were frequently visited. When asked how often employees read the company portal, 47% said sometimes and 27% often, this indicates a logical place to put the tool. However, this may not signify a prominent enough position and more questions may need to be asked in order to determine how the tool could be promoted more successfully than simply making it available from the corporate portal.

It is also interesting to note that 81% of employees said that they received 25 or more emails per day and 92% stated that they left Microsoft Outlook running all the time. This represents a definite option for further investigation and research into possibilities of integrating the tool into emails will be worthwhile. Being able to automatically advise based on the outcome of previous decisions whilst working within Outlook could be a positive step.

Microsoft Word and Excel were also often used with 26% of employees stating they used Word always and 60% stating they used it often. Excel was used slightly less but still had over 60% saying they used it always, often or sometimes.

4.3. Culture

It has been said (Riege 2005) employees can take 'ownership of intellectual property because they do not feel they are given sufficient credit when sharing knowledge'. This will obviously cause employees to be reluctant to share knowledge in future and cause them to keep knowledge to themselves, and only sharing what is truly necessary. Almost 50% of employees said they sometimes receive credit and 25% said that they rarely receive credit. This is obviously a very negative thing. Methods for giving credit are often difficult. It is important that employees still feel an emotional attachment to their information even though it is being used by the team. What is quite surprising is although there was a lack of credit for knowledge sharing, 85% of participants stated this did not make them reluctant to share knowledge in the future.

A lack of time to share knowledge is also an issue, 12% of employees said that they rarely received enough time to share knowledge and 56% said that only sometimes did they get enough time to share knowledge. Only two employees felt that they always had enough time to share knowledge.

Actually identifying employees to share knowledge with and employees who need your knowledge is also important. Fifty-three percent of employees said that they did not have time to identify employees who have knowledge that they require. A slightly higher 61% said that they did not have time to identify employees who may require their knowledge.

Being able to actually record knowledge sharing in their time sheets presents an issue for most employees as 76% of the respondents felt that they couldn't record their knowledge sharing activities. While this should not be an issue for the use of the tool, as the tool will mostly be used within meetings where the activity can be recorded without problems, this is still an interesting finding.

Twenty-five percent of those questioned said they always benefit from sharing knowledge and 50% often do, with 21% saying that they benefit sometimes. This demonstrates there is a culture that realises the benefits of knowledge sharing.

Questions were also asked relating more to the organisational culture and encouragement and availability of knowledge sharing practices. When asked if knowledge was shared outside a participant's team 81% said that it was and over half felt that sharing knowledge outside their team was part of their work process. Only 47% were aware of the company wide goals for knowledge sharing. Often the 'Integration of km strategy and sharing initiatives into the company's goals and strategic approach is missing or unclear' (Riege 2005).With almost half of the employees unaware of the company's knowledge sharing goals and objectives, it may be difficult for a unified approach to succeed.

Whilst 40% of employees stated that they are often encouraged to share knowledge by their superiors and 13% always encouraged, this still leaves 32% who are only sometimes encouraged and 14% who felt that they rarely received encouragement to share knowledge.

Sixty-five percent said that they found sharing knowledge easy. Almost 60% felt that there were an adequate number of places to interact formally and informally to share knowledge with colleagues, for example within meetings and coffee rooms respectively. Only one-third of respondents felt that they were given the opportunity to interact with colleagues outside their immediate job, for example at conferences.

4.4. Reward Schemes and Recognition

The final key indicator area has been used to determine the mindset of employees within the department to whether they require a reward and recognition system, or if they currently use one how it affects their work. It is clear that the majority (90%) of employees do not know of any reward schemes that currently run within the organisation, yet the small minority that do (10%) feel that the scheme offers sufficient reward for knowledge sharing.

Interestingly only a small percentage of employees (35%) felt that they were in competition with employees both within and outside their department. This indicates that 65% do not feel they are in competition which is a good factor for knowledge sharing, although competition can be useful to motivate employees.

Also only Nine employees felt that their organisational structure prevented them from knowledge sharing. For example they felt that knowledge was only shared between themselves and their direct manager. Whilst this is not necessarily a real problem for the company as a whole, for those individuals the sharing of knowledge is being suppressed.

Finally, almost 50% of employees stated they would be encouraged to share knowledge if it were incorporated into their yearly review process.

5. CONCLUSIONS

This paper has detailed the results of stage one of the research which involved assessing the environment (employees and culture) within the drug development department of the pharmaceutical company with regards to knowledge sharing and capturing.

In the Technology section of the questionnaire the results indicate that the majority of employees are comfortable with using IT, but what was clear is that the benefits of any new system need to be made explicit to the employees. In the Process section, the majority of employees use Microsoft tools on a daily basis followed by the organisations intranet. When a new tool is developed it is important that it can be embedded into existing frequently used tools to aid in its use. In the Culture section employees indicated that knowledge sharing should be recognised as bonafide activity and to aid this they should be allowed to list it on their timesheets. Finally in the Reward and Recognition section, employees indicated that they would be encouraged to share knowledge if it was incorporated into their annual review process.

The four key findings from this research are listed below:

1. Enable knowledge sharing to be recorded in its own right and as a valued activity (timesheets).
2. Benefits of the new system need to be explicit.
3. Build new tools into existing applications.
4. Make knowledge sharing part of the employee's job by including it in their yearly review process.

The results from the cultural side of this study show that employees are willing to share knowledge if it is made explicit that it is part of their job and that they can record their knowledge sharing activities to projects. From a technological viewpoint any new system should be embedded within frequently used existing systems, and the benefits must be made clear to employees.

The sorts of problems highlighted in this study are not thought to be unique to this organisation and other organisations could benefit from repeating such a study before introducing new tools to aid in decision capturing and knowledge sharing.

6. BIBLIOGRAPHY

Argote, L. & Ingram, P. 2000, "Knowledge transfer: A basis for competitive advantage in firms", *Organizational behavior and human decision processes,* vol. 82, no. 1, pp. 150-169.

Argote, L., McEvily, B. & Reagans, R. 2003, "Introduction to the Special Issue on Managing Knowledge in Organizations: Creating, Retaining, and Transferring Knowledge", *Management Science,* vol. 49, no. 4, pp. 5-8.

Drucker, P.F. 1993, *Post-capitalist society,* Butterworth-Heinemann Oxford.

Galliers, R. 1992, *Information Systems Research: Issues, Methods, and Practical Guidelines,* Blackwell Scientific.

Myers, M. 1991, "Knowledge Management: How Do You Know What You Know? - Industry Trend or Event", *Computer Technology Review,* [Online], , pp. 02/06/06. Available from: http://www.findarticles.com/p/articles/mi_m0BRZ/is_4_21/ai_77058294.

Nomura, T. 2002, "Design of 'Ba' for successful Knowledge Management—how enterprises should design the places of interaction to gain competitive advantage", *Journal of Network and Computer Applications,* vol. 25, no. 4, pp. 263-278.

Richardson, D. 2001, "The Practical Reality of Knowledge Management within Development Initiatives", *International Fund for Agricultural Development's Electronic Networking for Rural Asia/Pacific Projects (ENRAP) 2ndComprehensive Workshop,* .

Riege, A. 2005, "Three-dozen knowledge-sharing barriers managers must consider", *Journal of Knowledge Management,* vol. 9, no. 3, pp. 18-35.

Schweizer, L. 2005, "Knowledge transfer and R&D in pharmaceutical companies: a case study", *Journal of Engineering and Technology Management,* vol. 26, no. 3, pp. 315-331.

Sullivan, P.H. 2000, *Value-driven intellectual capital: how to convert intangible corporate assets into market value,* Wiley.

Blending Synchronous and Asynchronous Learning Approaches for Teaching Knowledge Management Courses

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ABSTRACT

Knowledge management (KM) has been one of the core operations of most companies and organizations since the early 1990s. As a consequence, KM education is experiencing exponential growth around the globe. In recent years, development in info-communication technologies (ICTs), increase in digital content, and the escalating use of the Internet and wireless capabilities have reformed the way learning is carried out. Many academic institutions are trying to fully exploit the potential of online learning tools and offer a variety of innovative pedagogical approaches that utilize information technologies in order to make the learning process more effective, interesting, meaningful, and engaging for students. However, face-to-face communication in a traditional classroom setting has its own advantages as it provides immediate feedback and answers to students' queries. This in turn, brings about increased student motivation, involvement, information and knowledge sharing, and development. The blend of these two approaches enhances their benefits and at the same time minimizes their limitations. This paper reviews the approaches adopted by the Division of Information Studies, Nanyang Technological University, Singapore, for teaching various modules in its Master's of Science in Knowledge Management (KM) program. This paper also explains the various ways in which the NTU online learning system, edveNTUre, is used for collaboration and content delivery for teaching the KM program, which helped improve the level of communication, collaboration, and interaction between students and lecturers.

1. INTRODUCTION

The global knowledge-based economy and growth of technologies have made it inevitable for online learning environments to spawn, in order to keep up with the demand for updated information and new knowledge, within the constraints of time and distance. Online learning, with its open access and independent learning environment (Stansfield, McLellan & Connolly, 2004), transcends physical and geographical boundaries to allow students to exchange ideas and share experiences cross-culturally. These characteristics of online learning make it an ideal learning mode that can effectively complement the traditional learning mode in meeting challenges posed by the digital age.

2. ISSUES CONCERNING ONLINE LEARNING

With the popularity and acceptance of online learning as a valid and effective learning method, there is a gradual change from lecturer-centered to student-centered learning approaches (Stansfield, McLellan & Connolly, 2004). As a result, the lecturer's role is becoming more of a facilitator in the learning process, while students actively participate and contribute to their own learning (Lee & Tan, 2004). It encourages students to view things differently, more critically and creatively (Pan, 1999). DeRienzo (2000) claims that in online learning, interaction is the key factor. She argues that the role of the lecturer is transforming from a broadcaster of knowledge to that of a mentor.

Kumar (2004) claims that online teaching and learning would become more effective through incorporating multimodality in content delivery which involves dissemination of knowledge in different modes of representation (eg. visual, textual, audio). Multimodal presentations are believed to stimulate and fully utilize all the abilities of human brain (Thomas, Kellogg & Erickson, 2001), allowing more opportunities for erudition, creativity and the generation of ideas.

In the traditional classroom, the synchronous or face-to-face social interaction with immediate feedback to learning queries by the teacher, facilitate student learning (McInnerney & Roberts, 2004) and help to allay doubts that may arise in the course of learning. This immediate feedback to questions helps students to quickly evaluate and guide their learning (Galusha, 1997). However, in the online learning environment, the lack of face-to-face interactions with their teachers can be exasperating for students and even hinder their learning process (Dzakiria, 2005). In addition, teachers may not be able to assess the learning situation immediately through students' facial expressions or signs of doubt (Stansfield, McLellan & Connolly, 2004). Nonetheless, the lack of face-to-face interaction with the teacher and other students are not necessarily barriers to learning. Students have indicated that asynchronous communication, such as emails and listservs, provide sufficient opportunities for collaboration with other students and feedback from the teacher (Daugherty & Funke, 1998).

Therefore, a balanced approach, using various learning methods and tools, and incorporating both synchronous (real-time) and asynchronous (delayed time) learning approaches, is more appropriate in overcoming barriers to online learning.

3. EDUCATING KNOWLEDGE MANAGEMENT PROFESSIONALS

The emergence of the knowledge-based economy and the popularity of e-business initiatives have made KM an essential area of activity in organizations. KM is a systematic process of taking advantage of the intellectual capital and knowledge assets for organizational success. In the current complex, dynamic, and volatile business environment, proper knowledge management can provide a competitive edge to an organization over its competitors.

Other than providing a competitive edge over rivals, good KM practices also allow information and knowledge sharing to take place. Many studies have claimed that information and knowledge sharing plays an important role in the learning and development of individuals (Rafaeli & Ravid, 2003). However, Majid and Yuen (2006) found that a barrier to information and knowledge sharing includes limited socializing opportunities. Hence, proper KM practices that utilize online capabilities would effectively improve the sharing of information and knowledge amongst people who frequently complain of a lack of time or social opportunities to do so. In the Division of Information Studies, School of Communication and Information, Nanyang Technological University, Singapore, various approaches are used to teach KM, which includes the innovative use of various features of an online learning system deployed by the University.

4. ONLINE LEARNING AT NANYANG TECHNOLOGICAL UNIVERSITY (NTU)

Nanyang Technological University is considered as one of the most prestigious and leading academic institutions in Asia, known for providing high quality education by using innovative pedagogical approaches. The university has a strong engineering college ranked among the best in the Commonwealth, a prestigious business school, an internationally acclaimed National Institute of Education, and one of the best Schools of Communication and Information in Asia. Recently several new schools such as the School of Biological Sciences, the School of Humanities and Social Sciences, the School of Physical and Mathematical Sciences and the School of Art, Design and Media, have been established.

The faculty at NTU extensively uses IT for instruction and delivering course content. All lecture theaters are equipped with state-of-the-art technology such as the latest computers, projectors, visualizers, VCR/ DVD players, wireless communication hubs and other gadgets. The campus is equipped with broadband high-speed telecommunication capabilities and all classroom computers are linked to the campus network as well as the Internet. Although currently NTU offers only selected academic modules online, it is considering using online modules extensively in the near future. As the physical size of Singapore is very small, students are expected to physically attend most of their classes. However, digital content is significantly used in all courses and the NTU online learning system plays a central role in instant communication between the instructor and students, student-to-student and other concerned parties.

4.1. The *edveNTUre* System

edveNTUre is the university online learning management system which was established in 2000 and within a short span of about 6 years, over 95% of all courses taught in NTU makes use of it. The *edveNTUre* (the letter 'e' stands for electronic; 'ed' for education, with the name of the university 'NTU' embedded in it) is powered by the Blackboard e-education system. The Blackboard system was preferred as it was used by over 3,300 institutions worldwide (Lee & Tan, 2004). It was also expected that a large user-base would ensure that the system continues evolving, and providing new tools and enhanced features. Several enhancements helped customize the Blackboard system into *edveNTUre* to meet specific needs of the NTU teaching community.

The use of *edveNTUre* has resulted in a paradigm shift in teaching and learning at NTU which was difficult to achieve by only using traditional classroom approaches. The e-learning platform has allowed dynamic content to be delivered digitally through the University through both wired and wireless networks to all students anytime and anywhere on a variety of devices (Lee & Tan, 2004). It complements traditional lectures through several online learning tools including discussion forums for collaborative knowledge sharing, personalized learning, dynamic content delivery and other automated teaching tools. The University is celebrating an e-learning week in October 2006 where all lectures and tutorial sessions will be conducted by using different online tools such as streaming of recorded lectures, virtual classes, online discussion board, short video presentations, and weblogs. This exercise is part of the University's initiative on "Pandemic Flu Response Planning for Business Continuity", to test the capabilities of the e-learning system to continue the teaching and learning process during a natural disaster or health epidemic.

5. KNOWLEDGE MANAGEMENT PROGRAM AT NTU

Recognizing the importance of knowledge management in the new economy, the Division of Information Studies introduced a specialization in Knowledge Management in 2000, as part of its MSc. in Information Studies programme. Soon it was realized that a more comprehensive and in-depth treatment is needed to prepare such professionals who can appreciate the complexities of this fast emerging discipline and be ready to provide leadership for implementing knowledge management initiatives in their organizations. In 2002, in collaboration with the Civil Service College, an MSc. degree in Knowledge Management was launched. NTU was among the pioneer to offer this degree in the Asia Pacific region.

The MSc. (KM) program provides a balanced coverage of management, technology, and information related topics, which are considered essential for preparing well-rounded knowledge professionals. In order to provide core competencies to all students and at the same time offer adequate flexibility for acquiring specialized skills, a three-tier programme was designed. As students in this programme come from diverse disciplines and backgrounds, three core courses, namely, *Foundation of Knowledge Management*; *Knowledge Management Tools*; and the *Professional Seminar*, were introduced to expose students to basic concepts, issues and the complexities of knowledge management.

At the second-tier level, Elective 'A' courses were structured to allow students to choose two out of four courses to focus on in the areas of human capital, knowledge tools, organizational behavior, and knowledge resources. These second tier courses provide basic competencies and prepare students for more advanced courses in the intended areas of specialization.

At the third-tier level, Elective 'B' courses provide an opportunity for students to select courses in their areas of interest. Moreover, students can either opt for the coursework only option where they take 11 modules (3 core, 2 Elective 'A' and 6 Elective 'B' courses) or a combination of coursework and dissertation (3 core, 2 Elective 'A', 4 Elective 'B' courses and a short dissertation). Currently, the programme is offered on a part-time basis and classes are held in the evening. However, from August 2007 this programme will also be available on a full-time basis, and as a result, overseas students will also be allowed to join this programme.

6. SYNCHRONOUS AND ASYNCHRONOUS APPROACHES FOR TEACHING KM

It is evident that where face-to-face instruction has its own merits, online learning and collaboration tools can bring students and lecturers together to discuss ideas and share opinions on a 24/7 basis, thus making the learning process more pragmatic, interesting, and unique. It is obvious that using a combination of approaches such as class lectures and online learning tools can supplement each other's strengths and at the same time help overcome their weaknesses. As a result, a dual approach comprising face-to-face instruction and the extensive use of online learning tools for content delivery and collaboration, has been adopted in NTU. As described in the next section, the combined approaches facilitated NTU's enhanced knowledge sharing through socialization and collaboration.

6.1. Face-to-Face Instruction to Facilitate Socialization

Considering the nature of the KM programme, which itself advocates the effective use of human capital and 'rich' communication channels in organizations, the face-to-face interaction between students and lecturers, and among fellow students was considered desirable. It provides an avenue for students to socialize as well as share their ideas and experiences, followed by active participation in online discussion forums. Moreover, the traditional classroom learning approach is considered more feasible in the Singapore context where students live in close geographical proximity. As all classes are held in the evening, even working students can easily visit the campus to attend classes.

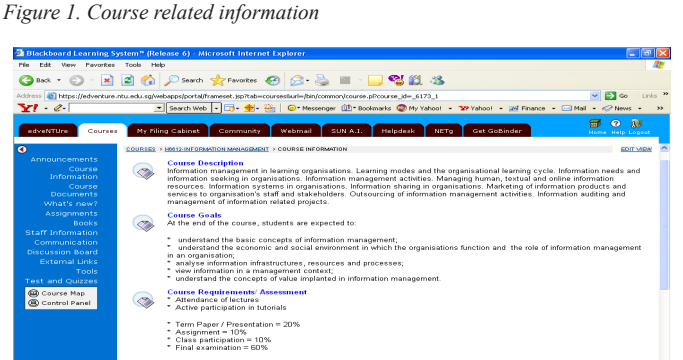
In addition to IT-supported lectures, ample emphasis is given on other interactive learning activities such as small group discussions, student presentations, case study analyses, group projects, hands-on sessions, and so on. The physical presence of students allows them to network and develop various interest groups. A study conducted at NTU to understand knowledge sharing patterns of graduate students in the School of Communication and Information also showed that other than e-mail, respondents preferred sharing their knowledge with their peers through face-to-face interactions (Majid & Yuen, 2006). The NTU experience also shows that longer tea breaks of half an hour have immensely contributed to increased informal interaction among students and developing alliances. It has been observed that this approach was helpful in providing an opportunity for students to carry out peer-to-peer learning.

6.2. Online System to Facilitate Collaborative Learning

In addition to taking full advantage of classroom learning, all KM courses extensively use IT, particularly the *edveNTUre* e-learning system, for delivering course content as well as a collaboration tool. At the start of a new semester, a new folder is created for each course offered during that semester. The course coordinator populates various areas in the folder such as course information, course documents, staff information, assignments, announcements, and tests and quizzes. Some important and frequently used areas in the course folder are described below:

a. **Course Information:** This section provides some basic information about

Figure 1. Course related information



the course such as the course description, course goals, course requirements, student assessment scheme, and recommended readings (Figure 1). In addition, it also provides details about the lecture and tutorial schedule.

b. **Staff Information:** This link provides contact information about the course coordinator, and all lecturers and tutors associated with that particular course. It often includes information about the names, email addresses, office telephone numbers and office locations of all the staff involved in teaching the course.

c. **Assignments:** In this section, information about assignment topics, recommended format and style for written assignments, assessment criteria, due dates, and so on are provided to the students (Figure 2). Almost all KM courses require students to submit written assignments, prepare individual or group term reports, and make presentations.

Often students are expected to submit a hardcopy of their written assignments for receiving the lecturer's feedback and grades as well as upload a softcopy through the *digital dropbox*. Many course instructors also upload the softcopies of student assignments and term reports in this area for reference by other students (Figure 3).

d. **Course Documents:** This is one of the most heavily used areas of the course folder. Most lecturers use PowerPoint slides with appropriate animations and they are expected to upload their lecture slides and other materials at least 2-3 days before the actual lecture day (Figure 4). It allows students to go through these materials before coming for class and bring a printout of these slides to class for taking additional notes. With the presence of wireless broadband Internet connection, students can also easily access the slides on their laptops in class and type in additional information discussed by the lecturer. In addition, instructors often use this area to either make available softcopies of additional readings or provide links to other electronic resources. The tracking feature of the system provides information about the use statistics of various course objects.

This area can also be used for providing access to other course materials. For example, in certain courses, various topics are given to the students during tutorial sessions for small group discussions. Each group picks, on a rotation basis, its leader to moderate the group discussion. Thereafter, all groups assemble and their leaders make brief presentations to the whole class, followed by a question-and-answer session. These group leaders are also expected to prepare a summary of the points raised during the class discussion and make them available online to all students.

e. **Collaboration Tools:** The edveNTUre system provides several collaboration tools that are available for easy and instant communication between the instructor and students as well as among the students. E-mail addresses of the

Figure 2. Description of student assignments

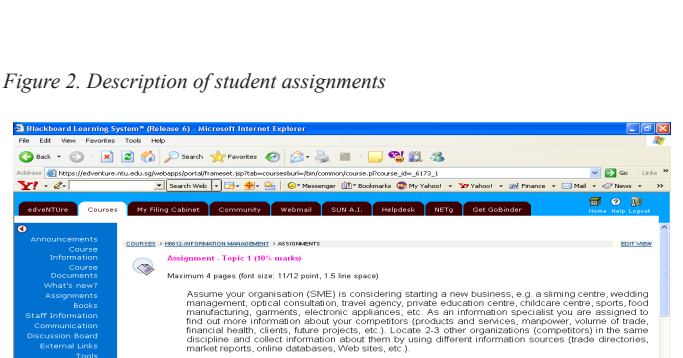


Figure 4. Lecture slides and discussion summaries

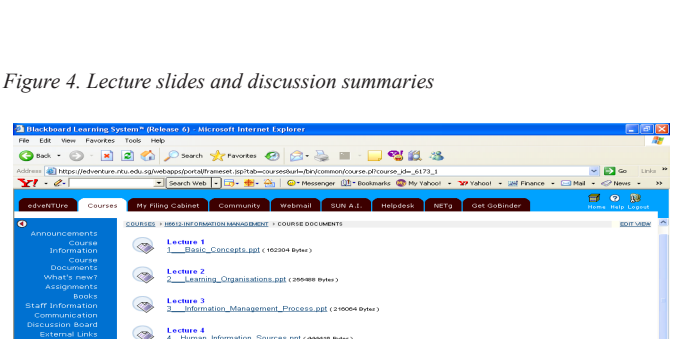


Figure 3. Softcopies of students' term reports and class presentations

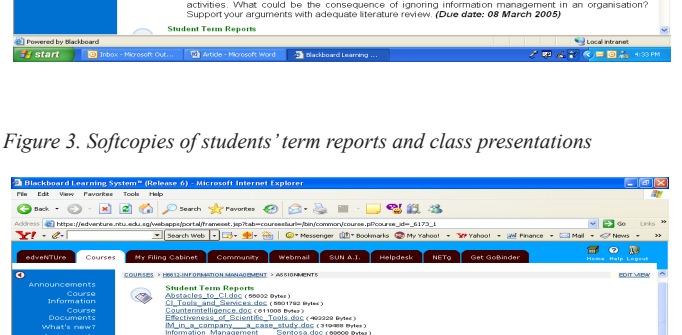
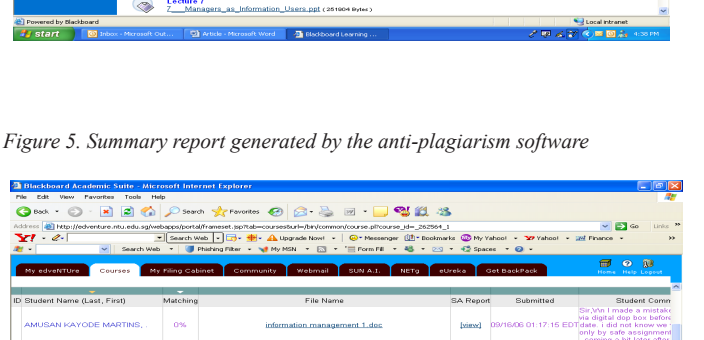


Figure 5. Summary report generated by the anti-plagiarism software



students registered for a particular course are available in the course folder for sending mass or individual e-mails to students within a class. Another very powerful and heavily used feature of the *edveNTUre* is the discussion board. Here, the instructor creates separate 'forums' for each discussion topic and students express their opinions on that topic. Students can read opinions of other students or add a new thread of discussion. Even shy students, who often do not actively participate in class discussions, feel comfortable expressing their opinions in these online forums where they can choose to remain anonymous. Threaded discussions can be reviewed and archived for future reference – an accumulation and documentation of real life scenarios, lessons learnt and shared, and best practices of doing things. Often, instructors become facilitators in such interactions so that students would not go astray in their discussions.

Staff and students can also join various university wide online interest groups created by different societies and professional associations, and participate in their discussions and other interactive activities.

f. **Safe Assignments:** Earlier, many lecturers have been experiencing and complaining about the widespread problem of student plagiarism. In most situations, they were unable to effectively control this problem due to the lack of time and difficulty in identifying the source documents. With the installation of this anti-plagiarism tool, it is much easier, faster, and less time consuming to get a complete report about the level of copying, sources used, and the copied text (Figure 5). Now, many course instructors require students to submit a softcopy of their assignments, term reports, and other materials through the safe assignment option. Students, at the time of submitting their work, can also see a plagiarism report and, in many cases, try to remove the plagiarized text before the final submission.

g. **Other Useful Features:** Certain other useful features available through *edveNTUre* include online announcements such as information about the availability of course materials, changes in class schedule, due dates for student assignments and other course related matters. Some other features available through *edveNTUre* are *Course Glossary*; *Digital Dropbox* where students can submit softcopies of their assignments and term reports, *Online tests and quizzes*, and external links to Web resources.

7. NEW E-LEARNING INITIATIVES AT NTU

In order to make online learning more interesting, interactive and engaging for students, certain new features are being introduced to 'humanize' the *edveNTUre*. The main objective is to add more human elements for effective "high tech – high touch" delivery of online contents (Lee, Tan & Goh, 2005). Some of the recent online learning initiatives introduced by the NTU are:

a. **Distance Education:** NTU is considering implementing distance education in certain academic programmes. Recently, a highly interactive and state-of-the-art distance learning facility, called the *Smart Classroom*, has been established. Currently, this facility has been successfully used for a distance learning programme with the Massachusetts Institute of Technology (MIT).

b. **PresseNTUr:** This tool enables lecturers to quickly and easily create their teaching contents either by using a talking head or their own face through using a digital camera. Through this technology, an instructor can synchronize his lecture with his PowerPoint slides or a video. Pace of the presentation can be changed by the students according to their learning speed. The recorded lecture can be delivered via PDAs as well as through Podcast.

c. **Breeze:** This Macromedia content creation tool allows converting PowerPoint slides into a low bandwidth format of the Macromedia Flash animation. It also allows voice narration to be synchronized with the PowerPoint slide delivery.

d. **Reusable Learning Objects:** The Centre for Educational Development in collaboration with the School of Communication and Information is in the process of implementing a taxonomy system aimed at building a better course management system. This system will enable staff to deposit learning objects in a repository organized to facilitate use and reuse for constructing lessons, presentations, and other documents. This system is expected to improve the use, reuse, and profuse of learning objects**.**

8. CONCLUSION

In recent years, advancements in online learning tools have encouraged many academic institutions to embrace this platform for dynamic content creation and delivery which is expected to make learning more interesting, effective, meaningful, and engaging. Although online learning has many notable advantages, it cannot entirely replace the need for a lecturer imparting knowledge in a face-to-face mode. Therefore, it is desirable that academic institutions, deploying online learning initiatives, should come up with a strategy that suits their local environment and teaching philosophy. Similarly, the success of the online learning initiatives would also depend on the technical competence, preparedness, and motivation of the academic staff and students. Lecturers need to learn creative and innovate ways of developing content which might need learning new skills, thus resulting in increased workload. Students also need to be more disciplined, organized, responsible and willing to share their ideas and opinions by using available collaboration tools. A major change in mindset is needed where both parties are ready and motivated to effectively play their roles. In this context, appropriate awareness strategies and training, both for the lecturers and students, can play a critical role in the success of the new initiatives. The use of a combination of approaches in teaching KM courses through active physical and virtual discussions emphasizing socialization and collaboration will enhance learning.

REFERENCES

Christudason, A. (1999). Fundamental teaching skills in an IT age. *CDTL Brief,* 6. Singapore: National University of Singapore, Centre for Development of Teaching and Learning.

Daugherty, M., and Funke, B. L. (1998). University faculty and student perceptions of web-based instruction. *Journal of Distance Education, 13*(1), 21-39. Available online at http://cade.icaap.org/vol13.1/daugherty.html

DeRienzo, E. (2000). *Teaching in a distance learning environment.* Boston: MIT, Centre for Advanced Education Services.

Dzakiria, H. (2005). The role of learning support in open and distance learning: Learners' experiences and perspectives. *Turkish Online Journal of Distance Education (TOJDE), April 2005, 6*(2). Available online at http://tojde.anadolu.edu.tr/index.htm

Galusha, J. M. (1997). Barriers to learning in distance education. *The Infrastruction Network.* Available online at http://www.infrastruction.com/barriers.htm.

Kumar, M. (2004). A critical discourse in multimedia design: A pedagogical perspective to creating engaging online courseware. *E-journal of Instructional Science and Technology, 7*(2). Available online at http://www.usq.edu.au/electpub/e-jist/docs/Vol7_no2/FullPapers/CriticalDisc_MM.htm

Lee, C.S. and Tan, T.H. (2004). Implementing and supporting campus wide e-learning services. Unpublished paper. Singapore: Centre of Information Technology Services, Nanyang Technological University.

Lee, C.S., Tan, T.H. and Goh, W.S. (2005). The next generation of e-learning: Strategies for media rich online teaching and engaged leaning. Unpublished paper. Singapore: Centre of Information Technology Services, Nanyang Technological University.

Majid, S and Yuen, T.Y. (2006). Information and Knowledge Sharing by Undergraduate Students in Singapore. 17th IRMA International Conference, 21-24 May 2006: Washington, D.C., USA

McInnerney, J. M., and Roberts, T. S. (2004). Online Learning: Social Interaction and the Creation of a Sense of Community. *Educational Technology & Society*, *7*(3), 73-81. Available online at http://ifets.massey.ac.nz/periodical/7_3/8.pdf

Pan, D. (1999). Helping students learn in the IT age. *CDTL Brief,* 2(2): 1-2. Singapore: National University of Singapore, Centre for Development of Teaching and Learning.

Rafaelie, S. and Ravid, G. (2003). Information sharing as enabler for the virtual team: An experimental approach to assessing the role of electronic mail in disintermediation. *Information Systems Journal*, *13*(2), 191-206.

Stansfield, M., McLellan, E. and Connolly, T. (2004). Enhancing student performance in online learning and traditional face-to-face class delivery. *Journal of Information Technology Education, 3*(2004), 173-188. Available online at http://jite.org/documents/Vol3/v3p173-188-037.pdf

Thomas, J. C., Kellogg, W. A. and Erickson, T. (2001). The knowledge management puzzle: Human and social factors in knowledge management. *International Business Machines (IBM) Systems Journal, 40*(4), 863-884. Available online at http://www.research.ibm.com/journal/sj/404/thomas.pdf

Project Scheduling Under Uncertainty

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ABSTRACT
Scheduling is a very important part of the planning phase of project management. But the fact that it is a planning phase process makes it susceptible to uncertainty. This paper discusses uncertainty at different phases in project scheduling and then provides a method for handling uncertainty at the planning phase. We consider the project-scheduling problem with multiple resource constraints, discuss the uncertainty involved in the activity duration and its effect on the schedule. We propose a priority rule for a new schedule generation scheme, which takes care of the criticality of the activities and the randomness involved in the current and future activities. The method is demonstrated on a problem taken from the literature.

Keywords: Project Scheduling, Uncertainty, Robustness, Resource, Heuristic

1. INTRODUCTION

Scheduling is a decision-making process, which plays a crucial role in manufacturing as well as service industry. Scheduling mainly concerns the allocation of limited resources to jobs over time. This decision problem exists in lots of manufacturing and production systems as well as most of the information-processing units. According to the *Project Management Institute (PMI)* scheduling software is a "run-the-business workhorse" in many companies and it may improve success rates for them by up to 20% (Essex, 2005).

Several methods have been proposed for solving scheduling problems. These methods take the values of some parameters (such as resource and time required to complete each activity, available resources etc.) of the problem as the input and generate a schedule for the problem. In most of the cases, the parameters of the projects are estimated based on the domain knowledge and past experience of the manager. So there is some amount of uncertainty embedded in these estimates. The uncertainty can be at two levels:

1. At the planning level when the manager may not be very sure about the estimates of the parameter itself and
2. At the implementation level, when the manager gives a deterministic estimate of the parameter, but they change while executing the schedule.

In the first case the nature of the manager defines the type of input to the problem to a large extent. For example when the manager is risk averse, she would not be willing to give a deterministic estimates for the parameters. Therefore, she can either chose to give a vague estimate (for example a fuzzy number) or a random estimate or she may use some other measure, which represents uncertainty. In the second case the schedule, which was developed using the estimated values, becomes inefficient which leads to rescheduling the project several times. So a schedule, which is robust enough to take care of these changes to some extent, should be a preferred schedule. This paper is focused around the first aspect of uncertainty discussed above and discusses it for project scheduling problem.

The *Resource Constrained Project Scheduling Problem (RCPSP)* has been extensively studied in the literature. There can be different objectives of a project-scheduling problem, but minimization of project completion time is one of the most important objectives of a project-scheduling problem (Schonberger, 1981; Willis, 1985; Ulusoy and Ozdamar 1995). If we solve the problem considering this objective, time required by each activity becomes a very important input that is estimated based on past data and the experience of the project manager. So, activity duration estimates are susceptible to uncertainty.

The project-scheduling problem under resource constraints has been studied to a large extent but the literature is the field of scheduling with uncertainty is scarce (Demeulemeester and Herroelen, 2002). The research in this field can be classified into three main sections: criticality indices of activities and paths, probability distributions related to activity times and scheduling of activities. The criticality index (CI) of an activity is defined as the probability that the activity will be on the longest path (Dobin and Elmaghraby, 1985; Bowman 1995; Cho and Yum, 1997; Elmaghraby *et al.*, 1999). A detailed discussion on this topic has been provided in the review paper (Elmaghraby, 2000). The second topic of discussion in this area is the probability distribution of the activity and project completion time. The basic assumption of PERT network is that the activity time follows a beta distribution (Malcom *et al.*, 1959). Ginzburg (1988) suggested a new measure for the mean and variance of the distribution for activity duration

The third area is scheduling of activities under uncertainty (Malcom *et al.*, 1959; Schmidt and Grossmann, 2000; Pontrandolfo 2000). But very few studies considered resource constraint. Ginzburg and Gonik (1997) have proposed a simulation-based heuristic to solve the problem. At every decision point, they run the simulation to find out the criticality of each activity and then use a heuristic to allocate resources to activities. Their main concern was that the decision taken at a point is not only dependent on the past decisions taken, but also are dependent on the future decisions. So, at each decision point they run the simulation to find out the probability of a particular activity lying on the critical path. This repetitive process makes the method cumbersome and time consuming.

In this paper, we propose a heuristic method to solve the project-scheduling problem with multiple resource constraints, which has random activity duration. This method takes care of the concern of Ginzburg and Gonik (1997) without getting into a time consuming and cumbersome job of repetitive simulation. The heuristic proposed in this paper is a non-recursive method and gives an efficient solution to the problem. We use three different distributions (uniform, normal and beta) to model the uncertainty in the activity duration. We use a problem from the literature (Ginzburg and Gonik, 1997) to demonstrate our method.

The rest of the paper is structured as follows. In the next section we introduce the notations used in this paper and then we explain the problem in section 3. We discuss the proposed heuristic in section 4 and use that to solve a problem taken from the literature in section 5. Finally, we discuss the results, future research directions and then we conclude.

2. NOTATIONS

- a_j Optimistic time required for activity j.
- b_j Pessimistic time required for activity j.
- σ_j The standard deviation of time for activity j.
- j Activity number of the project. $j = 0, 1, 2, 3, ..., N+1$, where 0 and N+1 are dummy start and dummy end nodes respectively
- t_j Duration of activity j, a random variable
- M_j Maximum remaining path length of activity j, a random variable.
- A_j Set of activities on the path of maximum length starting from j
- A_0 Set of activities on the critical path
- S_j Net standard deviation of the path associated to M_j. $S_j = \sqrt{\sum_{k \in A_j} s_k^2}$ for all activities on that path.
- r_{jk} Renewable resource of type k required to perform activity j. $k = 1, 2, 3, ..., K$.
- R_k Total available resource of type k.
- T Project completion time without resource constraint. This is the critical path length of the project based on the expected value of the time taken by each activity.
- S Standard deviation of the critical path. $S = \sqrt{\sum_{k \in A_0} s_k^2}$ for all activities on the critical path.

$\overline{R_k}$ Minimum resource of type k required to complete the project in time T assuming no other $(K-1)$ resource constraints.

T_k Time taken (based on the expected value of the activity time) to complete the project considering only the k^{th} resource constraint and no other $(K-1)$ resource constraints.

i Cycle number of a decision point. A decision point occurs either at the beginning of the project or when at least one of the running activities is completed.

R_{ik} Resource of type k available at cycle i.

C_i The set of activities which are ready to be scheduled in cycle i. This is the set of activities, which satisfies the precedence relationship.

C_{im} The subset m of the set C_i that can be formed taking as many activities as possible without violating any resource constraint. m = 1, 2, 3, ..., M. So, $C_i = \bigcup_{m=1}^{M} C_{im}$.

l_{im} Number of activities in the subset C_{im}.

Z_{im} The value of SPI (as explained in section 4) of subset m in cycle i

3. PROBLEM DESCRIPTION

The problem discussed in this paper is of scheduling the project under multiple resource constraints with ill-defined activity duration. Most of the time it is convenient to estimate the upper and lower bound of the activity duration. Based on these estimates, the problem is to find the expected completion time of the project. So the problem has the following properties:

- A set of activities
- Random activity duration, which is generated based on the lower and upper bounds
- Fixed resource requirement and availability. We consider only renewable resources.
- A fixed precedence relationship
- Preemption not allowed
- Objective of minimization of expected project completion time.

A mathematical formulation of the problem, as given in Ginzburg and Gonik (1997), formulates it as a stochastic optimization problem, which is a hard problem to solve. We propose a heuristic method to solve the problem.

4. THE PROPOSED HEURISTIC

Now we introduce the heuristic to solve the problem discussed above. This heuristic is based on a priority rule, which gives a priority list of set of activities at each decision point. A decision point occurs either at the beginning of the project, or when at least one of the running activities is completed, till the last activity is scheduled. At every decision point, a set of all activities (C_i) whose predecessors have been completed is formed. All possible subsets of this set are formed which satisfies the resource constraints. So, at every decision point, several subsets of activities compete for the same resource. We decide on the winning subset based on the priority rule. A deterministic version of the priority rule has been discussed (Bhaskar *et al.*, 2004), but the need of similar measure for probabilistic network is evident. We call this priority rule as Schedule Performance Index (SPI). The SPI is based on the following important points:

- The objective is to minimise the expected project completion time. So we need to take care of the most critical activities. So, we should schedule that subset of activities whose criticality factor is highest among all competing subsets.
- As discussed earlier, we agree with the concern of Ginzberg and Gonik (1997) that at every decision point we need to take care of the randomness of the duration of activities that has not yet been scheduled.
- The scarcity of the resources should be minimised. This can be done by scheduling, if possible, the subset of activities with maximum resource requirement at the earliest. By doing this we try to avoid any resource crunch in the future.

As discussed in the first two points above, we need to incorporate the criticality of the activities in SPI. The criticality factor in our work represents, for each subset of activities, its distance from the critical path taking care of the randomness in the activity duration. We use the concept of *Maximum Remaining Path Length* (MRPL) (Moder *et al.*, 1983) to take care of criticality. MRPL of a particular activity is defined as the length of the longest remaining path starting from that activity. This represents, at every decision point, how critical is a particular activity. If we add the net variance of the remaining path, it takes care of the randomness of the future activities. So, a factor that represents the proximity of subset of activities to the critical path, taking care of the randomness of future activities, can be given by:

$$\frac{M_j + nS_j}{T + nS}$$

Where n is a number representing the weightage given to the randomness of future activities. We discuss the effect of n on the final results in the later section. We divide the expression by $(T+nS)$ to make the parameter less than 1, as $(T+nS)$ is at least as much as the numerator and it remains constant throughout the project.

Now we consider the last point, i.e. regarding the utilization of the resources, discussed above. We schedule the subset that requires maximum amount of resources compared to other subsets. By doing this we minimise the probability of any resource crunch in future. This can be measured by the ratio of resource required to resource available. So we introduce the following factor in our priority rule:

$$\prod_{k=1}^{K} \left(\frac{\sum_{j \in C_{im}} r_{jk}}{R_k} \right)$$

It is now a known fact that the complexity of the project scheduling under multiple resource constraints is not a linear function of the types of resources we use. So, we take the product over the types of resources in the problem.

The factors defined above are the measure of the criticality and the resource management of the subsets respectively. These measures are calculated at all decision points. So, this gives the local perspective of the problem at the decision point. We now introduce some global measures of the problem which remains constant throughout the problem and which represents the overall perspective of the problem. We have calculated the weight of each resource type in the problem, which represent the criticality of that type of resource. This can be given by the probability of a resource crunch of that type of resource during the whole time span of the project. This can be measured by the ratio of the resource available and the resource required to complete the project in the minimum possible time. This ratio gives us the criticality of that project. So we use this ratio as the power to represent the weight of a particular type of resource. This can be represented as:

$$p_k = \frac{\overline{R_k}}{R_k}$$

Similarly, to measure the overall probability of time overrun as the weight of the time factor explained above can be given as follows:

$$q = \frac{\max_k(T_k)}{T}$$

The value of T and T_k in the above expression is based on the expected value of the time taken by each activity.

So, the final expression for SPI, which is used in finding the winning subset, can be obtained by combining all these factors and it is represented as:

$$Z_{im} = \prod_{k=1}^{K} \left(\frac{\sum_{j \in C_{im}} r_{jk}}{R_{ik}} \right)^{p_k} \cdot \frac{1}{l_{im}} \sum_{j \in C_{im}} \left(\frac{M_j + nS_j}{T + nS} \right)^{q}$$

$\overline{R_k}$ and T_k can be calculated using Burgess and Killewbrew Algorithm (Burgess and Killebrew, 1962) and Brook's Algorithm (Bedworth, 1973) respectively. It is evident from the expression of SPI that the whole expression becomes zero if the resource of one or more type required by the activities in a particular subset C_{im} at any decision point is zero. To take care of these situations, we introduce some remedies for this. For any subset of activities, C_{im}, at a decision point i, if one or more resource type (but not all) are not required, then we can postpone the activities as discussed above. So in this case where the value of

$$\left(\frac{\sum_{j \in c_{in}} r_{jk}}{R_k} \right)$$

goes to zero, we replace the value by a very small positive real number ∂ (say 0.001). Where as in the case where there is no requirement of any type of resource

Now we use the above priority rule (SPI) to develop the heuristic algorithm for scheduling the project with uncertain activity times. To find the final schedule, we follow the following steps:

- Find the critical path length and the standard deviation of the critical path based on the mean of the distribution considered for random activity time.
- Use the Burgess and Killewbrew Algorithm to calculate $\overline{R_k}$
- Use the Brook's Algorithm to find T_k.
- Calculate the values of p_k and q.
- At each decision point:
  - Generate the random variate based on the parameters of the assumed distribution. The distributions considered in this paper and its parameters have been discussed in section 5.
  - Find the activities whose predecessor activities have been completed and populate the set C_i
  - Make the subsets C_{im} from the elements of the set C_i, which satisfies the resource constraints.
  - Calculate Z_{im} for each of these subsets
  - Schedule the subset with maximum value of Z_{im}.

This algorithm takes care of the uncertainties of the activities, which have not been scheduled at a particular point in time. Using this algorithm we schedule the activities till all the activities are completed and find out the completion time.

5. EXPERIMENT AND RESULTS

In this section we test our heuristic algorithm using an example taken from Ginzburg and Gonik (1997). The project under consideration has 36 normal and two dummy (start and end nodes) activities. These activities require renewable resource of only one type. The number of resources available is 50. The details of time required to complete an activity, the precedence relationship and the resource requirements are given in Table 1. The time required to complete an activity is not well known, therefore the optimistic and pessimistic time estimates are provided in the data.

For this experiment, we use three different standard probability distributions to generate the project activity duration. The justification of a particular distribution for PERT type of network is outside the scope of this paper. The distributions used in this study are:

1. A beta distribution in the interval $[a_j, b_j]$;
2. A uniform distribution with the range $[a_j, b_j]$
3. A normal distribution with mean as $(a_j + b_j)/2$ and variance as $[(b_j - a_j)/6]^2$

We generate random variates based on the above distributions and use them as the activity durations. To take care of the randomness and to get the average characteristic of the solution, we run the algorithm for 1000 times for each distribution and take the average of those 1000 runs as the project completion time. The results for different n are given in Table 2. The average project completion time for each run is rounded off to the just higher integer in case of non-integer completion time. But the average completion time, which is stated below, is the exact average of those integer completion times.

Table 1. Initial data of the test project

Activity no. (j)	r_j	a_j	b_j	Successors
0	0	0	0	1, 2, 3, 4, 5
1	16	40	60	6, 7
2	15	35	70	10, 11
3	18	25	35	12
4	19	30	45	13
5	10	26	33	14
6	18	9	15	8, 9
7	24	38	50	27, 28
8	25	10	18	26
9	16	16	24	27, 28
10	19	30	38	17, 18
11	20	18	22	26
12	18	25	32	24, 25
13	15	31	45	17, 18
14	16	58	78	15, 16
15	17	35	45	20, 21, 22
16	19	25	35	23
17	21	35	60	19
18	24	30	50	20, 21, 22
19	13	35	42	35
20	16	20	30	33
21	12	14	21	34
22	14	15	20	35
23	16	30	42	33
24	15	28	40	30, 31
25	13	22	28	32
26	14	20	35	29
27	18	16	24	29
28	22	15	22	30, 31
29	10	13	18	36
30	18	27	38	36
31	16	35	55	37
32	17	20	30	34
33	19	25	27	37
34	20	17	38	36
35	15	38	55	37
36	24	12	22	37
37	0	0	0	-

The results stated above gives the expected completion time of the project and they reveal lots of interesting facts. The expected completion time in case of beta distribution is less than that of other distributions. So, the assumption of a beta distribution gives an optimistic estimate of the completion time compared to other distributions. As we increase the value of n, the completion time increases in most of the cases because the value of n represents the weightage we give to the randomness of the future activities. So, higher the weightage given to the randomness of the future activities, higher is the time of completion.

The result gives an indication that for higher value of n, the chance of completion of the project within the estimated time should be higher. We try to analyze this observation by doing one more experiment. For each distribution we calculate the project completion time by taking the $\mu_j + n\sigma_j$ as the deterministic activity duration of each activity and used the proposed method for scheduling. We calculate the number of instances of project (in case of random activity times) where project completion time lies within the time estimated by the deterministic

Table 2. Project completion time for different distributions

n	Uniform	Beta	Normal
0	422.22	410.25	421.53
1	436.86	412.62	438.21
2	433.69	424.82	437.56
3	453.11	418.56	448.58
4	468.73	432.56	462.86

case with $\mu_j + n\sigma_j$. This would give us an indication of chance of completion of project within the time estimated by taking $\mu_j + n\sigma_j$ as the activity duration. The preliminary results show that around 50% of the instances lie within the calculated time estimate in case of $n = 0$ for almost all the distributions (in case of beta distribution this value was 43%). As we increased the value of n, the chance of completion increases. For $n = 4$, the chance of completion of project was 97.1%, 97.5% and 95% for uniform, normal and beta distributions respectively. These are only indicative results, which show that there may be a relationship between the value of n and the probability of completion of project within some time. A theoretical study in this regard needs to be done and we consider it as an interesting area for future research.

6. CONCLUSIONS

In this paper we have discussed uncertainty involved in project scheduling under resource constraints. We have discussed uncertainty involved in the planning as well as the implementation phase of the problem and have proposed a method to take care of uncertainty in the planning phase. We have proposed a new efficient heuristic for project scheduling under multiple resource constraints and random activity duration. The heuristic is non-recursive and does not require simulation at each decision point. It also takes care of the concern of the researchers that the decision taken at any decision point should also be a function of the randomness associated with the future activities. The method is tested on a problem taken from the literature. The results also show that beta distribution, compared to the other two distributions, gives an optimistic measure of project completion time. In this work we have considered randomness only in activity duration.

This work can be extended in two directions. The result shows that the project completion time increases with increase in the value of n. It would be interesting to find out the exact value of the probability of completion of project as a function of n. Finding the most appropriate probability distribution or even a bound on the probability would be of interesting. The second extension can be considering uncertainty in the resource requirement and the resource availability as well. This study becomes more interesting as it is clear that the uncertainties in resource and activity duration are correlated.

REFERENCES

Bedworth D.D., Industrial Systems: Planning, Analysis and Control. The Ronald Press Co., New York, 1973.

Bhaskar T., Pal R. and Pal M.N., Resource Time Ratio Exponent Technique (RETIREXT):An Efficient Non-recursive Heuristic for Project Scheduling under Multiple Resource Constraints. Ninth International Workshop on Project Management and Scheduling (PMS 2004): 2004, pp. 92-95.

Bowman R.A., Efficient Estimation of Arc Criticalities in Stochastic Activity Networks. Management Science. 41(1), 1995, pp. 58-67.

Burgess R. and Killebrew J.B., Variation in Activity Level on a Cylindrical Arrow Diagram. Journal of Industrial Engineering. 13(2), 1962, pp. 76-83.

Cho J.G. and Yum B.J., An Uncertainty Importance Measure of Activity in PERT Networks. International Journal of Production Research. 35, 1997, pp.2737-2757.

Clark C.E., The PERT Model for the Distribution of an Activity. Operations Research. 10, 1962, pp.405-406.

Demeulemeester E.L. and Herroelen W.S., Project Scheduling: A Research Handbook (International Series in Operations Research and Management Science) 2002, First edition. Springer.

Dodin B.M. and Elmaghraby S.E., Approximating the criticality indices of the Activities in PERT Networks. Management Science. 31(2), 1985, pp.207-223.

Elmaghraby S.E., On Criticality and Sensitivity in Activity Networks. European Journal of Operational Research. 127, 2000, pp.220-238.

Elmaghraby S.E., Fathi Y. and Taner M.R., On Sensitivity of Project Variability to Activity Mean Duration. International Journal of Production Economics. 62, 1999, pp.219-232.

Essex D.E. Master the Clock. PM Networks: The Professional Magazine of the Project Management Institute. June, 2005.

Golenko-Ginzburg D., On the Distribution of Activity Time in PERT. Journal of Operations Research Society. 39(8), 1988, pp.767-771.

Golenko-Ginzburg D. and Gonik A., Stochastic Network Project Scheduling with Non-consumable Limited Resources. International Journal of Production Economics. 48(1), 1997, pp.29-37.

Moder J.J., Phillips C.R. and Davis E.W., Project Scheduling with PERT, CPM and Precedence Diagramming. 1983, Van Nostrand Reinhold Company.

Pontrandolfo P., (2000). Project Duration in Stochastic Networks by the PERT-path Technique. International Journal of Project Management. 18, 2000, pp.215-222.

Schonberger R.I., Why Projects are Always Late: A Rational Based on Simulation of a PERT/CPM Method. Interfaces. 11(5), 1981, pp.66-70.

Ulusoy G. and Ozdamar R., A Heuristic Scheduling Algorithm for Improving the Duration and Net Present Value of a Project. International Journal of Operations and Production Management. 15(1), 1995, pp.89-98.

Willis R.J., Critical Path Analysis and Resource Constrained Project Scheduling: Theory and Practice, European Journal of Operational Research, 21, 1985, pp.149-155.

Building Customers' Trust Through Mobile CRM-Related Activities: Mediating Effects of Customers' Commitment

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ABSTRACT

How can customers get trust from Internet-based companies? Among many activities to get trust, this study focuses on mobile CRM-related activities. Mobile CRM-related activities are efforts of companies to manage customer relationships using mobile technologies such as SMS (Short Message Service). This study analyzes if mobile CRM-related activities are effective to obtain customers' trust, considering moderate effect of commitment. Many CRM studies have focused on company's point of view. But, this study evaluates CRM-related activities from customers' side. The perceived evaluation of mobile CRM-related activities influences customers' commitment. The commitment explains customers' trust. Mobile CRM-related activities have three dimensions: content differentiation, contact frequency, and contents repetition. Also, commitment consists of three constructs such as affective commitment, continuance commitment, and normative commitment. In order to verify a research model, questionnaire surveys were conducted to collect data. The collected data were used to test hypotheses using structural equation modeling (SEM). The result shows that the customers' evaluation of mobile CRM-related activities contributes to build customers' trust through commitment (affective commitment, continuance commitment, and normative commitment).

Keywords: Trust, Mobile CRM, Commitment, Contact Frequency, Content Differentiation, Content repetition

INTRODUCTION

As Internet-based companies have more competition in the market, trust became a critical factor to survive in markets. Once customers trust the Internet-based company, they will visit the website more frequently and make more transactions. During the process of the transactions, the Internet-based company makes efforts to instill trust to customers' mind. For example, the Internet-based company sends s short message for the status of transactions with mobile technology, which is SMS (Short Message Service) using cellular phone. Once the customer gets the message, he/she may feel more comfortable for the transaction. This is one of methods to provide trust. However, some customers may have negative feelings of privacy intrusion when the Internet-based company contacts them using personal information, while others may feel comfortable, especially when the company provides coupon or promotion information. This kind of negative feelings could play as the barriers to build customer trust in the long term. When the company uses customer information, the company uses CRM (Customer Relationship Management). Thus, it may need to check if the mobile CRM-related activities can be helpful to build trust for the Internet-based company. If customers have negative feelings, the mobile CRM-related activities must be abandoned. Until today, many academicians and managers have stressed CRM-related activities to obtain competitive advantage and coped with changeable business environments. Since they think that using information from CRM can maintain the relationship between existing customers and companies (Kim, 2003), they have tried to expand CRM-related activities. But, it is necessary to evaluate whether or not CRM-related activities can really contribute to build customers' trust in Internet markets.

Most of previous literature has studied effects of CRM-related activities from company's viewpoint, not on customer's viewpoint (Kim, 2003; Hwang and Park, 2004). Even though Suh and Park (2005) studied evaluation and improvement of CRM-related activities from customers' side, they did not link CRM-related activities to customers' trust. Also, they did not consider mobile environments.

This study focuses on building customers' trust through mobile CRM-related activities from customers' viewpoint. The ultimate purpose of this study is to explain how to achieve customers' trust through Mobile CRM-related activities. Thus, this study tries to answer the following research question; "Is mobile CRM-related activities effective to build customers' trust with considering commitment?" Practically, the result of this study may suggest important guidelines to build successful mobile CRM strategies to obtain customers' trust for Internet-based companies.

Next sections review previous studies of CRM-related activities and commitment and develop hypothesizes. The following section explains data collection and analyzes the collected data. Finally, this study concludes with some comments and limitations.

LITERATURE REVIEW

Many scholars have defined trust in their own ways. According to Moorman et al. (1992), trust is "a willingness to rely on an exchange partner in whom one has confidence", while Morgan and Hunt (1994) explain that trust exists when one party has confidence in an exchange partner's reliability and integrity. Dwyer and Lagace (1986) state that trust is a belief, confidence, or expectation about an exchange partner's trustworthiness evaluated the partner's expertise, reliability, or intentionality. Also, they said that trust is a behavioral intention or behavior of "willingness" that reflects partner's reliance (Moorman et al., 1992; Moorman et al., 1993; Morgan and Hunt, 1994). Reviewing literature, trust is better to understand as confidence in the relationship.

Meanwhile, Gruen et al. (2000) analyzed trust building processes: calculative, prediction, capability, intentionality, and transference. *Calculative* refers that "trustor calculates the costs and/or rewards of target acting in an untrustworthy manner." *Prediction* means to develop confidence for behaviors to be predicted. *Capability* indicates to assess the target's ability to fulfill its promise. *Intentionality* is understood as evaluating the target's motivations. Finally, *transference* means that trustor draws on "proof sources," from which trust is transferred to the target. If this study applies mobile CRM-related activities to five processes to explain trust building processes, customers may calculate the costs/rewards, develop confidence, assess promise of the company, evaluate motivations, and transfer when they faced mobile CRM-related activities.

CRM (Customer Relationship Management) addresses all aspects of identifying customers, creating customer knowledge, building customer relationship, and

shaping their perceptions of the organization and products (Srivastava et al., 1999). Most existing literature focused on the effects of CRM system installment for customer performance (Kim, 2003), the relationship between CRM system and Marketing Performance (Hwang and Park, 2004), and the impact of customer partnership on CRM success (Lee et al., 2004). These studies were focused mostly on company's point of view, not on customers' point of view.

This study focuses on customer side's CRM evaluation under mobile environments. Thus, this study analyzes three mobile CRM evaluation criteria. The first criterion is *Contents Differentiation*, which means how different the contents are, compared with contents offered from other companies in the same industry. The second criterion is *Contact Frequency* defined as how frequent customers face CRM-related activities from the company. The last criterion is *Contents Repetition*. This indicates whether or not customers face repetitive contents from the company.

In order to build trust, commitment may play a mediating role between trust and mobile CRM-related activities. According to Dwyer et al. (1987), commitment is understood as a pledge of relational continuity between exchange partners. Moorman et al. (1992) explained commitment as a reflection of a positive valuation of a relationship. These definitions commonly mean an enduring desire to maintain a valued relationship. If people are committed to the product or the company, they feel that keeping relationship is valuable and do not frequently switch the product or the company. Finally, they may have trust for the company.

Some studies have taken a uni-dimensional approach to explain commitment (Dwyer et al, 1987; Morgan and Hunt, 1994). But, commitment is better to understand by multi-dimensional constructs such as affective commitment, continuance commitment, and normative commitment (Anderson and Gerbing, 1988; Gruen et al., 2000). The affective commitment is a positive emotional attachment, which means how favorable customer feels about product, service, or company. If customers psychologically feel drawn to the company, they maintain a relationship (Gruen et al., 2000). The continuance commitment is based on the sunk cost in a relationship. It indicates when customers give up the relationship they consider the cost and perceive lack of alternatives. Thereby, customers continue to have the relationship (Gruen et al., 2000). The normative commitment is a moral obligation derived from existing relationship. According to the normative commitment, customers keep the relationship because they feel a sense of belonging to the organization or the community. In brief, customers with affective commitment remain because they want to. Customers with continuance commitment remain because they need to. Customers with normative commitment remain because they feel they ought to do so (Anderson and Gerbing, 1988).

RESEARCH MODEL AND HYPOTHESES

The research model for this study is shown at the following figure 1. Three dimensions of mobile CRM-related activity evaluation positively influence to each dimension of commitment. And three commitment constructs affect customer trust. Three commitment constructs are affective commitment, continuance commitment, and normative commitment. Trust can be accounted for by mobile CRM-related activity evaluation through commitment. Thus, according to this research model, customer can build trust by mobile CRM-related activities through customer commitment. Customer can evaluate mobile CRM-related activities by content differentiation, contact frequency, and content repetition. These criteria can work with each dimension of commitment to build trust. Finally, customer has trust through each dimension of commitment.

Commitment is the key mediating variable in the field of relationship marketing. Since customers maintain relationship with companies, expect long-term benefits of staying with them, and have the faith that the companies will not act opportunistically, customers can consider potentially high-risk investments with awareness (Garbarino and Johnson, 1999; Morgan and Hunt, 1994). If company's mobile CRM-related activities offer customers a magnitude and numbers of benefits, customers will maintain the relationship (Becker, 1960). Thus, this study suggests three mobile CRM-related activity evaluation criteria (Contents Differentiation, Contact Frequency, and Contents Repetition) are positively related to commitment to build trust. The flowing hypotheses are suggested.

H1a: Contents Differentiation positively explains Affective Commitment.
H1b: Contents Differentiation positively explains Continuance Commitment.
H1c: Contents Differentiation positively explains Normative Commitment.
H2a: Contact Frequency positively explains Affective Commitment.
H2b: Contact Frequency positively explains Continuance Commitment.
H2c: Contact Frequency positively explains Normative Commitment.
H3a: Contents Repetition positively explains Affective Commitment.
H3b: Contents Repetition positively explains Continuance Commitment.
H3c: Contents Repetition positively explains Normative Commitment.

Once customers have commitment, they may continue to use the web site and make transactions with the Internet-based company. Since trust generally is regarded as a critical component for successful relationship (Dwyer et al., 1987; Moorman et al., 1993; Morgan and Hunt, 1994), positive relationship of each dimension of commitment is essential to build trust. The following hypotheses are proposed regarding the relationship between commitment and trust.

H4a: Affective Commitment positively explains Customer Trust.
H4b: Continuance Commitment positively explains Customer Trust.
H4c: Normative Commitment positively explains Customer Trust.

RESEARCH METHODOLOGY AND RESULTS

This study collected the data through questionnaire survey. Before the formal survey, two rounds of pre-tests were conducted to confirm face validity and

Figure 1. Research model

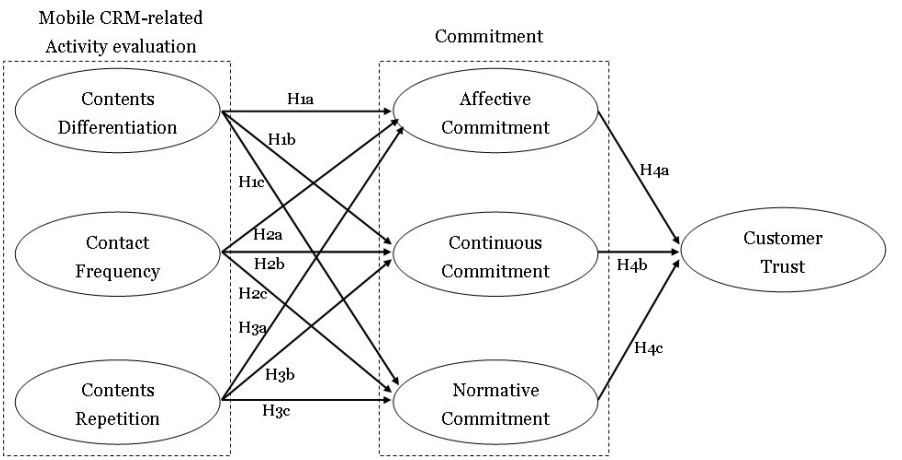


Table 1. Measures for each variable

Dimensions		Items
Mobile CRM-related Activity Evaluation (Suh and Park, 2005)	Contents Differentiation	• Valuable information • Useful information • Rare information • Special information • Use or not
	Contact Frequency	• Frequency satisfaction • Frequency suitableness • Future frequency
	Contents Repetition	• Known information • Information repetition • Similar information
Commitment (Allen and Meyer, 1990)	Affective Commitment	• Discussing CRM with people • CRM is good to me • Easy contact • Continuous relationship
	Continuance Commitment	• Happen inconvenience quit the relationship • More cost quit the relationship • Long term • Consider another company
	Normative Commitment	• Repeatedly change the company • Moral problems Important customer • Suggest better condition
Trust (Ribbink et al., 2004, Ball, 2004)		• Private information • Keep a promise • Reliable information • Honesty company • Trustworthy company

Table 2. Results of EFA and Cronbach's Alpha

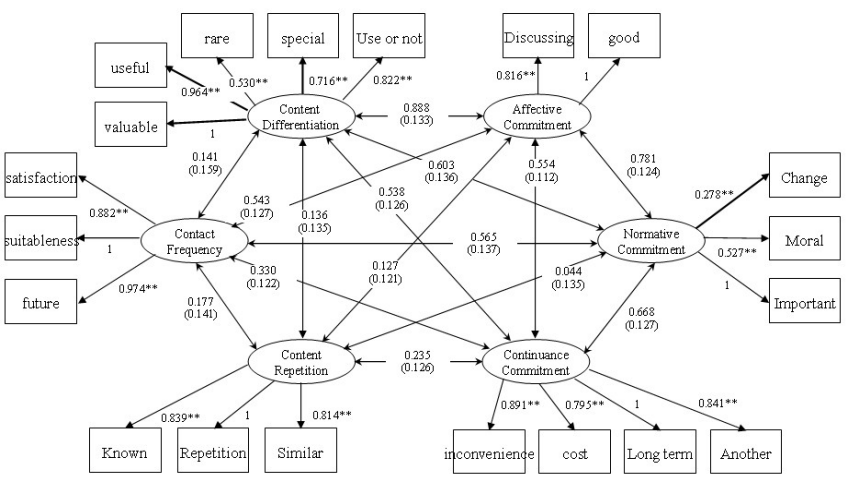
Dimensions	Items	Factor loading	Cronbach's Alpha
Contents Differentiation	• Valuable information	0.627	0.867
	• Useful information	0.688	
	• Rare information	0.753	
	• Special information	0.804	
	• Use or not	0.726	
Contact Frequency	• Frequency satisfaction	0.858	0.904
	• Frequency suitableness	0.886	
	• Future frequency	0.836	
Contents repetition	• Known information	0.832	0.790
	• Information repetition	0.862	
	• Similar information	0.793	
Affective Commitment	• Discussing CRM with people	0.767	0.740
	• CRM is good to me	0.555	
Continuance Commitment	• Happen inconvenience quit the relationship	0.739	0.740
	• More cost quit the relationship	0.730	
	• Long term	0.740	
	• Consider another company	0.651	
Normative Commitment	• Repeatedly change the company	0.812	0.568
	• Moral problems	0.648	
	• Important customer	0.575	
Trust	• Keep a promise	0.793	0.863
	• Reliable information	0.679	
	• Honesty company	0.796	
	• Trustworthy company	0.815	

content validity. First round involved sixteen undergraduate students who use cellular phones. Second round of pre-tests involved two doctoral students through face to face contacts. Based on their feedback, certain items in the questionnaire were re-worded and layout changes were made in order to improve clarity and readability. After two rounds of pre-tests, this study conducted survey.

Each item in the questionnaire was extracted from existing literature. The Table 1 summarizes items and sources. The seven point Likert type scales (1 is "extremely little" and 7 is "extremely much") are used to measure the impact of mobile CRM-related activity evaluation, commitment, and trust.

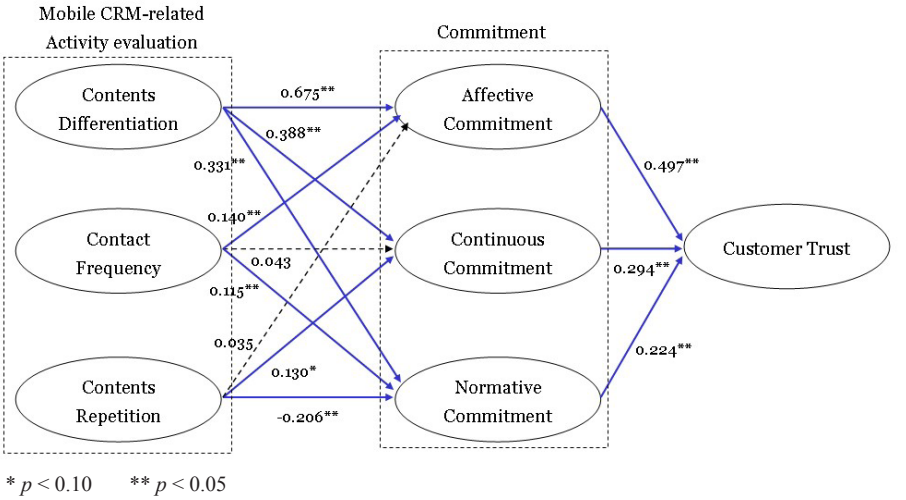
Population for this study is cellular phone users who have experience to have received any CRM-related service. Sample was selected from four major universities located in Seoul, Korea. The questionnaire double checked whether or not they have any experience to have received mobile CRM-related services, mainly SMS (Short Message Service), when they use cellular phones. The survey was conducted at the classroom setting. The 300 students were participated and 254 responses were usable.

Figure 2. Result of CFA



* $p < 0.10$ ** $p < 0.05$ ( ): S.E.

Figure 3. Standard estimation results for proposed model



Before testing hypotheses, this study conducted exploratory factor analysis (EFA) to cull out items that did not load on appropriate high-level constructs (Churchill Jr., 1979). EFA used principal component analysis and VARIMAX rotation method. After EFA, this study dropped four items because two items estimated under 0.4 factor loadings and other two items stretched over two constructs (Table 2). Cronbach's alpha values in Table 2 indicate that measures are reliable, even though Normative Commitment is relatively low. Thus, the result of EFA confirms that measures have construct validity after dropping four items.

In order to check convergent and discriminant validity, this study conducted confirmatory factor analyses (CFA) using Structural Equation Modeling (SEM) method (Figure 2). Convergent validity is the extent to which measures for a variable act as if they are measuring underlying theoretical constructs because they share variance (Schwab, 1980). Discriminant validity means the degree to which measures of two or more constructs are empirically distinct (Bagozzi et al., 1991). Most of model fit measures are acceptable (GFI=0.919, AGFI=0.883, NFI=0.904, RMSEA=0.048, CFI=0.962). For convergent validity, all factor loadings are significant, while for discriminant validity all the correlations pass the criteria that estimated correlation between any constructs±2S.E. should not include unity (Anderson and Gerbing, 1988). Thus, the result indicates that constructs are valid measurements.

The result of path analysis is at the figure 3. Most fit measure values are acceptable (GFI=0.911, AGFI=0.879, NFI=0.899, RMSEA=0.038, CFI=0.971). Thus, this study could check twelve hypotheses. The solid lines in the Figure 3 indicate significant coefficients, while dotted lines do insignificant coefficients. The data revealed that most hypotheses are significant except H2b and H3a.

The first hypothesis (H1) is regarding the relationship between contents differentiation and commitment. The results show that Contents Differentiation is positively related to three dimensions of commitment, respectively (H1a: 0.675, p=0.000; H1b: 0.388, p=0.007; H1c: 0.331, p=0.018). The second hypothesis (H2) involves the relationship between Contact Frequency and Commitment. H2a (the relationship between Contact Frequency and Affective Commitment) is supported at the 5% significance level, while H2c (the relationship between Contact Frequency and Normative Commitment) is supported at the 10 % significance level (H2a: 0.140, p=0.016; H2c: 0.115, p=0.056). But H2b (the relationship between Contact Frequency and Continuous Commitment) is not supported even at the 10% significance level (H2b: 0.043, p=0.463). The result of the third hypothesis (H3) testing shows that Contents Repetition affects Continuous Commitment positively (H3b: 0.130, p=0.040) and Normative Commitment negatively (H3c: -0.206, p=0.009). However, it is difficult to say that Contents Repetition can explain affective commitment (H3a: 0.035, p=0.559). At first, in the case of H3c, this study expected to have positive relationship between Contents Repetition and Normative Commitment. But, on the contrary, the result shows negative relationship even though the coefficient is statistically significant. At the next section, this study discusses this result in detail. The result of last hypothesis (H4) is confirmed positive relationship between Commitment and Trust. All of three hypotheses are supported at the 5% significance level (H4a: 0.497, P=0.000; H4b: 0.294, P=0.001; H4c: 0.224, P=0.040).

DISCUSSION

The purpose of this study is to analyze trust building processes as the effect of mobile CRM-related activities. In order to explain the processes, this study adopted the concept of commitment. Commitment plays a role of mediator between trust building processes and mobile CRM-related activities. Customers who have experienced mobile CRM-related activities from Internet-based companies become to have commitment with the companies and finally have trust for the companies.

Scrutinizing the results, this study raises several issues to be discussed. First, Contents Differentiation is the critical component for customers to have trust through commitment. As shown at the figure 3, Contents Differentiation positively influences three dimensions of commitment. Considering the coefficients, the values are much higher than other relationship with 0.675, 0.388, and 0.331, respectively. This indicates Contents Differentiation is the most important factor to make customers feel commitment to the company. Generally, customers prefer various and useful information. If Internet-based companies provide valuable information for customers, customers cannot help using the service from the Internet-based company.

Second, the hypothesis regarding Contact Frequency and Continuous Commitment (H2b) is not supported. It may imply that customers do not like too frequent contacts from Internet-based companies. Thus, the Internet-based company needs to realize the fact that if the company contacts customers so frequently the company may lose the customers because customers do not like too frequent contacts. However, frequent contact makes customers feel that the company is making efforts to have good relationship with them (H2a) and that customers feel belonging to the kind of community that the company made (H2c). Despite the result of H2a, customers do not like repeated contents (H3a), which may make customers lose affirmative feelings for the company.

Third, Contents Repetition and Normative Commitment (H3c) show statistically significant result, even though it shows negative relationship. This study initially expected to have positive relationship between two dimensions, but the results proved to be negative relationship. These results indicate the customers harbor ill feeling against excessive frequency and repetition. Subsequently, customers do not have feelings that they belong to the part of community for the company.

Finally, three dimensions of commitment affect positively customers' trust. In particular, Affective Commitment has larger effect on Trust compared with other commitment. Considering the result, the best way to build trust is making commitment through content differentiation. In other words, content differentiation as one of the mobile CRM-related activities can trigger to have commitment (affective, continuous, and normative), which influences to build trust. Therefore, Internet-based companies need to focus more on Contents Differentiation, along with Contact Frequency and Content Repetition.

CONCLUSION

This study highlights trust building processes through evaluating mobile CRM-related activities in the perspectives of customers. Despite the wide adaptation of cellular phone technology in the communication between the company and customers, the nature of information exchange in mobile technology is yet little known. In order to build trust, Internet-based companies have to make efforts for customers to have commitment to the company. When the company uses mobile CRM-related activities as a tool to provide commitment, the company needs to emphasize content differentiation, along with mobile contact frequency and contents repetition.

This study suggests two essential implications for managers. First, this study confirms contents differentiation is a very important factor for Internet-based company's mobile CRM-related activities rather than the other two factors. And customers have negative affection about frequency of mobile CRM-related activities. In addition, repetitive information makes customer distrustful to the company. Second, all of three commitments are positively related to trust. Most of all, affective commitment is the most powerful factor to build customer's trust.

REFERENCES

Allen, N. J. and Meyer, J. P. (1990) "The measurement and antecedents of affective, continuance and normative commitment to the organization", *Journal of Occupational Psychology*, pp. 63: 1-18.

Anderson, J. C. and Gerbing, D. W. (1988) "Structural Equation Modeling in Practice: A Review and Recommended Two-Step Approach", *Psychological Bulletin*, pp. 411-423.

Bagozzi, R. P., Yi, Y., and Phillips, L. W. (1991) "Assessing construct validity in organizational research", *Admin. Sci. Quart*, pp. 36(3): 421-458.

Ball, D., (2004) "The role of communication and trust in explaining customer loyalty", *European Journal of Marketing*, pp. 38:1272-1293.

Becker, H. S., (1960) "Notes on the Concept of Commitment", *American Journal of Sociology*, pp. 66: 32-42.

Churchill Jr., S. C., (1979) "A paradigm for developing better measured of marketing constructs", *Journal of Marketing Research*, pp. 16(1):64~73.

Dwyer, R. F. and Lagace, R. R., (1986) "On the Nature and Role of Buyer-Seller Trust. in AMA Educators' Proceedings", T. Shimp et al., eds. Chicago: *American Marketing Association*, pp. 40-5.

Dwyer, R. F., Schurr, P. H., and Oh, Sejo, (1987) "Developing Buyer-Seller Relationships", *Journal of Marketing*, pp. 51: 11-27.

Garbarino, E. and Johnson, M. S., (1999) "The Different Roles of Satisfaction, Trust, and Commitment in Customer Relationships", *Journal of Marketing*, pp. 73: 70-87.

Gruen, T. W., Summers, J. O., and Acito, F., (2000) "Relationship Marketing Activities, Commitment, and Membership Behaviors in Professional Associations", *Journal of Marketing*, pp. 64: 34-49.

Hwang, J. H. and Park, B. G. (2004) "A Study of the Relation between CRM System and Marketing Performance", *Journal of DAEHAN Association of Business Administration*, pp. 44: 1351-1365.

Kim, J. S. (2003) "A Study on the Effects of CRM System Installment in Customer Performance of Hotel Business", *Journal of KAMS*, pp. 11: 147-163.

Lee, H. S., Lee, Y. J., and Suh, Y. H. (2004) "The Impact of Customer Partnership on CRM Success and New CRM Success: The Role of Relational Systems and Trust", *Journal of KSQM*, pp. 32: 21-39.

Moorman, C. , Zaltman, G., and Deshpandé, R. (1992) "Relationships Between Providers and Users of Market Research: The Dynamics of Trust Within and Between Organizations", *Journal of Marketing Research*, pp. 29: 314-328.

Moorman, C., Deshpandé, R. and Zaltman, G.(1993) "Factors Affecting Trust in Market Research Relationships", *Journal of Marketing*, pp. 57: 81-101.

Morgan, R. M. and Hunt, S. D. (1994) "The Commitment-Trust Theory of Relationship Marketing", *Journal of Marketing*, pp. 58: 20-38.

Ribbink, Dina, Allard C.R. van Riel Veronica Lilhander, and Sandra Streukens. (2004) "Comfort your online customer: quality, trust and loyalty on the internet", *Managing Service Quality*, pp. 14(6) : 446-456.

Schwab, D. P. (1980) "Construct validity in organizational behavior", B. M. Staw and L. L. Cummings, eds. *Research in Organizational Behavior*, vol. 2. JAI Press, Greenwich, CT, 3-43.

Srivastava, R. K., Shervani, T. A., and Fahey, L. (1999) "Marketing, Business Processes, and Shareholder Value: An Organizationally Embedded View of Marketing Activities and the Discipline of Marketing", *Journal of Marketing*, pp. 63: 168-179.

Suh, C. J. and Park, H. K. (2005) "An Empirical Study of Evaluation and Improvement of CRM in View of Customer", *Journal of Management*, pp. 34: 423-444.

Constraint Relaxation on Topological Operators Which Produce a Null Value as Answer to a Query

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ABSTRACT

In the field of spatial information systems, and especially in particular of geographical databases, many authors have studied how to formulate queries using pictorial configurations. The constraints deriving from topological relationships between pairs of symbolic graphical objects (the classic shapes point, polyline, and polygon) can be relaxed when a query search condition finds no match in the database, so that users can receive approximate answers rather than null information. In this paper a computational model for the similarity of the spatial relations is proposed. An operator conceptual similarity (OCS) graph describes the model, and links the more similar relations, defining the weight of each relaxation. The polygon-polygon, polyline-polyline, and polygon-polyline cases are discussed and matrices, which enlarge the known 9-Intersection model matrix are also considered.

1. INTRODUCTION

Many researchers have recently focused their attention on different approaches to expressing geographical data queries. The evolution of visual query languages has led to the proposal of pictorial query representation. Furthermore, computer networks and distributed computing technology have transformed many computer-based applications from the traditional stand-alone mode to the networked mode.

Geographical databases have received considerable attention due to the emergence of new applications. These databases too, some research efforts have focused on the problem of human-computer interaction and the representation of visual queries for geographical data.

In the field of spatial databases, many authors have studied how to formulate queries using pictorial configurations. In a geographical database these enable the configuration of geographical objects to be described, thus expressing the user's "mental model" of the query [4, 13].

The user's mental model corresponds to the semantics of the query (in the user's mind). It may show some mismatching with the Visual Sentence for the query. Let us suppose the user wishes to express the query that has the following textual description:

"Find all the regions passed through by a river and partially overlapping a forest"

The user is not interested in the relationship between the river and the forest; however the absence, in natural language formulation, of any explicit relationship between them produces ambiguity. In fact, the user implicitly thinks that no relationship exists between any river and any forest, but the correct query expression without any ambiguity using natural language is:

"Find all the regions passed through by a river and partially overlapping a forest, irrespective of the topological relationships between the river and the forest".

To represent this query graphically some authors use the classic shapes "point, polyline, and polygon". In [4, 12] the authors propose a pictorial query language called GeoPQL (Geographical Pictorial Query Language) to express any queries, and call these shapes Symbolic Graphical Objects (SGO) [4, 12]. The topological relationships between pairs of SGO use operators based on the Object-Calculus proposed in [14, 15], where a set of topological, metric and logical operators are defined. When a query search condition finds no match in the database, it would be useful for the system to produce not only configurations with an exact correspondence with the drawing representing the pictorial query, but also similar configurations obtained by relaxing some of the constraints. The most common approach to relax constraints is to measure the distance from the drawn query using criteria defined for the specific domain. In the case of pictorial queries of a geographical database, the constraints can be classified as three main types: spatial, structural and semantic constraints.

In this paper we discuss spatial constraints [5, 6], in order to decide which constraints must be relaxed and which maintained. To do this, we define a computational model for the similarity of the spatial relations by which to transform the pictorial query.

The similarity between topological relations is described by the ***Operator Conceptual Similarity graph*** (OCS graph), which links the most similar operators (in the sense explained in the following section), defining the weight of each relaxation. The query answers are produced by assigning a total score computed by this computational model.

In recent years, various papers have discussed the problems with topological relations between pairs of objects in a 2-dimensional space. Two models for binary topological relations - the 4-Intersection model and the 9-Intersection model - have been proposed [1, 2, 3] and compared [7]. In the 9-intersection model, as described in [8], the interior (A°), boundary (∂A), and exterior (A^-) of a 2-dimensional point set embedded in IR^2 are defined as usual and will be referred to as the topological parts of an object. The definition of binary topological relationships between a polyline L and a polygon R is based on the nine intersections of L's interior, boundary, and exterior with the interior, boundary, and exterior of R. A 3 x 3 matrix M, called the 9-intersection, concisely represents these criteria.

$$M = \begin{pmatrix} L^o \cap R^o & L^o \cap \partial R & L^o \cap R^- \\ \partial L \cap R^o & \partial L \cap \partial R & \partial L \cap R^- \\ L^- \cap R^o & L^- \cap \partial R & L^- \cap R^- \end{pmatrix}$$

Starting from these studies, two other models of conceptual similarity among topological relations between a polyline and a region were developed [8]. A further study of spatial similarity and a computational method to evaluate the similarity of spatial scenes based on the ordering of spatial relations is discussed in [9]. More recently, two papers have studied the spatial neighbourhoods between objects [11, 12]. In [11] the authors studied topological relationships between two regions, comparing two strategies for minimizing topological constraints in a query expressed by a visual example, and giving search results in terms of number and similarity values. In [12] the authors present an idea on how qualitative spatial reasoning can be exploited in reasoning on action and change. They investigate how its conceptual neighbourhood structure can be applied to the situation calculus for qualitative reasoning on relative positional information.

The paper is structured as follows: in Section 2 the GeoPQL operators are briefly introduced and two query examples are also shown. Section 3 proposes a computational model to determine the most conceptually similar relationships for each configuration, and the three cases polygon-polygon, polyline-polygon and polyline-polyline are studied. Section 4 gives an example of transformation to an approximate query, and finally Section 5 concludes.

2. THE GEOPQL OPERATORS

The GeoPQL algebra consists of 12 operators: Geo-union (UNI), Geo-difference (DIF), Geo-disjunction (DSJ), Geo-touching (TCH), Geo-inclusion (INC), Geo-crossing (CRS), Geo-pass-through (PTH), Geo-overlapping (OVL), Geo-equality (EQL), Geo-distance (DIS), Geo-any (ANY), and Geo-alias (ALS). Geo-touching refers to a pair of touching graphical objects, Geo-crossing refers to the cross-over between two polylines, Geo-pass-through refers to a polyline which passes through a polygon, Geo-alias allows an SGO to be duplicated in order to express the OR operator, and Geo-any allows any relationship between a pair of SGO to be considered valid, i.e., no constraint exists between them. This last operator allows an unambiguous visual query to be obtained, as explained in [4].

3. THE COMPUTATIONAL MODEL

The answer to a query may sometimes be "zero elements". In this situation, it would be useful if the system automatically relaxed one or more topological constraints until a positive result is achieved. To do this, we need to define the *operator conceptual similarity* (**OCS**) *graph*. This is obtained from the configuration of two disjointed (DSJ) objects through three operations: object shifting, rotation, and size change (smaller, larger). If we consider two disjointed polygons as our initial configuration, as shown in Figure 1(a), their relative positions can be modified by shifting and/or rotating one of them. By shifting (or rotating and shifting) polygon B towards A, we obtain the second situation, in which they are touching (Figures 1(b) and 1(c)). Note that polygon B can touch polygon A in two different ways: at one point or along a line.

If we continue to shift polygon B we obtain the third situation, which presents in reality two sub-situations. The former (Figures 1(d) and 1(f)) produces only an overlap between the two objects, while the latter (Figure 1(e)) produces an overlap and a touch. Still shifting polygon B, we pass from Figure 1(e) (OVL + TCH) to Figure 1(f) (OVL), or to Figure 1(h) (INC + TCH).

From Figure 1(h) we pass to Figure 1(i) (INC), or, with a shift towards the outside), to Figure 1(f) (OVL).

The enlargement of SGO B as shown in Figure 1(j) causes it to coincide with SGO A (Figure 1(k)). But it is also possible to move from the condition "TCH + INC", shown in Figures 1(g) and 1(h), to the condition "EQL", shown in Figure 1(k). In contrast, by shifting SGO B as shown in Figure 1(h), we obtain the condition shown in Figure 1(i) (INC). Finally, from Figure 1(g) we can also obtain the condition shown in Figure 1(j) (INC).

We have six possible conceptual similarity graphs which refer to all the combinations between two features (point-point, point-polyline, etc.). However, the three cases in which one point is one of the two SGO are sub-cases of the others. We will therefore study only three cases: polyline-polyline, polygon-polygon and polygon-polyline.

Not all the operators defined in GeoPQL are considered in each case. For example, in the polyline-polyline graph, the operator Pass-through (PTH) does not need to be considered, as it is valid only in the case of polygon-polyline. In the polygon-polyline graph, the operator Cross (CRS) need not be considered as it is valid only in the polyline-polyline case. Similarly, Overlap (OVL) is valid only in the case of polygon-polygon. We now consider and discuss the three cases separately.

3.1 Case of Two Polygons

The graph shown in Figure 2(a) represents the *OCS graph* for the pair "polygon-polygon". It begins from the condition of two disjointed SGOs (row of the graph). Using one of the three operations described above to modify the configuration, we arrive, step by step, at the leaf of the graph, i.e. the operator EQL. The 4x4 matrix structure that enlarges the classic 9-intersection matrix [8] is shown in Figure 2(b). In the 9-intersection matrix the authors consider an object's internal, boundary and external points and their position with respect to the other object (without distinguishing if the boundary contact points consist of one or more points or lines and without considering the number of times that each condition is verified). In contrast, in the 4x4 matrix of Figure 2(b) we distinguish the kind of boundary between the two SGO (point and/or line), as well as the number of times which each condition can arise (expressed as a whole, positive number inside the crossover point in the matrix of the points considered for each SGO). Each side, representing in this case one polygon, has three rows, which refer to the points of each polygon: i (interior), b (boundary), and e (exterior). The boundary points are subdivided into p (point) and l (polyline). The values inside the matrix represent the number of times that a given configuration appears in the sketch representing the pictorial query. In Figure 2(b), for example, the symbol " – " represents an impossible case and n is a generic natural number.

Figure 1

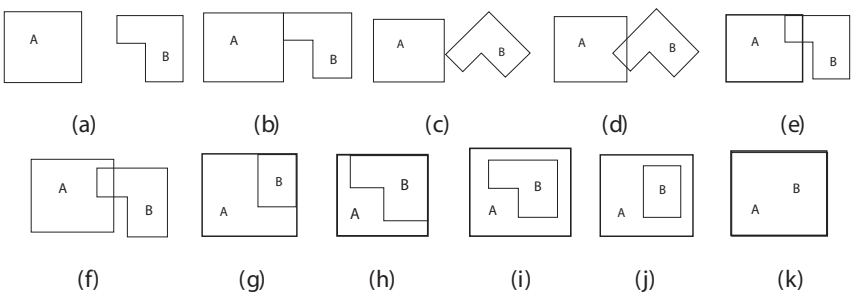
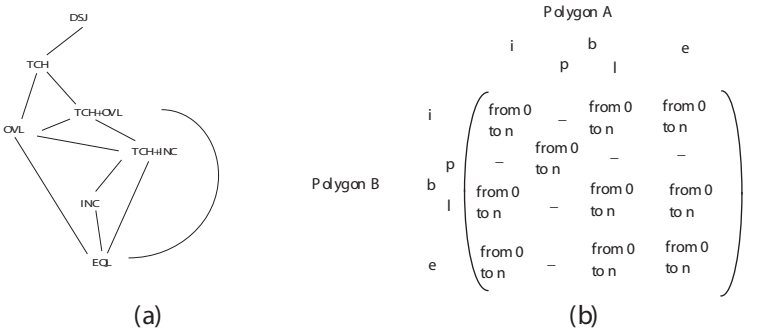


Figure 2



3.2 Case of Polygon-Polyline

The *OCS graph* of the operators valid for the polygon-polyline case is shown in Figure 3(a). The graph was obtained from the configuration of two disjointed (DSJ) objects. The three operations described above are applied to the polyline (or polygon) to obtain all other possible configurations (from touching to pass-through, etc.). The 4x4 matrix structure, which enlarges the classic 9-intersection matrix, is shown in figure 3(b).

3.3 Case of Two Polylines

The *OCS graph* of the operators valid for the polyline-polyline case is shown in Figure 4(a). Again, the graph was obtained from the disjointed polyline-polyline configuration (DSJ), by shifting, rotation, and extending/shortening.

The matrix structure for this case (a 5 x 5 matrix), which enlarges the classic 9-intersection matrix, is shown in Figure 4(b), while the part within the two lines is explained (in its different configurations) in Figure 4(c).

Here too, we can obtain the three different configurations TCH, EQL, and INC from two disjointed polylines, as shown in Figure 5(1(a)), 5(1(b)), and 5(1(c)).

Continuing this procedure, we can obtain four other configurations from the configuration of Figure 5(2(a)).

With a rotation of B_1 we obtain Figure 5(2(b)) (EQL, equal) if $B_1 = A$ in length, or Figure 5(2(c)) (INC) if B_1 is shorter than A; if the two lines touch (TCH) as in Figure 5(3(a)), shifting B results in the crossover (CRS) configuration of Figure 5(3(b)). Finally, if the starting configuration is that shown in Figure 5(3(c)), by lengthening B we obtain Figure 5(3(d)) (CRS + TCH).

In Figure 5(2(c)), lengthening B results in Figure 5(2(b)) (EQL), while, from Figure 5(3(b)) we obtain Figure 5(2(c)) (INC), if B is shorter than A, or Figure 5(2(b)) (EQL) if B = A.

From the configuration of Figure 5(2(d)) we can then obtain Figure 5(2(e)) (CRS), similar to Figure 5(2(b)).

If A = B in length, rotating B in Figure 5(2(b)) results in Figure 5(1(b)) (EQL).

The exterior points are subdivided into two: x and $\bar{x}$, which represent the two semi-planes obtained by extending one polyline from the two points of boundary. The terms X_1, X_2, Y_1 and Y_2 assume the numeric value 0 or 1 or 2 depending on the value of b / b (boundary of the Line A and boundary of the Line B), as shown in Figure 4(c).

If the boundary of line A is not in common with that of line B_2 they (two points) may be all in the semi-plane x of B, or all in the semi-plane $\bar{x}$ of B, or one in x and one in $\bar{x}$. So, in correspondence with "0" of b (A) cross b (B) we have 0 and 2, 2 and 0 or 1 and 1, in correspondence with B (e (x and $\bar{x}$)), as shown in Figure 4(c).

If the line A boundary has a point in common with a point of the line B boundary, the other boundary point is in either the semi-plane x of B or the semi-plane $\bar{x}$ of B. So, in correspondence with "1" of b (A) cross b (B) we have either 1 and 0 or 0 and 1, in correspondence with B (e (x and $\bar{x}$)), as shown in Figure 5(4). Finally, if both points of the line A boundary are in common with both points of the line B boundary then in correspondence with "2" of b (A) cross b (B) we have 0 and 0, in correspondence with B (e (x and $\bar{x}$)), as shown in Figure 5(5).

Figure 3

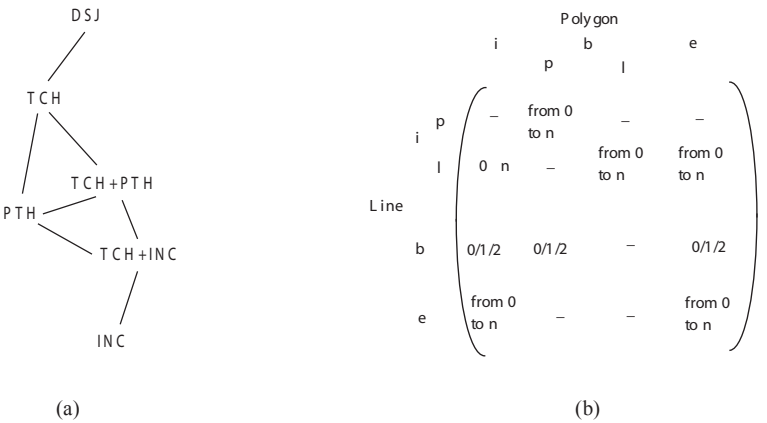


Figure 4

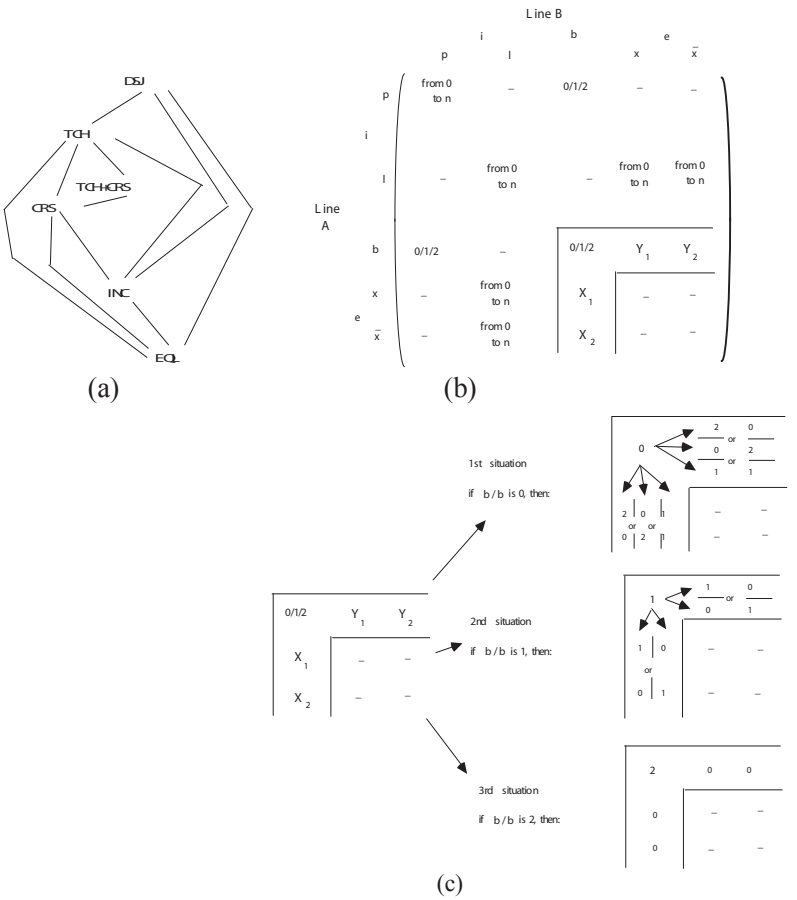


Figure 5

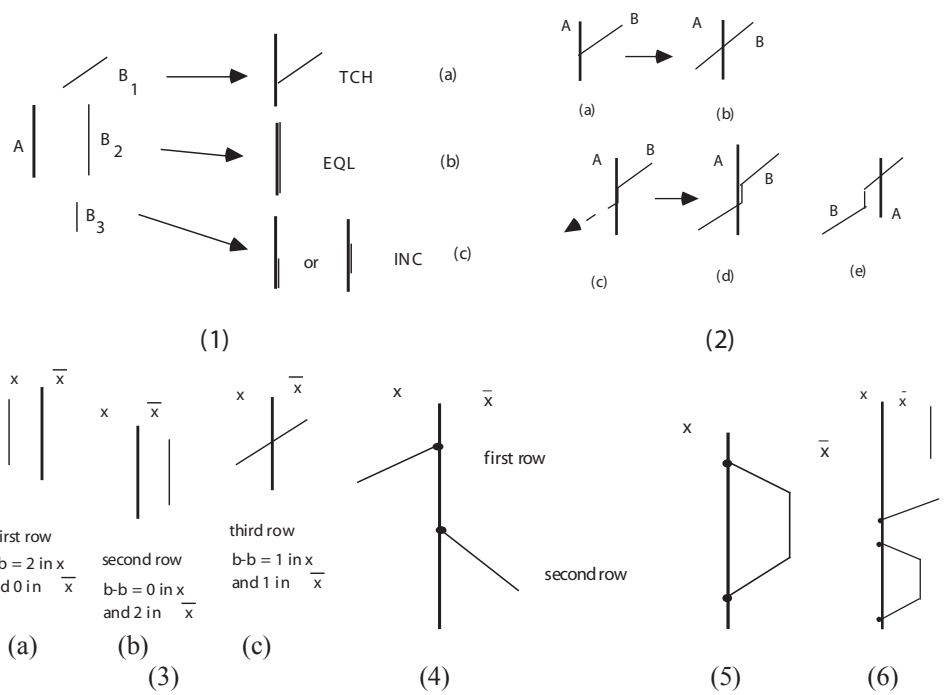
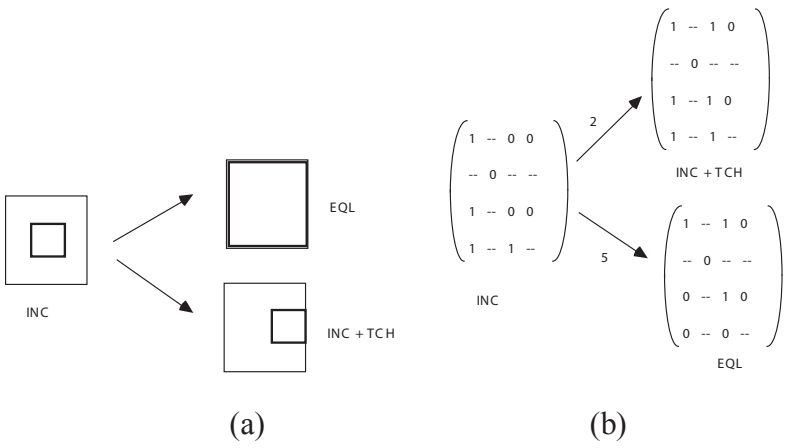


Figure 6



Obviously, the boundary points of one line can be 0, 1 or 2 internal points of the other, as shown in Figure 5(6).

4. APPROXIMATE QUERIES RELAXING OPERATORS

Suppose that the user formulates the query:

"Find all the lakes which are Inside a Province"

Using GeoPQL, the pictorial query drawn is shown in Figure 6(a). Suppose also that the query gives "zero elements" as the answer.

The system then asks if the user wishes to relax the topological constraint "INC" and, if "yes", it goes to the neighbourhoods relative to "two polygons", selects the operator INC and determines the nearest configurations: in this case, INC+TCH (by a shift) and EQL (by an extending), as shown in Figure 6(b). For each of these pairs the *degree of neighbourhoods*, obtained from the matrix of Figure, is evaluated. By "degree of neighbourhoods" we mean the number of changes in the new matrix compared with the original (from the INC to the INC+TCH matrix and from the INC to the EQL matrix).

In the first case, we have "2" (the third value of the first row, and the third value of the third row). We leave the reader to evaluate the second case.

The minor degree of neighbourhoods (also called *weight*) between the two relaxations allows the system to automatically select the relative operator(s) (in our case, INC+TCH) by which the original operator (in our case, INC) is relaxed. Following the original, unsuccessful query, the system therefore automatically processes the query "Find all the lakes which are **Inside Or Touch** a Province". The new result is still evaluated.

The procedure stops when a result is found.

5. DISCUSSION AND CONCLUSION

In this paper we proposed a complex matrix for each of the three configurations polygon-polygon, polygon–polyline, and polyline-polyline and a computational model for the similarity of their spatial relationships. This is described by an *operator conceptual similarity (OCS) graph*, linking the most similar relationships and defining the weight of each relaxation.

A large number of different configurations exist between a polyline and a polygon, two polylines and two polygons - more than the 19 binary topological relationships presented in [1, 2]. We have defined a correspondence between these configurations and said 19 topological relationships and have considered the number of contact points (whether touching or crossing) between the two objects, i.e. the cardinality (points number) of the intersection between the polyline interior and the polygon boundary. These considerations led us to consider a more complex matrix and the relative OCS *graph* for each pair of objects in order to design a computational model to determine more conceptually similar relationships for each configuration. We discussed the three different configurations and gave an example of query relaxation.

REFERENCES

1. M. J .Egenhofer, "Reasoning about binary topological relations" 2nd Symposium SSD'91, LNCS n. 525, pp. 143-160, August 1991
2. M. J. Egenhofer, J. Sharma "Topological relations between regions in R^2 and Z^{2*} " 3rd Intern. Symp. on Large Spatial Databases – SSD93, LNCS n. 692, pp. 316-336, 1993
3. M. J. Egenhofer, R. D. Franzosa "Point-set topological spatial relations" Intern. Journal of Geographical Information Systems, Vol. 5, N.2, pp. 161-174, 1991
4. F. Ferri, M. Rafanelli "GeoPQL: a Geographical Pictorial Query Language that resolves ambiguities in query interpretation" *Journal of Data Semantics*, Springer-Verlag Publ., LNCS n. 3534, pp. 50-80, 2005
5. M. A. Rodriguez, M. J. Egenhofer "Comparing Geospatial Entity Classes: an Asymmetric and Content-Dependent Similarity Measure" International Journal of Geographical Information Science 18(3), pp. 229-256, 2004
6. M. A. Rodriguez, M. J. Egenhofer "Determining Semantic Similarity among Entity Classes from Different Ontologies" IEEE Transactions on Knowledge and Data Engineering, Vol. 15, n.2, pp. 442-456, 2003
7. M. J. Egenhofer, J. Sharma, D. M. Mark "A critical comparison of the 4-intersection and 9-intersection models for spatial relations: formal analysis" Autocarto 11, R. McMaster & M. Armstrong Eds., October 1993
8. M. J. Egenhofer, D. M. Mark "Modeling conceptual neighborhoods of topological line-region relations" Intern. Journal of Geographical Information Systems, Vol. 9, N.5, pp. 555-565, 1995.
9. H. T. Bruns, M. J. Egenhofer "Similarity of spatial scenes" 7th Int. Symp. On Spatial Data Handling, pp. 173-184, Delft, The Netherlands, 1996
10. M. A. Rodriguez, M. J. Egenhofer, A. D. Blaser "Query pre-processing of topological constraints: comparing a composition-based with neighborhood-based approach" SSTD'03, pp. 362-379, 2003
11. F. Dylia, R. Moratz "Exploiting qualitative spatial neighborhoods in the situation calculus" Int. Conference on Spatial Cognition, LNCS n. 3343, pp. 304-322, 2005
12. F. Ferri, P. Grifoni, M. Rafanelli "XPQL: a pictorial language for querying geographic data" 15th Int. Conf. on Data Base and Expert System Applications - DEXA '04, Zaragoza, Spain, LNCS N. 3180, Springer-Verlag Publ., pp. 925-935, 2004
13. F. Ferri, P. Grifoni, M. Rafanelli "Querying by Sketch Geographical Databases and Ambiguities" 16th Int. Conf. on Data Base and Expert System Applications

- DEXA '05, Copenhagen, Denmark, LNCS N. 3588, Springer-Verlag Publ., pp. 925-935, 2005.
14. E. Clementini, P. Di Felice "An object calculus for geographic databases" ACM Symposium on Applied Computing pp. 302-308, Indianapolis, February 1993
15. E. Clementini, P. Di Felice, P. van Oosterom "A small set of formal topological relationships suitable for end-user interaction" SSD, pp. 277-295, 1993

Enterprise Architecture Evaluation: A Case Study on the Purposes of Enterprise Architecture for E-Business

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ABSTRACT

Enterprise Architecture (EA) is an ill-understood concept, especially in the context of e-business. The aim of this paper is to explore the elements that make up EA and to classify the kinds of purposes EA could serve for the realization of e-business. Using literature research, we derive three elements of EA frameworks. We applied the EA elements on a running case at a large multinational firm, which is currently migrating towards an e-business platform. In the case study, EA was only useable for descriptive purposes, making EA a valuable instrument for communication and analysis. EA was not useable for prescriptive purposes such as the design or redesign of information systems in relation to changing business processes. The main cause of this is the lack of comprehensive tooling support, something that will hamper using EA for developing and deploying e-business solutions in the future.

1. INTRODUCTION

Businesses are constantly facing the need to adapt to new international legislation, technological innovations, increasing competition and changing customer demands. Adaptability is a multidimensional concept [8], requiring comprehensive alignment between the strategy of a company, its business processes and the supporting information technology (IT). Achieving alignment between business processes and IT requires an integrated approach to all aspects of the enterprise [20]. Various consultancy and research institutes [10][21][24][28][34] suggest using the concept of enterprise architecture (EA) as an integrated approach towards business-IT alignment. Veasy [30] states that one of the key objectives for using architectural concepts is to achieve organizational flexibility and adaptability for complex organizations to manage the increasing rate of change. In addition, EA proponents advocate that the use of EA will leverage strategic adaptability, increased organizational performance and technology integration resulting in significant cost reduction and growth potential [1], [6], [12], [30].

Many EA frameworks e.g. Zachman, TOGAF, DODAF and GERAM were developed [4], [5]. Usually, such EA frameworks are offered with design approaches, modeling notations and principles aimed at guiding architects during the business-IT alignment process.

Although there are many whitepapers on EA presented by consultancy firms and governmental agencies, scientific contributions on EA and its practical value is scarce [2][7]. Moreover, it is unclear what constitutes an EA, as EA is an ill-defined [23] and still evolving concept [14]. In this paper, we derive the main elements of EA by analyzing existing EA frameworks in order to obtain better understanding of what constitutes EA. We endeavor to identify what purposes enterprise architecture should serve in the transition to e-business platforms.

This paper is structured as follows. In the following section, we present the state of the art in EA. Section three presents the research approach. In section four, elements which constitute EA are derived from literature. Next we identify the business needs for EA using a single case study. In section six we develop an EA reference framework. Then we evaluate the purposes of the devised framework in a case study environment. Finally, section eight presents the main conclusions and some directions for further research.

2. STATE OF THE ART IN ENTERPRISE ARCHITECTURE

With the original article published in 1987, Zachman [33] was the first to discuss architectural concepts in relation to IT. Zachman's article was his response to the needs of his IBM clients that had requirements for data standards and information sharing strategies across several systems, which called for an overarching architecture [4].

The idea of enterprise architecture is that it can be used to guide design decisions and limit the solution space by setting constraints [16]. Architecture aims at creating some kind of structure in a chaotic environment using systematic approaches [1]. In general, the architecture concept intends to establish standards for the employment of information technologies in ways that responded to strategic and business requirements, and that helps an enterprise to manage the ongoing transition from its current processes and systems to a desired future architecture [27].

Since Zachman's pioneering work [33], IT architects and managers used numerous proverbs in conjunction with the term 'architecture'. The term "enterprise" refers to the scope of the architecture, dealing with the organization as a whole or in case of EA, dealing with multiple departments and organizations rather than with a certain organizational part [7]. Other proverbs (e.g. business, process, application, service, network etc.) usually suggest a certain aspect or technical component that the architecture is meant to depict. Due to the use of the proverbs, it has become evermore complicated to clarify enterprise architecture. Moreover, Khoury & Simoff [18] underline that scarce attention has been paid to the theoretical basis of EA methods and frameworks until now.

3. RESEARCH APPROACH

In order to study the concept of EA in a business environment, we adapted the Information Systems Research Framework (ISRF) [9]. The ISRF suggests an interactive cycle of four main steps including: 1) literature review, 2) analysis of the business needs, 3) framework development, and 4) evaluation of the developed framework.

To analyse the business needs, we use the case study instrument. This approach allows us to investigate EA in a real-life setting [31]. As a case study, we used a multi-national company that is in a transformation process to become an e-business company in some of its operations. We conducted a single case study by analyzing multiple sources of information, including semi-structured interviews with two head architects (one responsible for business and the other for IT), archival analysis and participatory observation.

4. ELEMENTS IN ENTERPRISE ARCHITECTURE FRAMEWORKS

Generally EA frameworks embody a constellation of elements which architects consider relevant for modelling both business and IT systems. We found five common elements of EA in the reviewed literature (see table 1).

As first element, we found that most EA frameworks make use of layers [12], which are distinguished using various proverbs (e.g. business, process, organiza-

Table 1. Some elements of enterprise architecture found in literature

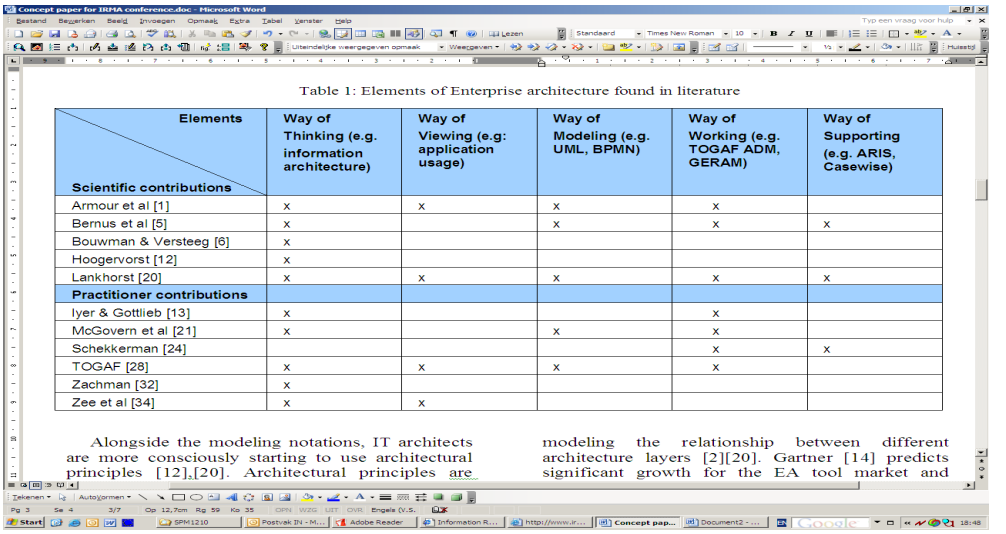


Table 1: Elements of Enterprise architecture found in literature

Elements / Scientific contributions	Way of Thinking (e.g. information architecture)	Way of Viewing (e.g: application usage)	Way of Modeling (e.g. UML, BPMN)	Way of Working (e.g. TOGAF ADM, GERAM)	Way of Supporting (e.g. ARIS, Casewise)
Armour et al [1]	x	x	x	x	
Bernus et al [5]	x		x	x	x
Bouwman & Versteeg [6]	x				
Hoogervorst [12]	x				
Lankhorst [20]	x	x	x	x	x
Practitioner contributions					
Iyer & Gottlieb [13]	x			x	
McGovern et al [21]	x		x	x	
Schekkerman [24]				x	x
TOGAF [28]	x	x	x	x	
Zachman [32]	x				
Zee et al [34]	x	x			

Alongside the modeling notations, IT architects are more consciously starting to use architectural principles [12],[20]. Architectural principles are

modeling the relationship between different architecture layers [2][20]. Gartner [14] predicts significant growth for the EA tool market and

tion, application, information and infrastructure). These proverbs represent the functionality within an enterprise system [21].

As second common element, we found that EA frameworks often suggest some predefined views. The notion of views is so basic that some researchers consider the Zachman Framework merely as a table consisting of 36 different views on an IT system [24]. In the IEEE1471 Standard for Architectural Descriptions [10], the derivation and definition of views is a crucial step for architectural design. EAs are disclosed by means of views; typically, stakeholders of an enterprise access and use the architecture through views presenting the information they need in a user-friendly format and supported by useful analysis techniques [20]. It is agreed upon that the use of views reduces the size and complexity of architecture layers [10][20][33].

The third common element in EA frameworks is the modeling notation. The modeling notation refers to a language allowing for description of the components and the relationships in the architectural layers. While the most frequently used notations for modeling EA are languages originating from the software engineering field such as the Unified Modeling Language (UML) and IDEF, some languages are emerging specifically for the description of business processes such as the Business Process Modeling Notation (BPMN) [5]. We emphasize that the EA modeling notations found in literature are not only different in their syntax and semantics; they also differ in the objectives they aim to achieve. Consequently, there is currently no single modeling notation suitable for modeling multiple distinguished architecture layers.

As a fourth element, we found architectural development approaches. Spewak [27] was amongst the first to discuss the EA planning process, considering the fact that the original Zachman framework does not propose an EA design approach. The design approaches constitute a way of working or a prescriptive process model, which specifies the activities, required for migrating from the current situation to a target situation. Hence, the design approaches provide a process-oriented view of information system development. Examples of EA development approaches are TOGAF-ADM [28] and GERAM [5].

Usually, the third and fourth element some architectural principles [12],[20]. Architectural principles are considered guidelines that describe the constraints imposed upon the organization, and/or the decisions taken in support of realizing the business strategies [15]. In this way, principles restrict the design freedom of designers and set the direction for the future.

Finally, tools are necessary to support EA frameworks. By nature, EA requires the interconnection and accumulation of large amounts of information from different sources [20]. Modeling the content and relationships of enterprise elements can only be successful if supported by adequate tooling [2][14]. Most of the EA tools currently on the market have started as CASE (Computer Aided Software Engineering) tools [5] and are not yet capable of modeling the relationship between different architecture layers [2][20]. Gartner [14] predicted significant growth for the EA tool market and predicts current tools will evolve into more comprehensive and customizable tools capable to model all layers of the enterprise.

In order to create some clarity, we classified the elements mentioned according to the terms used by Sol [25]. This framework has proven to be useful in similar research [15] on working with information systems. This framework compromises a way of thinking, controlling, working, viewing, modeling and supporting as six interrelated aspects to capture a problem area and has proved to be helpful in similar research [15].

We relate the way of thinking to the concept of layers in architectural development. The way of controlling refers to the overall management (e.g. financial, risk) of EA and is left out of table 1. The way of working refers to the steps taking to develop an EA. The way of modeling relates to modeling notations for EA. Finally, the way of supporting refers to repository tools for electronically documenting and relating the current processes, information flows and applications. We illustrate the elements after a brief discussion of the business needs.

5. THE BUSINESS NEEDS: A CASE STUDY

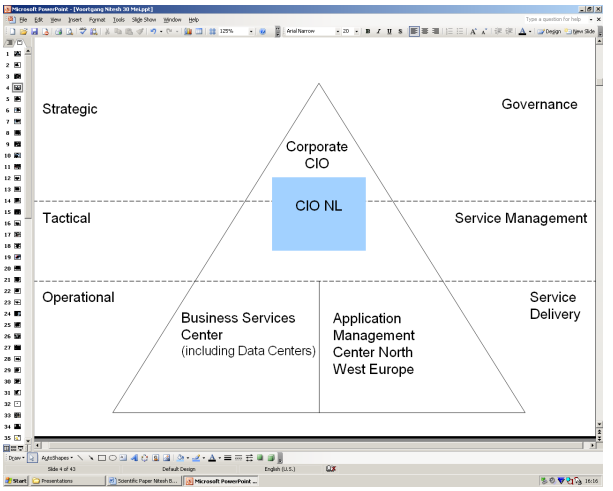
We conducted a case study at a major multinational company operating in over two hundred countries. The goals of the case study are to 1) understand the need for EA for e-business and 2) describe an environment in which an EA framework can be applied.

Within the multinational, the various country-oriented units are using their own customer relationship management (CRM) system. Consequently, there are more than hundred different systems throughout the entire firm. As these systems were developed separately, it is difficult to gather customer information on the global level. In order to attain synergy and reduce cost, the companies Corporate CIO (Corporate Information Office) plans to deploy a common SAPCRM landscape. The objective is to move from separate systems towards a shared CRM architecture, designed to support information exchange for cross-country sales.

We conducted the case study at the CIO in the Netherlands. In collaboration with the CIO's of nine other west European countries, the Dutch CIO is planning and anticipating the roll out of the global SAPCRM. In doing so, the Dutch CIO is devising a future CRM architecture for the Netherlands in collaboration with the Business Services department (BS) and the Application Management Center (AMC). The following figure depicts the relationships between the stakeholders involved.

In this figure, both Corporate CIO and the Dutch CIO (CIO NL) operate on a strategic level, respectively looking at the global environment and the local situ-

Figure 1. The layered governance structure



ation within a country. For each country, the migration from the existing CRM architecture to the CRM target architecture must be specified individually.

However, developing such a comprehensive architecture for the SAPCRM rollout requires a detailed description of the current sales processes, information flows, application services provided by AMC and infrastructure services provided by BS. As the role of some application, meant to support some specific process at any given department, may change in the future, the relations between the processes, information flows and applications needs to be described as well. Therefore, the main problem the Dutch CIO faces is the development of a comprehensive architecture describing the current and future relations between the processes, information flows and applications.

6. REFERENCE FRAMEWORK

In order to analyze the alignment of the CRM processes and the supporting IT, we developed a reference framework. The reference framework should enable both business and IT designs to focus specific layers and the establishment of the link to corresponding elements [10]. The term 'reference' also indicates that the framework is generic and can be used in similar companies.

The reference framework we propose contains three main parts: aspects, layers and five ways of Sol [25].

The top level of the cube shows some essential aspects of EA for the stakeholders. These aspects are adapted from a multi-client study by the Nolan Norton Institute [34], mainly because their study showed that the five aspects (governance, objectives, cost, capabilities and change-processes) are the primary IT concerns of 17 large companies.

The side level of the framework represents the five 'ways of information systems' suggested by Sol [25]. We believe that an explicit description of the ways of controlling, working, viewing, modeling and supporting are essential for architectural development.

Figure 2. The reference framework

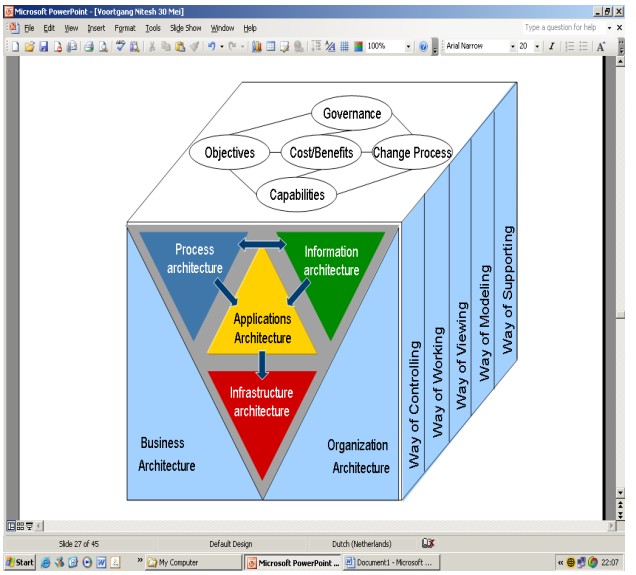


Table 2. Application of the framework elements

	Elements	Findings
Aspects	Governance	The governance structure is left implicit, some planning and control mechanisms are in place steering the e-business projects on a global level.
	Objectives	The objectives for the SAPCRM project are clearly documented and well communicated throughout all countries. The objectives were formulated using a top-down approach.
	Cost-benefits	The costs of the project are estimated on a global level, the benefits and risk (e.g. data migration and versioning) are not yet agreed upon.
	Change process	The change processes required for the migration from the current CRM platform to the future SAPCRM are not prescribed.
	Capability	The required capabilities for the project are not stated in the project documents.
Layers	Business Architecture	Stakeholder representatives are working on various business plans during the implementation of SAPCRM.
	Organization Architecture	The roles of the actors are explicit while the responsibilities of the actors and their relationships with the other layers are vague.
	Process Architecture	The CRM process architecture are well documented and communicated.
	Information Architecture	The information objects and their relationships are not modeled.
	Application Architecture	There is a static list of all the applications in the enterprise, however not in relation to the other layers.
	Infrastructure Architecture	The infrastructure services required for CRM applications are clear, however, not in relation to the other layers.
Ways	Way of controlling	There are some generic cost, quality and security mechanisms defined and used.
	Way of working	Architectural development is still intuitive and unstructured, except for the process layer.
	Way of viewing	Generally, the three-tier view (presentation, logic and data) is used for the categorization of (e-) business solutions. Other views are not standardized.
	Way of modeling	No common modeling language is defined or used in the firm, except for process modeling.
	Way of supporting	ARIS and maybe Casewise, however, there is no tool for modeling all layers in relationship to each other (there is no integrated tooling support).

Table 3. Possible purposes of EA

Timeline / Purposes	Ex-ante	Ex-post
Descriptive	Communication instrument	Analysis instrument
Prescriptive	Design instrument	Redesign Instrument

The cube front depicts the architecture layers as these four layers are already widely used for IT modeling throughout the firm.

In the following section, we illustrate the application of this framework and discuss the purposes of EA.

7. EVALUATION OF EA PURPOSES

Using a tabular structure, we present the application of the framework elements on the CRM case of the multinational. A comprehensive description of the case study can be found in [2]. The following table summarizes the main case study results.

Using the proposed framework as an analysis instrument, we found that the firm, more specifically the Dutch establishment, does not cover all of the elements for architectural development. Especially elements such as an enterprise wide way of working, modeling and supporting are still lacking. This means that for CRM processes there is no complete documentation of the information flows, supporting applications and infrastructure services. Moreover, there is no description of the relations between these layers, making it difficult to determine which processes and information flows will be affected by introducing SAPCRM. Therefore, we cannot say that the firm has an integrated approach for aligning business with IT.

However, application of the framework showed that the EA elements in the framework do have purposes when planning for the deployment of SAPCRM. We summarized the possible purposes in the following table.

First, we distinguish two types of elements: descriptive and prescriptive. An EA element is prescriptive when it limits the freedom of the architect and systems engineers, for example when specifying particular ways of working, viewing or modeling. When an element does not suggest any guidelines or specific approaches such as the aspects and layers, the element is descriptive.

A descriptive element allows for documentation and analysis of for instance the business processes in the company. On the other hand, a prescriptive element should help in setting a common way of designing, redesigning and supporting the architecture layers.

When an EA framework (set of elements) is used prior to the actual implementation of an e-business solution (e.g. SAP CRM), the major roles it could play are those of a communication instrument or a design instrument. On the other hand, when a framework is used to look at the functioning of a specific service or application, the framework functions as an analysis instrument or a redesign instrument.

In the case study, we found that not all of the elements of EA (proposed in our framework) are in place. The elements in place are the aspects and layers, which were management used mainly for communication and analysis, limiting the use of EA to descriptive purposes.

8. CONCLUSIONS

In the paper, we explored the ill-defined concept of Enterprise Architecture (EA) using literature research by identifying its main elements and purposes. We illustrated the elements and potential purposes for e-business using a case study. We reviewed a variety of academic and practitioner contributions to gain insight in what constitutes an EA. As a result, we found that EA is an organization specific constellation of three main elements: aspects, layers and ways for architectural development.

While the aspects (e.g. governance, capabilities) represent the more high-level managerial side to EA, the layers depict a vertical decomposition of processes, information flows, applications and infrastructure services.

Application of the developed EA framework on the case study allowed us to identify four possible instrumental purposes of EA frameworks. The purposes are communication, evaluation, design and redesign instrument. The case study showed that without a repository-based tool containing descriptions of the enterprise's processes, information objects and applications, EA is only useful as a communication and evaluation instrument. Considering the number of business processes and the underlying IT applications, a repository tool is essential in order for EA to be used as a design or redesign instrument.

Our findings are based on a single case, therefore we suggest further research on the purpose of EA for firms in the transition towards an e-business platform. We underline the need for more comprehensive repository based tooling support, supposedly with a modeling notation that is suitable to describe and relate both business (processes, structures and actors) and IT (information objects, applications and services).

9. REFERENCES

[1] Armour, F., Kaisler S. & Liu, S. (1999). A Big-Picture Look at Enterprise Architectures (I). *IT Pro.* Vol. 1 No. 4 , pp. 35-42.

[2] Bharosa, N. (2006). *Enterprise Architecture: Demystifying and developing an integrated business-IT alignment approach.* Unpublished master thesis report, Delft University of Technology.

[3] Benade, S. (2004). The application of systems engineering principles on organization al level. *IEEE Africon* 2004, pp. 879-884.

[4] Bernard, S. (2005). *An Introduction to Enterprise Architecture*, Authorhouse.

[5] Bernus, P., Nemes, L., and Schmidt, G. (eds) (2003*). Handbook on Enterprise Architecture*. Springer Verlag, Berlin.

[6] Bouwman, H. & Versteeg, G. (2004). Business Architecture: A New Paradigm to relate Business Strategy to ICT. *Journal of IT frontiers*, vol 8. pp. 91-102.

[7] Bouwman, H., Versteeg, G., Janssen, M., Wagenaar, R.W. (2005). *From Business to services architectures: concepts and a research agenda*. Report Delft University of Technology,

[8] Gortmaker, J., Janssen, M. & Wagenaar, R.W. (2006). Adaptivity in public service networks. *5th International Conference on E-Government*, DEXA EGOV 2006, Krakow, Poland), Trauner Verlag, pp. 225-232.

[9] Hevner, A., March, S., Park, J. and Ram, S. (2004). Design Science in Information Systems Research. *MIS Quarterly* 28(1): 75-105.

[10] Hillard, R. (2000). *IEEE-std-1471-2000: Recommended Practice for Architectural Description of Software-Intensive Systems*. http://standards.ieee.org/reading/ieee/std_public/description/se/1471-2000_desc.html

[11] Hjort-Madsen, K. (2006). Enterprise architecture implementation and management: a case study on interoperability. *Proceedings of HICSS-39,* Hawaii.

[12] Hoogervorst, J.A. (2004). Enterprise Architecture: enabling Integration, Agility and Change. In: *International Journal of Cooperative Information Systems,* Vol. 13, No. 3, September 2004, pp. 213-233.

[13] Iyer, B. & R. Gottlieb (2004). The four domain Architecture: An approach to support enterprise architectuire design. *IBM System Journal*, Vol 43, no.3, pp. 587-597.

[14] James, G.A & Handler, R.A (2006). Magic Quadrant for Enterprise Architecture Tools, 1Q06. *Gartner Research.*

[15] Janssen, M. & Cresswell, A. (2005). Enterprise Architecture Integration in E-government. enterprise architecture Proceeding of *HICSS-38,* Hawaii.

[16] Janssen, M. & Kuk, G. (2006). A Complex Adaptive System Perspective of Enterprise Architecture in Electronic Government. *Proceedings of HICSS-39,* Hawaii.

[17] Kaisler, S.H., Armour, F. & Valivullah, M. (2005). Enterprise Architecting: Critical problems. *Proceedings of HICSS 38,* Hawaii.

[18] Khoury, G. & S. Simoff (2004), Enterprise modeling using elastic metaphors, *Proceedings of the first Asian-pacific conference on Conceptual modeling,* Vol. 31, pp. 65-69.

[19] Krafzig, D., Banke, K. & Slama, D (2005) *Enterprise SOA, Service Oriented Architecture Best Practices*. New Jersey, Prentice Hall.

[20] Lankhorst, M. et al. (2005). *Enterprise Architecture at Work. Modeling, Communication and Analysis*. Telematica Institute. Springer.

[21] McGovern J. et al (2003). *A Practical Guide to Enterprise Architecture.* Prentice Hall PTR.

[22]Rohloff, M. (2005). Enterprise architecture: Framework and methodology for the design of architecture in the large. *European Conference on Information Systems, 2005.*

[23]Ross, J. (2003). Creating A strategic IT Compentency: Learning in stages. *MISQ Executive* (2:1). March. pp 31-43.

[24]Schekkerman J. (2004). *How to survive in the jungle of Enterprise Architecture Frameworks.* Second Edition. Trafford Publishing.

[25]Sol, H.G. (1990). Information Systems Development: A Problem Solving Approach. In*: Proceedings of the International Symposium on System Development Methodologies*. Atlanta.

[26]Sowa, J. & Zachman, J. (1992). Extending and formalizing the framework for information systems architecture. In IBM Systems Journal, Vol 31, No 3. pp. 590-616.

[27]Spewak, S.H. (1992). *Enterprise Architecture Planning*. New York. John Wiley & Sons.

[28]TOGAF (2003). The Open Group Architecture Framework. Version 8.1, Enterprise Edition, pp. 23-27.

[29]Turban, E., et al (2004). *Electronic commerce.* Prentice Hall.

[30]Veasey, P. (2001). Use of enterprise architecture in managing strategic change. *Business Process Management Journal.* Vol 7 (5) 420-436.

[31]Yin, R. (1989). *Case Study Research: Design and methods*. Sage publications, California.

[32]Zachman, J. A. (2001). You Can't 'Cost-Justify' Architecture, Data To Knowledge Newsletter, 29, 3.

[33]Zachman, J.A. (1987). A framework for information systems architecture. *IBM Systems Journal*, Vol. 26, No. 3, pp. 276-292.

[34]Zee et al (2000). *Architecture as management instrument (translated)*. Nolan Norton Institute, The Hague.

Potential Consumer Responses to RFID Product Item Tagging and Emergent Privacy Issues

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ABSTRACT

Using the theories of procedural justice/fairness, expected utility, and literature on consumer privacy, this study uses the survey method to measure consumer willingness to purchase radio frequency identification (RFID)-tagged product items within the Canadian context. Procedural justice/fairness is operationalized using the implementation of the Personal Information Protection and Electronic Documents Act (PIPEDA) enacted in Canada on January 1, 2004.

1. INTRODUCTION

This empirical study seeks to understand how consumers will react to radio frequency identification (RFID) tagging at the product item level before this becomes standard practice when major retailers like Walmart mandates its implementation. This study uses the concepts behind procedural justice/fairness, expected utility theory, and consumer privacy protection to anticipate the public consumer reaction to product item tagging at the retail store and answer the following questions:

1. What impact will the implementation of procedural fairness have on the willingness of consumers to purchase RFID-tagged product items?
2. How will consumers respond to RFID tagging initiatives at the product item level?
3. Will there be differences in consumer responses?
4. How can retailers use the findings to design and plan RFID product item initiatives at the retail store level?

2. CONSUMER PRIVACY AND EXPECTED UTILITY THEORY CONCEPTS

Privacy has been defined as "…the ability of the individual to *control* the terms under which personal information is acquired and used…." (Westin, 1967, p. 7). Information privacy, in turn, has been clarified as "…the claim of individuals, groups, or institutions to determine for themselves when, how, and to what extent information about them is communicated to others…." (Westin, 1967, p. 7). On the basis of social science literature, Goodwin (1991) defines consumer privacy based on two dimensions of control: (1) control of information disclosure which pertains to capture and storage of shopper information in databases, and (2) control of unwanted intrusions into the shoppers' environment which pertains to receiving unsolicited promotional or advertising material. Research on consumer privacy has also shown that there are different consumer segments representing varying levels of information privacy sensitivity. In an earlier body of work, Westin (1967) considered "privacy fundamentalists" as those consumers who were very concerned about the use of their personal information so much so that they would not participate in online data collection efforts despite privacy protection measures that web sites might offer. Cranor et al. (1999) also describe this group and found that its members are twice as likely as other consumers to report having been a victim of invasion of privacy acts on the Internet. The polar opposite of this group are those who are "privacy unconcerned" or those who easily share personal information as they do not care about personal privacy. The "middle-of-the-roaders" are the "privacy pragmatists" who selectively share personal information depending on the expected perceived benefits they hope to gain in the exchange.

3. EXPECTED UTILITY THEORY

The expected utility theory or utility maximization theory presents the idea that consumers conduct a quick cost-benefit analysis procedure in their minds within the limits of the information presented to them before deciding to trade off some of their personal information in the marketplace (Rust et al., 2002). If the net expectation is positive or beneficial to them, they will engage in the information exchange transaction.

4. PROCEDURAL FAIRNESS/JUSTICE

The concept of "procedural fairness or justice" refers to the notion that the individual perceives a particular activity in which they are participating as being conducted fairly (Lind and Tyler,1988). Providing the consumer or shopper with voice and control over outcomes appears to lead to their perceptions of procedural fairness (Lind and Tyler, 1988; Folger and Greenberg, 1985; Awad and Krishnan, 2006; Malhotra et al., 2004; Gunther and Spiekermann, 2005). Culnan and Armstrong (1999) point out that in the field of marketing, the principles behind "notice" and "consent," which are the hallmarks of the Fair Information Practices Act, operationalize procedural fairness. "Notice" means that when shoppers provide personal information to retailers or vendors, they have the right to know why the information is being collected, what will be done with the information, the measures taken to protect its confidentiality, the consequences of providing or withholding information, and mechanisms for addressing shopper complaints involving personal privacy should these arise (Culnan and Armstrong, 1999). "Consent" means that shoppers could control how the information they share will be used and be able to voice their dissent and stop the use of their personal information when the retailer collects the information for one purpose but uses it for another.

5. THE PERSONAL INFORMATION PROTECTION AND ELECTRONIC DOCUMENTS ACT (PIPEDA): THE CANADIAN CONTEXT

This study also makes reference to the Personal Information Protection and Electronic Documents Act (PIPEDA) passed in Canada last January 2004, as the legislation that seeks to protect consumer privacy in that country. Critical provisions in PIPEDA also embody the principles supporting the Fair Information Practices Act. Thus, compliance of retailers will PIPEDA will be a surrogate for the implementation of procedural fairness within a retailing shopping environment.

6. VARIABLES USED IN THE STUDY

This study focuses on whether or not there are significant differences between groups A (those who would purchase RFID-tagged items given the procedural item provision and B (those who would not purchase RFID-tagged items given the procedural item provision) across a number of variables.

6.1 Basis for Grouping Respondents (Groups A and B): Response to Procedural Fairness/Justice item

The following conditions, which also represent key directives of PIPEDA, were hypothesized in this questionnaire item to operationalize the concept of "procedural

fairness/justice": 1) the retailer/firm informs shoppers fully about the collection of customer purchasing and profile information via RFID tags and how the collected information would be used; 2) the retailer/firm posts notices in areas of the store notifying shoppers of the use of RFID tags with certain products; 3) the retailer/firm allows shoppers to 'opt-in' or agree to cooperate with their data collection effort or 'opt-out' or choose not to participate in the data collection effort involving RFID tags; 4) the retailer/firm uses 'deactivation kiosks' in the store so that shoppers can deactivate RFID tags attached to products they purchased; 5) the retailer/firm distributes brochures clearly explaining how RFID tags work in the store, how tag readers work with the tags, what information is stored in the tags, what information about you will be collected from the tags, and what will be done with the information downloaded from the tags; 6) the retailer/firm posts notices in the store indicating that it is in compliance with the Personal Information Protection and Electronic Documents Act passed by the Canadian government in January 2004; 7) shoppers could control the types of products and services advertised to them as well as when and for how long advertising messages would be displayed on the screen; 8) shoppers could indicate what information in their customer profile could be used for marketing; and 9) shoppers could review the information in their customer profile and correct any errors. Study participants were asked to respond with a "yes" or "no" to this item called the "decision" variable: "If the rules and safeguards I've just mentioned [i.e., pertaining to the conditions previously listed] were adopted by companies offering (RFID-tagged products), how interested would you be in purchasing RFID-tagged products from those companies?" For the purposes of the rest of this study's discussion, the respondents who decided they would purchase RFID-tagged product items given the procedural fairness/justice conditions are referred to as "group A"; those who decided they would not purchase these items, in any case, are referred to as belonging to "group B."

6.2 Other Variables Used

T-tests and chi-square tests were used to see if there are significant differences between groups A and B across the following other variables used in the study. The first variable refers to the following specific conditions that respondents require, reflecting measures that they would want the retail store management collecting RFID tag information at the product item level to put into effect before they decide to purchase the RFID-tagged item: a) the retail store would inform respondents of the collection of their purchasing information through RFID tags and how it would be used; b) the respondents could control the types of products and services eventually advertised to them as well as when and for how long advertising messages would be displayed on the screen; c) respondents could indicate what information in their profiles could be used for marketing and what could not; and d) respondents could review the information in their customer profiles and correct any errors. Respondents were asked to indicate the importance of these requirements using a seven-point Likert scale, with "1" anchoring on "Not important at all" and "7" anchoring on "Very important."

The second variable refers to the following nine different retail shop scenarios described to the survey respondents that are expected to affect their decision to buy or not buy RFID-tagged items. In these scenarios, the retail store: (1) captures shoppers' purchasing behavior using RFID tags prior to, during, and after a sales purchase; (2) captures shoppers' purchasing behavior via RFID tags and stores the information in a database, which they will later sell to another firm; (3) captures shoppers' purchasing activities via RFID tags, stores the information in a database, and later uses the information to send shoppers more targeted advertising; (4) captures shoppers' movements in the store via RFID tags as they pick up store product items and put these back on the shelves; (5) captures shopper information via RFID tags embedded in their clothing or other personal items like wallets or purses; (6) collects shopper information via RFID tags and later associates sales transaction information with shoppers' personally identifiable information stored in a database; (7) uses RFID tags which cannot be disabled or "killed" prior to shoppers' purchase of items or exiting the store; (8) uses an RFID system that can pickup information remotely from store products without shoppers' knowledge or consent as they carry tagged items around the store; and (9) collects shopper purchase information via RFID tags and later links this information with certain personal data items such as their name, phone number, credit card number, etc.

The third variable refers to the following specific measures that the retail management might implement in the store that may encourage respondents to purchase the RFID-tagged items: a) observance of PIPEDA by the retailer; b) allowing customers to "kill" or disable or remove the RFID tag after the purchase; c) allowing the opt-in/opt-out choice for the consumers regarding the information collected by the tag; d) allowing the customers to choose whether or not they will allow gathering of information by the RFID tag; e) manufacturers and retailers use clear, understandable labels indicating that a product is RFID-tagged; and f) manufacturers and retailers publicize using web sites, news releases, or other means, their policies concerning the use, maintenance, and protection of customer records that have information gathered by RFID tags. For each condition, respondents were asked whether or not they would be encouraged to purchase the tagged items.

The fourth variable refers to the relative intrusiveness of RFID when compared to the following other technologies used by consumers: cell phones, debit/credit cards, automated teller machines, shoppers' loyalty cards, camera phones, and access-control badges. Respondents were asked to indicate if the RFID tags violated individual privacy "more than," "less than," or as much as each of these technologies.

The fifth variable is the privacy variable the covers a number of personal situations that give some indication of the privacy threshold of the respondent. (The detailed descriptions of these personal situations are given in the "Findings" section.)

And finally, the sixth variable is the respondents' perception of the effect of RFID-tagging at the case/pallet and individual product item levels on the final selling price of the tagged item. Respondents were asked to indicate if they thought RFID tagging would raise product prices, lower product prices, or have no impact on product prices.

7. RESEARCH METHODOLOGY

Undergraduate and graduate students at the Faculty of Business Administration, University of New Brunswick Fredericton were surveyed within the period 2004-2005. A brief lecture on RFID, its uses in supply chain management, and the provisions of PIPEDA was given. Short video clips on how RFID tags are deployed at the case and pallet levels in both the manufacturing and retail environments and the use of RFID tags at the product item level within a retail shopping scenario were shown to the respondents. Data analysis techniques used in the study include standard descriptives procedures (i.e., frequencies), reliability tests, t-tests, and chi-square analysis.

8. STUDY FINDINGS

A total number of 380 respondents in the convenience sample agreed to participate in the study with the following demographics: (1) gender: 172 females (45.1 percent) and 208 males (54.6 percent); (2) age groups: 18-22 years old, 266 (69.8 percent); 23-59 years old, 110 (28.9 percent); under 18 years old, 4 (1.0 percent); (3) years in college: one year, 67 (17.6 percent); two years, 104 (27.3 percent); three years, 114 (29.9 percent); four years or more, 83 (21.8 percent); (4) educational attainment: less than a college degree, 340 (89.5 percent); college degree, 35 (9.2 percent); master's degree, 4 (1.0 percent), and doctoral degree, 1 (0.3 percent).

Differences between groups A (those who would purchase RFID-tagged items given the procedural item provision and B (those who would not purchase RFID-tagged items given the procedural item provision) across a number of variables was investigated. The t-test was used to test the differences between groups A and B in their evaluation of the importance of the different requirements they would like to see the retail store's management put in place before buying tagged items. Chi-square tests were used to test the differences between each of the remaining five categorical variables and the general willingness of the respondents to purchase the tagged item represented by the variable, "decision," which divides the sample into groups A and B as previously explained given retail store conditions where the procedural justice measures are observed.

The following are the study's findings. T-test results show that groups A and B did not differ in terms of their perceptions of the level of importance of each of the four requirements they would like the retail store's management to take into consideration (i.e., the first variable). In terms of the second variable, those respondents who expressed willingness to buy tagged items under nine specific store retailing scenarios were also more likely to purchase the tagged items under general conditions, given the procedural justice provision (Table 1).

Table 1. Differences between groups A and B on their willingness to buy RFID-tagged Items under Specific Retail Shopping Scenarios and their Decision to Buy RFID-tagged Items with the Procedural Justice Provision

Variable	N	Shopper Decision (with Procedural Justice Provision)			Chi-Square	p
		Will Purchase RFID-tagged item	Will not purchase RFID-tagged item	Missing Values		
Store scenario 1: Store captures customer purchasing behavior by RFID tags prior to, during and after a purchase					31.746	.000
Will buy RFID-tagged item given store condition 1	215					
Actual		194	21			
Expected		172.6	42.4			
Will not buy RFID-tagged item given store condition 1	164			0		
Actual		110	54			
Expected		131.6	32.4			
Missing Values	1	1	0	0		
TOTALS	380	305	75	0		
Store scenario 2: Store captures customer purchasing behavior info using tags, stores it in a Database, and later, sells it to other firms					29.465	.000
Will buy RFID-tagged item given store condition 2	132					
Actual		126	6			
Expected		105.9	26.1			
Will not buy RFID-tagged item given store condition 2	248					
Actual		179	69			
Expected		199.1	48.9			
Missing Values	0	0	0	0		
TOTALS	380	305	75	0		
Store scenario 3: Store captures data on customers' purchasing behavior captured in RFID tags, stored in the database, and later, used by the store to send customers targeted advertising on products that may be of interest to them					36.120	.000
Will pay more for RFID-tagged item to get this benefit	168					
Actual		158	10			
Expected		134.8	33.2			
Will not pay more for RFID-tagged item to get this benefit	212					
Actual		147	65			
Expected		170.2	41.8			
Missing Values	0	0	0	0		
TOTALS	380	305	75	0		

Table 1. continued

Variable	N	Shopper Decision (with Procedural Justice Provision)			Chi-Square	p
		Will Purchase RFID-tagged item	Will not purchase RFID-tagged item	Missing Values		
Store scenario 4: Store collect customer information from RFID tags on products that customers pick up and put back on the shelves prior to the purchase transaction					17.210	.000
Will buy RFID-tagged item given store condition 1	198					
Actual		175	23			
Expected		158.9	39.1			
Will not buy RFID-tagged item given store condition 1	182					
Actual		130	52			
Expected		146.1	35.9			
Missing Values	0	0	0	0		
TOTALS	380	305	75	0		
Store scenario 5: Store collects customer information from RFID tags attached to clothing items and other items carried in purses or bags					12.425	.000
Will buy RFID-tagged item given store condition 2	61					
Actual		59	2			
Expected		49.0	12.0			
Will not buy RFID-tagged item given store condition 2	319					
Actual		246	73			
Expected		256	63			
Missing Values	0	0	0	0		
TOTALS	380	305	75	0		
Store scenario 6: Store has RFID system that collects customers' purchasing data that is later associated with personally identifiable information in a database					17.634	.000
Will pay more for RFID-tagged item to get this benefit	104					
Actual		98	6			
Expected		83.6	20.5			
Will not pay more for RFID-tagged item to get this benefit	276					
Actual		207	69			
Expected		221.5	54.5			
Missing Values	0	0	0	0		
TOTALS	380	305	75	0		

Table 1. continued

Variable	N	Shopper Decision (with Procedural Justice Provision)			Chi-Square	p
		Will Purchase RFID-tagged item	Will not purchase RFID-tagged item	Missing Values		
Store scenario 7: Store uses RFID tags on products which cannot be disabled or "killed" prior to the customers' purchase of items or when they leave the store					8.018	.005
Will buy RFID-tagged item given store condition 1	68					
Actual		63	5			
Expected		54.6	13.4			
Will not buy RFID-tagged item given store condition 1	312					
Actual		242	70			
Expected		250.4	61.6			
Missing Values	0	0	0	0		
TOTALS	380	305	75	0		
Store scenario 8: Store uses an RFID system that can pick up information from store products without customer knowledge or consent as they carry these tagged items around the store					19.033	.000
Will buy RFID-tagged item given store condition 2	144					
Actual		132	12			
Expected		115.6	28.4			
Will not buy RFID-tagged item given store condition 2	236					
Actual		173	63			
Expected		189.4	46.6			
Missing Values	0	0	0	0		
TOTALS	380	305	75	0		
Store scenario 9: Store captures customer purchasing information through RFID tagged product items and later links this information with customer personal data such as name, phone number, credit card number, etc.					14.485	.001
Will pay more for RFID-tagged item to get this benefit	50					
Actual		50	0			
Expected		40.1	9.9			
Will not pay more for RFID-tagged item to get this benefit	329					
Actual		254	75			
Expected		264.1	64.9			
Missing Values	1	1	0	1		
TOTALS	380	305	75	1		

In terms of the third variable, respondents who admitted being encouraged to purchase tagged items if the retail management implements six specific measures in the store are also more likely to purchase the tagged items in, in general, given the procedural justice provision.

Regarding the fourth variable, there were no significant differences between groups A and B in their perceptions of the intrusiveness or privacy invasiveness of RFID technology compared to cell phones, debit/credit cards, automated teller machines, shoppers' loyalty cards, camera phones, and access control badges.

Concerning the fifth variable, which is the privacy variable covering a number of personal situations, selected items within the "privacy variable" construct significantly distinguished group A from group B: (1) refusal of the person to give out personal information to a firm; (2) use of an unlisted home phone number; (3) refusal of the person to be included in a mailing list put out by a firm which is later used for promoting products or services; (4) use of television to help the person purchase something from a home shopping club; (5) use of a toll free phone number to purchase a product or service. Study respondents who fit the following profile were also more likely to purchase tagged items given the procedural justice provision: (1) gave out personal information to a soliciting firm; (2) have a listed home phone number; (3) agreed to be part of a firm's mailing list for promotional purposes; (4) used the television to buy a product or service; and (5) used a toll free phone number to buy a product or service.

Finally, concerning the sixth variable, there were no significant differences between groups A and B in their perceptions of the effects of RFID-tagging at the case/pallet and individual product item levels on the final selling price of the tagged item in retail stores.

9. IMPLICATIONS OF FINDINGS

This study's findings support the concept that consumers do exercise their "privacy calculus" by anticipating costs and benefits before giving away personal information, and that the consumer population is segmented between those who are more privacy sensitive and those who are less so. One should, however, bear in mind that this study's findings cannot be extended to the wider population as they have been based on a convenience sample of fairly young and well-educated participants who are more open to the use of emerging technologies in the marketplace.

Retailers should initially address the consumer segment that will potentially be more responsive to product item tagging initiatives at the retail floor. Assuring the delivery of benefits to this segment and soliciting their "buy-in" in the use of RFID in the retail floor could pave the way towards chipping away at the resistance of the more privacy conscious group.

REFERENCES

Awad, N.F., & Krishnan, M.S. (2006, March) "The Personalization Privacy Paradox: An Empirical Evaluation of Information Transparency and the Willingness to be Profiled Online for Personalization", MIS Quarterly, Vol 30 No 1, pp. 13-28.

Cranor, L.F., Reagle, J. and Ackerman, M.S. (1999). "Beyond Concern: Understanding Net Users' Attitudes about Online Privacy," *AT&T Labs Research Technical Report TR 99.4.3*.

Culnan, M.J. and Armstrong, P.K. (1999, January-February) "Information Privacy Concerns, Procedural Fairness, and Impersonal Trust: An Empirical Investigation", Organization Science, Vol 10 No 2, pp. 104-116.

Folger, R. and J. Greenberg, J. (1985), "Procedural Justice: An Interpretative Analysis of Personnel Systems", in Rowland, K.M. and & Ferris, G.R. (Eds.), Research in Personnel and Human Resources Management, Vol. 3, JAI Press, Greenwich, Connecticut.

Goodwin, C. (1991, Spring) "Recognition of a Consumer Right", Journal of Public Policy & Marketing, Vol 10, pp. 149-166.

Gunther, O. and Spiekermann, S. (2005, September) "RFID and the Perception of Control: The Consumer's View", Communications of the ACM, Vol 48 No 9, pp. 73-76.

Lind, E.A. and T.R. Tyler, T.R. (1988), The Social Psychology of Procedural Justice, Plenum Press, New York.

Malhotra, N.K., Kim, S.S., and Agarwal, J. (2004, December) "Internet Users' Information Privacy Concerns (IUPC): The Construct, the Scale, and a Causal Model", Information Systems Research, Vol 15 No 4, pp. 336-355.

Rust, R.T., Kanna, P.T., and Peng, N. (2002) "The Customer Economics of Internet Privacy", Journal of the Academy of Marketing Science, Vol 30 No 4, pp. 455-464.

Westin, A.F. (1967), Privacy and Freedom, Athenaeum, New York.

A Concept Map of Information Systems Research Approaches

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ABSTRACT
This paper presents a simple concept map of the wide and diverse spectrum of information system (IS) research approaches, focusing on helping researchers in having an overview of what these approaches are, what they are grounded on and what methods are available for them. It considers research philosophy, methodology, and method. It should help researchers, especially those getting started in IS research, in getting acquainted with the approaches and in justifying their choices coherently.

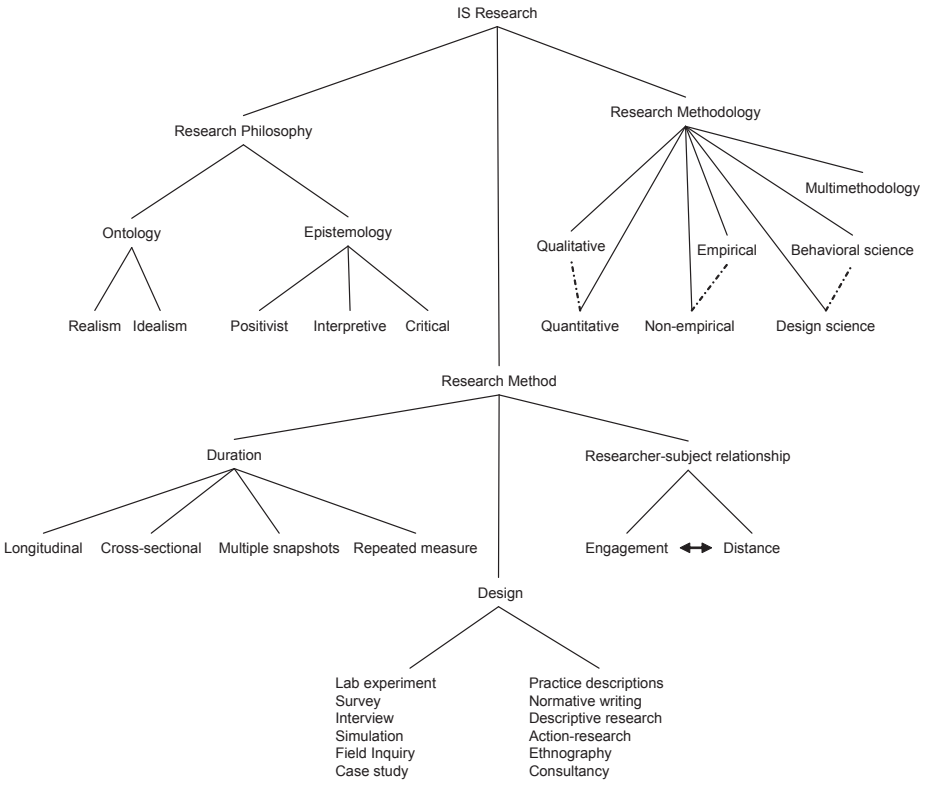
1. INTRODUCTION

Research in information systems (IS) has received much attention and many different interpretations probably because the field itself is broad and multidimensional, as noted by Mingers (2001). Most researchers see IS as a social science or a socio-technical field (Hirschheim, 1992) and many disciplines (including management, sociology, computer science, and psychology, among others) are cited as informing its research and practice (Land, 1992; Checkland & Holwell, 1998). Walsham (2005) even reminds us that information systems are social and organizationally-embedded systems that use information and communication technology (ICT) for what technology is supposed to be used: improving the lives of people. This socio-technical understanding of IS, has given rise to multiple approaches to IS research.

In this paper, we present a concept map of IS research for navigating through the different existing approaches, highlighting their differences, background and relationships. It must be noted that this paper is not about research in general, so it will omit many fundamental topics (such as variables, hypothesis, and induction versus deduction). Also, the authors' background is not in philosophy, so even though there is a lot of philosophical terminology, this paper is not about philosophy, it is about research in information systems. This paper is not about information systems development (ISD); even though similar classifications have been proposed for ISD, we will not be looking into development approaches or methods, only research. One final warning is that due to space limitations this paper takes a bird's eye view of the subject and should help as a guide, but detailed accounts of the approaches are outside the scope and as a consequence limits and definitions appear stricter than they really are.

On the next section we present the concept map itself and then go into each of its categories individually. Starting with the research philosophy in section three,

Figure 1. IS research concept map



followed by the research methodology in section four, further specified with the research methods in section five. Section six presents concluding remarks, concluding hints on how to select the research approach. The reference list in the end should also help in getting more detailed accounts and comparisons of the approaches.

2. INFORMATION SYSTEMS RESEARCH CONCEPT MAP

The following set of concepts related to IS research borrows ideas from different authors and does not provide absolute definitions, but rather a guide, especially aimed at budding researchers, of available approaches, how they differ from each other and what their philosophical grounds and available methods are. Because of its general view, it is quite possible that a concept may belong to more than one category and that some others may be left out. We will first look at the concept map in Figure 1 and then at its description on subsequent sections.

3. IS RESEARCH PHILOSOPHY

The research philosophy provides the ideological basis of a methodology. Typically, it is seen as composed of ontology and epistemology (Nandhakumar & Jones, 1997), but it may also embody ethics and axiology (Mingers, 2001), although we will not include these last two dimensions. Ontology refers to the nature of being (Nandhakumar & Jones, 1997), while epistemology refers to the theory of knowledge (how we acquire knowledge) (Hirschheim, 1992).

The dominating ontologies are realism and idealism, or more specifically:

- **External realism** – reality exists independently of individuals and their representations of it (Nandhakumar & Jones, 1997; Dobson, 2001; Hirschheim, 1992);
- **Internal realism** – reality is an intersubjective construction (Nandhakumar & Jones, 1997);
- **Critical realism** – sees science as a process of explanation and enlightenment, rather than a derivation of predictive laws, and states that structures can only be identified indirectly through their effects (Dobson, 2001); and
- **Idealism** – can be viewed in the sense of the early platonic World of Ideas, can be linked to German Idealism (Kant synthesizes concept and experience, Hegel sees consciousness as crucial for understanding and Fichte also sees consciousness as linked to the external world) (Hirschheim, 1992), or can be seen more generally as subjective idealism, in which reality is simply a construction of each individual (Nandhakumar & Jones, 1997).

We will dedicate the next subsections to epistemology. For IS research, some (Galliers, 1992; Wynn, 2001) have used a binary classification (empirical-interpretivist, quantitative-qualitative); others (Klein and Myers, 1999) offer a threefold classification of IS research (positivist, interpretive, critical), which we will use to distinguish epistemological foundations.

3.1. Positivist Approach

Positivism emphasises the role of science as the only method conducing to truth. It claims that the social world can be described by law-like generalizations stemming from collection of value-free facts (Nandhakumar & Jones, 1997; Chen & Hirschheim, 2004). It aims at verifiability or falsification of theories (*ibid.*). It believes in causality and usually takes on a quantitative-empirical methodological approach (*ibid*.; Hirschheim, 1992). Positivist research can be identified by the presence of: hypotheses, propositions, models, quantitative variables and statistic inference of "objective" data (Klein & Myers, 1999). Hirschheim (1992) describes positivism as based on five pillars: unity of the scientific method, search for causal relationships (through reductionism), empiricism, value-free science, and the logical and mathematical foundations of science. Positivism subscribes to an ontology based on realism, which sees the world as made up of immutable, observer-independent objects (*ibid*.; Chen & Hirschheim, 2004). The assumption is that the truth is out there and that it can be reached through the methods of science (Wynn, 2001). Extreme positivism in IS research sees technology as neutral, believes in rational management, ignores power relations and conflict, sees organizations as individual closed entities and focuses on the business environment (Mitev, 2000). This method may be appropriate for the natural sciences (although also under scrutiny in this domain), but not for the social ones (Checkland and Holwell, 1998; Hirschheim, 1992) and since we have established that IS are social in nature, then it seems clear why many researchers consider positivism inadequate for IS research. However, despite this criticism, it is still the dominant epistemology (Chen & Hirschheim, 2004).

3.2. Interpretive Approach

Interpretivism argues that both the researcher and the human actors in the phenomenon under study interpret the situation (Nandhakumar & Jones, 1997). Instead of generalization it aims at in-depth understanding (Chen & Hirschheim, 2004). Since researchers need to be engaged in the phenomenon, field studies are seen as most appropriate interpretive methods (*ibid*.). Interpretive research is identified with the presence of participant's perspectives as primary sources of information analyzed against cultural or contextual circumstances (*ibid*.; Klein & Myers, 1999). Many advocate interpretivism as the most appropriate for IS intervention (*ibid*., Checkland & Holwell, 1998). Interpretivism sees organisations as social (conversational) processes in which the world is interpreted in a particular way, which legitimates shared actions and establishes shared norms (*ibid*.). Interpretive approaches aim at understanding the IS context and the way in which actors draw on and interpret elements of context; furthermore, they question the utility of generalizations, emphasising on the insight obtained with descriptive efforts (Mitev, 2000). Interpretivism's main methods are action research and ethnography.

3.3. Critical Approach

According to the critical approach, there is no way to infer that a given law is true, no matter how many instances are analysed (Hirschheim, 1992). This approach denotes a critical process of inquiry seeking emancipatory social change through revealing hidden agendas, inequalities and manipulations (Klein & Myers, 1999; Cecez-Kecmanovic, 2001). It is characterized by reflexivity (self criticism) and the belief that no one has the monopoly of truth (*ibid*.). Self-conscious criticism exposes ideological and political agendas bringing the possibility of emancipation to the actors involved: only by subjecting the imperatives of the system to the needs of its members could an organization be emancipated (*ibid*.). This emancipation should be reached through public discourse which allows understanding purpose rather than simply achieving consensual action (Panagiotidis & Edwards, 2001). Seeking an "ideal-speech situation" (even if unreachable at its core) allows participants to go through a public process of discursive will-formation, rather than accepting an arbitrary political rule from established authorities (Ulrich, 1983). In practice, this means that participants are given the same chance to speak, that they are regarded as accountable (truthful) and that they are given the chance to question each other from a higher level of abstraction; meaning that they can raise criticism to the foundations of an argument, not only to the argument itself. This implies changing the search for objectivity, to a search for discursive validity. Critical research is still seen as lacking sufficient clarity and intertwining between theory and practice and thus not widely embraced (McGrath, 2005).

4. IS RESEARCH METHODOLOGY

Defining research methodology is not easy, especially when trying to distinguish it from method or approach. One understanding is to see it as a systematic approach involving guidelines, activities, techniques and tools (Wynekoop & Russo, 1997). But this notion is more readily associated to method than to methodology (Mingers, 2001). We take the view that a methodology is a more abstract concept relating either to the study of methods or to a more general and less prescriptive approach than a method (*ibid*.; Checkland, 2000). As a complete definition we adopt the following:

"Methodology is understood here in its philosophical sense as an overall strategy of conceptualizing and conducting an inquiry, and constructing scientific knowledge. Methodology, therefore, refers not only to research methods or techniques (such as case study or interview), but also to the epistemological assumptions of methods and how they are linked to a particular theory." (Cecez-Kecmanovic, 2001, p. 142)

On top of its philosophical underpinnings, a methodology can be qualitative or quantitative, empirical or non-empirical. There is another possible division between design science and behavioral science (Hevner & March, 2003) but we feel it is not general enough to be taken as the opposing poles for IS research

(technical versus social, in this case). In any case, both in practice and in theory it is quite possible to find a pluralist approach at combining methods in what is dubbed multimethodology.

4.1. Qualitative vs. Quantitative

Quantitative research has long dominated scientific inquiry through its pursuit of measurable, statistic, data-laden truths. Qualitative research has, however, emerged in IS with the recognition that it is a social field not subject to numeric measurement and that traditional approaches did not give an adequate understanding of its social nature. Qualitative research is motivated by Weberian assumptions that truths are approximate and by a shift in the use of IS to support social processes instead of just transactions (Wynn, 2001). Qualitative shouldn't be immediately associated with interpretivism or quantitative to positivism, since for example, surveys and questionnaires (quantitative in nature) can be used in interpretive research (Nandhakumar & Jones, 1997). Quantitative is the dominating tendency in IS, although qualitative research is on the rise (Chen & Hirschheim, 2004).

4.2. Empirical vs. Non-Empirical

Empirical research, based on observation or experience, is typically regarded as "scientific" because it is repeatable, refutable, objective and rigorous. Non-empirical (sometimes equated to interpretive) research has different interpretations of social phenomena, recognizes the influence of the scientists over the studied situation and highlights the difficulty in forecasting human activity (Galliers, 1992). Although some radical scientists claim that "if it can't be measured it's not real", we have seen how different approaches, from the social sciences, have increasingly been used in IS research (*ibid*.).

4.3. Multimethodology

Methodological pluralism is based on the idea that diversity (inherent in information systems) implies strength, since different methods provoke different responses, which means that complex situations benefit from different methods (Mingers, 2001). Although philosophical, cultural, psychological and practical barriers may hinder its use, Mingers (*ibid*.), a long-time advocate of pluralism, has argued it is feasible in all these issues. Pluralism has been used both as a way to transcend positivism (and its criticism) (Hirschheim, 1992) and as a way to combine behavioral and design science (Hevner & March, 2003).

5. IS RESEARCH METHOD

The research method is understood here as more specific than a methodology: it is the systematic approach to inquiry which implies skills, assumptions and practices as the bridge, so to speak, between the methodology and the actual design of the research. Thus, the method defines, informed by a methodology, the type of research in terms of duration, researcher-subject relationship and design (for lack of a better word): methodology leads to method in the form of the specific things the methodology user chooses to do in a particular situation (Checkland, 2000).

5.1. Method According to Duration

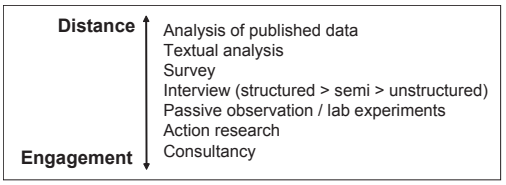
In terms of duration, a method can have different levels of time-related involvement. They can be categorized into (Chen & Hirschheim, 2004):

- Longitudinal (evolves over uninterrupted period of time and focuses on process),
- Cross-sectional (collects data through one snapshot at a particular point in time),
- Multiple snapshots (cross-sectional with more than one data collection), and
- Repeated measure design (various time periods to examine evolution of phenomenon).

5.2. Method According to Researcher-Subject Distance

The magnitude of the distance between the researcher and the subjects (or participants) can change within a single inquiry, but it helps to previously consider what that engagement might be and decide on how close we need to be to gain the most insight; a helpful range, according to distance is presented in Figure 2.

Figure 2. Distance end engagement in IS research, adapted from (Nandhakumar & Jones, 1997)



5.3. Method According to Design

Finally, the research method may be supported in different designs, although most imply a whole methodology when used. The reason they are considered method, rather than methodology is because we have already stated that methodology indicates philosophical strategy and assumptions. This means that, for instance, case study and action research can be conducted qualitatively or quantitatively, but only when making that clear does it become a full methodology. This argument is, however, debatable. The following are some of the most used methods:

- **Normative writing**: concept development not based on empiricism or theoretical grounding, but on speculation or opinion (Wynekoop & Russo, 1997).
- **Lab experiment**: studies within a designed, controlled environment, which typically include contrasting related variables (Chen & Hirschheim, 2004).
- **Field Inquiry**: generally speaking, field inquiry may involve case studies, action research or ethnography; particularly, a field experiment is an experiment which is designed in the spirit of a lab experiment but is carried out in the real world (*ibid*.).
- **Case study**: an empirical inquiry that investigates a contemporary phenomenon in real life, when boundary and context are not clearly evident or the prior knowledge of constructs and variables is inferior, differentiating it from field studies (Yin, 1994; Darke *et al*., 1998). The case study can take a positive or interpretive epistemological approach and is thought to be particularly appropriate for the study if information systems within organizations (*ibid*.).
- **Action-research**: Action research, in contrast with a case study (although it may be part of one), is concerned with actual planned change and production of theory in the process (Avison *et al*., 2001). It is assumed as a never-ending learning cycle in which informed practice improves a social system and feeds-back on theory. Baskerville and Wood-Harper (1998) point out some of action research's main characteristics: (1) multivariate social settings, (2) interpretive assumptions about observation, (3) intervention by the researcher, (4) participatory observation and (5) the study of change in the social setting.
- **Descriptive research**: Interpretive research studying literature or past research or events (Wynekoop & Russo, 1997).
- **Practice Descriptions**: descriptions of a practitioner with implicit bias and no *a priori* research intent (*ibid*.). These are of course hard to place within a rigorous scientific structure, but can still find a place within certain academic communication outlets.
- **Consultancy**: although mainly regarded as a source of income, consultancy may be strongly related to (or regarded as) research when conducted by university staff (Freestone & Wood, 2006) or indeed considered as a research method, at least for management science (Nandhakumar & Jones, 1997).
- **Simulation**: as a research method, simulation is used for prediction and explanation in numerous disciplines, helping researchers identify universal principles and processes of the real world, formalized into models, which can then offer new cognitions (Becker *et al*., 2005).
- **Ethnography**: coming from anthropology, ethnographic research requires that the researcher immerse him or herself for a longer period of time than a case study in an unfamiliar situation, seeking to place the phenomena in a social and cultural context and relying heavily on detailed first-hand observational evidence (Myers, 1999). Ethnography is increasingly being used in computer systems development as pointed out by Wynn (2001).

There are also some research instruments that usually make part of some of the above designs, but sometimes may be sufficient as methods themselves. Two common cases of such instruments are:

- **Survey**: gathering data through questionnaires (Chen & Hirschheim, 2004).
- **Interview**: an interview can be associated to other research designs (most notably case study) mainly as a data collection technique; as a qualitative method, it seeks to describe the multiple realities of the subjects (Stake, 1995).

6. CONCLUDING REMARKS

Since all approaches have advantages and disadvantages, a first conscious criterion for selecting them is the context, which limits both the choice of methods and they way they are used (Cecez-Kecmanovic, 2001); this context includes the researcher's assumptions (Olesen and Myers, 1999). According to Trauth (2001), when choosing a research method, five factors come into play: the research problem, the researcher's theoretical lens, the degree of uncertainty surrounding the phenomenon, the researcher's skills and academic politics (at an institutional, disciplinary and cultural level). Fitzpatrick *et al.* (1998) further suggest that personality traits and skills are equally important as the topic, objective and questions and the idea is to find the best fit between the situation and the way to obtain conclusions from it.

How exactly these factors determine the choice is outside the scope of this paper, but we believe that by having awareness of the possibilities and their background, the choice will be better informed. When in doubt, a researcher is probably better off following institutional tradition, supervisor preference or past experience. Also, it should be noted that even though political structures, reward systems and authorities are aware of the social or human side of things, they still favour and are guided by conservative methods (Trauth, 2001).

We believe that by using the concept map in Figure 1, a researcher can get acquainted with IS research approaches, know what decisions ought to be made, have an idea of how to justify them and employ the reference list when more detail is required. The main suggestion is to be coherent in the choices made, instead of forcing a design into an inadequate epistemology or even worse, using a design without even considering its underlying philosophy.

It is still possible to explain the concept map in much more detail and include some concepts that may have been left out. We believe that there have been several accounts of IS research, but there is a need for unifying them in order to help researchers, rather than to stimulate philosophical discussion or distinction among schools of thought (although this is also relevant).

REFERENCES

Avison, D.; Baskerville, R. & Myers, M. (2001) "Controlling Action Research Projects", *Information Technology and People*, Vol. 14, No. 1, pp. 28-45.

Baskerville, R and Wood-Harper, A. (1998) "Diversity in information systems action research methods", *European Journal of Information Systems*, Vol. 7, pp. 90-107

Becker, J.; Niehaves, B. & Klose, K. (2005) "A Framework for Epistemological Perspectives on Simulation". *Journal of Artificial Societies and Social Simulation*. Vol. 8 No. 4.

Cecez-Kecmanovic, D. (2001) "Doing Critical IS Research: the question of methodology" in Trauth, E. (Ed.) *Qualitative Research in IS: issues and trends*. Idea Group Publishing, Hershey.

Checkland, P. (2000) "Soft Systems Methodology: A Thirty Year Retrospective". *Systems Research and Behavioral Science* 17, pp. 11-58, John Wiley & Sons.

Checkland, P. & Holwell, S. (1998) *Information, Systems and Information Systems*. John Wiley & Sons, Chichester.

Chen, W. & Hirschheim, R. (2004) "A paradigmatic and methodological examination of information systems research from 1991 to 2001". *Information Systems Journal*, No. 14, pp. 197-235, Blackwell Publishing Ltd.

Darke, P.; Shanks, G. & Broadbent, M. (1998) "Successfully Completing Case Study Research: combining rigour, relevance and pragmatism". *Information Systems Journal*, No. 8, pp. 273-289, Blackwell Science.

Dobson, P. (2001) "The Philosophy of Critical Realism—An Opportunity for Information Systems Research". *Information Systems Frontiers*, Vol. 3 No. 2, 199- 210, Kluwer Academic Publishers.

Fitzpatrick, J.; Sacrist, J. & Wright, D. (1998) *Secrets for a Successful Dissertation*. Sage Publications, Thousand Oaks.

Freestone, R. & Wood, D. (2006) "Exploring Strategies for Linking Research and Teaching". *Journal for Education in the Built Environment*, CEBE.

Galliers, R. (1992) "Choosing Information Systems Approaches" in in Galliers, R. (Ed.) *Information Systems Research: issues, methods and practical guidelines*, Alfred Waller Ltd., Henley-on-Thames.

Hevner, A. & March, S. (2003) "The Information Systems Research Cycle". *Computer*, Vol. 36, Iss. 11, Nov. 2003, pp. 111-113, IEEE Computer Society.

Hirschheim, R. (1992) "Information Systems Epistemology: an historical perspective" in Galliers, R. (Ed.) *Information Systems Research: issues, methods and practical guidelines*, Alfred Waller Ltd., Henley-on-Thames.

Klein, H. & Myers, M. (1999) "A Set of Principles for Conducting and Evaluating Interpretive Field Studies in Information Systems". *MIS Quarterly* Vol. 23, No. 1, pp. 67-96.

Land, F. (1992) "The Information Systems Domain" in Galliers, R. (Ed.) *Information Systems Research: issues, methods and practical guidelines*, Alfred Waller Ltd., Henley-on-Thames.

McGrath, K. (2005) "Doing critical research in information systems: a case of theory and practice not informing each other". *Information Systems Journal*, 15, pp. 85-101, Blackwell Publishing.

Mingers, J. (2001) "Combining IS Research Methods: Towards a Pluralist Methodology". *Information Systems Research*, Vol. 12, No. 3, September 2001, pp. 240-259, Informs.

Mitev, N. (2000) "Toward Social Constructivist Understanding of IS Success and Failure: introducing a new computerized reservation system", *Proceedings of the twenty fist international conference on information systems*, December, Brisbane, Queensland, Australia, pp. 84- 93.

Myers, M. (1999) "Investigating Information Systems with Ethnographic Research". *Communications of the AIS*, Vol. 2, Article 23, pp. 1-20.

Nandhakumar, J. & Jones, M. (1997) "Too Close for Comfort? Distance and engagement in interpretive information systems research". *Information Systems Journal*, No. 7, pp. 109-131, Blackwell Science Ltd.

Olesen, K. and Myers, M. (1999) "Trying to Improve Communication and Collaboration with Information Technology: an action research project which failed", *Information Technology & People*, Vol. 12, No. 4, pp. 317- 332.

Panagiotidis, P. and Edwards, J. (2001) "Developing Intrinsically Motivated Information systems – a critical systems approach", *Information Systems Frontiers*, Vol. 3, No. 2, pp. 211- 226, Kluwer Academic Publishers.

Stake, R. (1995). *The Art of Case Study Research*. Sage Publications, Thousand Oaks.

Trauth, E. (2001) "The Choice of Qualitative Methods in IS Research" in Trauth, E. (Ed.) *Qualitative Research in IS: issues and trends*. Idea Group Publishing, Hershey.

Ulrich, W. (1983) *Critical Heuristics of Social Planning: a new approach to practical philosophy*, John Wiley & Sons, Chichester.

Walsham, G. (2005) "Development, global futures and IS research: a polemic", *Journal of Strategic Information Systems*, Vol. 14, pp. 5-15, Elsevier.

Wynekoop, J. & Russo, N. (1997) "Studying Systems Development Methodologies: an examination of research methods". *Information Systems Journal*, No. 7, pp. 47-65, Blackwell Science Ltd.

Wynn, E. (2001) "Möbius Transitions in the Dilemma of Legitimacy" in Trauth, E. (Ed.) *Qualitative Research in IS: issues and trends*. Idea Group Publishing, Hershey.

Yin, R. (1994) *Case Study Research: design and methods*. Second Edition. Sage Publications, Thousand Oaks.

Responsibility in User Participation in Information Systems Development

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ABSTRACT

Information systems (IS) are social in nature; they structure and use information technology within an organisation to fulfil its needs. If we are to fully understand IS development in an organisational context, those needs must come in great part from the users of the system. However, this is something that is not properly addressed by current IS research and practice. This article shows some of the reasons and consequences of this neglect. It also points at responsibilities that different actors (managers, users, developers, researchers) have on this issue.

1. INTRODUCTION

Information systems (IS) are social, rather than technical systems (Hirschheim, 1992). One of the crucial components of this social structure is the user of the IS. In principle, everybody agrees that information systems should not be developed and designed without an intense communication process with the user. Mumford has been one to acknowledge this, by saying that "people at any level in a company, if given the opportunity and some help, can successfully play a major role in designing their own work systems." (Mumford, 2001, p. 56); sentiment echoed by Omland (1999) and Schultze (2001). Kettinger and Lee (2002) also argue that if users and the IS function in a company agree on the need and characteristics of a new information technology (IT) project before its adoption, it is likely that the satisfaction of the users will be higher.

Before continuing, it is important to clarify what is understood by information systems and why they are considered to be of social nature. Checkland and Holwell (1998) describe IS broadly as the organizational need to manage IT in relation to an organisation's activities and intentions, and characterize it as a hybrid discipline, which draws from exact science, technology and social science. Land describes an information system as "a social system, which has embedded in it information technology" (Land, 1992, p. 12). IT, by the way, is defined as a collection of practices, techniques and devices concerned with collecting, storing, processing and distributing data or information (Checkland and Holwell, 1998). Thus, any inquiry regarding IS requires a grasp of both the structured and structuring influence of social action, particularly in those scenarios where technology, information and social action are inextricably intertwined (Schultze, 2001). In other words, as de Moor (2002) points out, the social and technical systems in an organization co-evolve by changing each other; methods to deal with this should focus on the interpretation of this complexity rather than its representation, preventing the generation of new specifications which do not involve the community (and are thus artificial, obsolete and alien to the group). Furthermore (*ibid*.), many specification methods assume that the initiating, coordinating and integrating roles are played by external analysts and designers, while users are assumed to have only tacit knowledge and insight.

The next section presents some background of the treatment of user participation in existing literature. Section three discusses some of the reasons why user participation is neglected in IS development, followed by some of the negative consequences of this neglect. Section four presents a list of the main actors of IS development (from the researchers to the managers) and what their responsibility or role is or might be in improving user participation. Section five presents some final remarks and suggestions.

2. BACKGROUND

User participation in IS development is by no means a new or ignored subject. At least since the early 70s it has been addressed as cooperative design, participatory design, user-centered design and even end-user development. Some of the initial input was provided by Scandinavian trade union cases (Kyng, 1991) and the topic has been present in several issues of the Communications of the ACM. The use context has not been ignored (Karat, 1997), among other things because it has been recognized that doing so ends up being more difficult in the end (Brown & Duguid, 1994).

Accordingly, users have been proposed as co-designers (Fischer *et al*., 2004; Kyng, 1991). A general argument is that all work is social and cooperative in nature (*ibid.*), which translates to the information systems domain (Brown & Duguid, 1994). Kyng (1991) sees cooperative design as a mutual learning experience with limitations because neither the user nor the designer will enter fully into each other's role. Another limitation is that in spite of cooperation, design decisions still draw lines and some users may feel that features have been left out (Brown & Duguid, 1994). One strand of cooperative design is participatory design (Kyng, 1991), justified by early arguments for user involvement, such as: combining sources of experience, creating ownership and experience, and enabling participation in decision-making by those affected. However, despite there not being any serious critique against it, participatory design has been slowly or partially implemented (*ibid*.; Karat, 1997; Mao *et al*., 2005).

Another approach is that of user-centered design, or UCD (Karat, 1997; Mao *et al*., 2005). According to a recent survey (*ibid*.), UCD improves usefulness and usability. Indeed, stemming from this approach, the ANSI/HFES 200, ISO 9241, and ISO 13407 standards for usability were developed, including design principles and evaluation measures (*ibid*.; Karat, 1997). Some of these practices focus on user analysis, which are highly context sensitive and difficult to generalize and to be agreed upon (Dillon & Watson, 1996). Other difficulties of UCD are: complexity, cost-benefit relationship, and lack of formal methods (Mao *et al*., 2005). UCD also risks focusing too much on internal user requirements at the expense of external, equally important ones (Brown & Duguid, 1994). A problem that remains for UCD and other participatory approaches is that they tend to be only partially applied, usually at the initial phases of IS development, and not in a rigorous end-to-end manner (Mao *et al*., 2005; Fischer *et al*., 2004).

An increasing trend, both more radical and risky than the previous approaches, is end-user development (EUD). At first, this may be seen as a consequence of inadequate user participation in the past, prompting users and user communities to "upgrade" their role to that of developers, aided by easier tools and access to knowledge. However, seriously treated, EUD is a viable socio-technical approach, which according to the principles of meta-design (*ibid*.) empowers users to become not just participants or co-designers, but designers in control of the continuous development of the systems they use, in a style similar to some successful open source developments (*ibid*.). For EUD to consolidate itself as a successful IS development approach, it is necessary that user motivation, effective tools, and management support create an effective balance (*ibid*.). The challenges presented in this section, prompt us to continue treating the subject.

3. NEGLECTING USERS: REASONS AND CONSEQUENCES

Some authors (Mumford, 2001; Collins *et al*., 1994; Armour, 2002) consider user involvement in IS development an ethical issue. Whatever the reasons may be for ignoring users or just calling on them partially or with false intentions, the fact is that introducing a new IS will alter the way people go about their jobs or communicate amongst each another. Ignoring this is a lack of vision that may

decrease the quality of work life. This is coupled with the fact that the success of the IS may be compromised and failures may result in economic or even human loss. We will present an incomplete, yet relevant, set of reasons and consequences for not involving users adequately in IS development.

3.1. Possible Reasons for Neglecting Users

A reason for neglecting user participation stems from the belief that this is a *soft issue***,** which pertains to other actors or disciplines. It is not uncommon to hear IS practitioners disregarding the user participation issue as one that is related with human aspects that don't concern them. This is not to say that they are unaware of its impact, they just believe it is someone else's responsibility to care for this. The hard-core technicians consider these social details as something that they shouldn't be bothered with. Besides, they might argue that it is not scientifically possible to deal with human issues: "for something to be considered scientific it must use the agreed set of conventions – the scientific method" (Hirschheim, 1992, p. 30), and since the scientific method does not offer an adequate way to handle user participation, it is regarded as an unscientific or soft issue.

A second, not often recognized, reason for not including users is an intent to *strengthen or enforce power relations*, especially within a hierarchical organization. Information technology, by changing the communication medium, may alter in a positive or negative way the meaning of a message. There is a discourse built in the system, which determines hidden meaning, and may be in fact reinforcing power structures. There might be a direct conscious manipulation of an IS to maintain power relations, as shown in (Olesen and Myers, 1999), who describe how top level assistants modified a Lotus Notes implementation, so that other employees wouldn't have access to managers' agendas and in doing so maintained their control over them. There are also more subtle ways to enforce power through IS, such as the one mentioned by Cecez-Kecmanovic (2001), in which a University President apparently calls for employee involvement in a restructuring, through the use of computer-mediated communication, but in reality takes covert strategic action by ignoring the criticism posted on the system and going ahead with his initial ideas, without the staff being able to argue that they didn't have a say in it.

Another common reason for user participation to be ignored or brought to a minimum is the desire to *build fast and cheap* systems. This is an increasingly strong objective, in part because of the dynamics of IT, which may make a long-lasting development an already obsolete product when it comes out. At least that is the assumption, and it is one which sees IT as a technical device in isolation. The downside to this is that usually, on the long run, this may not be the case and, in fact, a simplified design can produce a system that doesn't work as desired. One should keep in mind that "managing complexity requires flexibility and diversity while profit generation requires efficiency and control. These two sets of needs are difficult to combine." (Mumford, 2001, p. 49)

Now that some of the reasons for not appropriately involving users have been put forward, it seems attuned to examine some of the consequences.

3.2. Consequences of Neglecting Users

The first direct consequence of neglecting users in IS development is potential *failure of the system*. All new software can be assumed to contain errors, even after millions of executions (Collins *et al.*, 1994) and not all of them can be blamed on not involving users. The Hubble's faulty mirror, the AT&T shutdown of long-distance for hours in 1990, the USS Vincennes unreliable radar system (which ended up in shooting down an Iranian commercial flight), the Therac-25 radiation therapy machine killing people with x-ray overdoses, are all notorious examples of IT failure (*ibid*.). One can't help but wonder if user input would have avoided any of these failures. Usually the managers have an idea of what they would like to see in the new system, the developers understand this in a particular way, which may or may not be compatible, and then the users accommodate it to their daily work. Of course, a fool-proof, well documented system may be taught and put to use according to plans, but it has already been underlined that IS are coupled with organizational issues that cannot be handled by the system intrinsically, such as politics and culture. The management of this aspect necessarily must involve all the actors. Failure is not always technical failure.

Another natural negative consequence of not involving users is that they could manifest *resistance towards the system*, Collins *et al.* (1994) discusses a hospital case in which medical staff distrusts a new automated pharmaceutical process and the solution is to put it out of production. Mitev (2000) notes that, regarding IS, some actors go along with the will of others, while some resist. Resistance is in fact a common feature of any social system. Another example: a few years ago, one of the authors was involved with the help desk of a relatively large IT provider in Colombia where they managed service calls with the aid of an in-house developed database system. It was a simple, single-user database, which technicians and managers used to register and follow-up the calls. The company had recently been absorbed by a bigger one (not related to IT) and part of this deal meant switching to one particular large helpdesk software. Nobody argued that the new system would be full of best-practice features; nonetheless, during the process of adapting the tool, not once were the technicians involved; they were simply trained on using the software and forced to use it in parallel with the old tool for a complete switchover a few weeks after. There were a lot of details that the technicians were accustomed to filling in a certain way and the new tool proved to be rather tedious for this purpose, resulting in the users not including this information in the new tool and simply relying on the old one for their work. This ended up in a growing rejection of the system, which in turn caused further training (cost), a longer adaptation period (time), general dissatisfaction and a decrease in productivity for quite some time.

Strengthening of power structures was already mentioned as a reason for not involving users, but it can also be an undesired or unexpected consequence (from a user's perspective). Mitev (2000) describes the implementation of *Socrate*, a reservation system derived from the popular and successful *Sabre* (for airlines) in the SNCF (French railways). Though this system failed in many aspects, one in particular illustrates the purpose of this paragraph: the adoption of airline-like yield management was implemented to make the railways competitive at a European level. This, however, changed the practices of both railway workers and passengers, conducing to major strikes, criticism and basic chaos. Top executives were convinced that yield management would achieve a techno-commercial solution to the problems in the SNCF and make it cost-effective. However, they did not account for the fact that yield management is hardly just a techno-commercial tool, because it is linked to power relationships, mainly through pricing, that got transferred to staff and passengers, introducing a previously non-existing power structure. Someone could argue that the French are just too eager to strike at any chance they get; regardless of whether this reputation is deserved or not, it certainly means that changes at a technological level should have considered consequences at a political level.

Now that we have seen some reasons and consequences of neglecting users, we argue that someone must take responsibility for involving them effectively, this is the topic of the next section.

4. WHO IS RESPONSIBLE FOR USER PARTICIPATION?

Among the possible actors to take responsibility in user involvement, we can consider those involved in IS development and use, according to Collins *et al*. (1994): provider, buyer, user and penumbra (those affected by system, yet not part of the organisation). They propose a set of responsibilities that these actors have on each other and on themselves, which point to the fact that their interests are different and many times conflict.

Some *managers (buyers)* sometimes take on the responsibility of considering the human aspect of IS development and giving due place to users. Armour (2002), a manager himself, for instance, calls for a "spiritual life of projects" and states that "in our cold, cost-cutting pursuit of efficiency and productivity, we shouldn't forget that software is only made by people" (*ibid*., p. 14). However, it is likely that managers will answer to their functional responsibility and concentrate on profits. As Jackson (1985) puts it, they wouldn't give up their position of power for an idealized design.

One wouldn't expect *users* to be responsible for involving themselves in the development, but they have increasingly taken on this vacant responsibility, when they feel others don't. Due to delayed IT delivery, poorly prepared requirements and resistance to change – coupled with easier and widely available access to programming languages and the Internet – users have increasingly become confident enough to develop their own solutions without the IS department (Kettinger and Lee, 2002). This has even resulted in user-driven innovation, as opposed to the IS function's traditional role in this (*ibid*.). Users now consider themselves as more experts than what the IS function might expect from them. Enabling the user's recognized expertise and grasp of what the organisation needs, coupled with IS department's know-how might produce better results than any of the two separately.

Another fundamental actor is made up by the *developers (providers)*. Their job is to build an IS which complies with high quality standards, but most importantly, that does what is needed and adds value to the organisation; in order for this to happen, its users are crucial for its success and must be included in the development. On the one hand, there are ethical codes of behaviour that could be interpreted as suggesting user involvement when they recommend acting consistently with public interest (Gotterbarn, *et al*., 1999). On the other hand, their own professional and group success is tied to the success of the system, so it is short-sighted to only serve a limited set of interests or cut corners.

Lastly, we can include another actor, not necessarily involved with the development or implementation of IS, but crucial in establishing the way in which these two activities are carried out: the IS *researcher*. Being responsible for knowledge production in IS, a researcher's role in user participation is very important. Through publications, conferences, associations and, perhaps more importantly, teaching activities, they influence the way in which developers learn how to build an IS, how managers understand and use IS and, furthermore, how users themselves are seen. In a recent paper, Geoff Walsham (2005) argues that researchers should take on the responsibility of carrying out their inquiries with a critical approach that understands that knowledge is a social construct, that there are historical and cultural contingencies in its production and that power relations influence its development. Furthermore, Walsham suggests that through teaching, publishing and institution building, researchers can influence the way in which IS are understood and used, highlighting the obvious but undermined notion that IT is aimed at improving the lives of people around the world. In other words, IS should contribute towards development (in a broad sense, not a purely economic sense), particularly contributing to reducing the digital divide, questioning the ethnocentrism in existing technology and taking into account gender issues. All three contributions are related to the end-users of IS. A teaching example of this can be found in (Omland, 1999) that presents an IS development course emphasising the human (user) factor.

5. CONCLUSION

This paper offers an invitation to understanding user participation in information systems development not by looking at the benefits, but rather at the reasons and consequences of partially or totally neglecting users. This negative approach to the user participation issue is meant to raise awareness on the responsibility that different actors have on changing the situation.

We hope that by showing the reasons, consequences and responsible actors we can enhance understanding of the user participation issue with a call on each of these actors to take responsibility. We recognize that by presenting seemingly negative reasons and consequences we have left out what sometimes may be positive aspects of not involving users, such as keeping a project within budget and time constraints, allowing for decision-making not to turn into endless discussion, or innovating without user bias on comfortable tradition. But we do this in order to stress the fact that IS development has a social-nature and approaching it instrumentally (whether it be a technology or management-centred perspective) may be counterproductive for the system itself, which includes all stakeholders.

Participation doesn't start with asking the users about functionality or interfaces; it does not end with questionnaires about usability or friendliness either. It should start by discussing the problem situation with the stakeholders (users in the foreground) without the IS being already the preconceived solution; and it should also be an open-ended learning experience.

REFERENCES

Armour, P. (2002) "The Spiritual Life of Projects", *Communications of the ACM*, January 2002 / Vol. 45, No. 1, pp. 11- 14.

Brown, J. & Duguid, P. (1994) "Borderline Issues: Social and Material Aspects of Design", *Human-Computer Interaction*, Vol. 9, pp. 3-36.

Cecez-Kecmanovic, D. (2001) "Doing Critical IS Research: the question of methodology" in Trauth, E. (ed.), *Qualitative Research in IS: issues and trends*, Idea Group Publishing, Hershey.

Checkland, P. and Holwell, S. (1998) *Information, Systems and Information Systems: making sense of the field*, John Wiley & Sons, Chichester.

Collins, W.; Miller, K.; Spielman, B. & Wherry, P. (1994) "How Good is Good Enough", *Communications of the ACM*, January 1994 / Vol. 37 No. 1, pp. 81- 91.

Dillon, A. & Watson, C. (1996) "User analysis in HCI—the historical lessons from individual differences research", *Int . J . Human – Computer Studies*, Vol. 45 , 619 – 637.

Fischer, G.; Giaccardi, E.; Ye, Y.; Suttcliffe, A. & Mehandjiev, N. (2004) "Meta-Design: A Manifesto for End-User Development", *Communications of the ACM*, Vol. 47, No. 9, pp. 33-37.

Gotterbarn, D.; Miller, K. & Rogerson, S. (1999) "Software Code of Ethics is Approved", *Communications of the ACM*, Vol. 42, No. 10, pp. 102- 107.

Hirschheim, R. (1992) "Information Systems Epistemology", in Galliers, R. (ed.), *Information Systems Research: issues, methods and practical guidelines*, Alfred Waller Ltd., Henley-on-Thames.

Jackson, M. (1985). "Social Systems Theory and Practice: the need for a critical approach", In Flood, R. and Jackson, M. (eds.), *Critical Systems Thinking: directed readings*, John Wiley & Sons, Chichester.

Karat, L. (1997) "Evolving the Scope of User-Centered Design", *Communications of the ACM*, Vol. 40, No. 7, pp. 33-38.

Kettinger, W. and Lee, C. (2002) "Understanding the IS-User Divide in IT Innovation", *Communications of the ACM*, February 2002 / Vol. 45, No. 2, pp. 79- 84.

Kyng, M. (1991) "Designing for Cooperation: Cooperating in Design", *Communications of the ACM*, Vol. 34, No. 12, pp. 65-73.

Land, F. (1992) "The Information Systems Domain", in Galliers, R. (ed.), *Information Systems Research: issues, methods and practical guidelines*, Alfred Waller Ltd., Henley-on-Thames.

Mao, J.; Vredenburg, K.; Smith, P. & Carey, T. (2005) "The State of User-Centered Design Practice", *Communications of the ACM*, Vol. 48, No. 3, pp. 105-109.

Mitev, N. (2000) "Toward Social Constructivist Understanding of IS Success and Failure: introducing a new computerized reservation system", *Proceedings of the twenty fist international conference on information systems*, December, Brisbane, Queensland, Australia, pp. 84- 93.

de Moor, A. (2002) "Language/Action Meets Organisational Semiotics: situating conversations with norms", *Information Systems Frontiers*, Vol. 4, No. 3, pp. 257- 272, Kluwer Academic Publishers.

Mumford, E. (2001) "Action Research: helping organizations to change", in Trauth, E. (ed.), *Qualitative Research in IS: issues and trends*, Idea Group Publishing, Hershey.

Olesen, K. and Myers, M. (1999) "Trying to Improve Communication and Collaboration with Information Technology: an action research project which failed", *Information Technology & People*, Vol. 12, No. 4, pp. 317- 332.

Omland, H. (1999) "Educating Systems Analysts Emphasising the Human Factor", ACM *SIGCSE Bulletin*, September 1999 / Vol. 31, No. 31, pp. 44-47.

Schultze, U. (2001) "Reflexive Ethnography in Information Systems Research" in Trauth, E. (ed.), *Qualitative Research in IS: issues and trends*, Idea Group Publishing, Hershey.

Walsham, G. (2005) "Development, global futures and IS research: a polemic", *Journal of Strategic Information Systems*, Vol. 14, pp. 5-15, Elsevier.

Wynn, E. (2001) "Möbius Transitions in the Dilema of Legitimacy" in Trauth, E. (ed.), *Qualitative Research in IS: issues and trends*, Idea Group Publishing, Hershey.

Changing Healthcare Institutions with Large Information Technology Projects

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ABSTRACT

This paper reviews the development of institutional theory in direct relations to historical changes within the UK's National Health Service (NHS) with an eye to contributing to the theoretical specification of social information processes. This is done partly by extending certain paradigms (see Powell & DiMaggio, 1991; Meyer & Rowan, 1977; Tolbert & Zucker, 1994) through a proposed model of causes and consequences of variations in levels of institutionalisation in the healthcare sector. It reports findings from a three-year study on the NHS implementation of the largest civil information systems worldwide at an estimated cost of $10 billion over a ten-year period. The theoretical basis for analysis is developed, using concepts drawn from "IT conversion effectiveness", "productivity increases", realization of business value", and "organisational performance improvements", as well as mixed empirical results about the lack of IT investments value in the NHS. The findings suggest that large-scale IT change imposed upon a highly institutionalised healthcare is fraught with difficulty mainly because culturally embedded norms, values and behavioural patterns serve to impede centrally imposed initiatives to automate clinical working practices. It concludes with discussion about the nature of evaluation procedures in relation to the process of institutionalizing IS in healthcare.

INTRODUCTION

An historical overview of IT projects on the UK's National Health Service (NHS) during the last five decades is presented here with the intention to both clarify the links between institutional theory and previous traditions of sociological work on organisational structure. The initial exposition of this theory by works of established institutionalists (Tolbert & Zucker, 1994; Meyer & Rowan, 1977; Scott et al, 2000) focuses on the ways of challenging dominant theoretical and empirical traditions in organizational research. While this paper clarifies some ambiguity and elaborates on the logical and empirical implications of a phenomenologically-based version of institutional theory, the primary aims are to clarify the independent theoretical contributions of institutional theory to analyses of the NHS and to develop this theoretical perspective further in order to enhance its use in empirical research in other healthcare environments (internationally and globally).

Markus (1983) claims that interaction theory draws together three principal strands of resistance: internal factors, technical problems and political context. This theory has been highly influential in IS strategy and other social sciences generally since Markus first developed the ideas over two decades ago. The focus here (see Table 1) is on how interaction theory offers a new way of looking at IS implementation in the healthcare industry.

Much has been researched in the last few decades about the major lack of a coherent implementation strategy for information systems (IS) in the healthcare industry (Stevens et al, 1993). Most of such claims have been levelled against an apparent "productivity paradox" with respect to investments in healthcare management (in general) and IS (in particular). Wanless (2002) and Committee on Quality Health Care in America (2002)—both national government's mandated investigations into the UK and USA national healthcare systems respectfully—among others, have failed to find a convincing body of evidence that investment in Healthcare IS is associated with increased output (refuting the productivity paradox), but not with healthcare value as measured by patient satisfaction.

WHAT IS INSTITUTIONALISM?

Institutionalism is continuously being used to mean different things by researchers of political science, economics and sociology. Lowndes (1996:182) presents institutionalism as informal codes of behaviour, written contracts and complex organisations with four elements:

- A middle-level concept. Institutions are devised by individuals and therefore constrain individuals' actions. Institutions here are seen as part of the broad social fabric and medium for individuals' day-to-day decisions and other activities. DiMaggio and Powell (1994) argue that institutions shape human actions, imposing constraints whilst providing opportunities for individuals.
- Having formal and informal aspects. Lowndes views institutions to involve formal rules or laws, which allows informal norms and customs to be practiced. That is because some institutions are not consciously designed nor neatly specified, yet part of habitual actions by its members. Such institutions may be expressed in organisational form and relate to the processes within.
- Having legitimacy. Legitimacy in institutions goes beyond the preferences of individual actors. Such preferences are valued in them and go beyond their immediate purpose and outputs.
- Showing stability over time. Lowndes views institutions as gaining their legitimacy due to their relative stability over time, and their links with a 'sense of place'.

Table 1. Implementation theory: Usage, fitness, relationship & sufficiency

Authors	IS Implementation	Theory Description
Lucas, 1993	Appropriate Use of IS	Process theory explaining appropriate IS use. Variance theory linking use with business value.
Grabowski & Lee, 1993	Strategic Fitness of IS	Process-type relationship between strategic fit and performance of IS.
Markus, 1983	Relationship of IS assets	How IS investment do or do not become IS assets. How IS assets do or do not yield improved organizational performance.
Sambamurthy & Zmud, 1994	Insufficient to produce impacts	Process model connecting raw material inputs to outputs. Variance theory of IS management competencies and IS impacts Variance theory linking impacts and business value.

New institutionalists generally view institutions to have "the humanly devised constraints that shape human interaction" (North, 1990: 3) what March and Olsen, (1989:162) refer to as "rules of the game" that organisations and individuals are constantly expected to play the game. Another stand taken by new institutionalists sees informal institutions (tradition, custom, culture and habit) are embedded in culture and conventions defined as behaviour structuring rules (North, 1990; March and Olsen, 1989). New institutionalists stress embodied values and power relations of institutions together with interaction between individuals and institutions (Lowndes, 1996). They attempt to distinguish between informal institutional rules and personal habits. Such distinction forms the basis for the definition of institution in this research where informal conventions and their impact upon the NHS and its partners are being explored.

RESEARCH METHODOLOGY

The research study began in 2001, with the initial interest of conducting an exploratory-descriptive study in ten NHS hospitals to explore why, 'historically, the NHS has not used or developed IT as a strategic asset in delivering and managing healthcare' (DoH, 2000). Intensive literature review unveiled few longitudinal studies, which systematically and rigorously examined how IT systems were introduced and changed over time. There were no studies that examined inter-organizational relationships between different constituents in the adoption and diffusion of IT systems (NHS directorship, hospital management systems or IT suppliers and patients). Not only were most of these studies descriptive and lacked an historical dimension, they presented IS in healthcare as largely theoretical with most contributions reporting the findings of a specific IT project implementation using simple success and failure criteria—Scott et al (2000) being amongst the most significant contributions.

Using such relevant and wide-ranging backdrop this research study recognized that it was important to extend the empirical enquiry for two reasons: (i) exploratory-descriptive case studies on a single organization (or one hospital) would not elicit in-dept and rich data to develop any meaningful analysis and conclusions on how IT was being deployed and managed; (ii) the introduction of a large-scale IT-enabled change program needed to be researched at the wider societal, organizational field and individual levels, covering an extended period of time, to understand the processes of institutionalisation (Tolbert & Zucker, 1994). The research study was therefore designed to capture the myriad of views and opinions about the NPfIT over a three-year period to build a rich picture of such processes underpinning large-scale IT change.

Three methods of data collection were adopted: (i) a range of academic, government and industry studies on the healthcare sector were assembled—both UK and healthcare services in other countries. The materials proved invaluable for understanding the societal, economic, political, cultural and technical differences in healthcare nationally and internationally; (ii) participation in trade fairs, conferences, workshops and exhibitions on healthcare—focusing on general or more specific healthcare activities. These events also generated many useful research contacts that proved invaluable for targeting interviews.

A semi-structure interview (see Table 2) schedule was used to enable interviewees to expand on their answers. While most interviews lasted for about ninety minutes, nearly all interviews were tape-recorded and transcribed. Respondents were later contacted with feedback from the interviews and where necessary errors were corrected. This method of data collection was critical for allowing interviewees to raise additional themes, issues and concerns that they felt were important to the research study. As a result of the political contention of some of the interview content, some interviewees asked that names of individuals and hospitals be anonymous.

During the first year of interviews, the scope of the study had to be extended, as it was important to elicit data and information from a wider range of respondents engaged in the implementation of NPfIT. These included IT service providers bidding for public sector IT contracts and doctors in general practices around the country. Most IT service providers offered critical insights into the political and procurement processes within the NHS and public sector more generally. General practitioners, on the other hand, offered useful insights about the communication channels underpinning the institutional processes underpinning NPfIT. Given the range of constituents involved, the resulting data was evaluated and interview schedule refined, ensuring questionnaires be more closely targeted to the professional and personal situation of the individual, as generic questions were less meaningful. The final questionnaire was ultimately divided into the following major themes involving 15 questions:

Vision for the National Programme for IT: overall vision and how it was compatible with individual hospital objectives.

Strategy for the National Programme for IT: Who was engaged with and how the strategy was being communicated within different organization.

Implementation of the National Programme for IT: What professional, managerial and technical skills or capabilities were needed to implement various elements of the National Programme for IT.

Value Delivery for the National Programme for IT: The main risks identified by each hospital and how past IT failure could be avoided, as well as looking at the cost/benefit choices and issues for each organization.

Risk Analysis for the National Programme for IT: The value being derived from the National Programme for IT?

The aim was to get the perspectives of a number of different informants using structured interviewing, by building up intensive longitudinal cases which would, nevertheless, be amenable to statistical analysis. In this method, differences of

Table 2. Numbers of interviews conducted

Categories of Interviewees	Year 1		Year 2		Year 3	
	Contacts Made	Persons Interviewed	Contacts Made	Persons Interviewed	Contacts Made	Persons Interviewed
NHS Information Authority	32	5	30	10	10	15
Major IT Service Providers	90	65	60	45	17	12
Primary Care Trusts Admin	15	5	25	12	22	12
Secondary Care Trust Admin	0	0	9	3	7	4
Local NHS IT Managers	15	6	20	11	60	42
Medical Consultants	3	1	8	4	9	6
Nurses & Junior Doctors	13	3	15	3	11	4
Healthcare Researchers	35	20	20	8	10	7
Total Interviews		**105**		**96**		**102**

Table 3. Frequently described implementation attributes and benefits

Implementation Attributes		
Item	**Count**	**% of Cat**
Applications work together	40	13
Data sharing	173	57
Common database	127	42
Real-Time processing	106	35
Record once, use everywhere	121	40

Implementation Benefits		
Item	**Count**	**% of Cat**
Improved data accuracy/reliability	61	20
Lower Costs of support, maintenance	212	70
Greater efficiency & productivity	167	55
New or increased functionality	106	35
Better management, decisions, analysis	136	45

perception of informants become part of the data, not an inconvenience to be explained away in the search for some objective truth.

DATA ANALYSIS

Content analysis was used to surface themes in the interview data that reflected participants understandings related to systems implementation. The approach suggested by Weber (1990) was used to code the interview data. A set of codes used to classify the data was developed, based on concepts from the research literature and augmented with major additional concepts discovered by the researchers during the coding. We used a content analysis form where each sentence from the interview transcripts was assigned one or more codes. Each data element was coded with an assessment of the level of agreement in code assignments, involving certain degree of recoding of data sources. As this was the first study that uses content analysis about modelling of system implementation in the NHS, certain degree of recoding was considered acceptable.

Table 3 contains a list of the most frequently cited attributes and benefits of system implementation model. The audiotapes were fully transcribed, and individual site summaries were produced before conducting a content analysis of each transcript. After a complete review of all summaries, issues describing IS implementation strategies by iterative examination were identified. Certain themes emerged which were explored using the competing values framework as an interpretive framework where appropriate (see Table 3). The trustworthiness of such analysis has been assessed by triangulation between data sources and exploring any differences in the researcher' interpretations during a couple of follow-up meetings with selected interviewees.

During the period of the field study, there was a continuing, vigorous, informal debate within NHS Information Authority as to the merits of establishing a fault proof IS implementation framework in healthcare, particular for the NHS, during this period of healthcare reform. Benefits in terms of improved quality, greater structure and more discipline were widely accepted.

THE NHS CASE STUDY

The NHS is the institution responsible for all health care and services in the UK with the goal of undertaking this responsibility at no costs to the public, at the point of delivery. The NHS was created in 1948 by a parliamentary art of the UK government of Mr. Howard Wilson, after a national healthcare review by Mr. Black immediately after World War II. Within the past 58 years, the NHS operating environment has changed radically.

The period from late 1980's to early 1990's brought in the advent of competitive bidding bringing long-term increase costs to the management of the NHS, as well as a feeling of internal market within the NHS. By the mid-90's, management of IS in the NHS was division-based. Divisions were spread across several sites and medical functions were centrally controlled. Computing services and IS development project were beginning to be contracted to external private businesses and staff at the NHS were beginning to feel disgruntled and unappreciated. The increasing influence of global communications, Internet and other new technologies demanded a response from the NHS.

In the late 1990's the government increasingly recognized the opportunity to use IT to improve the delivery of service within the NHS. After a series of reviews of NHS IT service delivery, a more integrated and seamless IT organization was recommended (DoH, 2000, Wanless, 2002). The NHS Information Authority embarked on the Integrated Care Report Service (ICRS) project to provide, among other services, a nationwide electronic patient database. The result was a document called "*Information for Health*" that specified the need for the complete automation and integration of various patient information databases in the country (DoH, 2000). The system was commissioned to selected IS service providers at a combined price of $10 billion.

In spite of its vision—to transformation IT—the NHS has a history of introducing large-scale IT development projects that has not been an overall success, with some suggesting a failure rates of between 60 to 80 percent (Brown, 2001). Though the UK public sector spent around $3.5 billion per annually on IT, the failure of major IT-enabled projects were characterized by delay, overspend, poor performance and abandonment (NAO, 2004, p.3). At the political level, it is argued that 'better IT is needed in the NHS because the demand for high-quality healthcare continues to rise and the care now provided is much more complex, both technically and organizationally (Connecting for health, 2004, p.7). About $250 million is spent on management and administration in the NHS, a controversial figure, as many believe more doctors and nurses should be recruited.

THEORETICAL ANALYSIS OF THE CASE

The NHS case study illustrates the dynamic nature of a national healthcare information system implementation, set within the context of a rapidly changing organization. As with all large IT-enabled programs, the success or otherwise of the strategic plan is in its implementation (Herzlinger, 1989; Doolin, 2004; Hendy et al, 2005). The lessons IT costs versus medical decision-making are well documented in the literature and involve the lack alignment between the business and IT strategy (Luftman, 2000); a lack of ownership and leadership of the IT project among senior decision makers (Brown, 2001); poor risk assessment skills (Heathfield et al, 1998); over-scoping of the functional and technical specification leading to IT projects becoming over-budget and late (NAO, 2004); poor communication between program/project managers and potential users of the system (Guah & Currie, 2005); inadequate resources to deliver/implement IT systems (Currie & Guah, 2006).

The empirical research found that issues of project risk were at the forefront of the minds of clinicians, GPs hospital managers and IT staff. Formal project management methods and tools were perceived as offering only part of the solution to mitigate the considerable risks from introducing the NPfIT.

The fragmentation was not just about the diversity of IT systems within the NHS, but also about the political geographical, social, organizational and financial complexity of delivering healthcare.

The overriding view was for the NPfIT to become an integrated IS across and beyond the NHS. The threats to achieving this were perceived by many clinicians to fall within the control of politicians and IT service providers rather than from NHS staff. Project risk mitigation was a complicated issue, compounded by the political and ideological considerations, such as the PFI, which facilitated the increasing use of private sector firms. Whilst the NHS is often characterised as a top-down bureaucracy (Mohan, 2002), past achievements in IT development and implementation had often been initiated at a decentralised (hospital, departmental, unit) level. Although this was now discouraged by the centrist approach of the NPfIT, staff participating in the research expressed concerns that any failures associated with IT project implementation may be labelled '*staff resistance*' rather

than the shortcomings of external constituents, such as politicians, management consultants or IT suppliers.

The success or failure of information systems is inextricably linked with the dynamics of the organization within which they exist. Miranda and Saunders (2002) have demonstrated the complex interaction of technical, social, cultural and political elements that result in a failed IS. Equally, IS success depends on more than technical competence. The cultural and political environment of the NHS is difficult to study as it depends not only on the tangible organizational structure but also on the tacit knowledge and the perceptions of the participants (Guah & Currie, 2005). This is in addition to the cultural and political environment of an organization that is not static but in a rather state of constant flux and dynamic change.

Institutionalism of IS in the NHS is concerned with processes of cultural persistence and change of healthcare processes. The survival of an organization depends as much on conforming to societal norms of acceptable practice as to achieving high levels of production efficiency and effectiveness (Covaleski et al, 1993). Prior work has shown that an organization's formal structure, policies and procedures serve to demonstrate conformity with the institutionalised rules and requirements of external constituents (Meyer & Rowan, 1977; Dimaggio & Powell, 1983). In light of these concerns healthcare in the UK showed that the NPfIT was intended to play a high profile role within the heavily institutionalised environment of hospitals (Scott et al, 2000).

The vision for NPfIT was infused with the institutional logics more commonly associated with the private sector, as an innovation that would contribute to greater productivity, efficiency, cost control and customer satisfaction in healthcare delivery. Paradoxically, this externally directed institutional logic served to under represent and simplify the vast complexities and contradictions in how it was perceived, and reacted to, by those affected by government-led IT-enabled changed. Within the NHS, staff were increasingly sceptical about the merits of private sector logics, such as the PFI initiative, as their values, norms and goals invariably placed financial considerations secondary to choices about patient care.

CONCLUSIONS

The primary contribution of this paper has been to provide a theoretical basis drawing from Institutional theory, which was used to analyse the NHS implementation of NPfIT. The theorization goes beyond the relatively simplistic types of studies which dominate the IS literature today. Much to the contrary, it has been shown that an implementation strategy can accommodate elements such as the links between culture, contradiction and conflict, an analysis of detailed work patterns, and the dynamic and emergent nature of political involvement at national level.

The theory has been illustrated using limited empirical examples only, with a focus on the NHS systems, but it could be used to analyse any case study involving healthcare systems from any parts of the developed world. Viewed from a more critical perspective, however, any theory illuminates some elements of particular case situations and is relatively silent on others. The NHS has grown within an environmental niche that arose out of a complex interaction between the national healthcare environment, business environment, the organizational environment and the people within the NHS. Changes within the organization subsequently rendered the environment hostile to the NPfIT which was affected by its changing links with organizational structure and people, the changing responses of people within the NHS to the environment around them, and the changing individual and collective mindsets and understanding of those people. While a detailed discussion of ways in which this can be achieved is beyond the scope of this paper, some broad approaches have been mentioned.

In the current environment of increasing demands for better quality of healthcare from patient and seemingly reduced amount of funding from National governments, the need for suitable institutional theory is increasingly common and the IS field must increase its understanding of the problematic issues involved and approaches to resolving them. It is hoped that this paper makes a modest contribution to these goals.

REFERENCES

Brown, T. (2001). "Modernization or failure? IT development projects in the UK public sector." *Financial Accountability & Management,* 17 (4), pp. 363-381.

Connecting for health, Business Plan (2004): http://www.connectingforhealth.nhs.uk. (Accessed May 2005)

Covaleski, M.A., Dirsmith, M.W., & Michelman, J. (1993). "An institutional theory perspective on the DRG framework, case mix accounting systems and healthcare organizations," *Accounting, Organizations and Society,* 18 (1), pp.65-80.

Currie, W.L. & Guah, M.W. (2006). IT-enabled Healthcare Delivery: The U.K. National Health Service, *Information Systems Management,* 23 (2), pp.7-22.

DiMaggio, P.J. & Powell, W.W. (1983) "The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields". *American Sociological Review,* 48, pp.147-160.

DiMaggio, P.J. & Powell, W.W. (1994). The New Institutionalism in Organizational Analysis, edited by Powell and DiMaggio. Chicago: University of Chicago Press.

Department of Health (UK). (2000). *NHS Plan: An information strategy for the modern NHS*. London.

Doolin, B. (2004). Power and resistance in the implementation of a medical management information systems, *Information Systems Journal,* 14, pp.343-362.

Grabowski, M. & Lee, S. (1993). Linking Information Systems Application Portfolios and Organizational Strategy. In R.D. Banker, R.J. Kauffman & M.A. Mahmood (Ed.), *Strategic Information Technology Management: Perspectives on Organizational Growth and Competitive Advantage.* Harrisburg, Pennsylvania: Idea Group Publishing, pp. 33-54.

Guah, M.W. and Currie, W.L. (2005). Internet Strategy: The Road to Web Services. Pennsylvania: Idea Group Publishing.

Heathfield, H., Pitty, D. & Hanka, R. (1998). Evaluating information technology in healthcare barriers and challenges. *British Medical Journal,* 316, pp.1959-61.

Hendy, J., Reeves, B.C., Fulop, N., Huchings, A., Masseria, C. (2005). Challenges to implementing the national program for information technology: a qualitative study. *British Medical Journal,* 420, pp.1-6.

Herzlinger, R.E. (1989). The failed revolution in Healthcare – The role of Management. Harvard Business Review, March-April, pp.95-103.

Lucas, H.C. (1993). The Business Value of Information Technology: A Historical Perspective and Thoughts for Future Research. In R.D. Banker, R.J. Kauffman and M.A. Mahmood (Ed.), *Strategic Information Technology Management: Perspectives on Organizational Growth and Competitive Advantage.* Harrisburg, Pennsylvania: Idea Group Publishing, pp.359-3744.

Luftman, J. (2000). "Assessment Business IT Alignment Maturity," Communications of the AIS, 4 (14), pp.1-51.

March, J.G. & Olsen, J.P. (1989). Rediscovering institutions: The organizational basis of politics. New York: Free Press.

Markus, M.L. (1983) 'Power, politics and MIS implementation,' *Communications of the ACM,* 26(6), pp.430-445.

Meyer, J.W. and B. Rowan (1991) 'Institutionalized organizations: Formal structure as myth and ceremony', in Powell, W.W. and P.J. DiMaggio (eds.) The new institutionalism in organizational analysis. Chicago: University of Chicago Press.

Miranda, Shaila M. & Saunders, Carol S. (2002) 'The Social Construction Of Meaning: An Alternative Perspective On Information Sharing'. *Information Systems Research*.

Mohan, J. (2002). *Planning, Markets and Hospitals,* Routledge, London.

NAO (2004). Improving IT Procurement. Report by the Comptroller and Auditor General, HC 877 Session, 2003. The Stationary Office, London.

Powell, W.W. & DiMaggio, P.J. (1991). *The new institutionalism in organizational analysis.* Chicago: The University of Chicago Press.

Sambamurthy, V. & Zmud, R.W. (1994). IT Management Competency Assessment: A Tool for Creating Business Value Through IT. *Working paper*, Financial Executives Research Foundation.

Scott, W.R., Ruef, M., Mendel, P.J. & Caronna, C.A. (2000). Institutional Change and Healthcare Organizations: From Professional Dominance to Managed Care. University of Chicago Press, Chicago, USA.

Stevens, P., Schade, A., Chalk, B., & Slevin, O. (1993). *Understanding Research: A Scientific approach for Health Care Professionals*, Edinburgh, Campion Press.

Tolbert, P.S. & Zucker, L.G. (1994). Institutional Analysis of Organizations: Legitimate but not Institutionalized. Institute for Social Science Research working paper, University of California, Los Angeles, 6(5).

Wanless, Derick (2002). Securing Our Future Health: Taking a Long-Term View. Final *Report of an Independent Review of the long-term resource requirement for the NHS.* London.

Weber, R.P. (1990). *Basic Content Analysis*, 2ed. Newbury Park, CA: SAGE Publications, Inc.

Hybrid Architecture of OWL-Ontologies for Relational Data Sources Integration

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ABSTRACT

Data integration is one of the most important tasks in the data warehousing process. The use of ontologies in the mediation process allows semantic and structural integration. In this paper, we propose a new mediation system based on an hybrid architecture of ontologies modelled according to GLAV (Generalized Local As View) model. The hybrid architecture builds a local ontology for each data source and a global ontology viewed as a mediator. The integration model defines how sources, local and global ontologies are mapped. So we propose an ascending method for building ontologies, which facilitates the semantic reconciliation between data sources. Moreover, we use OWL (Ontology Web Language) for defining ontologies and mappings between data sources and ontologies. User queries are expressed in our specific language which handles global ontology concepts and local ontologies properties since we assume that the user is expert in its domain. Queries are decomposed by the rewriting algorithm to obtain a set of equivalent subqueries that are sent to the corresponding sources for execution, and after that recomposed to obtain the final result.

1. INTRODUCTION

In a data warehousing process, data integration is an important phases. Centralized data warehouse is a solution for companies that handle static data. However, when data change, this solution becomes not practical because of the refreshment cost. We think that data integration by mediation can solve this problem and allows to construct a mediation system for building analysis context on-the-fly using data from their real sources.

In this paper, we treat only the first part, which concerns the building of the mediation framework. It consists in creating a mediator based on ontologies. The use of ontologies in the integration by mediation is not recent [3, 4], it allows to implement a structural and semantic integration. There are several architectures based on ontologies in integration systems [1, 2, 16]. approaches with only one ontology as in the case of system *SIMS* [5], approaches with multiple ontologies as in *OBSERVER* [6] and hybrid architecture which associates a local ontology for each data source and a global ontology to link them [7]. The later is interesting because it is flexible for updates and there is no need to define mappings between local ontologies. Several structural models can be applied on this architecture: *GAV* (Global As View) [9, 10, 11], *LAV* (Local As View) [12, 13, 14, 6, 8]. The advantages and disadvantages of these two approaches are opposite [8]. *LAV* is flexible for updates but the construction of query's answers is complex, contrary to the construction of answers in a system adopting an approach *GAV* which simply consists in replacing the predicates of the query global concepts by their definition. *GLAV* (Global-Local As View) [15] is the combination of *GAV* and *LAV*. It inherits the query unfolding property of GAV, maintains independence between data sources and allows to indirectly computing mappings between them. It uses views in local and global levels. The query processing in this model is only feasible when the query is expressed in a language that takes into account global and local levels.

In this context, we propose an ascending method for building ontologies starting from the local ones, then we use these ontologies to build manually the global ontology and define mappings between global and local ontologies (figure 1). We use *OWL* (OntologyWeb Language) to define ontologies and their mappings. Our goal is to use the ontologies terminology to formulate user queries. To reach this goal, we propose a query language based on global ontology concepts and local ontologies properties. The problem of mediator using several ontologies according to the *GLAV* model is the query rewriting and the way how the obtained results are combined. For this end, we propose our query rewriting algorithm, which enables to reformulate user queries to queries comprehensive by the mediator.

Our work lies within the scope of a project of virtual data warehousing of banking data in LCL - Le Crédit Lyonnais (French bank). The purpose of the project is to manage and improve the decision process in LCL in the direct marketing activities domain. It contains many management applications and databases. The banking data are heterogeneous and change much, so the construction of cubes on-the-fly is pertinent. Each cube represents a specific analysis context.

The remainder of this paper is organized as follows. Section 2 presents our mediation system starting by our approach, which allows to create various ontologies applied to the case of the sources of the LCL. Next, we present our query language. After that, we present our query rewriting algorithm and give an example. The architecture and the implementation of our mediator are exposed in section 3. We finish this article by the section 4 which concludes our work and presents the prospects on new generated problems.

2. ONTOLOGY-BASED MEDIATION SYSTEM

The construction of the mediation system is decomposed into three steps:

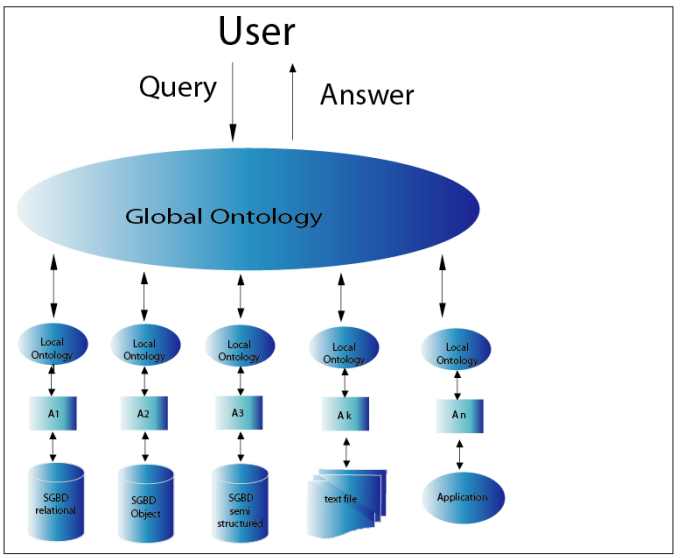
1. definition of local and global ontologies
2. definition of a query language
3. definition of the query rewriting algorithm.

2.1 Ontologies Development Approach

In this section, we present our approach of ontologies construction using the hybrid architecture modelled according to GLAV model. We also use OWL for the ontologies description. In fact, OWL is capable to describe data and metadata in order to make ontologies more powerful for the integration task. OWL is based on RDF (Ressource Description Framework), so it gathers the RDF description power and the mechanism of reasoning. The approach we propose consists in creating ontologies in an ascending way. We start from local ontologies, and extract a global ontology from the local ones in order to facilitate the semantic reconciliation between sources.

- The first phase consists in creating local ontologies. It contains two steps: (1) the analysis of sources; and (2) the definition of ontology concepts. The first step is a complete analysis of each source independently. The analysis consists in searching primitives used in sources, implicit information, its storage, its significance and its relation with other terms. After that, we define concepts which will constitute the ontology hierarchy, their relations and constraints on their use.
- The second phase is the extraction of the global ontology starting from various concepts used in local ontologies. It contains two steps: (1) local ontologies analysis; and (2) selection of all concepts and solving semantic conflicts. The first step is a complete analysis of local ontologies. Note that, ontologies analysis is easier than that of data sources. After concepts selection, the expert solves all kinds of heterogeneity (naming conflicts, confounding conflicts and/or scaling conflicts) to determine global ontology concepts.
- The third phase, which represents the core of the system, consists in defining mappings between the global and local ontologies. The global ontology is built

Figure 1. Ontology-based mediation system



from local ontologies. So, in order to identify the original ontological source of concepts, we use annotations. *OWL* enables the annotation of concepts and properties according to predefined meta data schema.

Our study is limited on relational data sources, where tables are represented by *OWL* classes. Relationships between classes are represented in *OWL* by *owl:ObjectProperty* and *owl:-DatatypeProperty. OWL* properties can represent various attributes and constraints in the relational schema. They also represent attributes by *Datatype*. If the attribute is a primary key constraint, then a functional characteristic will be added. In addition, we use *owl:ObjectProperty* to represent foreign keys attributes. Therefore, we obtain two ontologies representing the two relational data sources. The process of ontologies development must be particularly reliable for the global ontology construction. In fact, this ontology ensures the connection between various local ontologies and contains the knowledge for the query formulation and the data warehouse construction. The LCL has two relational data sources, each one contains two tables. the *OWL* schema is represented in the following table:

2.2 Query Language

The use of the global ontology as a model for query reformulation is not new. It can be more intuitive for the users. Our system allows queries to exploit concepts of the global ontology and properties of local ontologies. A basic user query is in the form:

Concept ^ Property ^ Concept or only Concept.

2.3 Query Rewriting

The *GLAV* Approach corresponds to each concept $Concept_G$ or V_G from the global ontology a concept $Concept_L$ or a view V_L from the local ontology. A query

Table 1. LCL relational tables representation in OWL

Tables	Equivalent OWL
Collaborator	owl:Class rdf:ID="Collaborator"
MarketingDemand	owl:Class rdf:ID="MarketingDemand"
Person	owl:Class rdf:ID="Person"
Profile	owl:Class rdf:ID="Profile"

expressed in terms of global ontology can not be always reformulated in a view from the local ontology only if the query is expressed in terms of the global and the local schemas. For that we propose the preceding query language (see example in section 2.3.2) and the following rewriting algorithm.

2.3.1 Rewriting Algorithm

The user query expressed in our language query will be rewritten by our algorithm to obtain a set of linked subqueries. If a concept in the user query is not linked with the preceding ones, it will be excluded. Semantically, this exclusion tends to make the query coherent. A coherent query is decomposable into subqueries, and of which its results can be recomposed. The query rewriting can be seen as a mapping between the global ontology and local ontologies.

- **Formal Algorithm**: Formally, a based-ontology mediation system *O* is a triplet *(G, S, $M_{G,S}$)* where *G* is the global ontology, *S* is the set of local ontologies and $M_{G,S}$ are mappings between the global ontology *G* and local ontologies *S* in O.
- **Global ontology**: Let C_g be the set of the hierarchic concepts of the global ontology, An_g the set of annotations, and Annotation a function defined from C_g to An_g.
- **Local ontologies**: Let *S* be a set of *n* local ontologies $S_1, S_2, ..., S_n$. We note A_{si} the set of a local ontology concepts. A_s is the union of the A_{si} of the n local ontologies. Local ontologies concepts are linked by a set Rsi of properties defined in $A_{si} * A_{sj}$. Let R_s be the union of all properties sets R_{si}. Let An_s be the set of annotations and let Wrapping be the function defined from As to An_s which associates to each concept an annotation.
- **Mappings**: the mapping $M_{G,S}$ defines how the concepts of the global ontology *G* and concepts of the local ontology S_i are linked. $M_{G,S}$ is a function from C_g to S_i.
- **Query language**: Queries are expressed in terms of a query language Q_g. In our system, queries are conjunctions of global ontology concepts and local ontologies properties, so we obtain two types of queries:

Algorithm 1 Query rewriting

Entry:
$Q : Userquery$
$G = \{C_{g1}, C_{g2}, ..., C_{gn}\}, S = \{C_{s_1}, C_{s_1}, ..., C_{sn}\}, R = \{r_{s_1}, r_{s_1}, ..., r_{sn}\}$
Result:
$Q_d[k] : The\ set\ of\ k\ queries\ deduced\ from\ Q$
$T[k] : The\ set\ of\ correspondence\ tables\ for\ the\ k\ queries$
$K \leftarrow 1, Q_d[k] \leftarrow Q, NoCorrespondent \leftarrow True$
for all $u \in \{1...Size\ Of\ (Q_d)\}$ **do**
  for all $Q_i\ (i = 1...n) \in Q_d[u]$ **do**
    if $Q_i\ is\ Q_{LAV}$ **then**
      for all $Q_j\ (j = 1...i-1)$ **do**
        Ψ : *the set of subsumed, subsuming or equivalent concepts* C_s *of* Q_i
        Ω : *the set of* C_j *concepts obtained using* C_s *concepts of* Ψ *such as* : $Annotation\ (C_s) = Annotation\ (C_j)$ *and* $C_j \in Q_j$
        for all $C_j \in Q_j$ **do**
          for all $C_h \in \Omega$ **do**
            if $CorrespondConcept(C_j, C_h) \neq \Phi$ **then**
              $HasCorrespondent \leftarrow false$
              $K++$
              $Q_i \leftarrow C_i \cup r_h \cup C_h\{r_h\ is\ the\ role\ which\ links\ C_i\ and\ C_i\}$
              $Q_d[k] \leftarrow Q_d[k] \cup Q_i$
              $T[k] \leftarrow T[k-1]$
              $Addcorrespondence\ (C_j, C_h)\ in\ T[k]$
            end if
          end for
        end for
      end for
      if $NoCorrespondent$ **then**
        $Q \leftarrow Q - Q_i$
      end if
      $Else\{Q_i\ is\ Q_{GAV}\}$
      for all $Q_j(j = 1...(i-1))do$ **do**
        if $CorrespondSubQuery(Q_i, Q_j) \neq \Phi$ **then**
          $add\ the\ correspondence\ (C_i, C_j)\ in\ T[k]$
        else
          $Q \leftarrow (Q - Q_i)$
        end if
      end for
    end if
  end for
end for
$return(Q_d, T)$

1. Either the user uses the global ontology concepts only, in this case we obtain a Q_{LAV} query.
2. Or the user uses the global ontology concepts and the local ontologies properties, and in this case we have a Q_{GAV} query.

- **Query rewriting**: the general idea is that the mediator must obtain a conjunction of Q_{GAV} subqueries and a table of correspondence between the different subqueries. In the case of a query which contains more Q_{LAV} subqueries, it is necessary to reformulate all Q_{LAV} subqueries to Q_{GAV} subqueries to allow the construction of the correspondence table. To rewrite the Q_{LAV} to Q_{GAV} we propose the algorithm (see previous page).

The reasoning mechanism of *OWL*, helps our algorithm to obtain a set of Q_{GAV} and/or Q_{LAV} subqueries, which are equivalent semantically. The goal of the user query rewriting is to eliminate Q_{GAV} subqueries, which have not any relationship with other ones in the same query. *Function2* has as parameters two concepts C_i and C_j and gives, as result the role (if it exists), which links them. *Function1* returns two equivalent concepts or two concepts linked by a role. Our algorithm uses all global ontology concepts and local ontologies roles to provide a set of equivalent subqueries. For each subquery Q_i of the user query Q.

Algorithm 2 Function1: CorrespondSubQuery(Q_i, Q_j)

Entry:
$Q_i, Q_j : TwoSubqueries$, $G = \{C_{g_1}, C_{g_1}, ..., C_{g_n}\}$, $S = \{C_{s_1}, C_{s_1}, ..., C_{s_n}\}$, $R = \{r_{s_1}, r_{s_1}, ..., r_{s_n}\}$
Result:
$(c_i, c_j) :$ *The relationships between* Q_i *and* Q_j
for all $C_k \in Q_i$ **do**
  for all $C_h \in Q_i$ **do**
    if $C_k = C_h$ **then**
      $Return\ (c_k, c_h)$
    else
      if $CorrespondConcept(C_k, C_h)$ **then**
        $Return\ (c_k, c_h)$
      else
        $Return\ \Phi$
      end if
    end if
  end for
end for

- If Q_i is Q_{LAV} subquery, that means it contains only one concept; the algorithm selects concepts C_j into all previous subqueries Q_j of Q. So, we obtain the set of all candidate concepts.
- If the algorithm finds a correspondence between C_i and concepts C_j then, for each concept $C_j \subset \Omega$, it verifies if there is a correspondence between this concept and the concept C_i. If C_i corresponds to C_j then, it will be replaced by C_j. The result is a new rewritten subquery using the corresponding concept.
- If there is no correspondence, the concept C_i is excluded.
- If Q_i is Q_{GAV} subquery, that means it contains two concepts and a role, the algorithm search in previous subqueries of Q, a corresponding subquery. If there is no one, Q_i is excluded.
- The algorithm processes all subqueries into Q. After that it processes new rewritten queries as the initial query.

Algorithm 3 Function2: CorrespondConcept(C_i, C_j)

Entry:
$C_i, C_j : Two\ Q_{GAV}\ Subqueries$, $G = \{C_{g1}, C_{g1}, ..., C_{gn}\}$
$S = \{C_{s1}, C_{s1}, ..., C_{sn}\}$, $R = \{r_{s1}, r_{s1}, ..., r_{sn}\}$
Result:
$(r :$ *The Role, which links* c_i *and* c_j
if $r(C_i, C_j) \in Rorr(C_j, C_i) \in R$ **then**
  $Return\ r$
else
  $Return\ \Phi$
end if

2.3.2 Example

Our approach is validated on LCL relational data sources. The following query concerns all collaborators having an address in .Lyon. and a certain profile:

(Collaborator(x) ^ hasAddress(x; y) ^ Address(y)) ^ (Address(z) ^ hasAsTown(z; "Lyon")) ^
(Profile(p))

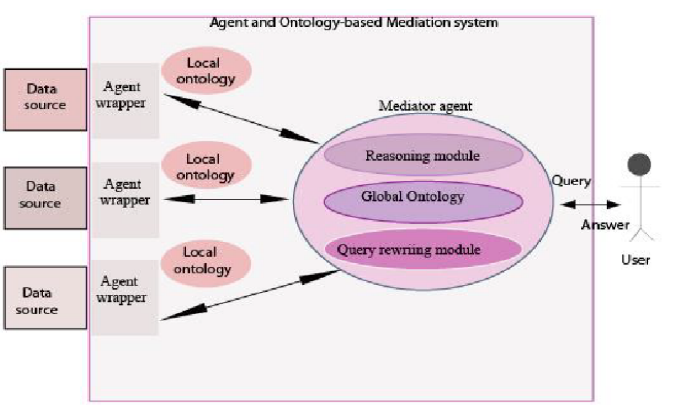
The mediator breaks up it into three subqueries. The two first are sent directly to the sources to be executed because they are linked by the concept Address and thus they can be recomposed by a classic join. However, the third subquery is not linked directly with the two previous subqueries. The mediator must find a link between Profile concept and concepts of the previous subqueries, if there is no link, it excludes this concept. In our example, the mediator must find a link between two concepts .Collaborator. and .Address., which is a property gathering directly these concepts with Profile concept. It can be also a property links Profile concept to another equivalent concept, subsumed or subsuming one of the two previous concepts: *Collaborator* or *Address*. In our case, *Person* concept is the concept subsuming *Collaborator*, and it has a link with *Profile*. The mediator must thus rewrite the third subquery *Profile(p)* into "*Person(r)* ^ *HasProfile(r,p)* ^ *Profile(p)*". It must add in his table of correspondence that *Collaborator* of the first subquery corresponds to *Persone* of the third subquery. It will join its result with the two previous one.

3. IMPLEMENTATION

To validate our approach, we develop a prototype that implements our architecture of mediation. Our system manages data sources independence and their distributivity. It manages also the interaction between global ontology and local ones during the query creation. Our prototype is based on Multi Agents Systems (*MAS*) since they are more adapted for distributed and cooperate environments. Our environment is distinguished from the existing integration systems by mediation by the fact that it enables to express descriptions of sources using the recent recommendation *W3C* for the ontologies description, which is *OWL*. It offers very interesting possibilities of descriptions and reasoning. Our objective is also to combine the power of expression and description of language *OWL* with the aspect communicating and cooperative Systems Multi Agents (*MAS*).

The mediator is an agent that communicates with other agents. It contains the global ontology and the rewriting module. The other agents are the sources agents. The process of query creation or rewriting is done by a dialogue between the agent mediator and the other agents. For the development of this environment, we used a certain number of tools: the ontology editor Protégé2000[1], the framework *JADE*[2] for agents, the framework *Jena*[3] for *OWL*-ontologies handling. Jena is a project of free source code developed by *HP* for the semantic Web. This framework offers us many advantages: it enables to have a uniform access for various ontologies because all information is stored in a *Jena* model. For the reasoning on *OWL*-ontologies, we use the free arguer *Pellet*[4], which allows to reason on the terminological part. Queries interface is presented in the form of a Java Web application based on the framework *Struts*[5].

Figure 2. Based-agent mediator architecture



4. CONCLUSION AND FUTURE WORK

In this paper, we have proposed a new approach of data sources integration based on ontologies in data warehousing environment. Our approach is based on a hybrid architecture, using a global ontology for the mediator and local ontologies for the sources. It is important to create global ontology starting from local ontologies, because this facilitates and improves the resolution of semantic heterogeneity between data sources. We defined a method of ontologies construction, a language which guarantees the correct treatment of queries , by allowing their expression in terms of global and local ontologies. We also proposed a strategy of query rewriting, which ensures the user query coherence, by eliminating concepts not linked with others of the same user query. We applied our approach of ontologies creation on the relational sources of the LCL.

These ontologies are used in our system of integration, and were useful in the phase of creation and rewriting of queries. Various perspectives are considered. Initially, completing the implementation. Then the adaptation of the system to the various sources of information. It will be necessary to automatize the ontologies conception method. To reach this goal, we think to use data mining techniques to generate concepts classes and relationships in a formal way.

REFERENCES

[1] G.Wiederhold. Mediation in information systems. In ACM Computing Surveys, 27(2) : 265-267, June, 1995.

[2] H.Wache, T. Vogele, U. Visser, H. Stuckenschmidt, G. Schuster, H. Neumann, S. Hubner. Ontology-Based Integration A Survey of existing Approaches, In proceeding of IJCAI-01 Workshop: Ontologies and information Sharing, SeattleWA, pp 108-117, 2001.

[3] M. Uschold, M. Gruniger. Ontologies: Principles, methods and applications. In KnowledgeEngineering Review,11(2):93155, 1996.

[4] Marco Ruzzi Data Integration : state of the art, new issues and research plan. 2004

[5] Y. Arens, Chun-Nan Hsu, C. A. Knoblock. Query processing in the SIMS information mediator. In Advanced Planning Technology. AAAI Press, California, USA, 1996.

[6] E. Mena, V. Kashyap, A. Sheth, and A. Illarramendi Observer: An approach for query processing in global information systems based on interoperability between pre-existing ontologies. In Proceedings 1st IFCIS International Conference on Cooperative Information Systems (CoopIS 96)Brussels, 1996.

[7] Chung Hee Hwang. Incompletely and imprecisely speaking: Using dynamic ontologies for representing and retrieving information In Technical, Microelectronics and Computer Technology Corporation (MCC),1999.

[8] M C. Rousset, A. Bidault, C. Froidevaux, H. Gagliardi, F. Goasdou, C. Reynaud, B. Safar. Construction de médiateurs pour intégrer des sources d'information multiples et hétérogènes : le projet PICSEL, In Revue I3 (Information Interaction Intelligence), Vol.2, N1, p. 9-59.2002.

[9] V. S Subrahmanian, S Adali, A. Brink, R. Emery, J. J. Lu, A. Rajput, T. J. Rogers, R. Ross and C. Ward HERMES: A heterogeneous reasoning and mediator system. Technical report, university of Maryland , 1995.

[10] H. Stuckenschmidt, H. Wache, T. Vogele, U. Visser Enabling technologies for interoperability. In Ubbo Visser and Hardy Pundt, editors, Workshop on the 14th InternationalSymposium of Computer Science for Environmental Protection,pages 3546, Bonn, Germany, 2000.

[11] D. Calvanese, G. De Giacomo, M. Lenzerini. Description logics for information integration. In Computational Logic: FromLogic Programming into the Future (In honour of Bob Kowalski), Lecture Notes in Computer Science ,Springer-Verlag, 2001.

[12] M. Friedman and D. S. Weld. Efficiently executing information gathering plans. In 15th International Joint conference on Artificial Intelligence,pages 785-791, Nagoya, Japan, 1997.

[13] O.Etzioni and D. Weld. A Softbot-based Interface to the Internet. Communication of the ACM ,37(7):72-76, 1994.

[14] M. R. Genesereth, A. M. Keller and O. M. Duschka. Infomaster: an information integration system. In Joan M. Peckman, editor proceedings, ACM SIGMOD International Conference on Management of data: SIGMOD 1997 ,May, 1997.

[15] Marc Friedman, Alon Levy, and Todd Millstein Navigational plans for data integration. In Proc. of the 16th National Conference on Artificial Intelligence (AAAI99), pages 67-73. AAAI Press/The MIT Press, 1999.

[16] J-C.R. Pazzaglia , S.M. Embury. Bottom-up integration of ontologies in a database context. In KRDB98 Workshop on Innovative Application Programming and Query Interfaces, Seattle, WA, USA, 1998.

[17] Cheng Hian Goh. Representing and Reasoning about Semantic Conflicts in Heterogeneous Information Sources Phd, MIT,1997.

ENDNOTES

1 http://Protégé.standard.org
2 http://jade.tilab.com
3 http://jena.sourceforge.net
4 http://www.mindswap.org/2003/pellet/
5 http://jakarta.apache.org/struts/

The Value of Virtualization for Web Environment

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ABSTRACT

The success of many e-commerce applications depends on their reliability, robustness and security. Designing a web server architecture that advances these properties without compromising performance is a challenging task. Effective and efficient web applications demand a virtual operating environment which is autonomic, integrated and based on open standards. A virtualized environment makes the most efficient use of its resources by sharing resources and providing what is needed only when it is needed. This paper, examines the role of virtualization as a booster of IT utilization and as a driver of IT operational agility.

Keywords: virtual system, operational agility, web-server, integration, flexibility, operational access

1. INTRODUCTION

While the business world has recognized the need to be agile in order to survive a tumultuous and unpredictable environment, the IT industry has been busy through the 1980s and 1990s investing hundreds of billions of dollars into creating complex, underused IT environments. This costly infrastructure has not been able to cope with constantly changing needs and a perpetually evolving business climate. In 1993 Brynjolfsson (1) examined the productivity paradox and questioned the value of increasing IT investment without corresponding benefits. The debate is still ongoing and has produced inconclusive results (2) Following drastic cost cutting measures of the early 2000s, the market settled for flat budgets, increased workloads, and intense pressure to achieve more with less. Inputs have been affected by less extravagant resources requests and helped by the tumbling hardware prices while outputs are increasingly raised through better utilization of existing computing assets. For example IDC estimates that the overall server average system selling price fell by about 16% from 2001 to 2002 (3). Yet, with business increasingly conducted online and with advertising, sales, and support highly dependent on the internet technologies, high volume web servers are now subject to intense scrutiny. The upgrading of existing workstations, servers, networks, or storage by adding additional hardware to accommodate new requirements often competes with other business priorities and faces reluctance from the other business functions to fund perceived cost centers. Better integration and consolidations have been sought as a way to improve IT effectiveness and efficiency.

Moving forward involves the coordinated efforts to integrate technologies, processes, and people while satisfying business priorities. Innovative solutions are percolating through industries and reaching the end-users. One of the most discussed topics of the last two years has been virtualization. Virtualization is not a new concept; after going through a golden age in the mainframe environment in the 1970, a dark age brought by the underpowered PC era, and a long incubation period as computing power followed the Moore's law since the 1980s, it is ready for a comeback. Experts in the field prescribe a resource virtualization renaissance to address problems such as security, performance, and reliability (4).

The old utopia of integration and better utilization across departments, firms, and the business eco-system at large is now enabled, in part by a number of technologies under the umbrella of virtualization. Virtualization is a technology about workload consolidation to drive up utilization by subdividing the resources of modern Information Technology. It divides one piece of real hardware into numerous virtual ones, where each is managed separately and is more resource constrained than the original machine. The technology can be deployed as both hardware virtualizations through partitioning and through software virtualization where each application brings its own set of configurations on-demand.

2. DEFINITION

Defining a concept is always open to different interpretations. For example agility, reliability, and flexibility have many facets and are defined differently by diverse professional community. Singh (5) defines virtualization as a framework or methodology of dividing the computer resources into multiple execution environments, by applying one or more concepts or technologies such as hardware and software partitioning, time sharing, partial or complete machine simulation, emulation, quality of service, and many others.

It is easy to perceive how this definition applies equally well to the concept of time-sharing adopted on mainframe in the early years of computing and the latest trends on operating system virtualization allowing for example a single laptop/desktop to run Apple OS X, Linux or Microsoft Windows Vista.

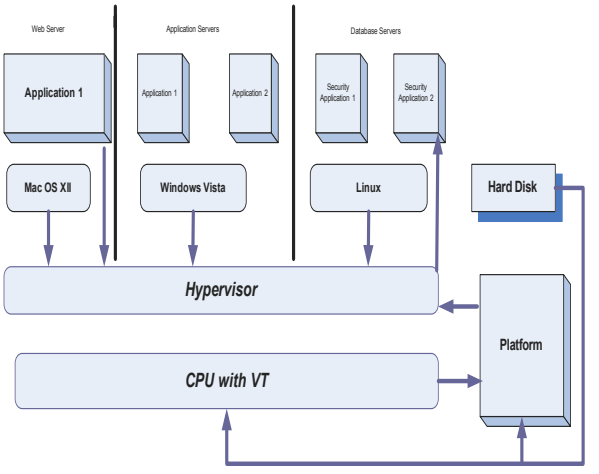
Figure 1 illustrates a generic e-business architecture with virtual servers.

3. DEPLOYMENT

While the hardware cost by itself was the main driver of virtualization in the 1960s, its recent incarnation is motivated by different factors. Standard IT budget could let both hardware and software stand at less than 10% of yearly IT expenditures. Thus the largest potential for added value is through better processes, people and utilization of existing resources. To achieve higher utilization, keep pace of changes in configuration, and maintain a high level of availability of systems (e.g. on a 24/7 e-business environment) virtualization should provide means to provision, deploy, and maintaining system using off band capabilities.

Chris Wolf (6) contends that virtualization is going mainstream. Virtualization is now considered a serious tool for production environment. The use of virtu-

Figure 1. Virtualization architecture



alization expands from its traditional use as a development platform to critical production environments.

Leading IT industry software companies are jousting to have a role in this evolution. Big players such as Microsoft, IBM, EMC, and HP are considering virtualization either as a hardware, software, or storage advantage and are acquiring smaller companies that have a head start in virtual systems. Microsoft, once reluctant to the idea has recently adopted a more flexible stance with its purchase of Connectix and the release of *virtual server.* Anticipating the market trend Microsoft acquired Softricity, a leader in virtualization and application streaming solutions, and promoted Windows Server Virtualization as a part of the new Longhorn platform using software code-named Viridian as a hypervisor by 2008. It will only be available on 64-bit versions of the server operating system, and similarly only available if the physical hardware supports either IVT (Intel's Hardware Assistance for Virtualization) or AMD-V (AMD's Hardware Assistance for Virtualization). The open source has also been working on evangelizing virtualization and the Xen project is the most widely distributed hypervisor coming through this avenue.

IBM (7) claims that today CIOs are making significant headway in *On Demand* Business and aims its virtualization to the idea of utility computing. They are leveraging their mainframe experience (i.e. They introduced the concept in the 1960s) and present virtualization and other on demand technologies to deploy services and to lower computing infrastructure and labor costs. They are supplementing their portfolio with acquisitions such as Rembo that provides the ability to maintain and deploy software images, automated installation and customization across multiple locations. The product has security features that can protect workstations used by multiple people in a virtualized environment by automatically "wiping away" operating systems and personal data after each use and re-installing clean software thereby addressing security concerns.

HP has similar ambitions. HP virtualization solutions will help an organization pool and share IT resources, lowering its costs by optimizing utilization while increasing agility, enabling the rapid response to changes in the marketplace. HP's offerings encompass three levels: element virtualization, integrated virtualization, and complete IT utility, which represent increasing business value and strategic importance to an organization.

EMC has been the major player with virtualization products it obtained from its 2004 acquisition of VMWare that provided a range of products including VMWare Workstation, GSX server software, and ESX server with its hypervisor directly installed on bare metal machine without additional host operating system (6).

In the enterprise storage domain, There is a great deal of excitement in the storage industry about the potentials of virtualization technology to reduce total cost of ownership (TCO) and increase utilization of existing enterprise storage systems. Virtualization leverages the connectivity that is provided by storage area networks (SANs), by creating an abstraction layer between the servers and the SAN. This abstraction enables the servers in the SAN to view the physical storage as a common pool of capacity. While forthcoming, this view has not yet been fulfilled for lack of complete solution across heterogeneous vendor products (9).

As the most established IT industry contenders push for its deployment, virtualization is deemed to become one of the dominant trends in the coming year and is one of the most exiting areas of IT. Virtualization is commonly quoted when associated with main aspects of IT. Primarily organizations use virtualization in conjunction with servers, operating systems, applications, storage, data center, and networks (10).

3.1 Web Server and Virtualization

Increasingly business is conducted online. With advertising, sales, and support depending on the internet technologies, high volume web server are critical to business continuity.

Efficient web applications demand a virtual operating environment which is resilient, autonomic, integrated and based on open standards.

A virtualized environment makes the most efficient use of its resources by sharing resources and providing what is needed only when it is needed. Not only are resources highly used, excess capacity can easily be used for new or unexpected needs.

Nowadays the success of many e-commerce applications, such as online banking, depends on their reliability, robustness and security. Designing a web server architecture that keeps these properties under high loads is a challenging task because they may conflict with performance.

3.1.1 Value of Virtualization for Web Server

Virtualization is directly relevant to a web server life cycle. From inception to replacement a web server (both physical and logical) is a prime candidate for virtualization. Web servers with dynamic content have particular attributes. They have an accelerated life cycle and need to be developed, provisioned, deployed, and maintained on a short timetable. In addition, in e-commerce, loads are difficult to predict and web servers located in the insecure Internet or a demilitarized zone (DMZ) are subject to intense security risks.

3.1.2 Consistent Platform

The virtual server software hides the physical hardware and creates a generic hardware platform that is consistent regardless of the physical server used to host virtual servers (11). This virtual platform makes the transition from development to deployment to operation seamless and alleviates problem of compatibility among platforms. Load testing can also be achieved by varying the resources allocated to the VMM.

For example VMware ESX allows you to control CPU time, memory space, network bandwidth, and storage bandwidth. Similarly in the Sun architecture, the Solaris Resource Manager software gives its administrators almost unlimited flexibility to assign and isolate resources to specific containers. Resource pools can be changed either manually or automatically on a rule basis.

3.1.3 Isolation of the Development Environment to the Production Environment

During development it is not rare to have systems crash unexpectedly. The partitioning of resources into secure containers will avoid side effect of the crash on the host system and concurrent VM. Virtualization will also provide almost instant recovery of an instance through a pre-staged process.

With the many generations of computer hardware reaching the market and constituting a complex mix of basically incompatible resources, virtualization in the server space hides the physical hardware from the virtual servers (12). The virtual server presents a generic consistent interface making restoring a virtual server easier.

3.1.4 Increased Automation

Manually tuning is often infeasible due to unpredictable loads and requests arrival rate. Computer systems, Web servers included, could use analytic performance models as a guide to dynamically adjust configuration parameters such as the number of active processes (13,14,15). Virtualization technology is well equipped to solve the problem by automating resources allocation initially and adjusting them based on simple rules sparing human intervention.

Automation of the provisioning, maintenance or recovery process is a problem derived from shifting cost from hardware/software to servicing systems and the unfeasibility to tend to individual server on a timely basis. For years firms such as Landesk, Softricity, and Rembo have been dedicated to such endeavors. Layering virtual solutions above the bare hardware makes the deployment of a number of virtual machines painless and will make the upgrade of virtual machine feasible with techniques such as in VMWare vmotion allowing to move a running virtual machine from one physical server to another.

3.1.5 Higher Hardware Utilization

One of the leading detriments of distributed powerful computers is their low utilization and stretched low ratio of server/administrator. Hardware costs, while not the burden it once was, still are remarkably ineffective. With rapidly advancing technology organizations wants to spare unnecessary hardware purchase, knowing that the next generation will bring more power at less cost. Running multiple virtual servers per physical host adds significant savings that can be better invested in other aspects of the systems.

While potentially using hardware resources to their limit could raise problems with power consumption, its planning is enhanced by better measurement of the existing assets.

Security. As distributed architecture and increasing dependence on the Internet has grown, security has become a critical preoccupation for most organization. Risks and threats are being addressed by virtualization by isolating environment. Before virtualization, control was often a tradeoff for agility. The only way to restrict exposure was to limit the number of applications running on a server,

which lead to reducing flexibility and increasing administrative operating costs. For example for a Internet service provider hosting traditionally was procured by either offering expensive dedicated physical servers or sharing through software running on a unified platform. In the first case customers could have managed service or simply take advantage of the co-location of a data center. In both cases administration still was difficult to control. In the second case restrictions were more stringent, limiting installation or use of customized software packages. With virtual servers this is no longer the case, allowing more freedom in a more robust environment.

4. PERFORMANCE

Performance has always been an issue in IT. In fact database, storage or network experts are quite obsessed with benchmarks and measurements. Processor manufacturers have measurements by MHz for particular architectures and recently they are moving to multi-core CPU in order to take full advantage of multithreading. In networking flows are monitored with bandwidth speed. In such competitive environment any overhead is looked at unfavorably. The concept of Virtualization may be a solution to performance problem, but while it is showcased as decreasing complexity and increasing flexibility, complaints still abound about machines running slowly when running emulation.

One solution is IBM's virtual machine model where each virtual machine is an exact copy of a real machine with limited set of resources, but often optimized by hardware support. High security is achieved through filtering by a control program of instruction potentially damaging to concurrent virtual machine (e.g. memory changes, storage modification). In the Java virtual machine the software provides an abstract layer sandboxing the real hardware from harmful access.

4.1 Sources of Overhead

With full virtualization or emulation the system is simulating a completely different computer chip. Virtual applications running on top of an emulated system incur a level of overhead which almost always lead to disappointment. Even with increasingly powerful processors and faster computer memories the interpretation of programs will be slower than running in their native form.

The additional sources of overhead include the reflection of exceptions and I/O interrupts to the virtual machines, support of virtual timers and clocks, and the translation of I/O channel programs before the VMM initiates I/O. When the application depends on time synchronization with actual time, emulation often leads to incorrect results or excruciating complex solutions (16).

The virtualization control software, called a hypervisor or virtual machine manager, imposes a performance penalty as it manages resources such as memory or input-output. Traditional CPUs were not designed to run a variety of operating systems simultaneously. With new set of processors the major CPU developers are trying to fix some of the performance penalties.

4.2 Improving Performance

Hardware facilitation of virtual machine monitors is seen as one avenue out of the performance bottleneck. Intel has recently launched its VPro line of microprocessor derived from the Vanderpool aimed at boosting both performance and security. AMD has competing line of Rev F processor with Pacifica and Presidio also emphasizing virtualization and security. IBM POWER5 systems combine enhancements to the processor architecture with greatly better firmware to increase its virtualization. The most recent microprocessors architecture with multiple cores is the response to demand for virtualization. This new approach has superseded the long time race for increase in clock speed. The first generation caught software vendors and organization by surprise and subsequently added the non-technical uncertainty in operating systems and applications licensing. Similarly to obtain full benefit from multiple core systems the operating system and applications should be multithreaded. Virtualization can also assign core to alternative operating environment, making full use of the processing capabilities. Since the market place has adopted compromises to the licensing issue ranging from a licensing per processor to reduced licensing cost per core.

5. PRACTICES

IT practitioners and researchers are by nature open to adopt latest technologies. Often burned by the initial hype of new technologies but also helped by subsequent ramping up of emerging techniques that make practice simpler or better. Although the market response to virtualization has been quite remarkable, as a practice, it is still in its infancy.

5.1 Future Trend for Virtualization

Currently processors such as IA-32 do not facilitate virtualization and the VMM has to work hard to get the benefit of full system virtualization. Without any hardware assistance virtualization running unmodified guest OS do not get the performance expected. Para-virtualization offer a remedy to performance at the detriment of requiring either special hardware or running a limited set of guest OS customized to run over the particular VMM. The most common Para-virtualization systems are Xen (17) and Denali. A side effect of the customized OS is that they support and provide a limited set of generic devices to the guest OS. This limits the use of most innovative new I/O devices for network or storage support.

The best hope in the near future is the upcoming generation of processors from Intel, AMD, or IBM. Providing the VMM with the possibility to run at ring -1 or have the necessary hardware assist for the common privileged instructions which would otherwise have to be trapped and simulated by the VMM. Similarly experience with virtualization and a healthy competition among future OS providers will lead to more robust guest operating systems, thereby alleviating some of the risks associated with potentially errand commands.

5.2 Security Impact

Virtualization is often perceived as having a positive impact on computing security. The isolation of applications within their own space, transparency, and segmentation of resources under a tight centralized control are potentially confusing to the attacker and make the system more reliable. The network fingerprinting by hacker is more difficult as real resources are opaque to a scan. In an environment with non expert end-user, open Internet access and traditionally less robust platform, virtualization add one layer of indirection which make virus or rootkit infection more difficult. As previously stated recovery from disaster is rapid.

On the other hand integration and aggregation of the pool of resources in a data center offered by virtualization(18) is attractive from an operation point of view but will makes the target more attractive to hackers. In a scenario where the Virtual Machine Monitor is infected by a rootkit, the attacker would be able to take control of a vast array of organizational resources and would go undetected by conventional methods. A VMM running on ring -1 infected by a rootkit would present a virtual virgin interface to virus/malware checker and applications file integrity would also be duped. Similarly virtualization will have to be more coordinated with security tool providers to solve real questions. For example of IDS/IPS rely on physical host data to check for traffic patterns when not relying on signature based detection. With virtualization and knowing where the data is coming from is more indeterminate. Other security issues will arise when n layer system could be based on MAC addresses or IP addresses for authorization. Example could be a Web Server talking to an Application Server talking to a Database Server for dynamic queries. Aside from performance issues of a virtual system, the transition from virtual to physical and back to virtual could become quite confusing especially if virtual machines are dynamically moved from server to server.

The scenario could either lead to consolidation in the market or lengthy alliance process making adoption of best of breed system more problematic.

6. CONCLUSION

Almost after 80 years since virtualization was introduced by IBM (19) around 1927, IT people entertain the same concern that machine utilization percentages are an important measure of data processing management competence. Virtualization across a number of information technologies has made a comeback with a transition from mainframes to distributed systems. Virtualization has rapidly been adopted by small to large organizations. Particularly when mass customization is to be applied to systems, virtualization offers the benefit of central control and the flexibility to have stakeholders have a system adapted to their needs.

REFERENCES

[1] Brynjolfsson, E. 1993. The productivity paradox of information technology. Commun. ACM 36, 12 (Dec. 1993), 66-77.

[2] Eastwood, M. and Yang, J. 2003. Worldwide Server Workloads 2003: The continuously evolving relationship between applications and servers, IDC #30686, Vol. 1

[3] Oz, E. 2005. Information technology productivity: in search of a definitive observation. Information & Management, Vol. 42, pp 789-798.

[4] Figueiredo, R. Dinda P.A. and Fortes J. Resource Virtualization Renaissance, IEEE Computer, Vol. 38, No. 5, 2005, pp. 28-31.

[5] Singh, A. An Introduction to Virtualization, Retrieved May 2006 from: http://www.kernelthread.com.

[6] Wolf, C. Virtualization goes Mainstream. Retrieved May 2006 from: http://redmondmag.com/features/ article.asp?EditorialsID=548

[7] Popek, G. J. and Goldberg, R. P. 1974. Formal requirements for virtualizable third generation architectures. *Commun. ACM*, Vol. 17, No. 7 , 1974, pp. 412-421.

[8] VMWare, ESX Administrative Guide, 2006.

[9] Yoshida, H. Virtualization: the Promise and the Reality, *Hitachi Whitepaper*, April 2002.

Usability Analysis of Concept Maps as Knowledge Discovery Tools

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ABSTRACT

The potential application of concept maps in knowledge discovery is examined using a framework comprising usability, learnability, and task & technology fit. An online survey and follow-up interviews indicated that teachers and administrators at the Ministry of Education in Singapore were comfortable in using concept maps. They expressed that concept maps should to be integrated with search engine tools. Usability analysis suggested that enhancements in functional design of concept maps, improvement in quality of contents, and regular updating of resources were important to attract mass usage of concept maps.

INTRODUCTION

Concept maps are one of the most notable methods for representing relationships between concepts. Using this premise as a basis for further investigations, many researchers have begun to analyse various applications of concept maps, including organising and presenting information to aid knowledge discovery. Concept maps have their roots in education. The idea was grounded in the sound learning theories of Ausubel (Novak & Gowin, 1984) who posited the importance of prior knowledge in learning new information. The fundamental idea is assimilation theory where learning takes place by the assimilation of new concepts and propositions into existing concepts and prepositional frameworks held by the learner.

Concept maps are tools for organizing and representing knowledge that include concepts; usually enclosed in circles or boxes of some type; and relationships between concepts or propositions; indicated by a connecting line between two concepts. Words on the line specify the relationship between the two concepts. The basic graphical elements are nodes and links, which are organised using common patterns, such as branches, arrows, groups, notes, lists and so on. Nodes (points, vertices, icons, and so on) represent the concepts, and links (lines or arcs) represent the relationships between concepts. Figure 1 portrays an example of a simple concept map.

Concept maps are representations of a set of concepts and their relationships and concept mapping is a technique for representing knowledge or information in graphical form by listing relevant concepts and then drawing lines between them to represent their interrelationships. When two or more concepts are connected, a meaningful statement or proposition is formed. Propositions are statements about some objects or events in the universe, either occurring naturally or constructed (Cañas et al. 2003). They are also called semantic units, or units of meaning. Typically a concept is expressed using one or a few words with labelled links. These links are lines or curves with phrases that connect concepts to form relationships. A linking phrase is used to join concepts to form a meaningful proposition, which is a basic unit of knowledge according to the theory of meaningful learning. Nodes in a map do not carry any information. Arrowheads in the links specify directions which determine the logical connection of the relationships. Curved lines can be used when straight lines cannot be used to link the nodes, thus providing the flexibility to avoid rearrangement. Another important element of concept maps is Cross-links. Cross-links make explicit relationships between or among concepts in different domains within the concept map.

Much research on users' perceptions of concept maps has been done in the context of the tool's application in education. Santhanam and Dawson (1998) investigated the effects of concept mapping to students taking subjects in genetics. Uzuntiryaki and Geban (2002) examined concept mapping instruction in the science subject by comparing it to traditional instruction. Potelle and Rouet (2003) studied the effects of concept maps on low and high knowledge students.

Figure 1. An example of a concept map

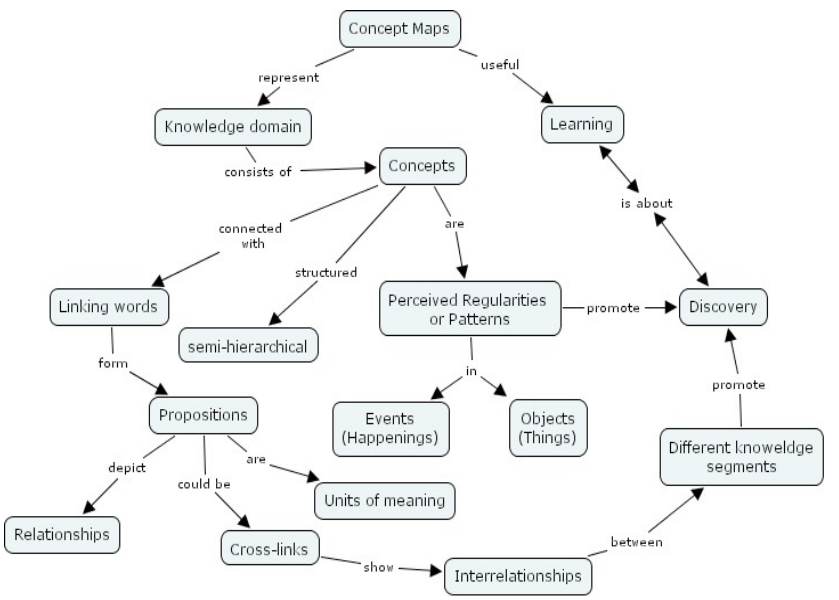
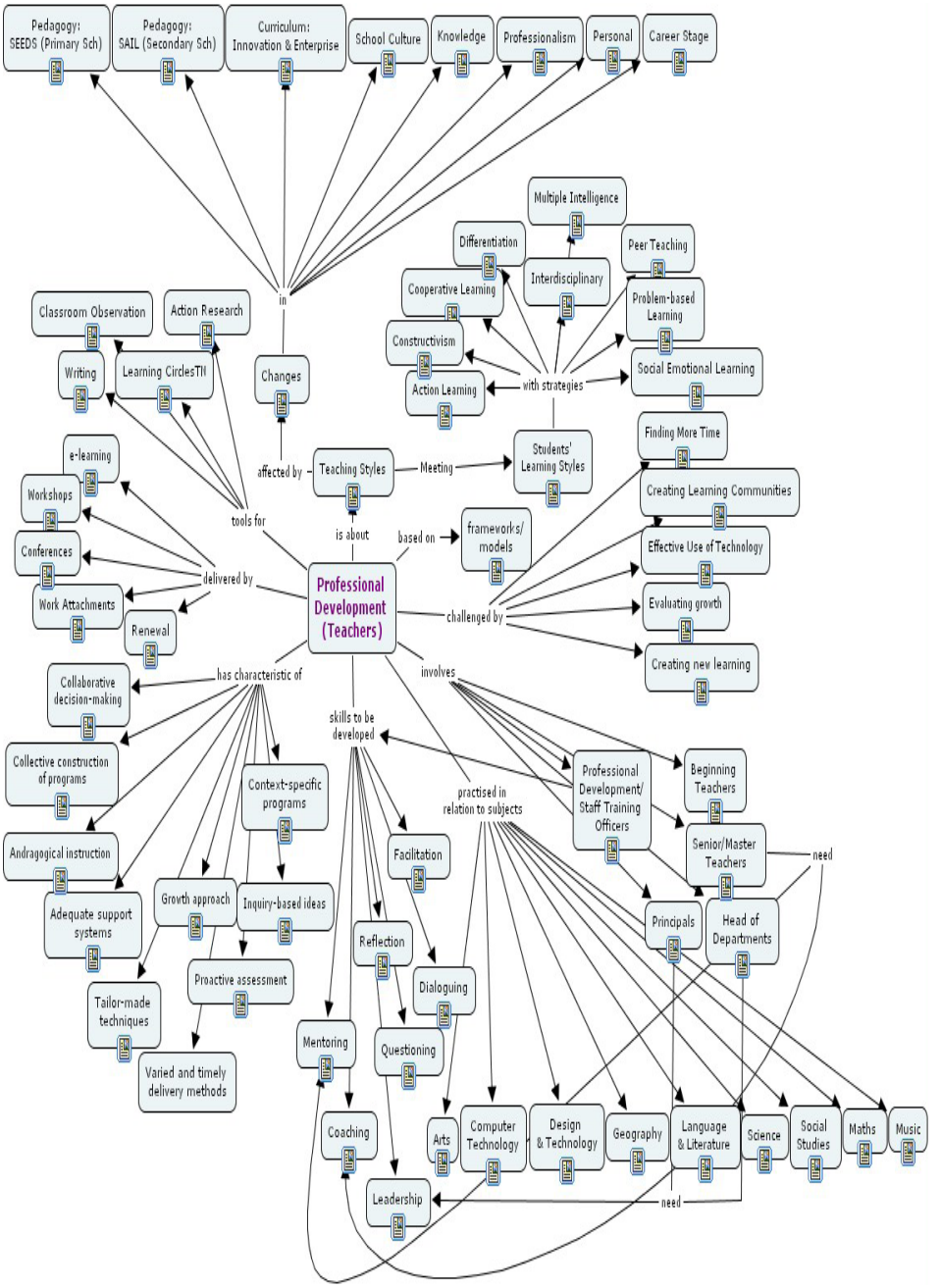


Figure 2. Concept map on teachers' professional development



Research on users' perceptions of concept maps in the knowledge management field is not very prevalent. Much of it deals with knowledge elicitation and knowledge construction. Ford, et al. (1996) described a nuclear cardiology expert system called NUCES in which concept maps were used for knowledge elicitation and navigation. Leaker et al. (2003) described an approach to support experts as they built their own knowledge models of a domain. Mularz and Lyell (2004) explored the integration of concept maps and semantic web technologies for the capture, visualization and navigation of knowledge in support of the lifecycle of knowledge management.

This study was aimed at investigating the potential application of concept maps in knowledge discovery. Teachers' professional development was chosen as the central topic for developing a prototype concept map to be used for review. Relevant concepts were derived from selected information repositories and reference questions received by READ@TN (Teachers Network's information resource centre at the Ministry of Education in Singapore). The prototype concept map covered a set of terms and their relationships, which also took references from Educause taxonomy (http://www.educause.edu/Browse/647), ERIC Thesaurus (http://eric.ed.gov/) & Library of Congress Subject Headings (*LCSH)*. Relevant documents were categorised and linked to the established concepts and their associations. User feedback on the usefulness was of the concept map was sought from a group of teachers. This domain-specific concept map was implemented to function as a finding aid.

A framework comprising usability, learnability, usability, and task & technology fit was used for review of concept maps. Based on this framework, several parameters were identified to perform usability analysis by two main groups of stakeholders: teachers and administrators. It served as a map of the knowledge for a community-of-interest in the area of continuing professional development for teachers.

DATA COLLECTION

Original concepts for the map were derived from the writings of Diaz-Maggioli (2004) and Zmuda (2004). These concepts were subsequently presented to a team working on teachers' professional development for comments and amendments. *CmapTools, (*an open source tool by the Institute for Human Machine Cognition (IHMC), University of West Florida) was used to construct the concept map. It allowed easy publishing of knowledge models in concept map servers and enabled concept maps to be linked to related concept maps and to other types of media. Linking phrases were added to the key concepts on the preliminary concept map to express the relationships among concepts. This was followed by adding cross-links to illustrate the inter-relationships between concepts in different areas or sub-domains on the map.

A total of 157 documents housed by READ@TN were linked to the relevant concepts. These included mostly documents in Microsoft Word and PDF format. In-house web pages and quality information from external websites were also linked to the concept map. Most concepts had one or two documents attached to them to give the respondents a flavour of what they could expect on the concept maps. The concept map was subjected to several rounds of reviews by senior education officers. Changes to the structure and contents were made prior to implementing the prototype on a hosting server (http://www.100free.com) at http://leeyf.100free.com. The availability of concept map on the Internet provided ease of access for participants. They could experience the working of the concept map at their convenience. On the basis of their experience they subsequently responded to a questionnaire survey (which was also web-based). Figure 2 show the final concept map constructed.

Thirty education officers and five administrators participated in the online usability survey. The participants were invited to view the concept map after a demo was arranged to introduce the concept map to them. Eighteen participants signed up for the follow-up interview (three senior administrators, nine senior education officers and six junior education officers).

FINDINGS

Usability

Three parameters including ease of use, effect, and satisfaction were used to review the usability aspects. Feedback from participants on these parameters is reported in the following section.

Ease of Use

Ease of use of the concept map encompasses the notion of simplicity and accessibility of finding and discovering information. Seventy-seven % participants reported that the concept map presented to them was easy to use. However, a fair portion of the respondents felt that, when the map was first presented to them, they were overwhelmed by the concept map and had difficulty understanding and using the map.

Twenty-nine % indicated that navigating the concept map was easy. All respondents were able to follow the logic of the navigation. Most participants were able to appreciate the navigational logic of the concept map. A large majority was able to easily navigate the concept maps for relevant information.

Sixty-eight per cent participants supported the proposition that concept maps improve the information searching output; while 14% did not agree that concept maps added value to the information searching experience. Despite the differences in opinion, all participants acknowledged concept map as a useful tool to aid knowledge discovery. They expressed that concept maps could provide guidance and direction to the information search process.

Satisfaction

Satisfaction is derived when a user is able to perform his/her information search task successfully. About one-third participants strongly supported the acceptance of concept maps while almost two-third expressed continuing interest to use concept maps in the future. When asked which group of Internet users could effectively use concept maps to search for information, 69% felt that concept maps would be accepted in all strata of Internet users; 71% felt that concept maps could only be accepted by novice Internet users while an astonishing 94% agreed that seasoned Internet users were capable to effectively use this finding aid. Forty-nine % felt comfortable using the concept maps. A further 31% were confident; only 17% experienced some stress while using concept maps to find information. The findings revealed a moderately high level of satisfaction and acceptance to the use of concept map in the context of teachers' professional development. The fact that participants had indicated strongly their desire to use concept maps shows a high level of confidence within them in this information search tool.

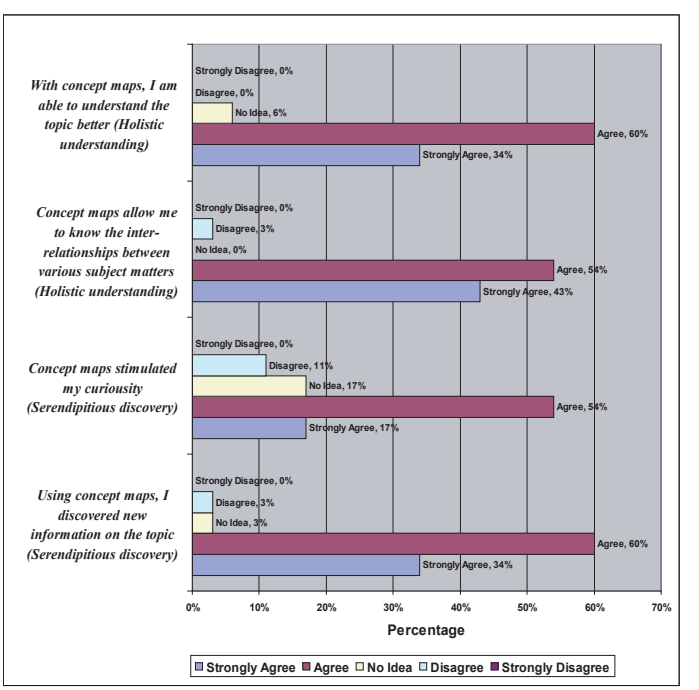
Effect

The effect of concept maps is tied to performance and outcome of the information searching exercise. There is a good spread of responses on the effectiveness of concept maps compared with other online search tools such as Internet search engines, Internet directories, library online catalogue. Forty-two % participants maintained that concept maps were more effective while 32% felt otherwise. More than three-quarter (77%) either agreed or strongly agreed that their overall experience with concept maps was successful and positive. All respondents felt that concept maps were able to guide them in their information search. They expressed full confidence in concept maps reflecting that concept maps provide a sense of purpose in finding information. However, statistical analysis suggested that concept map alone was not able to replace the role of other search tools like Internet search engines (e.g. Google, MSN Search) and search directories (e.g. Yahoo Directory), as less than half believed it could do so.

Learnability

Learnability refers to the ease of learning the system's functionality and gaining proficiency to complete the search for information. Our analysis attempted to review whether the concept map as an information search system encouraged holistic understanding and supported serendipitous discovery. We also reviewed if the concept map was able to enhance a broader understanding of concerning concepts surrounding each topic. When the concept map was developed, we expected that with the inter-relationships between various sub-topics (concepts) teachers would be able to gain breadth in their subject of interest. In the review, we wanted to

Figure 3. Learnability aspects of use of concept maps



find out whether the concept map demonstrated the ability to arouse interest on related concepts to facilitate the discovery of new information domains. Figure 3 displays the trends among participants on these learnability aspects.

Analysis of responses of participants indicated a good potential of concept maps on the various learnability aspects. In terms of holistic understanding, 94% participants agreed that concept maps provided them an overview of the topic and helped them understand the topic better. All respondents either agreed or strongly agreed that concept maps allowed them to explore the inter-relationships between various subject matters. In terms of serendipitous discovery, 71% of the respondents indicated that concept maps stimulated their curiosity. Almost all respondents asserted that they were able to discover new knowledge through the use of concept maps.

Task & Technology Fit

As the study looks into the learner's ability to interface with concept maps to find information, the issues on Task and Technology Fit (TTF) comes into play. Various elements of TTF were of concern in this study. These included the following parameters:

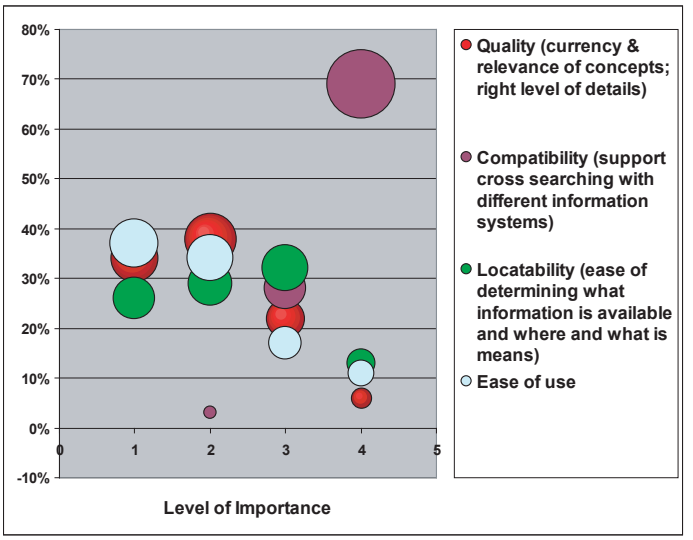
- Quality of concept maps
- Ability to locate information
- Compatibility with other information searching system
- Ease of use

The participants provided input on the importance of the various parameters. Ease of use and quality were viewed as the most critical elements, ability to locate information was ranked third, and majority viewed compatibility as least important. The issue of compatibility was not a serious concern to the respondents in their information finding. Figure 4 shows the level of importance attached to concept maps.

The study highlighted several interesting points in terms of TTF. Most participants pointed out that the quality and the ease of use of finding aids take precedence over other considerations. It is therefore vital that concept maps be designed taking these understandings in view. Despite concept maps' ability to enhance the searching experience and facilitate knowledge discovery, they are not widely used among educators in Singapore to find information, as discovered in this study.

In terms of human-computer interactivity, concept maps provided good interactivity between the system and the users. This was supported by more than half of the respondents. Again, with strong evidence from respondents that there was considerable interactivity between concept maps and the user, one could infer that concept maps are useful tool to facilitate knowledge discovery. In terms of functions, most of the respondents felt that concept maps were most suitable to search for well defined items. About one- third also recognized that concept maps were able to perform accidental discovery of useful information. Sixty-two % felt that concept maps made information finding easier, while only 6% disagree. About 45% agreed or strongly agreed that they could save time looking for information using concept maps, compared to occasions where they had to use Internet search engines and directories. About 30% disagreed with the earlier group. On the basis of these findings one can safely conclude that concept maps could complement other web-based search tools in providing users with a complete information finding abilities.

Figure 4. Task & technology fit



DISCUSSION

One of the strengths of concept maps is their facility to provide meaningful orientation and visual bearings to support information search through the use of nodes, labelled-links and cross-links. The participants of this study were able to appreciate this. An interviewee quoted *"What I liked about concept maps was that it gave me a birds' eye view of the information I was looking for. I get a good macro perspective of the topic and associated ones"*. Another said "*the links are especially helpful to let us know relationship between various subjects. I could never get such things from Google or Yahoo. The cross links added another useful dimension on the information, which is very valuable when I need to explain the subject to my course participants."*

The cross links value-add to the information finding process. They support the users in navigating the concept map. All participants agreed that the links contributed to their smooth accessing of relevant information. However, placing links on concept maps is a double-edge sword. Some interviewees have cautioned not to over-cluster and impair the smooth navigation of the concept maps by inserting excessive links.

More than 80 % participants claimed that concept maps had stimulated their curiosity; and almost all indicated that they were able to understand the topic better and discovered new information on the topic. As one interviewee cited *"Until I see your concept map, I didn't know I know so little about professional development"*. Another said *"What pleasant surprise! I learnt so much on professional development in just a few minutes."*

The source of purposeful learning is context stimulated by genuine interest and curiosity (Sylvie, Andrew & Jacques, 2001). While involving themselves in this study, many participants gained practical insights into teachers' professional development, which allowed them to view their profession in a wider perspective. A significant number of participants also pointed out that they experienced unanticipated findings of worthy information. In fact, one could see concept maps as a valuable platform for individuals to mine for concepts and ideas to further their understanding on specific topics.

When asked to rank factors most important to them in using concept maps to find information, the quality of concept maps came in second, behind ease-of-use. Users demand for prevalent and high-relevant concepts; and constantly updated information. Currently, concept maps are not able to match the vast amount of information one could access via Google or Yahoo. It is therefore advisable to look into the integration of concept maps with other common search tools to optimise the search outcomes.

Participants repeatedly stated that the noteworthy information search results were obtained through using both concept maps and search engine complementarily. For instance, they used the key words on the concept maps as search phrases on the search engines. They also used the articles available on the concept maps to trace other relevant documents on search directories. The challenge, as a result, is to establish a meaningful integration between concept maps and the various search tools to offer the best finding experience to users. It is with such an agenda that the greater potential of concept maps can be unleashed to support information discovery.

Functional design quality, or ease-of-use, was voted by the online survey participants as the most important characteristic of concept maps. This study surfaced three important areas of users' concern in the design of concept maps, namely over-crowding, interactivity and customisation. Over-crowding was flagged as a concerning issue when 37% of the online respondent felt that they were overwhelmed when first exposed to the concept map. Subsequently, the study found that a small group of individuals might need certain mental orientation to effectively comprehend the working of the map.

Some participants recommended implementing a "maps-within-maps" design concept and avoiding excessive cross-links as resolutions to avoid over-crowding.

But when discussed during the interview sessions, some interviewees warned that "maps-within-maps" would not be appealing to people who wanted fast information and it might put these users off. They added that it was good to be able to see all concepts at one glance. A suggestion was also made to technically code the concept map such that it allows scaffolding and hide details not needed. It might be appropriate for the concept maps designer to further conduct a design acceptance testing and seek feedback from intended users to arrive at an optimal design.

There is also a need to enhance the interactivity of the concept maps with users to increase the effectiveness of the map on information discovery. Many valuable suggestions were received from participants regarding this aspect. Among the suggestions are facilitating manipulation to the design by authorized users, providing templates and instructions to perform the manipulation, forwarding online comments and clarifications to concept maps designer/administrator and setting up communities of practice via online chat-room. In fact, more can be done to make concept maps even more dynamic, for example, allowing users, instead of just authorised personnel, to create concept maps. This is a "collaboration" feature which can be supported by using appropriate tools.

An important factor influencing the acceptance of concept maps is users' *competence* to handle their search. For instance, online chats may be included to enhance interactivity; font and colour setting may be made available to provide a higher level of customisation; and integration with other search tools may be developed to produce better search outcomes. There are also some concerns over who would be responsible for creating the maps, how the maps and related resources would be maintained and at what cost. These are all valid and practical concerns which are seldom dealt with in research papers.

Managing users' *expectation* is perhaps one of the most important considerations in gaining their acceptance to concept maps. An interesting feedback from a survey respondent reads *"there is a need to establish the link between what the concept maps could provide, and what each user actually needs. I feel that concept maps provided the "generally targeted" information (that caters to general needs) but not the "specifically targeted" information (that caters to each individual)."* Indeed, specific features and finding capabilities must be clearly demonstrated and communicated to users to ensure a full appreciation of what concept maps can genuinely offer.

CONCLUSION

This study has indicated that teachers are impressed with the simplicity, user-friendliness and usefulness of concept maps as an information finding tool. They seemed to be enthusiastic to adopt the tool in furthering their knowledge discovery efforts and to recommend it to their colleagues. However, concerns expressed by participants of the study did suggest that concept maps cannot be used in isolation. Drawing on their unique capabilities, there should be meaningful integration with other search tools to bring about higher search outcomes and richer resource discovery experience. The ongoing focus is therefore not to compare concept maps with other search tools but explore avenues to marry them. The study also indicated that while concept maps are generally accepted as useful information search tools, there are still many areas for improvement. To attract mass uses of concepts, the functional design needs enhancements and content quality of concept maps need to be constantly updated. Concept maps as knowledge discovery tools are desired to be promoted among different communities of practice through easy to use infrastructure support.

REFERENCES

Cañas, A.J. et al. (2003). A *Summary of Literature Pertaining to the Use of Concept Mapping Techniques and Technologies for Education and Performance Support*. ConceptMapLitReview/IHMC%20Literature%20Review%20on%20Concept%20Mapping.pdf

Díaz-Maggioli, G. (2004). *Teacher-centred professional development*. Alexandria, VA: Association for Supervision and Curriculum Development.

Ford, K. et al. (1996). Diagnosis and explanation by a nuclear cardiology expert system. *International Journal of Expert Systems, 9*(4), 499-506.

Leaker, D. B, et al. (2003). Aiding knowledge capture by searching for extensions of knowledge models. In *Proceedings of the international conference on Knowledge capture.*

Mularz, D. & Lyell, M. (2004). **Integrating concept mapping and semantic Web technologies for knowledge management. In** *Proceedings 15th International Workshop on Database and Expert Systems Applications*, *30* (pp. 449-453).

Novak, J.D & Gowin, D. B (1984). *Learning how to learn*. New York: Cambridge University Press.

Potelle, H., & Rouet, J.-F. (2003). Effects of content representation and readers' prior knowledge on the comprehension of hypertext. *International Journal of Human-Computer Studies*, *58*, 327-345.

Santhanam, E, Leach, C. & Dawson, C. (1998). Concept mapping: how should it be introduced, and is there evidence for long term benefit? *Higher Education, 35*(3).

Sylvie, C., Andre, P., & Jacques, T. (2001). Learning by reading: description of learning strategies of students involved in a problem-based learning program. *ERIC*.

Uzuntiryaki, E. & Geban, Ö. (2005). Effect of conceptual change approach accompanied with concept mapping on understanding of solution concepts. *Instructional Science, 33*(4), 311-330.

Zmuda, A., Kuklis, R. & Kline, E. (2004). *Transforming schools creating a culture of continuous improvement*. Alexandria, VA : Association for Supervision and Curriculum Development.

Implementation Differences Between DSS/BI and Other Types of Information Systems

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ABSTRACT

This paper considers concerns that arise in the implementation of TPS and those that arise in the implementation of DSS/BI systems, noting differences between the two. Important management focus areas in implementing TPS include low-level user training, extensive user testing, change management and cut-over strategy. With DSS/BI, attention should focus on data quality, higher-level user training, having an executive "champion" and adapting the system to its users. Managers approaching an implementation project must be aware of these differences, as should academics who write textbooks or who teach from textbooks that do not cover them adequately.

1. INTRODUCTION

No business information system is of value unless people use it to achieve business objectives. An unused system may be an impressive monument to technology but cannot justify the use of corporate funds. Therefore, no matter how well a system was designed and developed, it must be put to use before its goals can be achieved. That is the role of *implementation*.

However, not all systems are created equal in this regard. The critical success factors for implementing one type of system are not necessarily the same as those for implementing a different one. While this may seem obvious when stated, there are two practical problems:

1. Research tends to focus on one type of system in isolation. It does not compare the conclusions of one study, for one type of system, with the conclusions of research on other types of systems.
2. Even what is known about implementation of different types of systems has yet to make its way into the textbooks used to teach future practitioners and users of IS.

2. DEFINITIONS AND DISCUSSION OF IMPLEMENTATION

Implementation, as used here, is the process of preparing an information system for use. Kwon & Zmud (1987), in their seminal paper on the subject, define it as:

...an organizational effort directed towards diffusing appropriate information technology within a user community.

A similar definition comes from a popular introductory MIS textbook (Laudon & Laudon 2004):

...all organizational activities working toward the adoption, management and routinization of ... a new information system.

Both these definitions focus on organizational aspects. By the time implementation begins, technical work is (or should be!) complete.

This is not the only possible definition. The problem arises from different views of when something is ready for use. The major dichotomy is between the user and vendor communities. Vendors see a system, or whatever system component they sell, as ready for use when it's ready to ship to customers. User organizations see it as ready for use when it has been customized as needed, its databases fully populated, and its client software installed on individual users' desks. The user's implementation starts where the vendor's ends. The vendor's view includes more technical activities than does the user's. Attempts to resolve this conflict, without offending anyone who considers a given activity to be part of implementation, result in defining it to cover virtually everything after drawing data flow and entity-relationship diagrams—a "definition" so inclusive as to be nearly meaningless.

We will use the user view here, not the vendor's. This reflects our focus. It is not a value judgment of "rightness" or "wrongness."

Accordingly, we consider areas such as database preparation, system conversion, training, and other activities that occur after programming and database development are done.

The questions this paper addresses are: Are there significant differences in these areas between (a) decision support and business intelligence (DSS/BI) systems and (b) other enterprise-level information systems? (These latter will be referred to as "transaction processing systems," TPS for short, recognizing that this term often has connotations of older technology which are not intended here.) If there are, what does this imply?

The distinction here is between systems that update the organization's operational database and those that use it to support management activities but do not update it. The former are typically used at lower levels in the organization to carry out routine activities; the latter are used by managers and knowledge workers to support decision making and related higher-level tasks. The terminology *DSS/BI* versus *TPS* is a convenient way to express this but is not meant to restrict the discussion to specific technologies. Modern integrated enterprise-level systems such as ERP, CRM and SCM increasingly include DSS/BI capabilities that would have been provided by separate packages not long ago. Even when this is the case, however, the two sets of functions have different user communities and thus different implementation requirements. Phrasing the question in terms of modules of an integrated system, rather than separate systems, would change some of the discussion but would not affect either the underlying issues or the conclusions.

3. IMPLEMENTATION OF TPS

The stages of implementation for Enterprise Resource Planning systems (ERP), a prime example of a large-scale, enterprise-level TPS, have been studied extensively. Over 15 years ago, the implementation of its Material Requirements Planning (MRP) predecessor was studied in (Cooper & Zmud 1990). Rajagopal (2002) discussed a model for ERP implementation. Lai (2006) provides guidelines for successful ERP implementation, based on experience in China.

An example of TPS implementation is given in (Mandal & Gunasekaran 2002). They discuss a large (6000-employee) Australian wine producer and exporter's implementation of SAP R/3 ERP software. The system focused on online inventory control. In addition to the customization that any SAP installation requires, a separate bar-coding system was also developed and integrated with SAP. Key aspects of implementation here included:

- The system was tested extensively by its prospective users, with formally maintained lists of open issues and timing to complete all tasks.
- Shop floor personnel, many of whom had never before used a computer, were trained on the new system before its roll-out.

- Additional on-site training and support was provided after roll-out.

Some employees, whose jobs had not previously required them to use a computer, felt their new job requirements justified additional compensation. This was handled by providing overtime payment during the learning phase, returning to normal pay levels once computers were no longer seen as anything special.

Muscatello & Parente (2006) iterate the importance of training as part of ERP implementation, noting that "future employees will have to have a significantly greater skill set than previous employees," and also noting the frequently-mentioned need to be willing to modify business processes in order to achieve a better fit to the technology in use. While this is not an implementation issue *per se,* the need to adapt to changed business processes as well as to new technology can complicate the human aspect of the implementation process.

4. IMPLEMENTATION OF DSS/BI

Implementation of DSS/BI[1] systems has been studied less than that of TPS, with (Kivijarvi & Zmud 1993) being one example with a Finnish focus. The state of research was summarized in (Mora et al. 2002). Little has been reported that provides much practical guidance or contrasts DSS/BI issues with those that arise for TPS.

Fortunately, specific DSS/BI implementation cases have been reported. We can draw meaningful conclusions from them. Summarizing a conference at which executives reflected on their BI implementation experience, Havenstein (2006) reports that the two key implementation issues in this sphere are data quality and executive buy-in. These are less critical with TPS: data quality, while not unimportant, is more of a technical and clerical issue than a managerial one. Executive sponsorship may improve the acceptance of business process changes that a TPS requires, if it requires any, but those who are to use a TPS will ultimately do so because their jobs require it—not because they are inspired by the CEO's vision. Their attitude toward using it may be important as regards morale and motivation, but the usage itself is not optional if they want to keep their jobs.

An example of a DSS implementation that raises some of the same personnel issues that typically arise in the TPS context is provided by (Botha & Atkins 2006). In that study the target users were New Zealand farmers, not corporate managers and knowledge workers. One reason for the system's poor adoption was overestimating user capability vis-à-vis system complexity. This example is, in some ways, the exception that proves the general rule. Managers and knowledge workers in an office environment will usually be more computer-literate than this user community.

5. CONCLUSIONS

There are significant differences between the implementation of TPS and of DSS/BI systems. It is important for those who manage such implementations, and for those who will teach future managers their trade, to be aware of them.

These conclusions involve *focus*. It's not that low-level computer training (to use the first bullet below as an example) is always totally unnecessary with DSS. Sometimes it is, perhaps for an unusual user community (e.g., the New Zealand farmers of (Botha & Atkins 2006)) or perhaps for a small number of users within a group that is more typical overall. However, organizations have finite resources. They must allocate those resources where they will do the most good. Our purpose here is to point out (to continue with that example) that low-level training tends to be an important focus area with TPS, but not with DSS/BI.

5.1. With TPS:

- **Low-level computer training** is mandatory. TPS users may not have used computers before, though this is changing as teenagers flock to the Web, e-mail, online chat and personal networking sites. Even if they have used computers, they often do not have the professional sophistication to adapt easily to a new information system.
- **Extensive user testing** is essential, as the system carries the operational database which drives all business activities. Errors may not be detected until they have caused havoc down the line. (Testing by developers can never be complete since they only test for situations they can foresee, and which the software was therefore designed to handle. Users create situations that developers did not foresee.) DSS/BI output is reviewed by humans before it is acted upon, providing a level of protection against erroneous outputs.
- **Change management**. Users of an existing TPS often see their value to the organization as tied to their expertise with that system. They know no more about the new system than a new hire would, perhaps less. First- and second-level user management must be careful to show them that the new system will be to their advantage, or serious negative consequences may result. This responsibility cannot be passed off to technical support staff or "bucked up the ladder."
- **Cut-over strategy**. Since it is impractical to use two TPS in parallel[2], and is likewise impractical to give users a choice as to which they will use, it is necessary to move an organization systematically from the old to the new. Conversion approaches are beyond the scope of this paper but can be found in (Palvia et al. 1991), among other places.
- **Executive sponsorship** is important, as noted above, to the extent that the new TPS imposes cultural changes (including major business process changes) on the organization. This was common when organizations moved to their first ERP system but is becoming less of an issue as more and more companies have had one for a while. New TPS may involve usage changes, such as going from "dumb terminals" to PCs or to a Web-based user interface, but increasingly leave the processes behind the interfaces alone.

5.2. With DSS/BI:

- **Data quality** is more of a concern. DSS/BI systems often use data warehouses whose inputs come from multiple systems, some of them perhaps incompatible with others. Using data developed with inconsistent assumptions, based on different time periods, structured in different ways, etc., can lead to problems even if each individual system is internally consistent and (in its own context) fully correct. This raises broad data governance issues, often for the first time.
- Training is needed, but at a higher level. Today's knowledge workers are comfortable with technology in general. They need to be brought to a comparable comfort level with the technology of DSS/BI. As a Holland America Line BI project manager was quoted in (Songini 2003), they need to "spend the time to get to know the data." This is *information* literacy, not computer literacy. "Getting to know the data" would be a waste of time for most TPS users.
- Having **an executive "champion"** is vital. Whereas an airline check-in agent cannot issue a boarding pass without the appropriate computer system, a buyer can in principle decide how many blue shirts to order by "gut feel." Such users will adopt a DSS/BI system more readily if the executive suite uses it, or at least visibly backs its use.
- For similar reasons, it is more important to **adapt a DSS/BI system to its users** than the other way around. Xu & Quaddus (2005) point this out, suggesting that a pilot project permits this without impacting the majority of users. While this may result in a roll-out procedure that resembles pilot conversion of TPS, the motivation for using the pilot approach is totally different.

6. RECOMMENDATIONS

6.1. For IS Faculty

Information systems textbooks, in discussing implementation, do not differentiate by type of system[3]. To them, implementation is implementation. However, as we have seen, this is not the case. It falls to IS faculty to make up for deficiencies of the text in use, including this one. If a faculty member thinks implementation is worth more than the briefest notice, he or she must point these differences out. (I personally think it's worth more than a brief notice, since most introductory MIS students are not MIS majors, and implementation is an area where users play a big part.)

6.2. For IS Textbook Authors

Many IS textbooks spend a great deal of time discussing alternative system development methods: SDLC, various flavors of prototyping, modern variations such as agile development, RAD and extreme programming, etc. The descriptions are followed (in the better books) by discussions of where each fits best. That's good as far as it goes, but it doesn't go far enough. Implementation methods should be treated the same way: by discussing alternatives and when to use each.

6.3. For IS Practitioners

Most experienced practitioners intuitively have a good idea of what to do in this area, as the conference report of (Havenstein 2006) shows. One danger is that, in

reading the "one size fits all" recommendations of textbooks and perhaps hearing them repeated in an MBA classroom by an instructor with little real-world experience, experienced practitioners can become convinced that their intuition is at fault when it isn't.

However, we can *and must* say more than "get 20 years' experience, then trust your gut." Professional papers are published, in part, so that practitioners will learn from them. They must recognize, in reading a paper about system implementation, that its conclusions are probably limited to the type of system being studied. They generalize in finite ways, if at all, to others. Their limitations may be even narrower than system type, as in (Lai 2006) where the author cautions about generalizing his (already ERP-focused) results beyond China, or (Kivijarvi & Zmud 1993) where the limitation of the sample to Finland may limit the validity of extrapolation beyond its borders.

REFERENCES

Botha, N. & K. Atkins. (2006). The design, utility and adoption of decision support systems in the New Zealand pastoral industry. *Proceedings*, APEN International Conference (March).

Cooper, R. & R. Zmud. (1990). Information technology implementation research: a technological diffusion approach. *Management Science,* 36, 123-139.

Havenstein, H. (2006, October 2). Data governance, exec buy-in are keys to BI adoption. *Computerworld,* 40, 40, 8.

Kivijarvi, H. & R. Zmud. (1993). DSS implementation activities, problem domain characteristics and DSS success. *European Journal of Information Systems Research,* 2, 3, 159–168.

Kwon, T., & R. Zmud. (1987). Unifying the fragmented models of information system implementation. In *Critical Issues in Information Systems Research* (R. Boland & R. Hirschheim, Eds.). Hoboken, N.J.: Wiley.

Lai, I. (2006). The critical success factors across ERP implementation models: an empirical study in China. *International Journal of Enterprise Information Systems,* 2, 3, 24–42.

Laudon, K. & J. Laudon. (2004). *Management information systems* (9e: Managing the digital firm). Upper Saddle River, N.J.: Prentice-Hall.

Mallach, E. (2006). System conversion: teaching versus reality. *International Journal of Information and Communication Technology Education,* 2, 2, 17–26.

Mandal, P., & A. Gunasekaran. (2002). Application of SAP R/3 in on-line inventory control. *International Journal of Production Economics,* 75, 47-55.

Mora, M., F. Cervantes-Pérez, O. Gelman-Muravchik, G. Forgionne, M. Mejía-Olvera & A. Weitzenfeld-Reitel. (2002), DMSS implementation research: a conceptual analysis of the contributions and limitations of the factor-based and stage-based streams. In *Decision Making Support Systems: Achievement, Trends and Challenges* (M. Mora, G. Forgionne & J. Gupta, Eds.). Hershey, Pa.: Idea Group Publishing.

Muscatello, J., & D. Parente. (2006). Enterprise resource planning (ERP): A postimplementation cross-case analysis. *Information Resources Management Journal,* 19, 3, 61–80.

Palvia, S., E. Mallach & P. Palvia. (1991). Strategies for converting from one IT environment to another. *Journal of Systems Management* 10, 23.

Rajagopal, P. (2002) An innovation-diffusion view of implementation of enterprise resource planning systems and development of a research model. *Information and Management,* 40, 87–114.

Songini, M. (2003). Cruise line changes BI tack. *Computerworld* 37, 40, 32

Xu, J. & M. Quaddus. (2005). A six-stage model for the effective diffusion of knowledge management systems. *Journal of Management Development* 24, 4, 362–373.

ENDNOTES

1. The term *DSS* is older and more common in academic circles. The newer *BI* (often credited to Gartner's Howard Dresner in 1989) is more often found in industry. While one can argue that DSS is a broader concept that subsumes BI as well as other types of IS, that distinction is not important here. They share the characteristics—user community, nature of input data, use of output, etc.—that affect implementation.
2. Parallel conversion was an industry staple 30+ years ago. Lamentably, it persists in most MIS texts. It is impractical when both old and new systems are online and fundamentally flawed when input timing can affect output. This is discussed further in (Mallach 2006).
3. The author has examined over 25 MIS and systems analysis texts from major publishers over the past few years. Twenty are listed in (Mallach 2006). Others appeared since that paper was written. This statement applies to all, without exception. Listing them here would serve no purpose other than increasing the length of this paper's reference list.

A Proposal of Integration Between IT Governance and Business Balanced Score Card

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ABSTRACT

Useful management models have to work with the most important aspects in a modern organization: environment, market analysis, innovation, learning, operation, diffusion, reengineering and added value. These terms are related in a supply demand schema under a dynamic systems based frame, because the supply demand schema is the best way to understand and simulate the real daily operation of every organization. The New Economy behavior is not possible to replicate or simulate with classical theories based on internal organization characteristics or considering modern concepts (as innovation, for example) in a more or less isolated way. These concepts (environment, market analysis, innovation, learning, operation, diffusion, reengineering and added value) cannot glue any old how, they have to be absorbed in a modern system based context. A new conception of how to measure the value added is supported by this new business dashboard. Nowadays it is impossible to further delay the preponderance of Information Economics and Information Systems as an essential frame to understanding the enclosing of our organization in a marked leaded by concepts such as: effectiveness, integration and globalization. The name of this new conception that joins the best of IT Governance proposal with the best of Business Balanced Scored Card idea is IG4 (Information Governance Four Generation Model).

1. INTRODUCTION

There are many models to analyze the companies' management and strategies (Balanced Score Cards, EVA, etc) under a business perspective. Under the system and technological point of view there are other theories to plan and manage the systems in the companies such as IT Governance, Balanced Score Card for IT, System Strategy Planning and the Cobit initiative. These two perspectives, business and systems, are glued together in the current theories throughout alignment of IT with business (strategy alignment and operational alignment). However in the Modern Economy and under the powerful Internet, the private companies and the public organizations are completely dependent on the Information Systems: With hundreds of thousands of transactions the functions that are not covered by systems are impossible to accomplish in the daily company business. In this scenario to align systems with business is not enough and it is necessary to integrate both approaches, business and technology, in only one approach: the IG4 model. The IG4 model substitutes alignment for integration.

As is depicted in figure II, the IG4 model tackles the system perspective and the business perspective under an applied orientation. The SBMII model covers the disciplines of IT Governance, Systems Strategy (and its sub-component of System Strategy Planning) and Balanced Score Card. The IG4 model has a high management and strategy orientation due to this; it does not support the level of detail of the operation level. However the IG4 model considers the best analysis characteristics of these models: the CMMI model (process oriented) [Ahern, 2004], the Software Project Dynamics (software develop oriented) [Abdel-Hamid, 1991] the reengineering theories (process oriented), activity based costing (costing oriented) and Lean thinking (quality oriented) [Womack, 2003]. There are other studies based in different variables to measure the IT effectiveness [Scott, 1995]. These variables are more focused in levels of IT expenses (training, number of PC, etc) obtained by surveys than an added-value method and a complete review of the organization throughout their systems. In conclusion, none of these studies gives a complete response to the IG4 objectives thought in giving integral answers to New Economy requirements.

In addition, in recent periods, there has been a tendency to consider innovation and change as hackneyed fashion and the solution of every organization income problem. It is impossible to attend any conference or company meeting in which innovation is not a central theme. During the last decades, there were different fashions that rocked the organization department's boat: reengineering, ERP

Figure 1. Conceptual model of the modern organizations

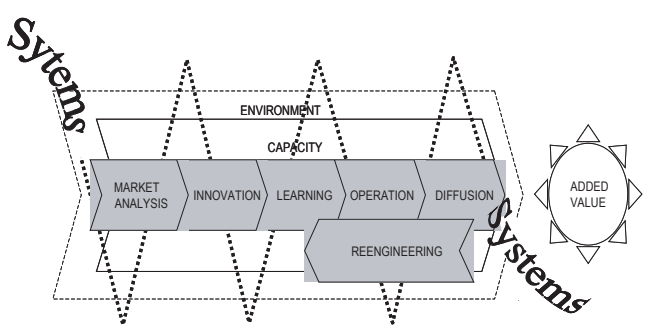
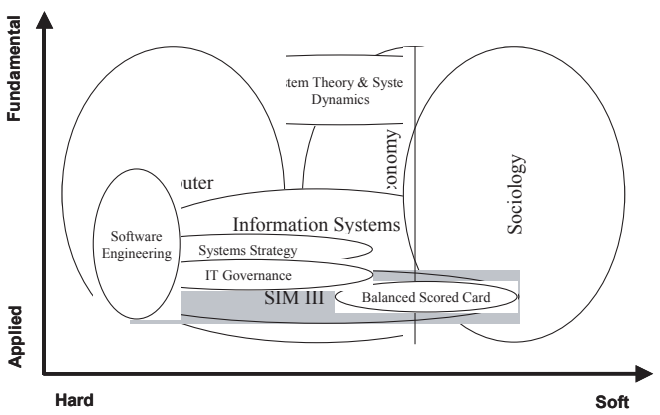


Figure 2. The fit of SIMIII between technology and business



(Enterprise Resource Planning), Internet, just in time, globalization, activity based costing, etc [Davenport, 1998]. After the dot com bubble burst, there has not been a new global movement that gives opportunities for quick growth and this makes innovation a recurrent conversation topic. However, to consider innovation in plain theories or in an isolated way is not giving good results [Sull, 2000]. There are several examples that confirm this fact:

- It is difficult to find clear and convincing relations between the research capacities (innovation) and the chances to create added value [Bryjolfsson 1993, 1996] [Hitt, 1996].
- In the last years, some sectors such as telecom and banking in order to improve results have preferred mergers or purchase strategies better than innovation strategies as different studies showed [Olazabal, 2002]. When telecom applied the 3G only considering a new innovative and powerful technological opportunity, the results were not as desired.
- Some areas have reached maturity (technological maturity, functional maturity and contents maturity) and sometimes only innovation is synonymous with new niches but with very low customer margins (in Internet history several examples can be found) [Johnston, 2003].

The present outlook follows a logical evolution; the industrial based management gave way to marked centered management, after that social centered management took its place, which presents a virtual and collaborative focus [Kaplan 1996, 2006]. But social models mainly give responses to important aspects such as leisure activities (chatting, peer to peer, etc) or transmission of ideas and information (wikis, blogs, etc). However, they do not cover the complete market and do not entirely explain the supply / demand based economic market. A framework is needed which conjugates more elaborated strategic ideas under the dynamic system glue [Forrester 1961, 2003] (as depicted in figure I these concepts are not isolated).

The general formula of this proposal is based on the general business formula "Demand = f (Supply)" and with more detail:

Value Added = Value Added Systems Depended + Value Added No System Depended

This research concentrates on the Value Added System Depended, where:

Value Added System Depended = f(Value Added in the Business by Systems) + f(Value Added in the Operations by Systems).

This formula marks the three views of the model: Value View = Business by Systems View + Operations by Systems View as is depicted in the figure III. If it expands all of this terms in a formula:

Value added + Operation effectiveness + Welfare = f (Environment, Market Analysis, Innovation, Learning, Operation, Diffusion, Reengineering) + f(Systems Quality, Operation, Maintenance, IS People & Organization, Development & Acquisitions)

The IG4 model is at the same time a model, a philosophy, a tool and a method. The measure unit is always the systems or its subdivisions (subsystem, functionality, characteristic, etc).

1. The IG4 model is supported in a methodology that allows in a clear and systematic way to analyze our systems: this is because IG4 incorporates human, technological and business considerations.
2. The IG4 model is at the same time a tool. It is supported in a simulating tool that allows implementing a continuous and dynamic process (it supports added-value and time delays) following the supply demand cycle of our organization and through continuous feedbacks about our systems. Because of this dynamic simulation tool the IG4 model is supporting the functionality of Strategy System Planning.

This paper is a summary of a study supported by three complementary validations (the complete model is showed in the figure V):

Figure 3. Three interrelated views support the whole model

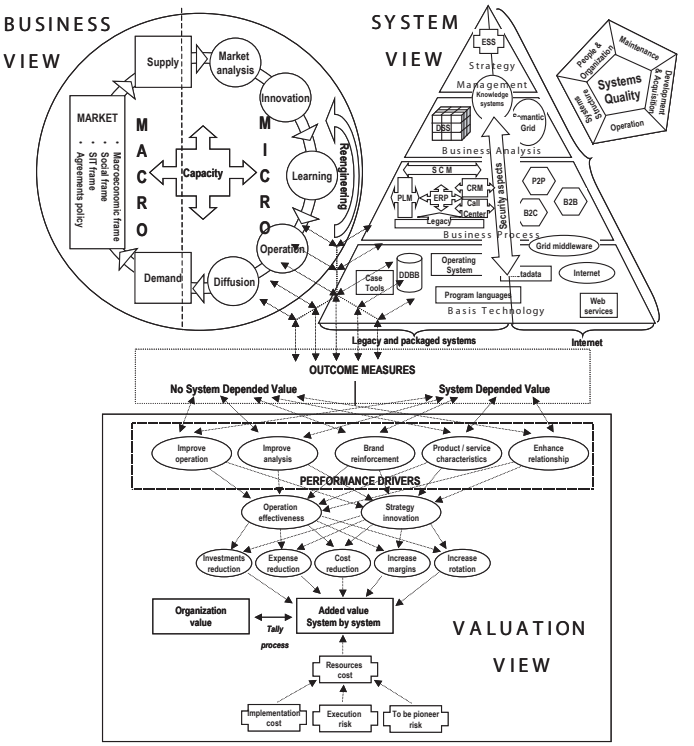
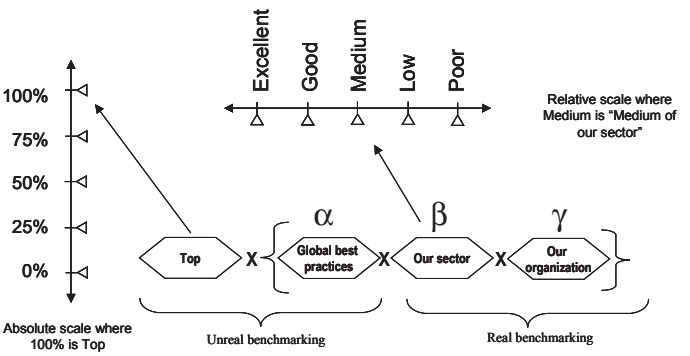


Figure 4. A comparative (benchmarking) scenario supported in four stages

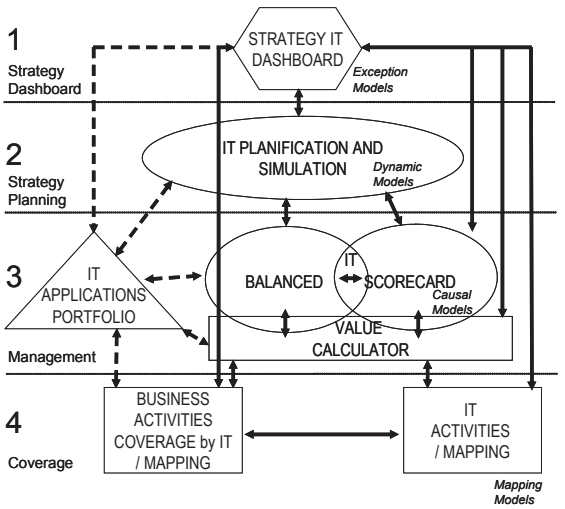


1. A review of the variables that have affected the IT industry history.
2. An empiric validation through a survey to project directors of thirty large system projects.
3. A review of the general admitted theories that mainly involve the IT frame.

2. THE MAIN CONCEPTS OF THE MODEL

In this paragraph the main conceptual points of the IG4 model are analyzed in more detail: Added value, environment, capacity, diffusion, reengineering, innovation and all of them glued with the concept of systems: Beginning analyzing added value. It is good to analyze the goal of every activity before building our balanced scorecard: Improving the **productivity**? Improving the **added value**?

Figure 5. Complete view of the information governance model (IG⁴)



Improving the organization's **profit**? It is necessary to combine the three concepts: productivity, value added and organizational profit, to analyze something as amazing as all around New Economy [Bakos, 1992] [Hitt, 1996] [Boehm, 2000]. Furthermore these concepts split the New Economy and allow us to separate and analyze concepts as different as a blog (value added disguised as journalism), a portal (productivity generated by the direct connection among different agents) and a complete solution such as MySAP.com (economic profit by manual tasks reduction and better management tools).

The productivity concept, as a relation between entry and exit economic flows, is supported in the elimination of intermediate steps (operation effectiveness). In today's Information and Knowledge Society where the communication and the knowledge are not always moved by direct economic transactions, to consider the concept of added value (it incorporates welfare) to the final users is critical. The third element is the organizational benefit that is the forgotten subject among the three concepts. This concept has to play a key role in the New Economy and by extension in the 21st dashboard [Porter 1980, 2000]. Figure II shows a more detailed approach of the three interconnected perspectives of the model: system view, supply / demand view and valuation view. The three views together are a powerful tool to analyze every 21st century organization.

What part of the company value is due to systems and what part is due to no-system causes (properly business)? When the value of a petrol company drops in the stock market it may be because the oil reserves are decreasing (no-system depended) or the management is not good (in large part system depended). In general when a telecom company is losing customers is because the quality of service is not enough good (in large part system depended). As systems are critical, the new balanced scorecard have to split the system depended added value from the no-system depended added value. For example, system analysis explains the large amount of mergers that happen nowadays when the organization cost structure is susceptible to resizing techniques. One main component of the last bank-merging wave is to save money by centralizing staff departments and sharing the costly IT systems investments. Just as a man is flesh and blood, the companies are systems and software. In this environment the role of the Information Economics (the economics of the overall information and knowledge industry) in the Economic theory is essential and has to be supported in the organization by an adequately balanced scorecard [Masuda, 1975] [Senge, 1990] [Lane, 1998].

If we want to decrease the digital divide we would make easy that public and private organizations to be catalysts of this change. The big problem is when it understands by New Economy only: to simplify the value chains, to reduce costs and where every intermediate expense or elaborated service is eliminated. With this simple format, Internet is not a useful means for the companies to expand their supply, and more than an opportunity it is a threat that destroys the entry barriers of new competitors. In contrast, what are the citizens of 21st century demanding about the New Economy? The citizens of 21st century where the life quality and the leisure are key concepts will not understand in medium and long term an Internet reduced to "single window" and they hope developed services that mix the aptitudes of traditional economy with the easiness supported by the New Economy.

21st human activity is completely influenced by the **capacity** possibilities (part of the environment variable). Hollywood movies and traditional cultures made to believe that the individual or the team effort is a decisive ingredient of success factor. In contrast, the global businesses are not a baseball game or a romantic script. The individual gave the baton to the team and in the modern organizations the team has to give the baton to the environment (where, the team and the individual are a modest part of this environment). For example the operating system market treats with products of more than 20 million lines of code (knowledge capital) where the social tendencies, the existence of clusters, the business models and the public opinion, all together, are essential to achieve the success. Because of that in the modern models, environment and capacity are not the border of our organization, are a crucial virtual part of our organization. Just as important or more important than the internal organization are the alliances, the links with the research centers or the connection with the icebreaker users (multinationals, young people, trend creators, universities, etc). The real organization edge is not the physical organization: there are no outsiders there are artificial walls.

The number of variables to value in an organization is huge (experience, sector, maturity, synergies, scale economy, technology, etc) and without a contrast method (feedback), all the benchmarking methods are worthless. In addition, the benchmarking techniques do not allow huge innovation because they are forcing the sectors to be similar and because of that, to link the organizations with the research centers is essential as is depicted in figure IV. The stock market is the only benchmarking scenario where there are contrasted rules and thousands of people assuring the data quality. As the same the stock market is a contrasted bank of value information, it is necessary to go down one step and to establish a "stock market" of contrasted ideas where a real match between the stock market value and the ideas that support this value is created.

The New Economy products are neither cars nor suits [Toffler, 1980]. The **diffusion** effect of new fashion in clothes or a new car model is easily assimilated by the market that only has to adapt to a new style or new features. In contrast, the information technologies bear important changes that affect the business models, not forgetting the user interface and finally legislation. In this situation, carefully determining the diffusion effect and the methods to accelerate it, becomes critical [Amabile, 1989]. Furthermore, it has to add two always over sighted adjustment effects to the innovation effect: reengineering and integration as part of the re-engineering. The New Market innovation produces without breaking new very complex products and services that require the essential **process reengineering** to obtain simplified solutions accepted by the marked. The adjustment process goes together with the internal learning and the external diffusion to complicate the process because it plays in the time delaying the implantation of optimized new business models. To try in a few years to deploy the third generation telecommunication wave (UMTS) over technologies not completely established and full of future (SMS, IP voice, bluetooth, 2,5G, etc) led to the failures that took place. In the real market, reengineering is not a second level concept or nineties old fashion because it interferes deeply in the actual knowledge and investment intensive organizations. Another mistake is to think only in technological language: the concept that beats the technology market is not the strategy or the functionality; the concept that beats the technology is the systems [Stewart, 2003] (systems = business + technology + human).

The New Economy as **innovation** has a part of adventure and a part of consolidated value added [DeBono, 1972] [Drucker, 2002]. In the Old West, the people who invested in gold mines assumed high risk and questionable earnings but for the people who invested in fashion jeans companies (the jeans that the miners wore), the profits were lower but have lasted to the present. The history is repeated and the balanced scorecard of the New Economy has to support both realities: adventure, innovation and risk and complement of the classic value chain contributing to new business opportunities and ways to face new business lines.

In 19th century, the companies were capital and workers. In 20th century, the companies were departments and business units. In 21st century, the companies are **systems** (more than software) [Folgueras, 2006]. Nowadays, important elements of companies are: links with other companies, business models, internal processes, analysis tools, accumulative knowledge, communications with stakeholders, etc [OECD, 2000] [Digital Planet, 2004]. In a big company with hundreds of thousands

of transactions, models that are not supported by systems are worthless. The only possible organization structure is the system structure. Aspects you cannot measure you cannot improve. But if you cannot automatically treat (systems) neither can you measure or operate them, because the concepts of balance scorecard, systems and value added are related [Forrester, 2003] [Abdel-Hamid, 1991].

3. CONCLUSIONS

There are many models to analyze the companies business and strategies (Balanced Score Cards, EVA, etc). Under the system and technological point of view there are other theories to manage the systems in the company such as IT Governance, Balanced Score Card for IT, System Strategy Planning and the Cobit initiative. These two perspectives, business and systems, are glued together in the actual theories by alignment of IT with the business (strategy alignment and operational alignment). However in the Modern Economy and under the powerful Internet, the private companies and the public organizations are dependent on the information systems: With hundreds of thousands of transactions the functions that are not covered by systems are impossible to accomplish in the company business. In this scenario aligning systems with business is not enough and it is necessary to integrate both approaches, business and technology, in only one approach: the IG4 model. The main model contributions of the IG4 model introduced in this paper are.

1. To follow the supply / demand schema as the real organizations do.
2. To use dynamic tools in a supply / demand schema facilitates the process simulation when there are several interconnections with feedback and when the value is the value of several years.
3. To control system by system the system depended value from no-system depended value (properly business).
4. To make up added value with economic concepts (profit and productivity) and no direct economic considerations (welfare and leisure).
5. To understand the virtual organization: In an intensive capacity (knowledge and investments) market, the environment and its agreements are crucial and are part of our virtual company.
6. To consider properly the innovation: Five connected terms (market analysis, innovation, learning, diffusion and reengineering) are focused in a changing environment, only one in the traditional cost vision (operation).
7. To avoid the Tower of Babel: The added value is the common language of the cause-and-effect relationships (together with other outcome measures and performance drivers). It allows tally processes.
8. To control the time is as important as control de value added, because the terms external diffusion and internal learning are critical.

This article asks if the classical management reports, which are based on many possible combinations of concepts such as strategy, human behavior, internal processes or technologies are optimum [Mintzberg, 1994]. With the balanced scorecard proposal introduced in this article, behind the glasses of environment, market analysis, innovation, learning, operation, diffusion and added value, it is not seeing the bubble burst and it is only seeing huge opportunities adequately planned in time. If the balanced scorecard incorporates these concepts, we will understand and predict the New Economy.

REFERENCES

1. Abdel-Hamid, T. and Madnick, S.E, 1991. Software project dynamics an integrated approach. Prentice Hall Software Series.
2. Ahern, D.; Clouse, A. and Turner, R., 2004. CMMI Distilled. Second Edition. A practical to introduction process improvement. Second Edition. Addison-Wesley. Pearson Education.
3. Amabile, Teresa M., 1989. How Work Environments Affect Creativity. IEEE 1989.
4. Bakos, J.Y. And Kemerer, C.F, December 1992.Recent Applications of Economic Theory in Information Technology Research. Decision Support Systems.
5. Boehm, B and Sullivan, K., 2000. Software Economics: A Roadmap. Future of Software Engineering. Limerick Ireland. ACM.
6. Bryjolfsson, E., December 1993. The productivity paradox of information technology. Communications of the ACM. Vol 36, No 12.
7. Brynjolfsson, E. and Yang, S., February 1996. Information technology and productivity: A review of the literature. MIT Sloan School of Management. Cambridge, Massachusetts. Advances in Computers.
8. Davenport, T., 1998. Putting the Enterprise into the Enterprise Systems. Harvard Business Review.
9. DeBono, E., 1972. Lateral Thinking for Management. New York Amacom.
10. Digital Planet, October 2004. The Global Information Economy. Global Insight, Inc. World Information technology and services alliance. Witsa.
11. Drucker, P.F., August 2002.The Discipline of Innovation. Harvard Business Review.
12. Folgueras, A.; Ruiz, B. and García, A, 2006. IADIS International Conference WWW/Internet 2006.
13. Forrester, J.W., 1961. Industrial Dynamics. MIT Press, Cambridge, MA.
14. Forrester, J.W., July 2003. Economic Theory for the New Millenium. Plenary Address at the International System Dynamics Conference. Massachusetts Institute of Technology. New York.
15. Hitt, L. and Brynjolfsson, E., June 1996. Productivity, Profit and Consumer Welfare: Three Different Measures of Information Technology's Value. MIS Quarterly.
16. Johnston, R.E. and Bate, J.D., 2003.The Power of Strategy Innovation. Amacom.
17. Kaplan, R.S. and Norton, D.P., 1996. The Balanced Scorecard: Translating strategy into action. Harvard Business School Press.
18. Kaplan, R.S. and Norton, D.P., March 2006. How to Implement a New Strategy Without Disrupting Your Organization. Harvard Business Review.
19. Lane, D.C., May 1998. Social theory and system dynamics practice. European Journal of Operational Research. Elsevier.
20. Leslie, J. and Lyytinen, K., 2006 Information Systems: The State of the field. Wiley Series in information Systems.
21. Masuda, Y., October 1975. The Conceptual Framework of Information Economics. IEEE Transactions on communications. Vol. COM-23. Nº 10.
22. Mintzberg, H., 1994. The Rise and Fall of Strategic Planning. New York: The Free Press.
23. National Research Council of the National Academies, 2003. Innovation in Information Technology. The National Academic Press.
24. Olazabal, N. G., 2002. Banking the IT Paradox. McKinsey Quarterly. Number 1.
25. Organization for Economic Cooperation and Development (OECD), 2000 A New Economy? The Changing Role of Innovation and Information Technology in Growth.
26. Porter, M.E., 2000. What is Strategy? Harvard Business Review OnPoint.
27. Porter, M.E. Competitive Strategy. Techniques for Analyzing Industries and Competitors, 1980. First Free Press Edition.
28. Scott, J.E., 1995, February. The measurement of information systems effectiveness: evaluating a measuring instrument. Data base advances. Vol.26. No 1.
29. Senge, P.M., 1990. The Fifth Discipline. The Art and Practice of the Learning Organizations.
30. Stewart, Thomas A. and letters of other readers. Does IT matter? An HBR debate, June 2003. Harvard Business Review (web exclusive).
31. Stelter, D. et al. The Boston Consulting Group, 1998. The Value Creators. A Study of the World's Top Performers 1993-1998.
32. Sull, D.N., 2000. Why Good Companies Go Bad? Harvard Business Review On Point.
33. Toffler, Third Wave, 1980. New York: Willian Alvin. The Morrow.
34. Ward, J. And Peppard, J., 2002. Strategic Planning for Information Systems. Third Edition. John Wiley & Sons, LTD.
35. Womack, J.P. and Jones, D.T., 2003. Lean thinking. Free Press. First Free Press Edition.

Internet Communication Technologies and Networked Learning: Identity Formation Through Social Exchange

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ABSTRACT

The purpose of this paper is to argue that communication technologies play a non-neutral rather than passive role in formulating both student and teacher identities in verbal and non-verbal social exchanges. Further research into group interaction within peer-based collaborative tools is required to determine how these cognitive tools can lead to higher levels of learning in students. For many years, educators have been exploring ways to improve teaching and learning practices with the help of technologically innovative tools. Cognitive tools used in collaborative learning environments support the interactive construction of knowledge during problem-solving processes as they promote students' adoption of an active learner mode. Increasingly, the social aspects of our e-learning environments are being used to inform how educational episodes should best be designed to take full advantage of the cognitive powers that students possess. While conceptual understandings are foremost to learning, we also need ways of expressing outwardly the representation of our concepts. Language, tools, symbols, and cues are the ways we objectify and communicate our concepts in everyday life inside and outside our classrooms. By furthering our understanding of various e-learning cultures, cues and contexts, we can ensure that the best possible educational scenarios emerge.

INTERNET COMMUNICATION TECHNOLOGIES AND NETWORKED LEARNING: IDENTITY FORMATION THROUGH SOCIAL EXCHANGE

Although instructors have always been faced with diversity in their classrooms, computer-mediated environments offer an even greater range of complex and multifaceted learning environments because of the shifts in geographic and temporal boundaries, as well as the lack of interpersonal social cues in interpersonal communication. Understanding this type of communication within networked learning environments is worthy of further research as trends toward flexible learning environments (e.g., tele-learning; m-learning; e-learning) are physically separating teachers and learners between and among each other. A physical separation affects interpersonal communication within the learning process in various ways. For example, monitoring student cues is important with respect to the provision of opportunities to gain understanding of teaching effectiveness (McAlpine, Weston, Beauchamp, Wiseman, & Beauchamp, 1999).

Building on prior knowledge, making thought processes more explicit, and developing organized knowledge structures are areas instructional psychologists have been intent on exploring for many years. Researchers have replaced a static notion of the learner with more dynamic process-oriented theories. Constructivist theories, although wide and varied, stress the social and active aspects of learning environments and advocate teachers acting more as guides than authoritarians. The learner's social and cultural interactions with the environment and the individual's self-regulation in terms of what they might attribute to their successful or unsuccessful learning experiences have become more pronounced. Weiner's attribution theory, for example, draws attention to attributions the learner makes explicit through self-monitoring, as well as the attribution cues that the teacher passes on to the students. When there is a separation between and among students and teachers, and communication technologies are used to facilitate the learning transactions, interpersonal communication processes change. These communication process changes, referred to by Moore as transactional distance, can alter expository teaching so significantly that new ways of teaching and learning are required (Kanuka, 2001; Moore & Kearsley, 2005). A good place to start in understanding these communication process changes is to begin with what we know about face-to-face interaction.

PSYCHO-SOCIAL RELATIONS TO PHYSICAL PROXIMITY

One way Burgoon, Bonito, Ramirez Jr., Dunbar, Kam, & Fischer (2002) derive an understanding of interdependent message exchange is by defining the properties of face-to-face interactions through the senses. Varying degrees of cognitive, emotional, and behavioural engagement, the ease or smoothness of the interaction, and perceptions of connection, receptivity, similarity and understanding all contribute to a rich, interactive experience. Nonverbal behaviours such as physical proximity, eye contact, touch, body orientation, and body lean enable sensory immersion and create psychological closeness as well as physical and social presence (Coker & Burgoon, 1987; Mehrabian, 1981; Short, Williams, & Christie, 1976). Two people in close proximity automatically share a heightened sense of mutual understanding, connection and common ground. In a study examining proximity, Burgoon *et al.'s* findings revealed that, "Actual or perceived distance can indeed weaken people's task engagement, their sense of connection with one another, and the credibility they ascribe to task mates" (p. 671). Further research is identified as being required to focus explicitly on what nonverbal cues might be available to augment verbal information and how such cues are actually utilized in the interaction process.

At a basic level, face-to-face interpersonal communication requires speakers and listeners to co-ordinate both content and process (Clark & Brennan, 1991; Whittaker, Brennan & Clark, 1991). Effective coordination of communication involves the construction and maintenance of shared beliefs, requiring listeners and speakers to infer and monitor each others' understandings, in addition to their attitudes and motivation. Much of our personal interaction in face-to-face classroom settings, which communicates our beliefs and intentions, requires paralinguistic and non-verbal cueing in addition to our individual utterances (Baron, 2000; Gram, Kanuka, Norris, 2004). Thus, both paralinguistic cueing and utterances infers a shared context that includes both linguistic and physical contexts (Grosz & Sidner, 1986), as well as the management of the conversation, or 'process coordination' (Whittaker, 1995). Individual utterances alone do not adequately convey beliefs and intentions (Allen & Perrault, 1986; Searle, 1990; Whittaker, 1995).

The importance of interpersonal communication on collaborative formations has been demonstrated by research. Research has revealed, for example, that people who are in close proximity to each other are more likely to communicate frequently. This, in turn, results in effective collaboration (see, for examples, Whittaker, 1995). Indeed, research has revealed that physical proximity has a significant impact on social and organizational knowledge, and we are more likely to not only be more familiar with the work of those who are close (e.g., an office next door; sitting in a chair next to us), but we are also more likely to respect the work of colleagues who are in close physical proximity (Kraut, Fish, Root, & Chalfonte, 1993).

CUEING IN COMMUNICATION AND MEDIATION

Theories on the impact of the non-verbal communication assert that paralinguistic cuing is critical to the management and coordination of the conversational content (Clark & Brennan, 1991). Non-verbal communication theories maintain that interpersonal communication requires cognitive cues (i.e., head nods and visual attention) (Clarke & Brennan, 1991; Clark & Schaefer, 1989), turn taking (i.e., head turning, posture, eye gaze) (Kendon, 1967) and social cueing (facial expression) (Argyle *et al.*, 1974). The latter, social cueing, is of particular importance in the formation of learning communities as this element of communication includes negotiations, bargaining, and conflict resolutions (Whittaker, 1995) – elements essential to higher level thinking and learning skills (Kanuka & Anderson, 1998). Further, research has shown that when we have access to visual information, our interactions are more personal, less argumentative, broader in focus, and less likely to end in deadlock (Reid, 1977; Williams, 1977).

There is also evidence that suggests text-based communication can be highly disruptive in the turn-taking process (Collett, Kanuka, Blanchette, & Goodale, 1999). Aspects fundamental to interpersonal interactions that require timely feedback, switching speakers, and clarifications are reduced, or absent; in text-based communications. Conversational turn-taking in this environment is also considerably more time consuming than face-to-face interactions making the communication system suitable for certain types of communication such as information exchanges which do not require fast, dynamic and animated exchanges. In teaching learners to learn, they become members in a community. They learn the social rules of that community, but also learn how to solve problems not just according to rules, but through good interpretations. Good interpretations involve the conceptual understanding of the roles and ways of interacting with a community. Producing and evaluating designs and policies is conceptually integrated with the person's identity as a member of the group (Clancey, 1995). Tools, activities and signs are representations which also give us more direct access to the conceptual understanding inherent within a particular group. While cognitive approaches provide analyses of the ways a learner's knowledge is structured, situative approaches provide analyses focused on the actions of individuals with material and informational systems in relation to one another. Cognitive studies which examine social interactions provide us with important clues about how communication can be used in e-learning environments to motivate students and stimulate their thought processes for deeper levels of learning and increased critical thinking skills.

COMMUNICATION BREAKDOWNS IN E-LEARNING

Garrison, Anderson, & Archer (2000) present a model of community inquiry to distance educators that acts as a guide for the optimal use of computer conferencing transactions. They identify three elements essential to an educational transaction in discourse environments: cognitive presence, social presence, and teaching presence. These authors note that group cohesion is a strong indicator of social presence and that the quality of text-based discourse is heightened when students see themselves as part of a group rather than as individuals. With regard to how social presence develops, Garrison *et al.*, assert that salient factors in participants' developing and sharing social presence through mediated discourse is created through familiarity, skills, motivation, organizational commitment activities, and length of time in having used the media (p. 95). They also note, similar to Burgoon *et al.* (2002), that participants in computer mediated communication environments develop compensating strategies in the absence or reduction of visual cues (Garrison *et al.*, 2000) and adapt technology to their communication practice (Burgoon, *et al.*, 2002).

Since simple information exchanges can be of limited benefit in student learning, distance educators remain committed to eliciting higher levels of thinking in asynchronous text-based communication environments. Jonassen (1997) proposed that cognitive tools were best used as reflection tools to amplify, extend, and even reorganize human mental powers in order to help learners construct their own realities and complete challenging tasks. Cognitive tools using asynchronous communication were thought to provide students with the opportunity to develop argument formation capabilities, increased written communication skills, greater complex problem-solving abilities, and increased opportunities for reflective deliberation (Abrami & Bures, 1996; Garrison, Anderson, & Archer, 2000; Hawkes, 2001; Winkelmann, 1995). Discourse models developed by Garrison *et al.* (2000), as well as Gunawardena, Lowe, and Anderson (1997) sought to explain how students involved in online discussion should move from lower to higher levels of learning. However, in practice, researchers such as Angeli, Valanides, and Bonk (2003), Gunawardena and Zittle (1996), Gunawardena, Carabajal, and Lowe (2001), Kanuka and Anderson (1997), and Thomas (2002) all found evidence documenting how student discussions remain primarily at lower levels of thinking due to an absence of challenging, debating and/or defending between and among students (Kanuka & Rourke, 2005). In testing Garrison *et al.'s* (2000) model of critical discourse, Kanuka and Rourke (2005) determined that students remain mostly in the exploratory phase (phase two of four phases). Similarly, in tests of Gunawardena *et al.'s* (1997) model, students remained in the lower two phases of sharing and comparing information, and discovering and exploring dissonance.

Further research into instructional strategies used in computer-mediated collaborative environments would provide even more empirical evidence of how these cognitive tools are able to promote higher order and critical thinking skills. To discover how higher levels of thinking might best be achieved in online discourse, Rourke and Kanuka (2005) conducted a study to analyze various types of instructional methods which incorporated discussion activities into their design. Specifically, within highly structured instructional methods (e.g., Webquests, Debates, and Deliberative Inquiry) findings revealed a denser concentration of discussion postings in the higher phases of critical discourse models. One explanation for these findings refers to discussion activities which explicitly require students to contend with one another's assertions. Research has also shown that with text-based computer mediated communication technologies, groups are less productive across tasks, have lower expressed satisfaction on tasks related to judgment, and lower cohesiveness than face-to-face groups (Straus, 1997). Moreover, computer mediated groups have less total communication, take more time to complete tasks than face-to-face groups (Hiltz, Johnson, & Turoff, 1986; Weisband, 1992) and experience higher rates of negative interpersonal communication (e.g., flaming). Alternatively, research has shown that face-to-face groups are more productive on all tasks and this difference becomes even greater when the number of task requirements increases (Straus, 1997). Hence, aspects of community important to higher education may be difficult to realize in text-based asynchronous computer-mediated distance education environments (Gram, *et al.,* 2004).

IMPACT OF TECHNOLOGIES ON IDENTITY FORMATION

Technology-mediated communication is a complex process. In particular, it is a complex multimodal process that involves not only speech, but also gaze, gesture, and facial expressions (Clark & Brennan, 1991, Clark, 1996). This research has given rise to the belief that multimodal technologies (such as video conferencing that provides both speech and vision) provide more effective communication than single mode technologies (such as audio conferencing or email and listservs). Somewhat surprisingly, research has not supported this assumption. A review of the research shows that speech alone can be as effective as speech plus video; under certain circumstances speech can be as effective as face-to-face communication and video is not significantly different from speech communication (Reid, 1977; Whittaker, 2003). Some research has even revealed that adding visual information may impair critical aspects of spoken communication (Anderson, *et al.*, 2000). Further, there is evidence from the research on communication media which indicates that audio systems (e.g., Elluminate, Centra), and audio and video systems (e.g., Web cams) can provide more effective interpersonal interactions than text-based communication systems alone (Collett, *et al.*, 1999). Though, this research should be interpreted with caution, as low quality video systems (e.g., discontiguous visual and audio transmissions) may provide distractions to a point where the communication process and the quality can be severely eroded (Whittaker, 1995; Whittaker, 2003). Currently, Internet networking bandwidths do not support high quality and/or stable video and audio systems.

Some research within the field of communication has also focused on aspects of media richness and/or the effects of filtered cues. Results of this research suggest that different communication media affect groups largely through differential transmission of social context cues (or paralinguistic cues). Text-based computer mediated communication is considered to be 'social cueing poor' as it limits the exchange of paralinguistic and interpersonal cues (e.g., age, sex, physical appearance) and other physical surroundings. Social cueing is an important aspect that facilitates and regulates interpersonal interaction, information and monitors feedback (Straus, 1997). Reductions in social cues through the use of reduced-channel media (e.g., text-based communication tools) disrupts the flow of communication causing difficulty in following and understanding discussions (Straus & McGrath, 1994). This can result in diminishing the intensity of interpersonal interactions and social connectedness, as well as increasing a sense of anonymity and feelings of depersonalization (Straus, 1997). In a depersonalized context, in

turn, there is reduced motivation to share personal information and/or inquire about others, as well as reduced expressive communication (Hiltz, *et al.*, 1986). Explanations for these results tend to revolve around the belief that the time and effort required to type versus speak results in considerably less communication in text-based discussions than face-to-face in addition to difficulties in following and understanding the text without supplementary social cues, adding to the cognitive workload (Straus, 1997).

Groups have access to a variety of interchanges: students of the same age interacting with their peers, younger students interacting with older students, and all students interacting with the instructor or various experts. Through this reciprocal interchange among several groups, novices adjust their perceptions and make new choices of language and activities. The computer is used as a tool to facilitate multiple interactions, since students of various ages are commonly placed in the same e-learning classroom. Younger students experience social relations differently from their instructors or older classmates, since the machines they use to mediate their communication often substitutes for face-to-face relations (e.g., Internet chats, cell phones). These technologies enable private subcultures to grow and exist in the public sphere. Hayles (2004) states that our ideas of the body change along with cultural changes, and declares that body boundaries intermingling with technology and information-rich environments leads to shifts in habits, postures, enactments, and perceptions.

DISCUSSION

While there is much we do not know about technology-mediated communication, we can glean from this literature that communication is a complex process. The purpose of this paper is to argue that communication and all its complexities in social interaction needs to be considered in terms of shaping both student and teacher identities with technology playing a non-neutral rather than passive role. Understanding how the non-neutral effects of technology affects students' experiences within the social context of distance learning could also provide distance educators with better insight into designing improved instructional environments which promote critical discourse while addressing a greater number of students' individual needs. Through social interactions in a local community-based practice, language, tools, symbols, and cues are used to objectify and communicate our concepts. Diminished social cues have also been shown to engender social apathy and foster socially undesirable behaviour. Students enter into dialogue with one another having also come from diverse ethnicities and a variety of personal experiences largely shaped by the technological devices which enable specific types of communication in the society within which they have been immersed. Important clues contained in interactive processes between humans in social networked systems may provide an increased level of adjustment by these systems to address the level of cognitive support required by learners. By furthering our understanding of various e-learning processes, we can ensure that the best possible educational scenarios emerge and are translated from theory into practice.

REFERENCES

Abrami, P. C. & Bures, E. M. (1996). Computer-supported collaborative learning and distance education. *American Journal of Distance Education, 10*(2), 37-42.

Allen, J & Perrault, R. (1986). Analyzing intentions in utterances. In B. Grosz, K. Sparck-Jones & B. Webber Eds. *Readings In Natural Language Processing*. Los Altos, California: Morgan Kaufmann.

Anderson, A.H., Smallwood, L., MacDonald, R., Mullin, J., Fleming, A. & O'Malley, C. (2000) Video data and video links in mediated communication: what do users value? *International Journal of Human-Computer Studies*, 52(1), 165-187.

Angeli, C., Valanides, N., & Bonk, C. J. (2003). Communication in a web-based conferencing system: The quality of computer-mediated interactions. *British Journal of Educational Technology, 34*(1), 31-43.

Argyle, M., Lefebvre, L., & Cook, M. (1974). The meaning of five patterns of gaze. *European Journal of Social Psychology*, 4, 125-136.

Baron, N. S. (2000). Alphabet to email. How written English evolved and where it's heading. New York: Routledge.

Burgoon, J. K., Bonito, J. A., Ramirez Jr., A., Dunbar, N. E., Kam, K., & Fischer, J. (2002). Testing the interactivity principle: Effects of mediation, Propinquity, and verbal and nonverbal modalities in interpersonal interaction. *Journal of Communication, 52,* 657 – 677.

Clancey, W. J. (1995) A tutorial on situated learning. *Proceedings of the International Conference on Computers and Education (Taiwan)* Self, J. (Ed.) Charlottesville, VA: AACE. 49-70, 1995. Available: http://cogprints.org/323/00/139.htm [Accessed 2004-12-23].

Clark, H. (1996). *Using language*. Cambridge University Press.

Clark H. & Brennan, S. (1991). Grounding in communication. In L.B. Resnick, J. Levine & S. TEASLEY, Eds. *Perspectives on socially shared cognition*. Washington DC, APA Press.

Clark, H., & Schaefer, E. (1989). Contributing to discourse. *Cognitive Science*, 13, 259-292.

Coker, D. A., & Burgoon, J. K. (1987). The nature of conversational involvement and nonverbal encoding patterns. *Human Communication Research, 13,* 463-494.

Collett, D., Kanuka, H., Blanchette, J., & Goodale, C. (1999). Learning technologies in distance education. Edmonton, AB: University of Alberta.

Garrison, D. R., Anderson, T., & Archer, W. (2000). Critical inquiry in a text-based environment: Computer conferencing in higher education. *The Internet and Higher Education, 2*(2-3) 87-105.

Gram, N. P., Kanuka, H., &, Norris, S. P. (2004). Distance education environments, higher education, and the concern for community. PAACE Journal of Lifelong Learning, 13, 39-56.

Grosz, B. & Sidner, C. (1986). Attentions, intentions and the structure of discourse. Computational Linguistics, 12, 175-204.

Gunawardena, C., Carabajal, K., & Lowe, C. A. (2001). *Critical analysis of models and*
methods used to evaluate online learning networks. (ERIC Document Reproduction Service No. ED456159).

Gunawardena, C., Lowe, C., & Anderson, T. (1997). Analysis of a global online debate and the development of an interaction analysis model for examining social construction of knowledge in computer conferencing. *Journal of Educational Computing Research, 17* (4), 395-429.

Gunawardena, C. N., & Zittle, F. J. (1996). Social presence as a predictor of satisfaction within a computer-mediated conferencing environment. *The American Journal of Distance Education, 1997, 11*(3), 8-26.

Hawkes, M. (2001). Variables of interest in exploring the reflective outcomes of network-based communication. *Journal of Research on Computing in Education, 33*(3), 299-315.

Hayles, K. N., (2004). Flesh and metal: Reconfiguring the mindbody in virtual environments. In R. Mitchell & P. Thurtle (Eds.), *Data made flesh: Embodying Information* (pp. 229-248). NY: Routledge.

Hiltz, S. R., Johnson, K., Turoff, M. (1986). Experiments in group decision making: Disinhibition, deindividuation, and group process in pen name and real name computer conferences. Decision Support Systems, 5, 217-232.

Kanuka, H. (2001). University student perceptions of the use of the web in distance delivered programs. *The Canadian Journal of Higher Education, 31*(3), 49-71.

Kanuka, H., & Anderson, T. (1997). On-line forums: New platforms for professional development and group collaboration. *Journal of Computer Mediated Communication 3*(3). Retrieved January 5, 2006, from *www.ascusc.org/jcmc/vol3/issue3/anderson.html#Professional*

Kanuka, H. & Anderson, T. (1998). On-line social interchange, discord, and knowledge construction. Journal of Distance Education, 13(1), 57-74.

Kanuka, H., & Rourke, L. (2005). *Questioning eLearning: What's gained and what's lost?* Manuscript submitted for publication.

Kendon, A. (1967). Some functions of gaze direction in social interaction. *Acta Psychologica,* 26, 1-47.

Kraut, R., Fish, R., Root, B. & Chalfonte, B. (1993). Informal communication in organizations. In R. Baecker Ed.,*Groupware and Computer Supported Cooperative Work*. San Mateo, California: Morgan Kaufman.

McAlpine, L., Weston, C., Beauchamp, C., Wiseman, C., & Beauchamp J. (1999). Monitoring Student Cues: Tracking Student Behaviour in Order to Improve Instruction in Higher Education. *The Canadian Journal of Higher Education, 29*(2), 113-144.

Mehrabian, A. (1981). *Silent messages: Implicit communication of emotions and attitudes* (2nd ed.). Belmont, CA: Wadsworth.

Moore, M., & Kearsley, G. (2005) *Distance education: A systems view* (2nd ed) (Belmont, CA, Thompson Wadsworth).

Reid, A. (1977). Comparing the telephone with face-to-face interaction. In I. Pool Ed., *The Social Impact of the Telephone*, pps 386-414. Cambridge, MA: IT.

Rourke, L. & Kanuka, H. (2005). *Barriers to online critical discourse*. Manuscript submitted for publication.

Searle, J. (1990). Collective intentionality. In P. Cohen, J. Morgan & M. Pollack Eds. Intentions in Communication. Cambridge, MA.: MIT Press.

Short , J., Williams, E., & Christie, B. (1976). The social psychology of telecommunications. London: Wiley.

Straus, S. G. & McGrath, J. E. (1994). Does the medium matter: The interaction task and technology on group performance and member reactions. Journal of Applied Psychology, 79, 87-97.

Straus, S. G. (1997). Technology, group process, and group outcomes: Testing the connections in computer-mediated and face-to-face groups. Human-Computer Interaction, 12(3), 227-266.

Thomas, M. (2002). Learning within incoherent structures: The space of online discussion forums. *Journal of Computer Assisted Learning, 18,* 351-366.

Weisband, S. P. (1992). Group discussion and first advocacy effects in computer-mediated and face-to-face decision making groups. Organizational Behavior and Human Decision Processes, 53, 352-380.

Whittaker, S. (1995). Rethinking video as a technology for interpersonal communication: Theory and design implications. International Journal of Human-Computer Studies, 42(5), 501-529.

Whittaker, S. (2003). Things to talk about when talking about things. Human Computer Interaction, 18(2), 149-170.

Whittaker, S., Brennan, S., & Clark, H.H. (1991). Co-ordinating activity: an analysis of computer supported cooperative work. In Proceedings of CHI'91 Human Factors in Computing Systems, 361-367, New York: ACM Press.

Williams, E. (1977). Experimental comparisons of face-to-face and mediated communication. *Psychological Bulletin*, 16, 963-976.

Winkelmann, C. L. (1995). Electronic literacy, critical pedagogy, and collaboration: A case for cyborg writing. *Computers and the Humanities, 29*(6), 431-448.

Construction of a Knowledge-Based Management System for Organizing Energy Management and Indoor Environmental Quality (IEQ) Related Data

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ABSTRACT

The National Center for Energy Management and Building Technology (NCEMBT) initiated a series of research projects related to the indoor environmental quality (IEQ) and energy performance of existing buildings. These projects have generated a vast amount of data on the operation of commercial and institutional buildings. The goal of the NCEMBT is to make these data available online via a knowledge-based resource management system (KBRMS). This paper describes the construction of the KBRMS including the data flow analysis, the data collection and assimilation process and the design, development and prototype demonstration of the KBRMS. The beta version of the KBRMS is operational. The system is divided into public and private sections with the enforcement of role-based access control (RBAC). The external public web portal displays general project information and the research-related publications while the internal web portal accesses project-related data analysis tools, analysis results and intranet communication modules. This paper shows some summary statistics that are automatically calculated through the pre-defined analysis tools using MS SQL Sever stored procedures. More field monitored building data will be put into the system resulting from future projects.

INTRODUCTION

Knowledge discovery in database (KDD) and data mining are emerging fields for extracting useful knowledge from volumes of data. As defined by Fayyad (1996a), "the KDD process is a nontrivial process of identifying valid, novel, potentially useful and ultimately understandable patterns in data". Data sets have little value unless meaningful knowledge can be extracting from the data (Fayyad, 1996b). The multi-step KDD process involves data integration, preparation and transformation, data mining and evaluation, and data visualization. A general framework for the KDD process, proposed by Ingolf (2002), identifies the relationship among management (process view), mining models (model view) and datasets (data view).

The NCEMBT initiated a series of research projects related to the IEQ and energy performance of existing buildings. Researchers from the University of Nevada, Las Vegas are major participants in these multi-year tasks. Each research project generates significant amounts of data. These data may be in form of building IEQ measurements, occupant perception questionnaire responses or underfloor air distribution (UFAD) flow simulation. NCEMBT is obtaining these data sets to transform the built environment by delivering applied research and educational information that results in sustainable building systems which are efficient, productive, secure and healthy.

The true value of the data does not lie within each set but rather in the sum of all the sets. The relationships contained between the individual building data sets are of most value not only to the NCEMBT researchers but also to other research entities, such as the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., the U.S. Environmental Protection Agency and private companies. Statistically significant relationships can only be developed and derived from the associations that exist among all the data sets. For example, a statistically valid correlation between ventilation rates and occupants' perception of the indoor environmental quality of their workplace can only be derived from the analysis of complete datasets of several buildings. However, to do so the existing datasets need to be upgraded to a data warehouse, which in turn will allow data mining. The development of the KBRMS is the first step towards the goal of data mining of large building sciences data sets. The concept of organizing and interpreting the discovered rules through the web as proposed by Ma (2000) will be used for this ongoing project.

Organizing such abundant, non-structured data on energy and IEQ performance of buildings using a well-designed, highly flexible internet-based management system, significantly increases the availability the inherent information resulting in greater knowledge generation. As discussed by Imielinski (1996), research on knowledge discovery scenarios can initially be achieved through the construction of performance-driven system and eventually move on to a complete knowledge and data discovery management system. The goal of this project is to create a system with KDD capability using results from multi-year research studies. This paper examines the flow of data collection and assimilation process, the design and development of the resource management system and presents the current stage of the KBRMS.

SYSTEM DESIGN

Based on its industrial experience, the NCEMBT has proposed an organizational framework to accommodate its data flow as shown in Figure 1. Because each functional area consists of various subjects, an analysis of the data flow needed to be completed prior to the implementation of the web-based resource management system. The analysis was followed by the design and development of the portal architecture.

DATA COLLECTION AND DATA FLOW

Information from NCEMBT projects was modularized and dissected into categories using the classification scheme depicted in Figure 1. Each category was further divided into (sub)levels depending on the underlying data structures (Figure 2). Such a classification approach provides strong data assimilation and reusability capabilities. Accessibility to individual modules was designed to be controlled by the user right definition. The system integrates and organizes all available information under designated repositories based on a customized user definition.

Figure 1. Requirement analysis performed based on the NCEMBT's functional areas

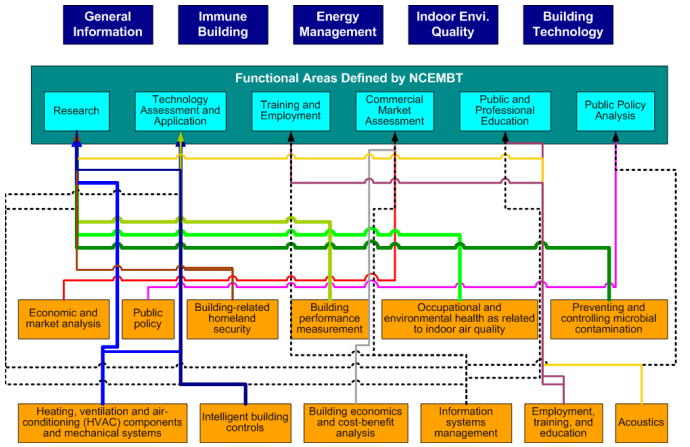
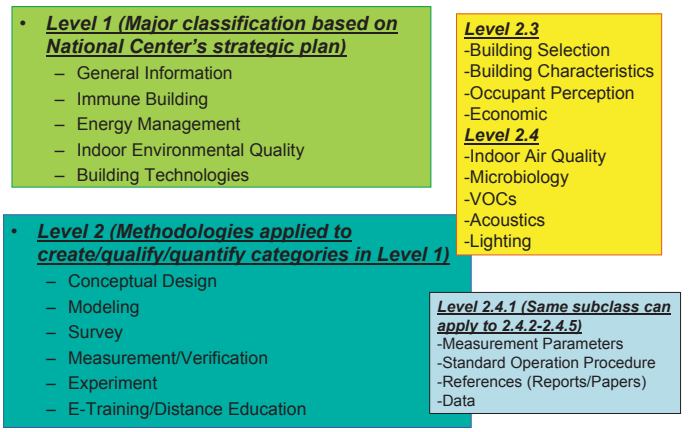


Figure 2. Hierarchy definition used for the portal system



Therefore, the same resources can be accessed by various users at pre-defined data resolutions. One primary development strategy was to minimize the administration effort for content managers and maximize the utilization of analysis and knowledge retrieval tools.

DATA FLOW

Analysis of the data flow as shown in Figure 3 defined the required modules and interfaces needed for the portal system. The data flow follows the path by which public users access the general information without undergoing a registration process. This path is also followed by the content manager to log in. This system is designed to allow

- building managers who participated in the building monitoring projects to access their respective building data and compare the performance of their building to all others contained in the data set
- users to download hourly averaged data sets through the web portal; and
- project team members to access all raw data up to a 10-second resolution.

SYSTEM DESIGN AND DEVELOPMENT

The web portal covers materials from passive information, such as general project introduction and organizational summary, to data-centered information pages, such as results of building occupant surveys or IEQ measurements.

A multi-tier application architecture was employed. The portal contains two data sources. The configuration settings are stored in an xml-formatted file while the content for the application is stored in a SQL Server database. Data access is provided through a Microsoft .NET assembly using the stored procedures. The portal framework was built using of a number of components that handle both the security and portal configuration information. The presentation layer is organized by several web forms and user controls that handle the display and management of the portal data for end users.

All portal contents are stored in MS SQL Server databases. The basic approach uses an xml file which contains all the configuration settings for the portal. This method provides a simple and easy way to manipulate configuration settings. The configuration file is used to store all high level portal, tab and module definitions.

The portal development was divided into three stages: database development, portal functionality module development and portal skin development. The knowledge management portal has two level of accessibility: external public web access and internal management tools. The internal management tools provide an efficient way for the content manager to update the web information. MS SQL Server was selected as the major data repository. Portal development and cosmetic presentation use MS .NET technology, including ASP.NET, VB.NET and XML.

Role-based access control (RBAC) is a proven technology for enforcing separation of duties, administration and access for web-based system. Ahn (2000) developed models, architectures and mechanisms for examining the application of RBAC in a web-based workflow system and implied suitability to deploy such control in large-scale collaborative environments. The system developed here builds upon Ahn's models.

Figure 3. Data flow definition for the portal

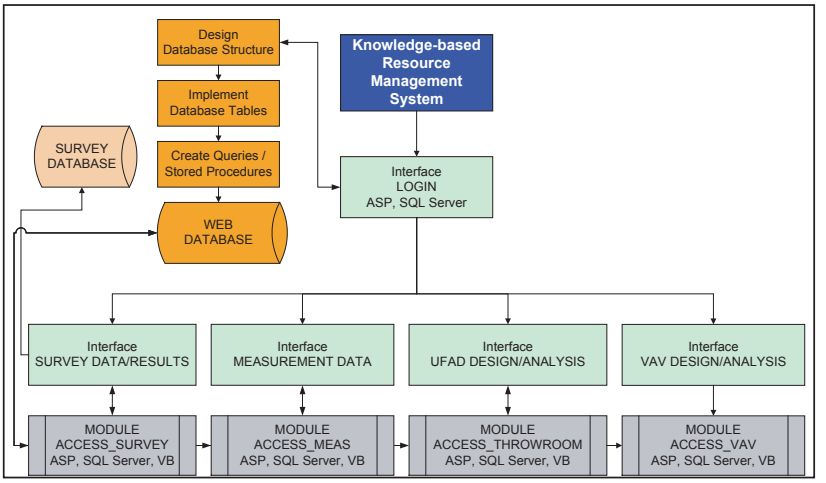
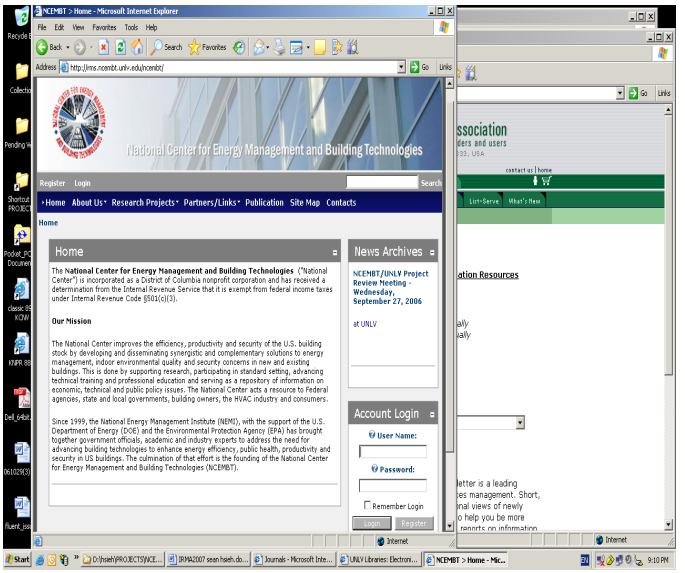


Figure 4. Public accessible web portal

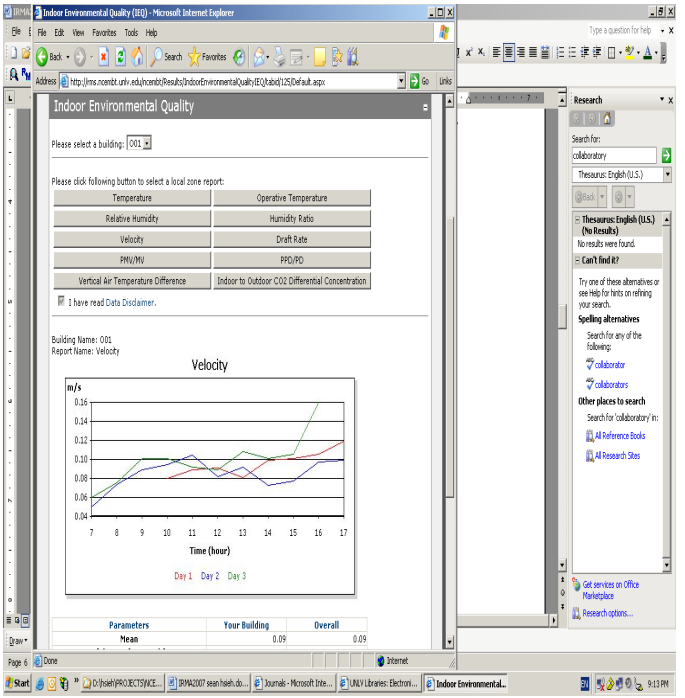


SYSTEM DESIGN

Portal Components

Nine basic portal components were implemented as shown in Figure 4. The web site can be accessed from public (seven modules) or private (nine modules) sections. General information can be viewed by all audiences without system login while private defined components/materials can only be viewed through a password-enabled mechanism.

Figure 5. Summary IEQ data reporting page



Reporting Module Example

Due to the complexity and large quantity of data collected from the first 20 buildings, a reporting module was developed to provide options for data aggregation, access to instant site-specific summary reports and download of the raw data files. Aggregated results and summary statistics of monitored building performance parameters can be accessed via pull-down menus. Figure 5 shows the screenshot of the IEQ parameters that can be displayed for each monitored building. A summary report was developed for each building and incorporates building demographics, recorded IEQ parameters including lighting, microbiological, and sound data and summary results of occupant perceptions of their respective indoor environments.

SUMMARY

An online knowledge-based resource management system to manage, organize and display large data sets of the performance of commercial and institutional buildings has been developed. Handling a large amount of data collected via various measurement techniques and approaches posed significant data storage and management challenges. It also offers a real-world experience on data cleaning, consolidation and manipulation. The knowledge-based resource management system provides pertinent stakeholders (i.e., researchers, engineers, building operators, and facilities managers) with a wealth of building performance data. The system allows users to access various aggregated monitored building parameter sets and provides results of statistical analyses of occupants' perceptions of their indoor environment questionnaire which have been compared to measured building performance parameters. The resulting knowledge is generated to further improve the built environment.

This is a continuous effort that will eventually evolve into the construction of data warehouse and data mining model of building sciences research. More energy management and building technology related knowledge from future projects will be made available along with the growth of the resource management system.

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REFERENCES

Ahn, G., Sandhu, R., Kang, M. & Park, J. (2000). Injecting RBAC to secure a Web-based workflow system. Proceedings of the fifth ACM workshop on Role-based access control, Berlin, Germany, 1-10.

Fayyad, U., Piatetsky-Shapiro, G. & Smyth, P. (1996a). From data mining to knowledge discovery: An overview. In Advances in Knowledge Discovery and Data Mining, U. Fayyad,, G. Piatetsky-Shapiro, P. Smyth, and R. Uthurusamy, Eds. AAAI/MIT Press, Cambridge, Mass.,

Fayyad, U., Piatetsky-Shapiro, G. & Smyth, P. (1996b). The KDD process for extracting useful knowledge from volumes of data. Communications of the ACM, 39(11), 27-34.

Imielinski , T. & Mannila, H. (1996). A database perspective on knowledge discovery. Communications of the ACM, 39(11), 58-64.

Geist, I. (2002). A framework for data mining and KDD. Proceedings of the 2002 ACM symposium on applied computing. Madrid, Spain, 508-513.

Ma, Y., Liu, B. & Wong, C. K. (2000). Web for data mining: organizing and interpreting the discovered rules using the Web. ACM SIGKDD Explorations Newsletter. 2 (1), 16-23.

Business Oriented Development of the IT Landscape: Architecture Design on a Large Scale

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ABSTRACT

The paper outlines enterprise architecture as a means of business IT alignment, the respective domains, and fundamental design techniques. It is based on three basic views on architecture. The component view describes the elements of architecture and their relationships. The communication view shows how the elements interact with one another. The distribution view describes how the elements are distributed in terms of location or organizational assignment. Key element of architecture design is to account for interdependencies among the building blocks of architecture. Blueprints are introduced as a means in planning the deployment of architecture on a large scale. Blueprints give a comprehensive view on the building blocks and how the interact. They show the effects of architecture design between business, application, and infrastructure architecture. The main stakeholders and their respective usage of the design techniques are outlined.

Keywords: business IT alignment, enterprise architecture, views, blue prints, stakeholders.

1. ENTERPRISE ARCHITECURE DEVELOPMENT AS A MEANS FOR BUSINESS IT ALIGNMENT

1.1 Enterprise Architecture Domains

Architecture is a commonly used term in the design of information systems. Yet, it is used very differently in scope ranging from the architecture of computer systems to information systems architecture. IEEE Standard 1471-2000 defines architecture as „.. the fundamental organization of a system, embodied in its components, their relationships to each other and the environment, and the principles governing its design and evolution" (IEEE 2000). We summarize the understanding of architecture in "architecture is the art and practice of designing and building structures".

Enterprise Architecture comprises the entire business with all its constituents. The alignment of the business and organizational design of the enterprise with the IT architecture is fundamental. However, understanding and structuring of the basic elements differs (see the discussion in Buhl and Heinrich 2004). The wide range of different domains and scope of enterprise architecture as well as its high complexity are characteristics of enterprise architecture.

The architecture domains introduced in this paper follow the basic structuring of the Open Group (TOGAF 2003) and details the respective domains in architecture building blocks in order to give a comprehensive overview of all constituents of enterprise architecture.

The *business architecture* describes the fundamental organisation and requirements of the business based on business strategy and objectives. It is composed of the following four building blocks:

The business model gives a high level view on the nature of the business in terms of products & services offered in the market, the value chain, business partners, market channels utilized, and the combination of resources and information for generating value add.

The organizational architecture describes the organizational design of the enterprise and the principal cooperation with customers and suppliers.

The process architecture classifies and describes all processes of the business and their respective value adds. It is the core building block of the business architecture.

The process architecture can be classified in the core business processes customer relationship management, supply chain management, product life cycle management and the management and support processes (see usage in figure 8).

The information architecture shows the logical structure of all information entities like products, business partners, logistic information etc.

The IT architecture is composed of the application - and infrastructure architecture.

The *application architecture* gives an overview on all applications supporting the processes of the business with the building blocks enterprise applications, portal & information management platform, data repositories, and EAI Services.

The *infrastructure architecture*, also referred to as technology architecture, comprises the software, hardware and network infrastructure required for operations of all applications. Infrastructure building blocks are basic services (e.g. Email, Telco), workplace services, server systems & storage, and the network. Security is integral part and described in an overlaying structure.

With this architecture definition in mind, it should be obvious that Enterprise Architecture is more than the collection of the constituent architectures. The interrelationships among these architectures, and their joint properties, are essential to the enterprise architecture.

In difference to TOGAF and META Group 2002 the Information Architecture in the above framework is not described as a separate architecture domain. It is split in a building block of the business architecture in terms of logical information structures and a building block of applications architecture in terms of implementation of data repositories. This provides for a clear distinction of the business oriented description of the enterprise architecture and the derived technological implementation (for an overview on other enterprise architecture frameworks see Lapkin 2004a and b).

This paper can only give an outline on the domains of enterprise architecture framework and sketch the main building blocks at a high level. All building blocks are detailed down to the level of modules, systems and components. The framework gives a comprehensive description of all relevant elements of enterprise architecture providing a principal structure and classification schema used as a reference for architecture development.

An Enterprise Architecture however, includes not only the three domains for the "as is" architecture (baseline architecture) and the target architecture. It contains also a strategic information base with a clear definition of business objectives and strategy.

The strategy is needed for the transitional processes in order to implement new technologies in response to the changing business needs. That means the enterprise architecture includes also the process to create, update and manage the evolution of the architecture domains in line with business strategy. The design of business architecture determines the development of the IT architecture.

The following listing sketches some objectives to be pursued with enterprise architecture (Aranow 2002, p. 9f., Masak 2005, p. 9f., Meta 2002, p. 6f., 49f., Günzel/ Rohloff 2003, p. 424, TOGAF 2003):

- Strategy and business orientation - enabling, leverage of IT, new business models
- Transparency - complexity and dependencies of architecture building blocks

- Communication between business and IT community - different people from management to IT experts involved
- Planning - target oriented, steering of I&C program with strong impact and to secure compliance to corporate standards
- Synergies - develop & implement the I&C landscape in a systematic manner and to utilize synergies
- Adaptability - dynamic development of market, business, and technology, provide for scalability and growth

Enterprise Architecture is a means to support business and IT alignment. Architecture planning is the ground for the development of the IT landscape and at the same time provides the agility to react fast to market requirements.

1.2 Overview on the Architecture Framework

An architecture description is a formal description of a system, organized in a way that supports reasoning about the structural properties of the system. It defines the building blocks and components that make up the overall system, and provides a plan from which products can be procured, and systems developed, that will work together to implement the overall system.

The IEEE-Standard "Recommended Practice for Architectural Description of Software Intensive Systems" (IEEE 2000) can be used as a basis for an architecture description: every system has an architecture, which can be recorded by an architectural description. The architectural description is organized into one or more constituents called (architectural) views. Each view addresses one or more of the concerns of the system stakeholders. The term view is used to refer to the expression of a system's architecture with respect to a particular viewpoint (Bachmann 2000, Clements et al. 2003).

In contrast to information systems architecture, which is widely discussed under the aspect of a single information system being integrated in an organization and aligned with business processes, enterprise architecture takes the entire IT landscape into focus. In comparison architecture is understood as city planning and not only as planning the architecture of a house (Gartner 2002, Burke 2003). It requires the definition of development plans for an entire area and not only the construction plan for a building. The development of the IT landscape in contrast to the information system architecture of a single system is architecture design on a large scale. It requires adequate features for architecture description.

Essential requirements for "architectures in the large" (compare Dern 2003, p. 81-83) are:

- Reduction to core entities and construction principles
- Balance of abstraction and specialization
- Representation of mutual dependencies
- Integration of architecture in the large and in the small

In the following we will show how an architecture framework and three distinct views on architecture support the reduction to core entities and construction principles. Blueprints give overview on the IT landscape and show interdependencies between the building blocks of architecture. Views and blueprints can be combined for large and small scale architecture development. The figure 1 depicts the architecture framework and the corresponding techniques for architecture description. It is based on the principal elements of the architecture framework for information systems described by Sinz (Sinz 1997, p. 3). The framework is based on the following elements:

Views: Each enterprise architecture domain can be described taking a specific view, which looks at the architecture, its structure and elements from a specific perspective.

Relationship/ dependencies between the enterprise architecture domains can be described using the concept of blueprints.

Standards are an essential element being used for all architecture building blocks which provide for inter-changeability, ease of across system communication etc.

Besides the use of standards, identification and usage of commonly recognized pattern is also an important objective for architecture design.

We focus on the introduction of three distinct views for enterprise architecture and the description of architecture dependencies with the means of blueprints. Pattern and standards are not described in this paper.

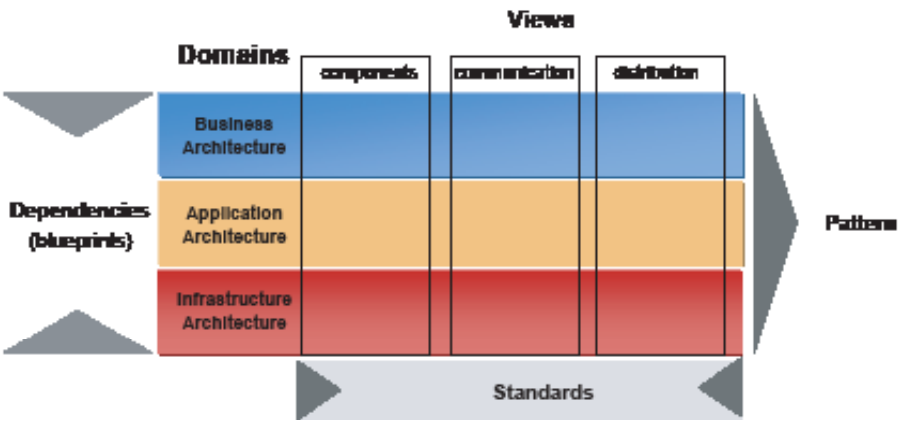
2. TECHNIQUES FOR ENTERPRISE ARCHITECTURE DESIGN

2.1 Views on Architecture

The principle of views is the basis of every reasonable architecture description and the need for multiple views in architecture descriptions is widely recognized in the literature. The IEEE standard 1471 (IEEE 2000), however, describes only the concept of views, stakeholders and concerns. Because of the wide range of opinions on selecting appropriate views, the standard does not make any statements on selecting views, the notation or name of views.

There exists a variety of views in different architecture frameworks. Data-, function-, process oriented views, and dynamic aspects are often named, sometimes supplemented by an organizational and resource view (e.g. for different views see the information system architectures discussed in Bernus et al. 1998). Zachman (1987, p. 291) was one of the first to state "There is not an information architecture but a set of them" and he introduced different views on architecture. This work was continued over the years (Sowa/ Zachmann 1992, Zachman framework). It comprises more than 30 views in a matrix with data, function, network, people, time, and motivation in scope from planning to implemented architecture. The main drawback is the fact that there are too many views included in it. The framework is a mix of views, domains of enterprise architecture, and different stakeholders.

Figure 1. Architecture framework and architectural description



Taking a close look on the diversity of views, we identified three basic views which are sufficient to describe all relevant aspects of enterprise architectures:

Component view: The view describes the logical and functional structure of the architecture in scope. All building blocks and their systems and components are described in terms of composition, structure and relationships among one another. The component view allows for different level of detail. Components, systems, subsystems, building blocks can be grouped or decomposed. The segmentation of the diagram is in building blocks based on the respective architecture in scope.

Communication view: The view describes the communication (interaction) between systems and components. The relationship among the systems is decomposed in the interaction of components within a system and to other systems. Different types of communication can be described with distinct notation for communication lines. The segmentation of the diagram is in communication areas based on the respective architecture in scope.

Distribution view: The view describes the allocation of systems or components in terms of geographical or organizational distribution. The diagram is segmented in organization or location based on the respective architecture in scope.

Figure 2 gives an overview, which illustrates the basic look of these views. An aggregated view on architecture is required which goes beyond the semantics of modelling techniques like UML, thus a notation specific for the purpose of architecture design has been developed (see figure 4 for more details).

These three views can be applied to all domains of enterprise architecture. However, the segmentation of the diagram is selected according to the appropriate context of the domain and chosen level of detail. In the following section we

Figure 2. Three views on Architecture (principal layout)

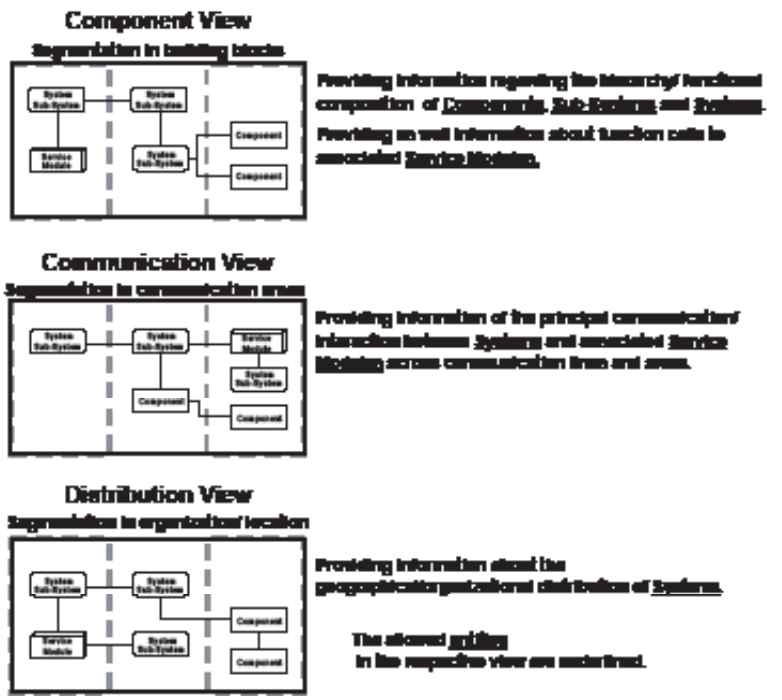
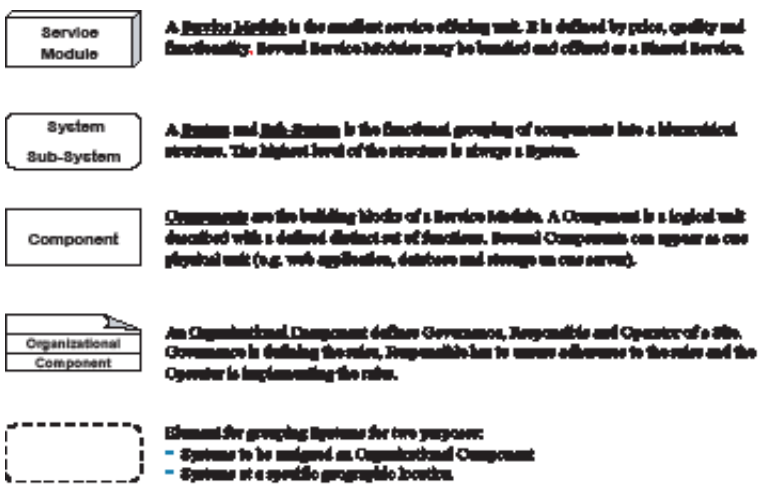


Figure 3. Notation for architecture views (extract)



illustrate the use of the views for the domain of infrastructure architecture using the example of an Email Service.

The high complexity of enterprise architectures can be reduced by taking particular views which focus on specific aspects of architecture. The three views facilitate the reduction to core entities and construction principles as well as the understanding of their behaviour.

One objective among others in the description of architecture is to identify pattern in order to establish standards for the design of architecture (Buschmann et al. 1996). These standards can be derived from these views for components, communication or distribution.

For the design of architecture a "Service Oriented Architecture" (SOA) approach is followed. Basically, IT architecture can be always seen as providing services to the business, e.g. an application supporting a business process or office and communication services at the workplace. This perspective puts the value add of IT into the focus. Consequently the building blocks of the architecture framework are structured in service groups, core services, and service modules. The example of an Email Service is used to demonstrate the description of this service using the three views. It is not only to show how these views describe the Email Service in all its aspects but also to outline the notation and features of these views. Figure 3 gives an extract of the notation of the essential elements.

Figure 4. Component view (example Email Service)

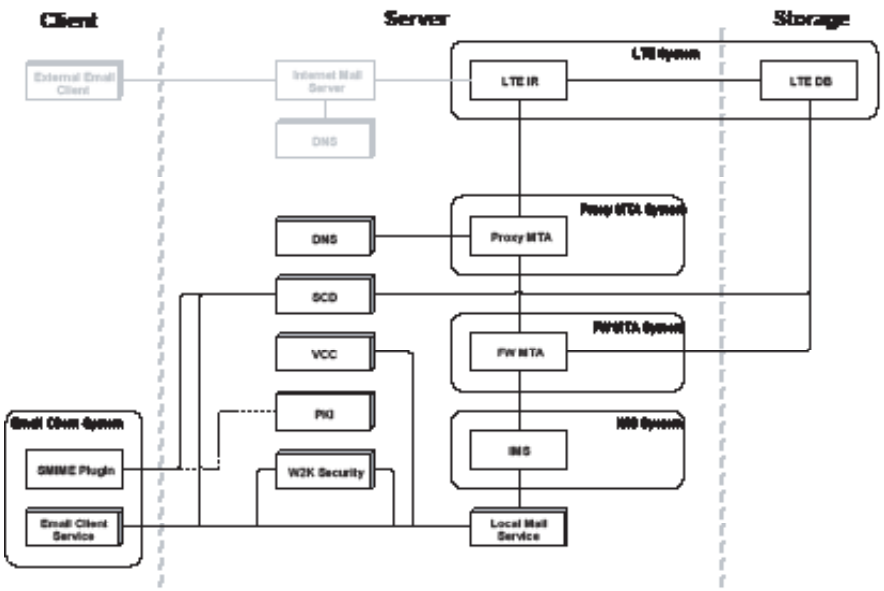
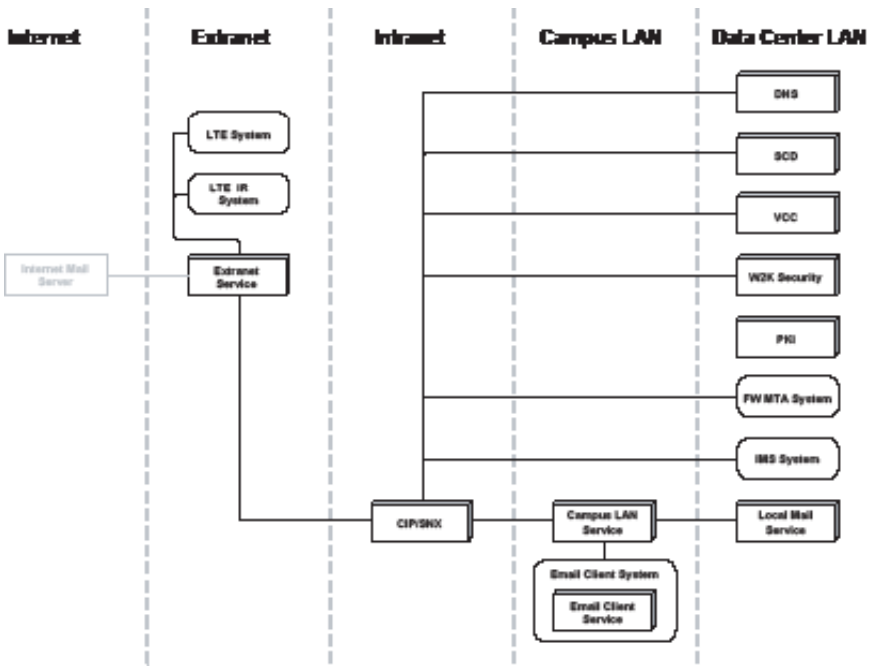


Figure 5. Communication view (example Email Service)



The component view is used to convey the functional and logical structure of architecture. As depicted in figure 4, the view is divided vertically into three major parts: client systems, server systems, and storage systems (infrastructure building blocks). All service modules, systems, and components are described in terms of composition, structure and relationships among one another.

The communication view describes the interaction between the service modules, systems, and components of the Email Service. The diagram is segmented in the communication areas Internet, Extranet, Intranet, Campus LAN, and Data Center LAN.

The distribution view describes the allocation of service modules, systems, or components in terms of geographical or organizational distribution. The distribution view is divided horizontally into three major parts. The segmentation of the diagram follows the company's organization in corporate, group, and region. In addition organizational responsibility is assigned which defines Governance, Responsible, and Operator of a Site. Governance is defining the rules, Responsible has to ensure adherence to the rules, and the Operator is implementing the rules.

The Email Service example illustrated the use of the three views for infrastructure architecture. The same principles for the design of the views are applied for applications architecture using the respective building blocks for the segmentation of diagrams. The views can be used at any level of detail for the decomposition of the chosen part of architecture (building block, service module, system). The combination of the architecture descriptions derived can be used for an integration of architecture in the large and in the small.

2.2 Dependencies of Architecture Building Blocks

Enterprise Architecture is more than the collection of the constituent architectures. The inter-relationships among these architectures, and their joint properties, are essential to the enterprise architecture. Thus, the architecture domains should not be approached in isolation. Key element of architecture design is to account for interdependencies among the building blocks of architecture. Blueprints are introduced as a means in planning the deployment of architecture on a large scale. Blueprints give a comprehensive view on the building blocks and how the interact.

Figure 6. Distribution view (example Email Service)

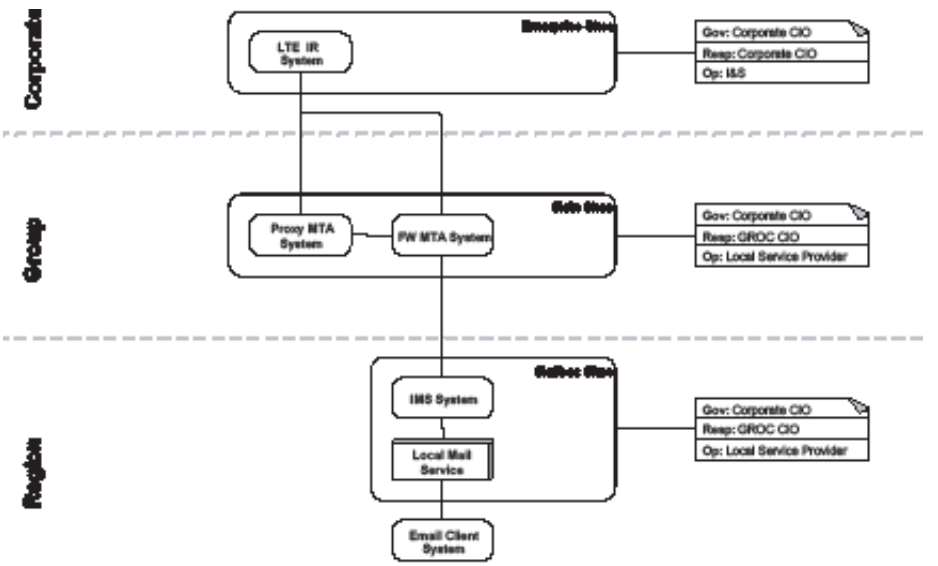
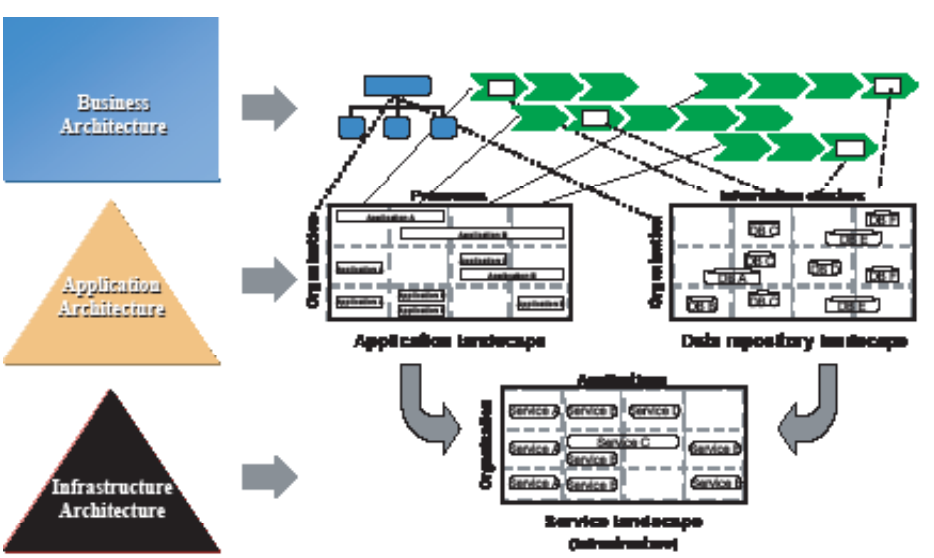


Figure 7. Main blueprints for IT architecture development



They show the effects of architecture design between business -, application -, and infrastructure architecture.

In the focus of enterprise architectures is the alignment of business and IT. In other words, the design of the business architecture determines the IT architecture which has to support and enable business. The building blocks of business architecture, with the process architecture as the core, define the frame for the design of the IT landscape. The dependencies between the different architectures can be described in blueprints. A blueprint is a plan which describes the deployment of an architecture building block across the enterprise. It pictures the landscape of this building block in a matrix of two business dimensions.

The Figure 7 illustrates the derivation of main IT blueprints from the organization and process architecture.

The application landscape describes for each business process how it is supported by applications. The second dimension shows the deployment in organizational units, like divisions, business segment etc.

The data repository landscape describes the deployment with databases and how they support defined information clusters of the information architecture. The second dimension shows the deployment of the databases in organizational units.

The service landscape shows the deployment of infrastructure services and the support of applications. The second dimension shows the deployment in organizational units.

In general, different types of blueprints can be generated depending which dependency of business -, applications -, and IT infrastructure architecture or respective building block is in focus. Also, the matrix dimensions can be chosen at different level of detail. However, the experience in architecture projects shows that a high level is sufficient in order to derive decisions for architecture development. Generating to detailed blueprints involves a lot of resources and time without enriching the decision base in the same degree. The three blueprints introduced provide a good information base for management decisions. The following section gives an example of an application landscape for Siemens Medical being worked out in a corporate architecture project.

Blueprints for application landscape are in the main focus in order to show IT support for business. The figure 9 gives an example of an "as is" application landscape of the medial solution group of Siemens AG. The applications in use are mapped to level 1 business processes of Siemens. Second dimension of the matrix are the divisions of medical solution.

In a number of projects these types of blueprint have been proven to give a transparent overview on the application landscape and are a sound basis to derive architecture decisions. At a glance one can see processes not supported by applications or redundancies where more than one application is in place for a process. Blue prints are used for presentation of "as is" as well as target architecture. The blueprint of the target architecture describes the deployment plan to implement IT strategy. From the gap analysis of "as is" and target architecture IT projects are derived. Finally, the projects are prioritized and the overall IT program is defined in order to implement the architecture.

3. ARCHITECTURE DESIGN TECHNIQUES AND STAKEHOLDERS

The scope of enterprise architecture and the architecture development process, ranging from strategic formulation to implementation, in mind it is obvious that a number of people coming from different organizational backgrounds and disciplines are involved. Figure 9 outlines the main stakeholders involved in planning, development, and implementation of enterprise architectures. It shows their basic roles and usage of architecture design techniques (see Dern 2003, p. 108f., META 2002, p 69f., 205f., 333f., TOGAF 2003). In addition to the techniques discussed in the prior chapter, methods for IT strategy definition and implementation are included in this overview due to the fact that this is the major reference for architecture development.

The stakeholders like CEO/CFO; CIO, IT strategy planer, and program manager are involved in the business/ IT strategy and decisions for direction, objectives

Figure 8. Blueprint example of "as is" application landscape medical group Siemens AG

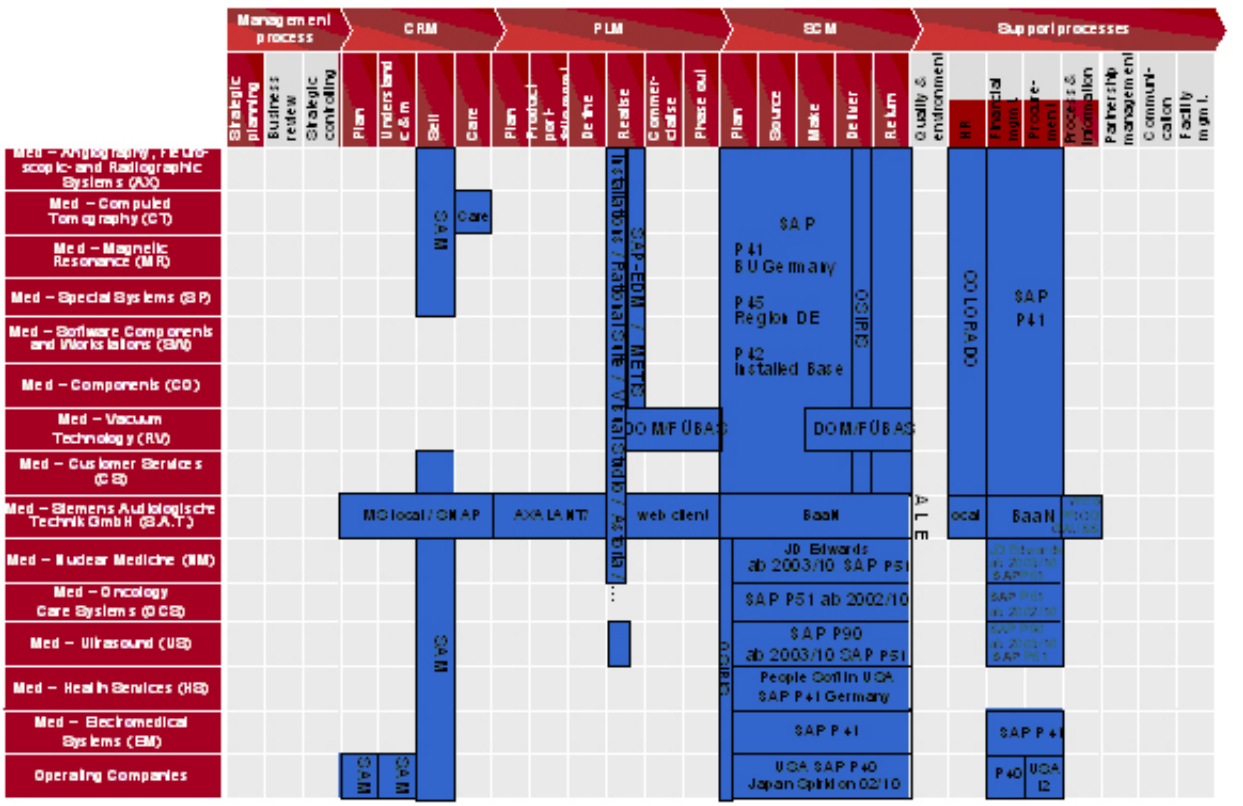
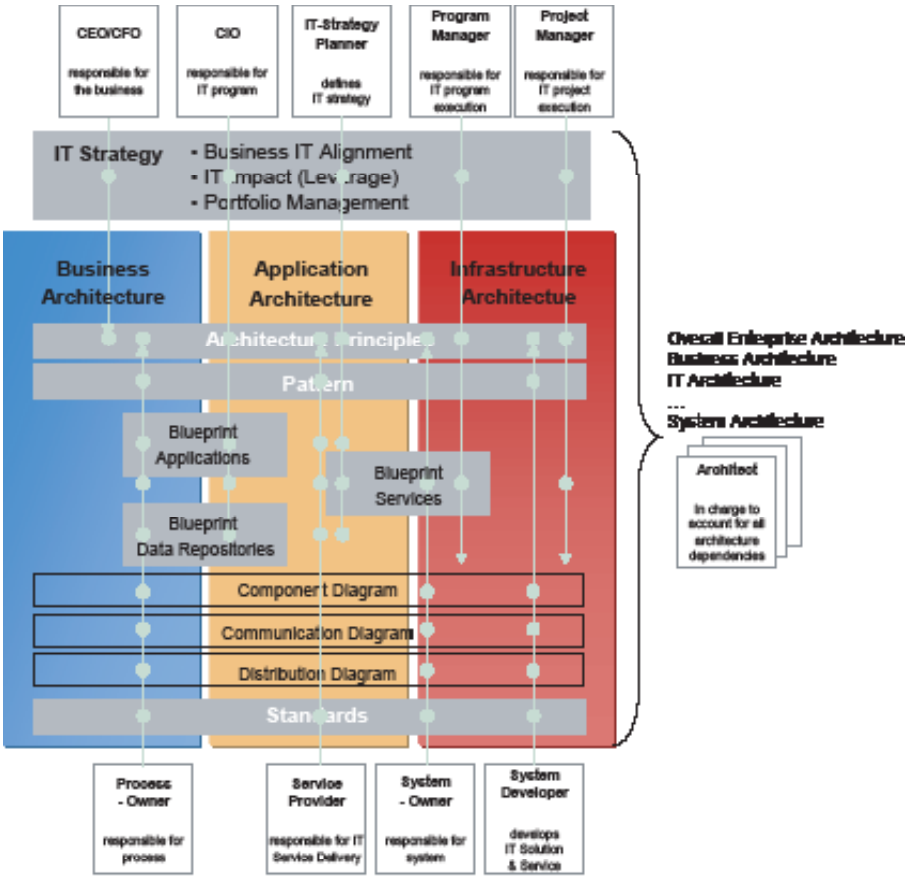


Figure 9. Architecture design techniques and stakeholders



of architecture, and IT program. They merely use methods of business IT alignment, IT impact, portfolio techniques and blueprints. Architecture principle and pattern are partly used.

The central role plays the enterprise architect who leads the architecture development and coordinates all respective activities. He is responsible for as is/ target-architectures and the dependencies among architectures. In addition, there are other domain related architects involved. Responsibility of architects can be on diverse domains ranging from enterprise - to system architecture. Architects use the entire range of techniques with different levels of detail depending on their respective domain.

Process owners focus on blueprints which show how processes are supported by applications and services. Principles and patterns for business architecture are also used.

Service providers use blueprints for an overview of the IT landscape and to allocate services. Principles and patterns are also used.

System owners and system developers use component -, communication - , and distribution diagrams with focus at system level. Defined principles and pattern are basis for their work.

Thus, these techniques are used differently by the stakeholders depending on the respective scope of work. The different ways of architecture description are an important means of communication among the stakeholders involved in the architecture development process and the alignment of business and IT. In order to generate different views of architecture, all architecture documentation is stored in a repository. The Corporate modeler (Casewise 2006) is used and enhanced with additional features for architecture description. The IT Navigator (IT Navigator 2002) was developed for analysis and assessment of architecture (blueprints, IT project portfolios etc.).

However, architecture development is very much management and communication among the different parties involved and not only technical construction. The techniques introduced are embedded in a well defined architecture development process. Within the scope of this paper only an outlook on the main stakeholders could be given. Architecture management and process are fundamental for a business oriented, sustainable development of enterprise architecture. Project experiences in this area will be addressed in a separate paper.

REFERENCES

Aranow, E. (2002): Enterprise Integration Strategies, Cutter Consortium 2002

Bachmann, F. (2000): Software Architecture Documentation in Practice: Documenting Architectural Layers, Special Report CMU/SEI-2000-SR-004, March 2000

Bernus, P./ Mertins, K./ Schmidt, G. (Editor) (1998): Handbook on Architectures of Information Systems, Berlin et al. 1998

Buschmann, F.; Meunier, R.; Rohnert, H.; Sommerlad, P.; Stal, M. (1996): Pattern-Oriented Software Architecture, A System of Patterns. John Wiley & Sons Ltd, Chichester, 1996

Buhl, U.; Heinrich, B. (Editors) (2004): Meinung/Dialog: Unternehmensarchitekturen in der Praxis – Architekturdesign vs. situationsbedingte Realisierung von Informationssystemen, Wirtschaftsinformatik 46(2004)4, p. 311-321

Burke, B. (2003): Enterprise Architecture or City Planning?, META Group, Report 2638, 2003

Casewise (2006): Corporate Modeler, see http://www.casewise.com/ , called 2006-07-30

Clements, P.; Bachmann, F.; Bass, L. (2003): Documenting Software Architectures: Views and Beyond, Addison-Wesley, 2003.

Günzel, H./ Rohloff, M. (2003): Architektur im Großen: Gegenstand und Handlungsfelder, in: Dittrich K.; König, W.; Oberweis, A., Rannenberg, K.; Wahlster, W. (Editors): Informatik 2003 Innovative Informatikanwendungen, Volume 2, Bonn 2003, S. 422-425

IEEE (2000): IEEE Standard 1471-2000, Recommended Practice for Architectural Description of Software-Intensive Systems. IEEE Computer Society, New York, October 2000

Dern, G. (2003): Management von IT-Architekturen, Wiesbaden 2003

Gartner Group (2002): Enterprise Architecture and IT "City Planning", July 2002

IT Navigator (2002): Siemens AG CIO, IT-Navigator Tool Description, 2002.

Lapkin, A. (2004a): Architecture Frameworks: How to Choose, Gartner Research, November 2004

Lapkin, A. (2004b): Architecture Frameworks: Some Options, Gartner Research, November 2004

Masak, D. (2005): Moderne Enterpise Architekturen, Berlin et al. 2005

Meta Group (2002): Enterprise Architecture Desk Reference, 2002

Sinz, E. (1997): Architektur von Informationssystemen, München 1997

Sowa, J.F./ Zachman, J. (1992): Extending and Formalizing the Framework for Information Systems Architecture, in: IBM Systems Journal 31(1992)3

TOGAF (2003): The Open Group Architecture Framework: Version 8.1, December 2003

Zachman, J. (1987): A Framework for Information Systems Architecture, in: IBM Systems Journal 26(1987)3,

Zachmann Framework, see http://www.zifa.com/ , called 2006-07-30

Influence Analysis in the Keiretsu of Mazda

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ABSTRACT

One of the most important issues in Customer Relationship Management (CRM) is how to measure the relationship with customers. More research into quantitative approaches to this measurement is needed. To help consider this issue, the reciprocal relationship between the automobile maker Mazda and its suppliers is analyzed and the results presented in this paper. This set of interlocking business relationships is known as a keiretsu. This paper uses the influence analysis tool DEMATEL (DEcision MAking Trial and Evaluation Laboratory), to measure one kind of reciprocal relationship, the influence, of each firm in the keiretsu of Mazda Yokokai. The results of this analysis are used to identify some characteristics of effective relationships between Mazda and its suppliers.

Keywords: influence, relationship, cross-shareholdings, transactions, DEMATEL

1. INTRODUCTION

A keiretsu is a set of companies with interlocking business relationships. In the Japanese automobile manufacturing industry, these relationships include cross-company transactions and cross-shareholdings between automobile manufacturers and companies supplying their parts. A keiretsu can be considered as a type of network organization. In the automobile manufacturing industry, the competition between manufacturers is substantially the competition between the keiretsu of manufacturers. Generally speaking, from 60 percent to 70 percent of the cost of each vehicle is derived from the cost of auto-parts. The remaining costs are labor, equipment costs, and various other costs such as advertising and distribution. For different automobile manufacturers, for each vehicle with the same displacement volume, the selling price, wages of employees, and the price of raw materials, are approximately the same. Consequently almost all of the profit is generated from the reduction in costs of the parts obtained from suppliers. Hence, one kind of reciprocal relationship, the influence between the manufacturer and its suppliers, is a key competitive factor in the industry. The aim of this paper is to use the influence analysis tool DEMATEL (DEcision MAking Trial and Evaluation Laboratory), to measure the influence of each firm in the keiretsu of Mazda Yokokai and hence uncover the effective structural relationships between suppliers and the automobile manufacturer.

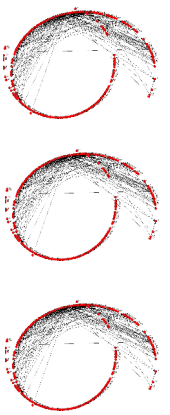
The structure of this paper is as follows: In Section 2 the authors briefly review some previous studies of relationships; Section 3 introduces and applies the DEMATEL measurement technique, showing the result of the influence of each firm in the keiretsu of Mazda; An analysis and discussion of the implications of the measurement results are presented in Section 4. The final section (Section 5) contains some concluding remarks.

2. BACKGROUND

There are many kinds of reciprocal relationships that can be considered. Dyer analyzed the relationship between firms based on distances between their locations and the frequency of face-to-face communication among engineers in the automobile industry (Dyer, 1994, 1996). Bensaou identified the successful portfolios of buyer-supplier relationships from the viewpoint of effective supply-chain management (Bensaou, 1999). Ito measured the firm's relationship in the keiretsu of Toyota from the viewpoint of centrality (Ito, 2004). Ito and Sakamoto developed a new method to calculate the importance of each individual firm in the keiretsu of Toyota and Nissan (Ito and Sakamoto, 2005). Recently, inter-organizational relationships in keiretsu have been analyzed with quantitative analysis tools such as CONCOR (Lincoln and Gerlach, 2004). Fukuoka et al reported a new trend in relationships between firms in the keiretsu of Nissan from the viewpoint of network organization (Fukuoka et al, 2006). All of these researchers focused on the relationship of each firm in the keiretsu. However, there are only a few empirical studies that analyze reciprocal relationships between the firms in the keiretsu (Nohria and Eccles, 1992; Hakansson and Waluszewski, 2002). One kind of reciprocal relationship is the level of influence between firms. Measuring this level of influence helps to identify effective relationships between firms.

3. MEASUREMENT

Influence is a term that refers to the power to indirectly control or affect the actions of other persons or things. In the social sciences, influence derives from an interpersonal relationship, and most research into influence is based on a psychological approach. Fontela and Gabus (1976) developed a tool for analyzing influence networks called DEMATEL, which is an abbreviation for DEcision MAking Trial and Evaluation Laboratory. DEMATEL is an approach for identifying the influence or the hidden or indirect power of a group of relationships, based on the principle "Friends of my friend are my friends". In this current research, DEMATEL is used as a new method to measure the influence of actors within the keiretsu of Mazda Yokokai.



3.1 Outline of DEMATEL

A brief overview of the mathematical basis of DEMATEL is as follows.

In a social network composed of n actors, the binary relation between each actor and the strength of this binary relation can be identified. Based upon the structure of this pattern of reciprocal relationships, an n×n adjacent matrix A^* can be obtained. The first step in the analysis is to normalize this matrix by multiplying each element of A^* by l , the largest row sum of A^*. The normalized matrix $A = l A^*$ is therefore obtained. The (i, j) element of a_{ij} of this matrix denotes the level of direct influence from actor i to actor j.

The reachable matrix, denoted by A^x, refers to the fact that actor i can reach actor j through the number of steps x. For instance, A^2 means that actor i can reach actor j through 2 steps. Therefore A^x measures the indirect influence from actor i to actor j. All of the levels of indirect influence can be summarized as follows, which the authors refer to as the indirect matrix.

$$A^f = A^2 + A^3 + \cdots + A^n = A^2(I - A)^{-1}$$

The total influence matrix, which includes both the direct and indirect influence matrix, can therefore be expressed as follows.

$$T = A + A^f = A + A^2 + A^3 + \cdots + A^n = A(I - A)^{-1}$$

3.2 Data Collection

In order to measure this pattern of influence, data showing the transactions and cross-shareholdings in the keiretsu of Mazda Yokokai were collected from the publications of the Japan Auto Parts Industries Association and Automotive Parts Publishing Company (JAPIA&ATJC, 2005). In 2004, the number of firms involved in transactions and cross-shareholdings was 181 and 223 respectively. This data set makes up about 42 percent of the complete set of transactions between Mazda and other firms.

The relationships between the firms in each category were identified through graph modeling. A tie shows the presence or absence of transactions or cross-shareholdings between each pair of firms. The authors collected directed 0-1

Figure 1. Relationship graph of transactions of Mazda Yokokai in 2004

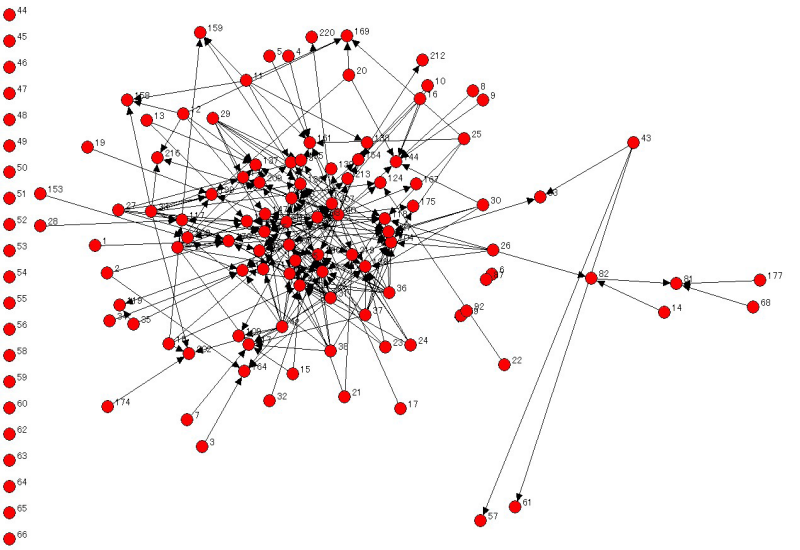
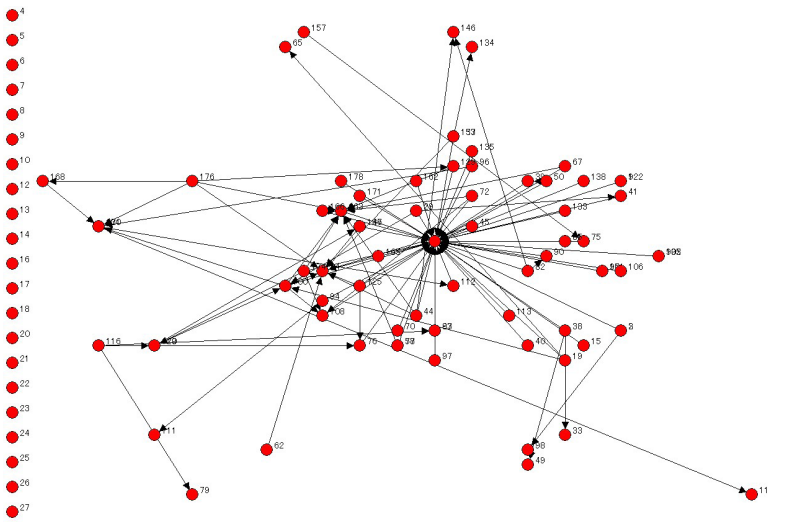


Figure 2. Relationship graph of cross-shareholdings of Mazda Yokokai in 2004



relationships to model the influence of each firm. The network of transactions in the Mazda keiretsu is shown in Figure 1, and the network of cross-shareholdings in the Mazda keiretsu is shown in Figure 2. The numbers in both Figures 1 and 2 refer to various companies in the keiretsu. The list of company names is provided in Appendix I.

3.3 Influence Measurement

Using a computer program developed by the authors, the influence of each firm in the Mazda keiretsu was calculated. The result of the influence of transactions is shown in Figure 3.

Figure 3 shows that the influence from Mazda to other suppliers is zero, but the influence from other suppliers to Mazda is quite high. Figure 4 shows the influence from other suppliers to Mazda in more detail. The total influence from other suppliers reaches 5.46. This shows Mazda received many parts from suppliers. The influence of cross-shareholdings was calculated using the same method. The influence from Mazda to other suppliers is 0.50, but the influence from other suppliers to Mazda is zero.

The results of this analysis clearly show that Mazda has investments in many of the companies that supply its parts, and consequently receives many parts from these suppliers.

4. ANALYSIS AND IMPLICATIONS

The finding that the more investment that Mazda makes in its supplier firms the more transactions Mazda will have with them, is not an unexpected result. The question that can now be asked is: "How strong is this relationship between level of investment and number of transactions?" To answer this question, the correlation coefficients between transaction and cross-shareholdings were calculated. The results of this analysis are shown in Table 1.

This analysis shows that two correlations, that between influence B of transactions and influence A of cross-shareholdings, and that between influence A of

Figure 3. Transactional relationships in the Keiretsu of Mazda Yokokai

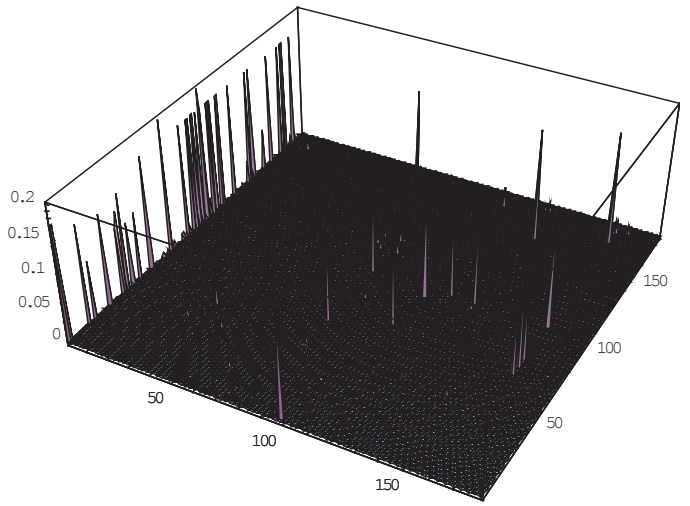


Figure 4. Influences from other suppliers to Mazda

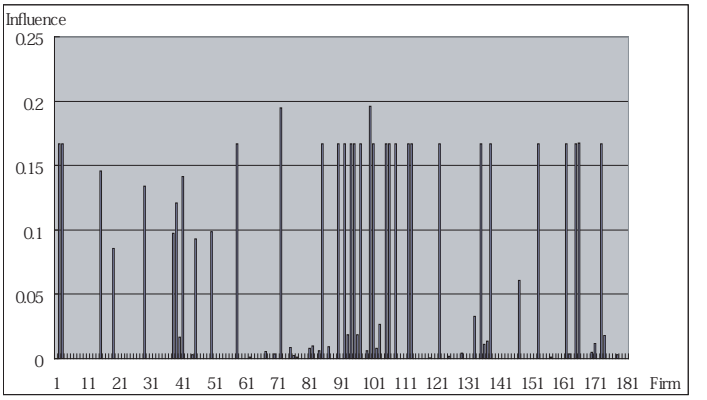


Table 1. Matrix of correlation coefficient between transaction and cross-shareholdings

		Cross-shareholdings		Transaction	
		Influence A	Influence B	Influence A	Influence B
Cross- shareholdings	Influence A	1	0.030	0.039	0.678**
		-	0.687	0.604	0.000
		181	181	181	181
	Influence B		1.000	0.399**	-0.033
			-	0.000	0.660
			181	181	181
Transaction	Influence A			1.000	-0.036
				-	0.633
				181	181
	Influence B				1.000
					-
					181

***p < 0.01*

Note: The first layer is the Pearson's correlation coefficient; the second layer is the probability (two-side test), and the third layer is the sample size. Influence A means actor i directly influences actor j; and Influence B means actor i is influenced from actor j.

transactions and influence B of cross-shareholdings, were significant ($p < 0.01$). The correlation values were 0.678 and 0.399 respectively, which shows that a strong relationship exists between the level of transactions and cross-shareholdings. In other words, the statement that "the more a firm invests in a supplier, the more the firm receives parts from that supplier" is valid. The reciprocal finding that "the higher level of investment that a firm accepts, the more parts that firm will supply" is also valid.

5. CONCLUSIONS

In this paper, the influence of each firm was measured in order to investigate the pattern of relationships in the keiretsu of Mazda. The study found that the influence of cross-shareholdings in other firms is closely related to the influence of the transactions between them. This means that the higher influence of cross-shareholdings has a strong impact on the influence of transactions. The implication of this finding for the automobile manufacturer Mazda is that an important strategy for them is to find those firms that have higher influence in the keiretsu and strengthen their reciprocal relationship with them.

One limitation of the paper is that the data of transactions and cross-shareholdings in this analysis are restricted to one fiscal year. Data from more years would be required in order to more completely study the trend of these identified influences through time series analysis. In addition, the form of influence investigated in this study is only one aspect of the reciprocal relationship between an automobile manufacturer and its supplies. Further quantitative research, such as the use of capacity analysis between two actors and clique analysis of the network structure, will be undertaken in the future, to attempt to capture the complexity of the relationships in the keiretsu of Mazda.

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REFERENCES

Bensaou M. (1999) "Portfolios of Buyer-Supplier Relationship", *Sloan Management Review*, Summer 1999, 35-44

Dyer H. J. (1994) "Dedicated Assets: Japan's Manufacturing Edge", *Harvard Business Review*, November-December 1994, 174-178

Dyer H. J. (1996) "Specialized Supplier Networks as a Source of Competitive Advantage: Evidence from the Auto Industry", *Strategic Management Journal*, Vol. 17, 271-291

Fontela E. and Gabus A.(1976) "Current Perceptions of the World Problematique", in C.W. Churchman and R.O. Mason, *World Modeling : A Dialogue*, North-Holland Publishing Company and American-Elsevier, 81-88, Retrieved October 4th, 2006, from http://homepage.sunrise.ch/mysunrise/agabus/eff'endi/dematel/ dematel.html

Fukuoka S., Ito T., Passerini K. and Sakamoto M. (2006) "An Analysis between Transaction and Cross Shareholdings in the Keiretsu of Nissan", *Managing Information in the Digital Economy Issues & Solutions*, IBIMA International Conference, Bonn, Germany, 163-169

Hakansson H. and Waluszewski A. (2002) *Managing technological Development*, *IKEA*, *The environment and technology*, Routledge

Ito, T. (2004) "Quantitative analysis of a firm's relationship in the Keiretsu of Toyota group", *Innovations through Information Technology*, IRMA2004 International Conference, New Orleans, USA, 1078-1079

Ito, T. and Sakamoto M. (2005) "Importance analysis of each firm in the Keiretsu of Toyota", *Managing Modern Organizations with Information Technology*, IRMA2005 International Conference, San Diego, USA, 930-933

JAPIA&APPC (2005) *Japanese Automotive Parts Industry*, Automotive Parts Publishing Company, (Japanese Edition)

Lincoln R. L. and Gerlach M.L. (2004) *Japan's Network Economy Structure, Persistence, and Change*, Cambridge University Press

Nohria N. and Eccles R.G. (1992) *Networks and Organizations*, Harvard Business School Press

APPENDIX I: KEIRETSU MEMBERS SHOWN IN FIGURES 1 AND 2

No.*	No.#	Company	No.*	No.#	Company
-	1	The Daishi Bank,Ltd.	71	113	N.E.CHEMCAT CORPORATION.
-	2	Mitsui Trust Holdings, Inc.	72	114	NOK CORPORATION
-	3	TAIYO LIFE INSURANCE COMPANY	73	115	ENKEI Corporation
-	4	The Ashikaga Bank,Ltd.	74	116	Autoliv, Inc.
-	5	SECOM General Insurance	75	117	KYB Co.,Ltd.
-	6	The Yamaguchi Bank, Ltd.	76	118	CALSONIC KANSEI CORPORATION
-	7	Nissei Dowa General Ins.	77	119	Kyosan Denki Co.,Ltd.
-	8	Saitama Resona Bank, Limited	78	120	Kyowa Leather Cloth Co.,Ltd.
-	9	Nisshin Fire & Marine Insurance Co.,Ltd.	79	121	Clarion Co.,Ltd.
-	10	ASAHI MUTUAL LIFE INSURANCE CO.	80	122	Continental Teves AG & Co.
-	11	The Bank of Yokohama, Ltd.	81	123	KOITO MANUFACTURING CO., LTD.
-	12	Mizuho Bank, Ltd.	82	124	Sanoh Industrial Co.,Ltd.
-	13	Fukoku Mutual Life Insurance Company	83	125	SANYO Automedia Co.,Ltd.
-	14	The Hiroshima Bank, Ltd.,	84	126	JATCO Ltd.
-	15	Tokio Marine & Fire Insurance Co., Ltd.	85	127	SHOWA Corporation.
-	16	Shinsei Bank, Limited.	86	128	Shin-Kobe Electric Machinery Co., Ltd.
-	17	Mizuho Trust & Banking Co.,Ltd.	87	129	STANLEY ELECTRIC CO., LTD.
-	18	Aioi Insurance Co., Ltd.	88	130	VALEO THERMAL SYSTEMS JAPAN
-	19	DAIDO LIFE INSURANCE COMPANY	89	131	CENTRAL GLASS co.,Ltd.
-	20	Nichido Fire & Marine Insurance Co., Ltd.	90	132	TAKATA Co.,Ltd.
-	21	Sumitomo Life Insurance Company.	91	133	T.RAD CORPORATION.
-	22	The Joyo Bank, Ltd.	92	134	TOKYO ROKI co.ltd.
-	23	Mitsui Sumitomo Insurance Company, Ltd	93	135	GKN Driveline Torque Technology KK
-	24	Resona Bank, Limited.	94	136	TOPY Industries Ltd.
-	25	Mitsubishi Trust and Banking Corporation	95	137	Nisshinbo Industries,Inc.
-	26	The Sumitomo Trust & Banking Co., Ltd.	96	138	Nittan Valve Co.,Ltd.
-	27	SOMPO JAPAN INSURANCE INC.	97	139	Nifco Inc.
-	28	Meiji Yasuda Life Insurance Company	98	140	Nippon Sheet Glass Co., Ltd.
-	29	Trust & Custody Services Bank, Ltd.	99	141	NIPPON THERMOSTAT CO.,LTD.
-	30	UFJ Trust and Banking Corporation	100	142	NSK Ltd.
-	31	Nippon Life Insurance Company	101	143	NHK SPRING CO.,Ltd.
-	32	Tokio Marine & Nichido Fire Insure Co. Ltd.	102	144	NIPPON PISTON RING CO.,LTD.
-	33	The Bank of UFJ	103	145	Japan Brake Industrial Co., Ltd.
-	34	The Nomura Trust and Banking Co., Ltd.	104	146	HARADA INDUSTRY CO.,LTD.
-	35	NIPPONKOA INSURANCE CO.,LTD.	105	147	Pioneer Corporation
-	36	The Dai-ichi Mutual Life Insurance Company	106	148	PIOLAX. Inc.
-	37	The Bank of Tokyo-Mitsubishi, Ltd.	107	149	Hitachi Metals, Ltd.
-	38	Meiji Yasuda Life Insurance Company	108	150	Hitachi, Ltd.
-	39	Mizuho Corporate Bank., Ltd.	109	151	Hitachi Cable, Ltd.
-	40	The Master Trust Bank of Japan, Ltd.	110	152	Fujikura Ltd.
-	41	Japan Trustee Services Bank, Ltd.	111	153	Bridgestone Corporation
-	42	SUMITOMO MITSUI BANKING CORP	112	154	THE FURUKAWA ELECTRIC CO.,LTD.
1	43	Mazda Motor Corporation	113	155	PRESS KOGYO Co.,LTD.
2	44	ASTEER co., Ltd.	114	156	Benteler Automotive K.K.
3	45	Ishizaki Honten Company, Limited	115	157	Bosch Corporation
4	46	UCHIYAMA MANUFACTURING CORP.	116	158	Marui Industrial Co., Ltd.
5	47	UBE INDUSTRIES, LTD.	117	159	Mikuni Corporation
6	48	OHMORI TECHNOS CO.,LTD	118	160	MITSUI MINING & SMELTING CO.,LTD.
7	49	OGINO INDUSTRY CO.,LTD	119	161	Mitsuba Corporation
8	50	ONDO CORPORATION	120	162	Mitsubishi Electric Corporation
9	51	Kautex Textron	121	163	Minebea Co.,Ltd.
10	52	KAINAN IRON WORKS CO.,LTD	122	164	Meiwa IndustryCo.,Ltd.
11	53	KATAYAMA KOGYO CO., LTD.	123	165	YAZAKI CORPORATION.
12	54	KAWAKAMI IRONWORKS.CO.LTD	124	166	U-SHIN LTD.
13	55	KAWADA Corporation	125	167	Unipres Corporation
14	56	KANDA CO.,LTD.	126	168	THE YOKOHAMA RUBBER CO.,LTD.
15	57	KEYLEX corporation.	127	169	YOROZU Corporation
16	58	Kitagawa Iron Works Co., Ltd.	128	170	RIKEN CORPORATION
17	59	KIYO INC	129	171	AISAN INDUSTRY CO LTD Hiroshima Sales
18	60	KUBOTA IRON WORKS CO.,LTD	130	172	Aisin AI CO.,LTD.
19	61	KURASHIKI KAKO CO., LTD.	131	173	Aisin AW CO.,LTD.
20	62	KUROISHI IRONWORKS.CO.LTD	132	174	AICHI STEEL CORP. Hiroshima Sales

21	63	Kostal Japan Co.,Ltd.	133	175	Ashimori Industry;Co., Ltd.
22	64	Kolbenschmidt K.K.	134	176	ADVICS CO.,Ltd.
23	65	SANKEI INDUSTRY CO., LTD.	135	177	INOAC CORPORATION
24	66	SANWA INDUSTRY CO.,LTD.	136	178	Imasen Electric Industrial Co., Ltd.
25	67	Sigma.co.ltd.	137	179	EXEDY Corporation
26	68	GP Daikyo Corporation.	138	180	NTN Corp.
27	69	SUGIHARA CO.,LTD	139	181	Osaka Rashi Mfg. Co., Ltd.
28	70	Sumitomo Electric Sintered Alloy Ltd.	140	182	OKUMURA FORGE CO.,LTD.
29	71	SUMINO KOGYO CO., LTD	141	183	owari precise products co.,ltd.
30	72	Dairiki IronWorks Co., Ltd.	142	184	Kanemitsu Corporation
31	73	CHUO INDUSTRIES, LTD.	143	185	Kawashima Selkon Textile Co.,Ltd.
32	74	CHUO SPRING INDUSTRY	144	186	KYOWA INDUSTRIAL CO.,LTD.
33	75	DELTA Inc.	145	187	GATES UNITTA ASIA COMPANY.
34	76	Toyo Advanced Technologies Co.,Ltd.	146	188	JTEKT Corporation.
35	77	TOYO SEAT Co.,Ltd.	147	189	KOKUSAN PARTS INDUSTRY CO.,LTD.
36	78	NAGATO CORPORATION	148	190	Samtech Co.,Ltd.
37	79	NANJO SOBI KOGYO CO., LTD.	149	191	GS Yuasa Corporation
38	80	NIITECH CO., LTD.	150	192	ShinMaywa Industries, Ltd.
39	81	Nishikawa Kasei Co.,Ltd.	151	193	STARLITE Co.,Ltd.
40	82	Nishikawa Rubber Co., Ltd.	152	194	Sumitomo Metal Industries, Ltd.
41	83	Japan Climate Systems Corporation	153	195	Sumitomo Electric Industries, Ltd.
42	84	HAMADA CORPORATION.	154	196	SUMINOE Co.,Ltd.
43	85	Visteon Asia Pasific	155	197	SEIREN Co.,Ltd
44	86	HIRUTA KOGYO CO., LTD	156	198	Daido Steel Co.,Ltd.
45	87	HIROSHIMA ALUMINUM CO., LTD	157	199	DAIDO METAL Corporation.
46	88	HIROSHIMA SEIKEN KOGYO CO.,LTD	158	200	Taihei Koki MGF Co.,Ltd.
47	89	HIROSHIMA SEIMITSUKOGYO CORP	159	201	Goodyear Japan Ltd.
48	90	HIROTANI Co.,Ltd.	160	202	Chuo Spring Co.,Ltd.
49	91	HIROTEC.Co,.Ltd.	161	203	TSUBAKIMOTO CHAIN CO.
50	92	FUTABA KOGYO CO., LTD.	162	204	TRW Automotive Japan.
51	93	Webasto Japan Co. Ltd.	163	205	DENSO CORPORATION
52	94	MICROTECHNO CORPORATION	164	206	TOKAI Corp.
53	95	Mazda Engineering & Technology Co.,Ltd.	165	207	Tokai Rubber Industries, Ltd.
54	96	MAPS CO.,LTD	166	208	TOKAI RIKA CO.,LTD.
55	97	MALOX Co.,Ltd.	167	209	TOYO TIRE & RUBBER CO.,LTD.
56	98	Matsumoto Heavy Industry Co.,Ltd.	168	210	TOYOTA MACHINE WORKS.LTD.
57	99	Minoru Kasei Co.,Ltd.	169	211	TOYOTA GOSEI CO.,LTD.
58	100	Molten Corporation.	170	212	Nikkei Kakoh Co., Ltd.
59	101	Yumex Corporation,	171	213	Nihon Cable System Co.,Ltd.
60	102	YOSHIWA INDUSTRY CO.,LTD	172	214	JAPAN DROP FORGE CO.,LTD.
61	103	LEAR CORPORATION JAPAN	173	215	NGK SPARK PLUG CO.,LTD.
62	104	Ryobi Limited.	174	216	Hanshin Electric Co.,Ltd.
63	105	Ring Techs Hiroshima Co.,Ltd.	175	217	BANDO CHEMICAL INDUSTRIES, LTD.
64	106	YNS INC.	176	218	HIKARI SEIKO CO.,LTD.
65	107	Y-TEC CORPORATION	177	219	Matsushita Electric Industrial Co., Ltd.
66	108	Akebono Brake Industry Co., Ltd.	178	220	MARUYASU INDUSTRIES CO.,LTD.
67	109	ASMO CO.,LTD.	179	221	MITSUBOSHI BELTING LTD.
68	110	Ishikawajima-Harima Heavy Industries Co.	180	222	MIYAGAWA KASEI INDUSTRY CO.,LTD.
69	111	ICHIKOH INDUSTRIES,LTD.	181	223	METALART CORPORATION
70	112	Usui Kokusai Sangyo Kaisha, Ltd.			

Note: No. is the sequential number in the transaction network, and No.# is the sequential number in the cross-shareholdings network.*

A Novel Method for Securing Online Databases

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ABSTRACT

In the past few years, we have experienced a rapid increase in the development and usage of Web-based systems. However, a main problem of these systems is the lack of security mechanisms to protect their data especially in cases where high security is required. In this work, we present the architecture of a secure system using voice biometrics. Among the existing security and biometric methods, voice biometrics can be an affordable technology providing high security. The proposed architecture includes a biometric server where the users' unique set of speech models (voiceprint) is stored. The authentication procedure requests from the user to pronounce a random sequence of digits and after capturing speech and extracting voice features at the client side are sent back to the biometric server. The biometric server decides whether the received features match the stored voiceprint of the user who claims to be, and accordingly grants authentication. By implementing the proposed architecture, online databases are provided with a higher degree of certainty based on the user's identity.

1. INTRODUCTION

Web-based systems, such as web-banking and e-commerce, are continuously growing and gaining a considerable part of the marketplace. Providing access to information has been handled so far by implementation of personal identification numbers (PINs), cards or tokens [1]. The problem with these is that they do not provide a robust solution for e-commence and they are vulnerable to fraud. To further increase e-commerce growth and public respect, higher security protection should be provided to users. By integrating advanced biometric authentication in an Internet application, secure, low-risk and convenient transactions can be executed. Biometric authentication means the automated use of physiological or behavioral characteristics, such as iris, face, signature, finger, or voice, to verify one's claimed identity [2].

Authentication methods using biometrics can replace or complement conventional authorization mechanisms, namely passwords and personal identification numbers (PINs), for higher security applications. The main risk of traditional authorization methods is that passwords and PINs are sensitive to be stolen, guessed or retrieved by a person. Moreover, considering the amount of Internet applications a customer uses that require a password, it is difficult for him/her to possess securely multiple and difficult to be guessed passwords. On the other hand, biometrics utilizes intrinsic characteristics of a person and is not susceptible to fraud. Another advantage of biometric methods over the traditional ones is that the authentication is not restricted to a binary decision, thus multiple levels of security can be posed.

Comparing the biometric methods mentioned above, voice biometrics could be regarded as the most promising one for being widely utilized in Internet applications for securing online databases. The increased presence of microphone devices and their low cost compared to other biometric acquisition devices makes voice biometrics the least expensive to deploy. Furthermore, voice biometrics do not invade customer's privacy and users are more willing to cooperate (voice has not been used for individual tracking and monitoring). Speaker authentication can be combined with other speech – enabled applications over the Internet, i.e. verbal passwords, speech recognition.

This paper, proposes a novel method for securing online databases using voice biometrics. The proposed method suggests the transmission of voice features instead of the whole speech signal to ensure maximum security and privacy and also to save on bandwidth. The structure of this paper is as follows: Section 2 discusses biometric authentication and its advantages and disadvantages. Section 3 provides an overview of the system. Section 4 explains the proposed voice biometric authentication including the enrolment process and the authentication process. This section also describes the tests performed to evaluate the performance of the system in real environment conditions. Finally, Section 5 sums up the findings of the paper and provides some concluding remarks.

2. BIOMETRICS

Biometrics is the science of using digital technology to identify the identity of individuals based on behavioural or physiological characteristics. By basing a security system on the physiological features rather than a few keystrokes or a password, the possibilities of fraud are drastically reduced. The terrorist attacks of September 11th 2001, and the desire to tighten security in every way possible, particularly in America, resulted enormous funds being made available to the research and development of biometric systems. As a result, the biometric industry is now emerging and is rapidly gaining acceptance from governments, companies and individuals.

Already, there are many industries employing biometrics, including the U.S. Immigration and Naturalization Service, major western countries armies, international banks, governments and healthcare organizations. The European Union also moves towards creating standards for biometric passports which will be deployed in the near future, while Britain plans to issue new identity cards which include biometrics. During the Olympic games in Athens in 2004, biometrics were also widely deployed to enhance the security of athletes and buildings.

There are many types of biometrics, but among the most common are scanning fingerprints, voices, faces, retinas or irises. Computer hardware and software programs have been developed to scan a thumb print, for example, and then compare it with a stored databank of other prints for an exact match. Or a voice is compared to a bank of voice-print samples using pattern classification algorithms. Face recognition is the measurement of certain characteristics, such as the distance between eyes. Retina scanning has the computer camera inspecting the pattern of veins in a human eye. And, finally, iris scanning takes retina scanning one step further by concentrating on the color pattern surrounding one's pupils [3].

Key features of voice biometric that differentiate it from other types of biometric procedure are that it is non-invasive and that it can be performed remotely by telephone or via Internet. Approaches such as fingerprint analysis and retina scanning are much less acceptable to users. In addition, the cost and complexity of the systems required for fingerprint or retinal scanning far exceed that of the single microphone of a voice-based system that is, in any case, already provided in typical PC systems, the telephone and the mobile handsets. Voice biometric systems generally include classical pattern recognition components; that is data acquisition (recording of speech signals), pre-processing, feature extraction and classification. These components are used in the two primary functional biometric system components, the *enrolment* and the *verification* processes discussed in section 3.

The main advantage that biometric can offer is security and convenience. Among the various types of biometric technologies available, voice recognition is one of the cheapest to implement [1]. Iris scanning provides high security and is convenient in that it allows the users to keep their glasses on throughout the scan [3]. A biometric system is not based on a standard true or false system [1] but by utilizing a threshold of acceptance closeness to the user's characteristic different levels of physical security, authenticity, integrity and confidentiality can be established [4].

While biometric authentication includes several advantages it does have some drawbacks as well. Even though it is difficult, but not impossible, fingerprints

and pictures can be copied from anywhere and voice can be recorded [4]. Another major drawback is the cost associated with these technologies with iris scanning as being more expensive [1]. Finally, users of these systems concern of their privacy data. However, educating these people will curb their misguided fears [1].

3. SYSTEM OVERVIEW

The system consists of the client, the Application Server and the Secure Voice Biometric Server (SVBS). The client could be any computer with Internet connection in which the user can access an Internet service. The role of the Application Server can be attributed to multiple, online database applications. The SVBS is a secure server that could be located away from the application server as a third party service. The SVBS generates trains and updates the user's unique set of speech models (voiceprint), stores them securely in a database, and performs the matching process to authenticate a user.

Consider the case when a user needs to purchase an expensive product from an e-commerce site utilizing the proposed voice biometric approach for enhanced security. After registering to the e-commerce service, the user is asked whether he requires biometric user authentication on his transactions. If the user selects this feature then he is redirected to the SVBS where he follows the enrolment procedure to create his voiceprint, which is stored in the secure server. Figure 1 illustrates the enrolment process while Figure 2 shows the e-commerce transaction process in an abstract form.

Every time the user wants to purchase a product, he is redirected by the application sever to the SVBS where biometric authentication is performed to verify (or not) the user's identity. If the user is the one who claims to be then authorization is granted and the user is free to proceed with the transaction.

4. VOICE BIOMETRIC AUTHENTICATION

During a speaker authentication procedure, the user provides an identity claim together with speech samples corresponding to prompts from the SVBS. The processing of the raw speech data results in distinctive and representative voice features (Feature Extraction), which contain information of the physiological characteristics of the user. The extracted features are then compared with the voiceprint of the claimed user, which was created during the enrolment phase, and a matching score is calculated (Verification). If the matching score is over a predefined threshold then the authorization is considered successful, otherwise a call back procedure is followed. The following sections describe in detail the feature extraction, enrolment and authentication processes.

4.1 Feature Extraction

Speech is produced by the flow of air through the various articulators such as the vocal tract, lips, tongue, and nose. Air is forced out of the lungs through the trachea and the glottis, where it passes through the vocal cords. The vocal cords, if tense, vibrate like an oscillator, but if relaxed, do not vibrate and simply let the air pass through. The air stream then passes through the pharynx cavity and, depending on the position of a movable flap called the velum, exits either through the oral cavity (mouth), or the nasal cavity (nostrils). In the former case, the tongue and the teeth may modify the flow of the air stream as well. Different positions of these articulators give rise to different types of sounds. The different sounds produced by human beings are strongly related to the physiological characteristics of the vocal tract of each speaker. The fact that different speakers have different vocal-tract configurations for the same utterance is the basis for using vocal-tract filter parameters (feature coefficients) to good effect for speaker identification. These unique characteristics can be identified through a parameterization procedure called feature extraction.

Feature extraction is the process of measuring certain attributes of speech needed by the voice biometric system to differentiate people from their voice. The most often used technique that we also use in our system, is the mel frequency cepstral coding (MFCC) [6] which uses the Mel scale which is based on the human ear scale. The proposed system suggests the feature extraction process to be performed locally on the client's hardware and the calculated features to be securely transmitted

Figure 1. Enrolment to the biometric server

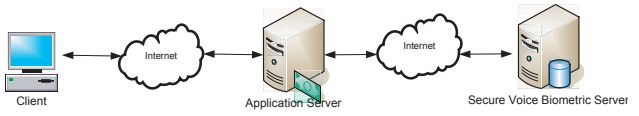


Figure 2. Voice biometric authentication for accessing an online database

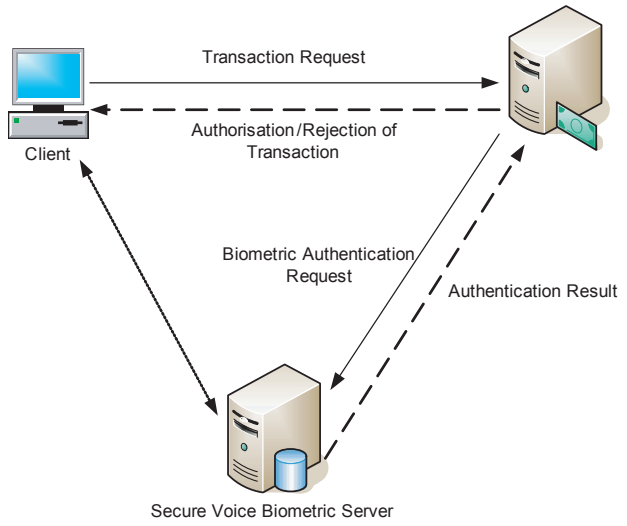
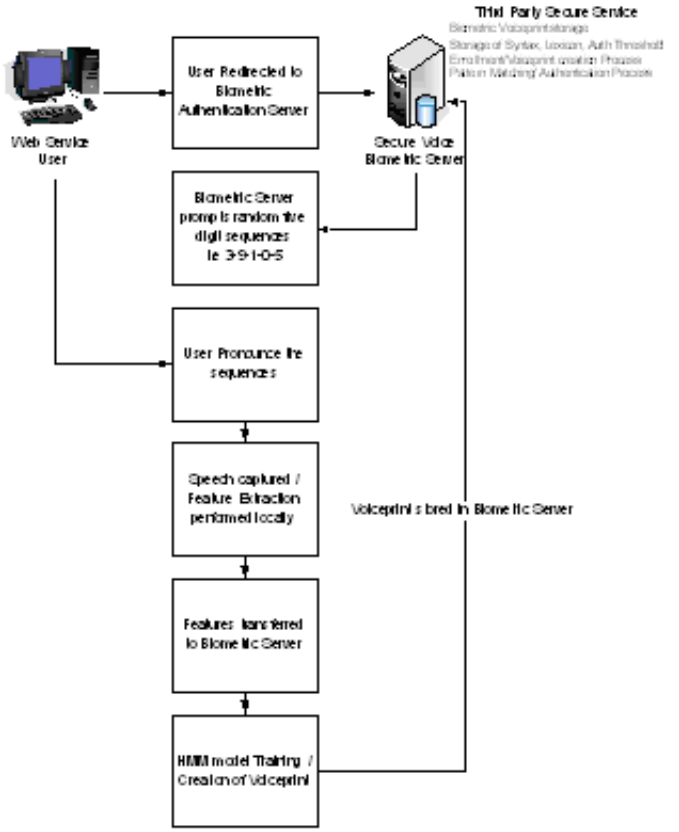


Figure 3. The enrolment process



to the SVBS. The reason is that due to their size, the features take significantly less bandwidth when transmitted over the Internet making the whole interactive procedure of verification much secure and quick.

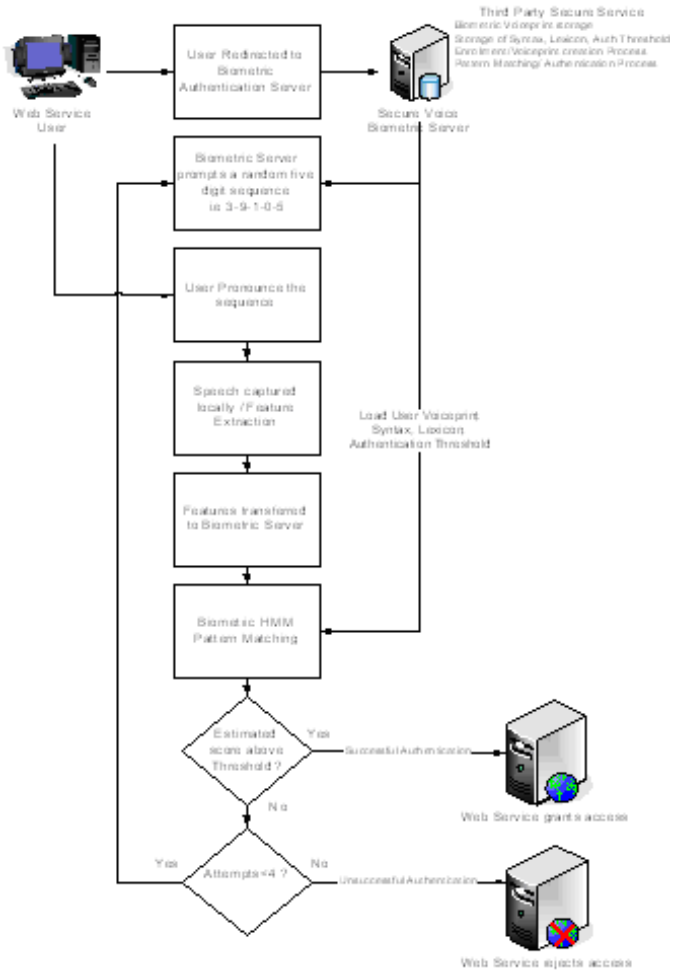
4.2 The Enrollment Process

When a biometric authentication is needed for transactions between a user and an Application Server, the interested user should enroll in the SVBS (Figure 3). Thus, the first time the user requests the service from the Application Server its client is redirected to the SVBS. To eliminate the probability of a fraudulent enrolment, SVBS sends a password to the interested user via email.

The user can log into the SVBS by using this password to establish a secure connection with the SVBS. The SVBS sends a random sequence of digits 0-9 to the client, and the client prompts it to the user. While the user is pronouncing the sequence, the speech signal is recorded and the client performs the feature extraction task. When the user has prompted the whole digit sequence (a procedure which lasts two to five minutes) and a specifically downloaded from the SVBS client's software has extracted all the appropriate speech features, these features are sent back to the SVBS. The SVBS processes the received features and trains whole-digit HMMs (Hidden Markov Models) [5] for the specific user. The user's voiceprint, which consists of all digits (0…9) HMM models, is safely stored at the SVBS database. Since the enrolment procedure is unsupervised, there is an increased risk of a low-quality but still valid enrolment. Such an enrolment can increase the probability of False Rejection (FR) as well as the probability of False Acceptance (FA) for a user. In order to avoid such a problem, after the voiceprint of the user has been created, the SVBS starts immediately an authentication process. If the authentication is successful, the user's voiceprint is considered accurate and the enrolment ends. Otherwise the SVBS deletes the problematic voiceprint from its database, terminates the enrolment process and suggests the user a second trial.

The strict protocol followed during the enrolment process is obliged by the fact that user's voiceprint is created for the first time. Early unsuccessful authentication indicates inadequate hardware, misspelled training phrases, noisy environment, or suspicious enrolment trial, and thus it should be rejected.

Figure 4. The authentication process



4.3 The Authentication Process

When the user's client starts a high-security transaction with the Application Server, it is redirected to the SVBS (Figure 4). After a secure network connection has been established between the client and the SVBS, the latter asks for an identity claim (such as a username) of the interested user. After receiving the username, the SVBS checks the user existence in its database. If such an identity exists, then the SVBS sends a sequence of five random digits to the client. The client's application prompts the user to pronounce the sequence, records the speech signal, extracts the required MFCC features, and sends them back to the SVBS. The SVBS performs the pattern matching operation between the received features and the voiceprint of the claimed user stored in its database and produces a matching score.

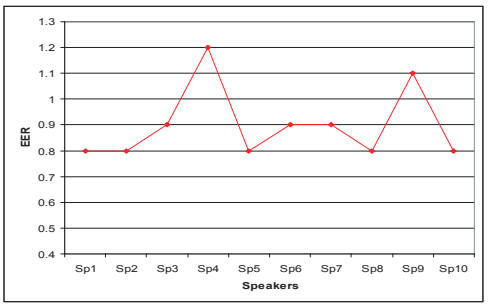
If the matching score is above the threshold obliged by the security level of the application, then authorization is granted and the result is forwarded to the Application Server to authorize the transaction. After a series of successful authorization, the SVBS updates the current voiceprint using the recently received features. In this way, the HMM models of each user are enriched to include more characteristics of the hardware configurations, and noise and emotional conditions. Such a statistical generalization increases accuracy of the system.

If the score does not meet the desired threshold, the authorization is repeated using a new digit sequence. In case the maximum number of three trials is exceeded, authorization is rejected.

4.4 Evaluation Results

Speaker authentication can be performed using various voice characteristics, while many approaches can be followed at the verification stage [3], [4]. Among the features one can extract from a speech signal for speaker authentication purposes, the proposed method utilizes Mel-Frequency Cepstrum Coefficients (MFCC) [5], [6]. Tests using an in-house single digit database recorded over the Internet were performed to evaluate the performance of the proposed system. Specifically, recorded speech (8 KHz, 16 bits, mono) from ten users, were segmented in 25msec frames overlapping with other by 60%, thus a feature vector was output every 10msec. After pre-emphasis of the speech signal, 12 MFCC were computed. To capture time dynamics of the signal, the energy and MFCC first and second time derivatives (called Delta and Delta-Delta or Acceleration Coefficients) [10] were also computed, leading to 36-dimensional feature vector. Notice that Delta and Acceleration Coefficients were not computed at the client-side and transmitted back to the SVBS, since they could be directly computed through MFCC coefficients at the SVBS. Speaker authentication is based on continuous density HMM

Figure 5. Tests with CMS



(Hidden Markov Models). More precisely, a five-state left-to-right HMM with four mixtures is used for each digit, as well as for the silence interval [11]. An additional silence model was trained so as to model the beginning and ending of an utterance and also the intermediate pauses. The HMM are trained through the Baum-Welch algorithm [8], while speaker verification is performed using the Viterbi algorithm [8]. Data from ten users were used to evaluate the speaker authentication performance against False Acceptance Rate (FAR), False Rejection Rate (FRR) and Equal Error rate (EER) [12]. Tests performed using the above conditions resulted an average EER equal to 5%.

In an Internet-based application, it is expected that different microphone configurations and/or environmental noise conditions will appear and affect the speech signal in a different way. This problem, known as the 'mismatched condition' can severely degrade a system's accuracy [6]. To maintain authentication accuracy, a technique such as Cepstral Mean Subtraction (CMS) [13] was used and identical tests were repeated.

It was found that CMS can reduce the effect of the channel appearing in the recordings over the Internet and increase authentication performance by reducing the EER just below 1% as can be seen in Figure 6. Moreover, the problem of mismatched condition can be eliminated through the dynamic update of user's voiceprint after every successful authentication.

5. CONCLUSIONS

Transaction-based Internet applications as continuously grow require higher security mechanisms to protect their data. Simple security mechanisms such as, username and password do not provide high security. Integrating advanced biometric authentication in Internet applications, secure low-risk and convenient transactions.

This paper proposed a novel method for securing online databases using voice biometrics. A system was developed and demonstrated very good verification performance based on this approach. The system consists of the client, the Application Server and the Secure Voice Biometric Server (SVBS). The SVBS generates trains and updates the user's voiceprints, stores them securely in a database, and performs the matching algorithm to authenticate a user.

The proposed architecture is advantageous since it is easily upgraded. Moreover, some heavy-duty functions (i.e. pattern matching, HMM training) have been loaded to the SVBS, and the main responsibility of the client is speech capturing and feature extraction. SVBS can apply different levels of security during the authentication procedure according to the security policy of the current application.

6. REFERENCES

[1] A. J. Harris and D. C. Yen, *Biometric authentication: assuring access to information,* Information Management & Security 10/1, pp. 12-19, 2002.

[2] J.L. Dugelay, J.C. Junqua, C. Kotropoulos, and R. Kuhn, *Recent Advantages in Biometric Person Authentication*, ICASSP 2002 , International Conference on Acoustics, Speech and Signal Processing , May 13, 2002, Orlando, Florida, USA.

[3] J. Ashbourn, *Biometrics: advanced identity verification: The complete guide,* Springer-Verlag, London, 2000.

[4] A. Klosterman and G. Ganger, *Secure continuous biometric-enhanced authentication,* Carnegie Mellon University, Pittsburgh, PA.

[5] L. R. Rabiner, *A Tutorial on Hidden Markov Models and selected applications in Speech Recognition*, Proc. IEEE, *vol. 77*, pp. 257-286, Feb. 1989.

[6] R. J. Mammone, X. Zhang and R. P. Ramachandran, *Robust Speaker Recognition, A Feature-Based Approach*, IEEE Signal Processing Magazine, 13 (5), September 1996, 55-71.

[7] J. P. Campbell, Speaker Recognition: A Tutorial, *Proceedings of the IEEE, 85*(9), September 1997, 1437-1462.

[8] L. Rabiner, BH Juang*, Fundamentals of Speech Recognition*, (Prentice Hall, 1993).

[9] S. Furui, *Cepstral Analysis technique for automatic speaker verification,* IEEE Transactions on Acoustics, Speech and Signal Processing, *vol. ASSP-29*, 1981.

[10] J.R. Deller, J.G.Proakis, and J.H.L.Hansen, *Discrete-Time Processing of Speech Signals*, Macmillan 1993

[11] D. Reynolds, *Speaker Identification and Verification using Gaussian Mixture speaker models*, Speech Communications, *vol 17*, pp. 91-108, 1995.

[12] S. Navanati, M. Thieme, and R. Navanati, *Biometrics: Identify verification in a networked world* (John Wiley & Sons, Inc. 2002.

[13] Hynek Hermansky, *Exploring Temporal Domain for Robustness in Speech Recognition,* 15th International Congress on Acoustics, 1995.

The Whole World at Work: Managers Around the Globe Describe Their IT Experiences – Suggesting a New Framework for Global IT Leadership Development

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ABSTRACT

The foundation of this paper is research titled: "The Whole World at Work: Managers Around the Globe Tell Us What's Changed and What Still Needs to Change in Organizations," conducted from late spring 2004 through early 2006. The research included 160 interviews with managers and consultants working in multinational corporations on five continents, an extensive literature review, and client interventions. We find that the subject of technology is very much on the minds of managers across the organizational value chain. Nearly 47% of "The Whole World at Work" interviewees mentioned technology when asked what has changed most in organizations during their careers, and interview content analysis indicates that a majority of manager comments about technology were mixed or negative in tone. However, when asked to envision the ideal organization of the future, less than 15% of managers made reference to technology. In contrast, more than 90% described the best organizations of the future as ones in which "people" will be at the forefront, with organizations focusing less on mechanics (technology, process and profits) and more on communicating, collaborating, and building consensus. Based on "The Whole World at Work" findings, we propose a previously unidentified global yearning for more holistic organizations and leaders. We have coined a term – E-vergence(SM) – postulating an emerging convergence of manager experiences, views and aspirations around the world. We also propose a model of leadership necessary to foster successful future organizations - The New Hybrid Leaders - multi-dimensional managers developed to exhibit "transformational," "transnational," and "trans-cultural" competencies (Bass, 1998; Trompenaars & Woolliams, 2003). This calls for rethinking and reformulating technology management education within a framework that will achieve comprehensive IT leadership development. New competencies are required for technology managers who aspire to influence increasingly global organizations and achieve career success.

INTRODUCTION

Technology: Promises vs. Reality

Technological change has been a key influencer of organizational strategies in the late 20th and early 21st century, considered one of the five most important organizational variables in the future (Laubacher & Malone, 1997).

As globalization received increasing attention in the 1990s, it was also suggested that a dispersed enterprise is nothing but fragments without common cultural values, and technology is what makes "getting it all together" possible (O'Hara-Devereaux & Johansen, 1994). Also, for many industries, technology continues to be viewed as a competitive driver. In its identification of the top five trends determining future retail banking success, the IBM Institute for Business Value predicted movement towards IT investments focused on "improving responsiveness, resilience and enterprise-wide collaboration" (IBM, 2005).

Yet, there is also a countervailing sentiment that expectations of technology are often unrealistic. Gartner, Inc. analyses indicated that companies' estimated spending on hardware, software, IT services and telecommunications would total $2.6 trillion in 2006. Yet, managers at the vast majority of companies making such investments complain that information overload actually slows down decision-making (Gantenbein, 2006).

So, what is it that happens inside corporations between the expressed hopes of technology and manager perceptions of suboptimal results? What is yet to be done differently?

"The Whole World at Work: Managers Around the Globe Describe Their Organization and Technology Aspirations and Frustrations – Suggesting a New Framework for Global IT Leadership Development" addresses these questions from the vantage point of qualitative interviews conducted with managers in multinational corporations (MNCs). The findings point to the efficacy of a more holistic IT leadership and development framework that can be employed on a global level. The envisioned "sweet spot" is an intersection between manager definitions of the best organizations of the future and a central role that technology managers could play.

METHODS

Research Design

The foundation of "The Whole World at Work" global research was conducted from mid-2004 through early 2006 and consisted of 160 semi-structured qualitative interviews with managers working in MNCs headquartered in North America, Europe, Asia/Oceania and sub-Sahara Africa. Thirty nationalities were represented in the sample.

As Hunter (2005) notes, "in situations where relatively little is known about an area under investigation, such as global research, qualitative approaches allow the researcher to conduct investigations to identify emerging themes" (p. I). In the 1990s, only a small percentage of organizational and human resource management articles was international in outlook (Adler, 2002). A review of the literature also confirms that cross-cultural research specific to technology is sparse. We designed our multinational research to explore particular questions of interest across geography, industry and gender, as well as to see what emerged naturally from the interviews.

We relied on an open-ended narrative interview protocol of ten essential questions with optional sub-question prompts focusing on what has changed, is changing, and still needs to change in organizations. The core interviewee constituency was comprised of 107 people representing MNCs in three industries – Retail Products and Services, Financial Services, and Paper/Printing/Publishing.

The three industries all have a track record of cross-border experience and have publicly articulated "global" as a strategic priority and challenge. Their differences include internal structures, systems and cultures, as well as certain aspects of industry dynamics. Noting both similarities and differences, we speculated that it would be of interest if we discovered a common pattern across these industries.

The 107 managers included 65 men (60.7%) and 42 women (39.3%). Regional representation included 46 from North America (43%), 26 from Europe (24%), 20 from Asia/Oceania (19%), and 15 from sub-Sahara Africa (14%). In the Asian sample, Japanese represented the largest single concentration of interviewees. This was intentional, given that among Asian corporations the Japanese MNCs have the most tenured modern history of competing globally.

Manager positions ranged from one level below CEO to one level above supervisor, and spanned line and staff roles across the organizational value chain. Few interviewees were in roles directly related to or responsible for technology functions. Many, however, had been indirectly responsible for and or largely affected by innovations and change initiatives involving technology. Collectively, 29% reported active involvement in a roll-out such as Enterprise Resource Planning (ERP) or Customer Relationship Management (CRM). The same percentage described involvement in a major restructuring with a required technology implementation. Nearly all had been involved in a major change initiative such as a new product or service introduction, merger, or acquisition that involved use of a new technology.

From the results, we were able to articulate the experiences, views and aspirations of managers across regions, industry and gender regarding:

- the ideal organization of the future;
- what works and does not work in change management;
- effective organizational leadership.

Our methods also revealed internal "barriers" that may prevent organizations from achieving ideals reflected in manager responses.

Interviews generally lasted from 60 to 90 minutes and were transcribed verbatim. We analyzed interviews employing grounded theory methodology and a qualitative data analysis software package (Glaser & Straus, 1967; Weitzman, 2000). We verified the validity of early findings with a subset of original manager interviewees and also incorporated select protocol questions into interviews during client organizational development projects and interventions.

RESULTS

Overall: Presence, Impact, and Effects of Technology on Productivity and People

We did not include questions about technology in our protocol. Yet, unsolicited, 65.4% of interviewees mentioned technology in their responses. (See Table 1). About one quarter (25.2%) of managers described technology as an organizational fact of life, a confirmation that issues of adopting and adapting to new technologies are crossing geographic (e.g. East-West) and economic development (e.g. North-South) boundaries.

Conflicting views were evident in references to effects of technology on productivity (34.6%) and people (35.5%). Managers acknowledged technology-enabled enhancements to productivity and remarked that it is now possible to do business from anywhere, anytime. Conversely, many comments indicated that managers often feel "controlled" by technology and compelled to "try and gain more control" of technology.

From a female manager in North America:

We [don't] get more done because there's just more piled on. You can be efficient if you focus on it. But if you walk around with your pager and cell phone and PC, you're less efficient. You have to know when to not be available, even if you'll get 'dinged.'

Reviewing the Past: What's Changed? People and Technology

"Technology" was the second most common response when managers were asked *what has changed most* and *what is currently changing* in organizations. Just over 50% of managers mentioned "people issues" – the ways employees are treated and the degree to which they are valued. Technology was referenced by 46.7% of managers.

Manager comments regarding technology and change were replete with paradoxes and tensions. Managers often characterized technology as both empowering and encumbering, equating technology with compressing time and fueling the push-pull of:

- *freedom* to work anywhere and *pressure* to work all of the time;
- *higher customer satisfaction* matched by *relentless consumer demand*;
- *more data* that can lead to *paralysis* and *diminished creativity*;
- *faster information flow* eroding *personal relationships* and communications.

From a male manager in Europe:

Globalization [has] been great because I've been able to gain ideas and reflect on how we do the business. The flip side of that, led by technology, is the pressure for global matrix management that can add levels . . . The opportunity is to learn from our peers but not get bogged down in bureaucracy.

Table 1. Talking about technology

Technology Category	ALL %	NA %	Eur. %	Asia %	Africa %
All Comments Concerning Technology Combined	65.4	78.3	61.5	40	66.7
What's Changed/Is Changing	46.7	60.9	46.2	20	40
Opportunities Created	44.9	58.7	30.8	25	53.3
Effect on People	35.5	54.3	23.1	10	33.3
Effect on Productivity	34.6	43.5	42.3	15	20
Ubiquity of Technology	25.2	37	19.2	10	20
Pace of Technological Change	16.8	28.2	11.5	0	13.3
Distances Us from Each Other	16.8	28.2	7.7	5	13.3
Technology as a Component of the Ideal Organization	14	8.7	7.7	20	33.3
Technology as a Change Management Constrainer	8.4	13	11.5	0	0
Technology as a Change Management Enabler	4.7	4.3	0	10	6.7
TOTAL Ns Per Region	107	46	26	20	15

NOTE: ALL=all respondents combined; NA=North Americans; Eur=Europeans; Asia=Asians; Africa=sub-Saharan Africans.

Concerns about technology "getting in the way" surfaced in other terms, as well, with 16.8% of managers identifying technology as something that distances us from customers and coworkers. Equal percentages of men and women articulated this view. North Americans (28.2%) expressed concerns about "distancing" more than other regions. Africans (13.3%) were less than half as likely as North Americans to convey this sentiment and Europeans (11.5%) less so. Managers in Asia-headquartered companies (0%) did not say anything that indicated such a concern.

From a female manager in North America:

We say that we're focused on customers [but] we distance ourselves from customers with technology . . . Some of these great technological advancements have created easier ways to do business, but we're not talking to customers as much anymore.

Reviewing the Past: Technology—Neither Change Enabler nor Constrainer

We asked managers to describe the most successful and least successful change projects that they had been involved in or led. Few highlighted technology as a factor either enabling successful change (4.7%) or constraining it (8.4%). Leadership, business understanding, and people factors emerged as more pivotal even in cases where technology implementation was the focal point of a change initiative.

From a male manager in Europe:

I have seen many examples of IT that are not rooted in business understanding. So, they are not as successful as they could be . . . We had to go to SAP [and] it's taken too long and hasn't gotten the results. But I think that this is because it wasn't run as a business transformation vs. a technology project . . . You have to provide the genuine business need and case, not just that you're striving for the latest technology . . . [and spend] a lot of time on stakeholder management.

Reflecting on successful organizational change, managers emphasized the importance of communications/education (70.1%), engaging people (41.1%), and integrating people/cultures (25.2%). Likewise, failures were attributed to a lack of attention to communications/behavior change (38.3%), mutual understanding/alignment (37.4%), and cultural resistance (30.8%).

From a female manager in North America:

You can't build a computer platform without knowing the business model . . . A big key to that is educating our employees. You can have all of the data in the world, but if you don't help people interpret it, and build bridges between departments, well, you don't go very far.

Collins has noted that none of the good-to-great companies began a transformation with technology, yet they all pioneered technology applications to great competitive advantage once they grasped how technology fit within their own context (Collins, 2001). Similarly, when manager interviewees recalled less-than-successful large-scale technology initiatives, they pointed to disconnects between abstract ideas and workplace realities.

From a male manager in Europe:

The least successful projects [were] thought of and executed on a very high and abstract level. For example, they had this big idea to reduce our IT costs by reducing IT infrastructure – consolidating it and getting us on common operating platforms and equipment . . . We're in more than 100 countries . . . You can't run the world with one system or solve all problems with three formulas . . .

Looking Forward: Defining the 'Ideal' Organization

We also asked managers to envision how an ideal organization of the future would look, feel, act, and be experienced by employees, customers and shareholders. In a reversal of interest, less than 15% of interviewees suggested technology would be a key aspect of the best organizations. More than 90% of interviewees described a desired future in which people would be at the forefront of organizational intentions – with leaders supporting strategies to engage, enable and even nurture employees in the face of pressure to focus on cost-savings and profits.

Managers who spoke of an important role for technology said that technology would enhance the future to the extent it builds customer relationships, fosters productivity, enhances communications, bolsters training and development, and achieves more work-life balance. We characterize this as a latent aspiration for organizations to more fully leverage the "human side of IT" (Goman, 2000; Gordon, 2003).

Technology Through a Regional Lens

It appears that MNC managers have much in common regarding experiences and views of the ideal organization of the future and technology. Nevertheless, there are intriguing regional variations. Due to the newness of "The Whole World at Work" research and small sample sizes in sub-Sahara Africa and Asia, we cannot definitively assert or explain these differences. Rather, they merit further investigations and analyses.

North Americans (60.9%) were most likely to cite technology as what *has changed* most and *is changing* in organizations. Asians (20%) were least likely. Technology was described as creating opportunities by 44.9% of managers, with North American managers (58.7%) and sub-Saharan African managers (53.3%) most likely to articulate this view in contrast with managers in Europe (30.8%) and Asia/Oceania (25%). North American managers were also most inclined to describe technology as disrupting their lives.

From a female manager in North America:

[Technology] has increased the pace and the amount that has to be done . . . It's much more of a struggle than ever. I have to consciously make an effort to balance. I do a horrible job of it. I'm struggling.

While European managers also described declines in work-life balance resulting from technology, the more prevalent theme was the detrimental effect of technology used to consolidate decision-making.

From a male manager in Europe:

IT capability has allowed for a lot of centralization capability and centralized control that from a management perspective makes sense, but from an employee standpoint undermines or undervalues the role of the employee in the field. It's compromised our organization.

Against conventional wisdom and stereotype, managers working in Asian MNCs made the fewest references to technology. This scarcity is intriguing given associations of Asian corporations with quality measures, process management, and state-of-the-art manufacturing. Asians speaking of technology focused on how it necessitates that organizations streamline and reduce costs in the spirit of fierce competition.

Sub-Saharan African managers may be divided into two subsets – those in South Africa and those in countries other than South Africa. Both can be described as "pro-technology," but each presents a unique attitudinal profile.

South African managers tended to talk about large-scale, system-wide applications of technology and be *generally* positive in their descriptions of outcomes.

Sub-Saharan African managers outside South Africa were *uniformly* positive about technology and viewed lack of access to technology (not technology itself) as problematic. Indeed, these managers described technology as a kind of Holy Grail, as well as a must-have for Africa's participation on the world stage.

From a male manager in the Ivory Coast:

I must invest in myself to make sure that I learn . . . Most of the work you are going to find incorporates technology . . . Those people [who] upscale themselves are going to succeed.

From a male manager in the Democratic Republic of Congo:

There are no more barriers [with] modern technology . . . You can't any longer say, 'No, I'm in the Congo.' There are [only] international values of performance, of quality . . . If you can't integrate into this new rhythm, you have a problem.

IMPLICATIONS AND DISCUSSION

E-Vergence and 'The New Hybrid Leaders'

Based on "The Whole World at Work" findings, we have suggested (Shafer & Trautlein, 2006) that there exists an *E-vergence*(SM) – an emerging convergence of experiences, views and aspirations for organizations that feel "whole" – where the ethos is one of people and relationships receiving ample attention in the course of managing technology, task and process.

We have also said that evolved organizations of the future will require a model of multi-dimensional leadership dubbed *The New Hybrid Leader* (Shafer & Trautlein, 2006), where the most leaderly of leaders would be equipped and eager to integrate, respond to and lead diverse groups; demonstrate situational flexibility in management style; and be effective in a variety of geographic, cultural and dual-gender settings. These are tenets of "transformational leadership," defined as: individual consideration (fostering partnerships between people, making contact with them, and active communications), intellectual stimulation (fostering learning, risk-taking and joint problem-solving), and charismatic inspiration (visioning and passion) (Bass, 1998).

Development Opportunities for Technology Professionals

"The Whole World at Work" findings indicate that organizations and therefore technology professionals face a shift in expectations. It can be argued that the time has come to develop new competencies. Managers will *value* professionals who can harness the technical aspects of technology as well as lead in new ways.

This suggests the importance of dramatically re-thinking approaches to leadership development in the 21st century, particularly in complex global organizations. A holistic global IT leadership development framework would "deal with the intensification of systemic complexity . . . [and] respond adaptively to the depth, scope and pace of change . . . " (Daloz Parks, 2005). It would be assumed that technology managers are increasingly at the center of networks of information and relationships, but they are able to influence organizations only to the extent that they think and behave as leaders.

From a male manager who heads an IT function for a European MNC that is one of the largest corporations in the world:

You have to align yourself with the business . . . You have to be in there talking about their strategies [and talking] their language . . . I make this a high priority . . . Poor or good communication is 90 percent of everything, especially in IT.

There is growing evidence of the tangible benefits of "soft capacities." Globalization is a process said to be both technological and human (Lodge, 1995). Among engineers and scientists at the top of academic IQ tests, the "stars" also rank high on emotional intelligence (EQ) (Goleman, 1995), and are adept at turning informal networks into ad hoc teams, persuading, and promoting cooperation. According to IT managers themselves, when IT leadership fails, poor interpersonal skills are a likely culprit (Caruso & Gentry, 2005).

From a male North American manager:

One of the consistent problems is mistaking technology as a leading component of the change process. In fact, it's usually the people side and the leadership that is the big challenge.

The current missing link is customized technology leadership development that goes beyond technical skills and topics to include *connectedness*. As we conceptualize it, a "Connected Technology Leaders"(SM) development framework steers clear of formulaic instruction and accounts for the human dynamics of change. Learning occurs through IT managers involved in facilitated dialogues, scenarios and simulations embedded within four foundational components:

- **Core and Context** – understanding personal strengths and weaknesses in reference to "transformational" leadership style assessments.
- **Customers and Colleagues** – appreciating viewpoints of customers and colleagues and integrating into internal and external social networks.
- **Company and Community** – comprehending the vision, strategies and goals of the organization and stakeholders.
- **Components of Continuity** – applying learning and insights through action plans related to real work issues.

Re-framing technology leadership involves increasing technology manager understanding of: 1) how managers define the ideal organization of the future; 2) what works and does not work in change management; and 3) effective organizational leadership. The desired outcome is technology professionals developed to be compelling catalysts of quality decisions in complex organizations.

REFERENCES

Adler, N. (2002). International dimensions of organizational behavior. (4th Ed.) Cincinnati, Ohio: South-Western, a division of Thomson Learning.

Bass, B.M. (1998). Transformational leadership. Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Caruso, D. & Gentry, K. (2005). Why IT leadership fails. Survey conducted by the Cutter Consortium: http://cio.com/archive.

Dalton, M., Ernst, C., Deal, J., & Leslie, J. (2002). Success for the new global manager. San Francisco, CA: John Wiley & Sons, Inc.

Collins, J. (2001). Good to great: Why some companies make the leap and others don't. New York, NY: HarperCollins.

Daloz Parks, S. (2005). Leadership can be taught: A bold approach for a complex world. Boston, MA: Harvard Business School Publishing.

Gantenbein, D. (2006). "Technology is the tool, people are the key." Microsoft Business & Industry: http://www.microsoft.com/business.

Glaser, B. & Strauss, A. (1967). The discovery of grounded theory: strategies for qualitative research. London: Weidenfeld & Nicolson.

Goleman, D. (1995). Emotional intelligence: Why it can matter more than IQ. New York, NY: Bantam Books.

Goman, C. K. (2000). The human side of high-tech: Lessons from the technology frontier. New York, NY: John Wiley & Sons, Inc.

Gordon, S. (2003). Computing information technology: The human side. Hershey, PA: IRM Press.

Hunter, M. G. (2005). Editorial preface: In support of qualitative information systems research. Journal of Global Information Management, 13(4), I-IV.

IBM Institute for Business Value (2005). Banking 2015: Defining the future of banking. http://www.ibm.com

Laubacher, R. J. & Malone, T. W. (1997). Two scenarios for 21st century organizations: Shifting networks of small firms or all-encompassing "virtual countries"? MIT Initiative on Inventing the Organizations of the 21st Century. Working Paper. http://ccs.mit.edu/21c/21CWP001.html.

Lodge, G. C. (1995). Managing globalization in the age of interdependence. San Diego, CA: Pfeiffer & Company.

O-Hara Devereaux, M. & Johansen, R. (1994). Globalwork: Bridging distance, culture and time. San Francisco, CA: Jossey-Bass Publishers.

Shafer, P. & Trautlein, B. (2006). The Whole World at Work: Multinational managers describe their ideal organization of the future and who should lead them. The Business as Agent of World Benefit Global Forum, Cleveland, OH.

Trompenaars, F & Woolliams, P. (2003). Business across cultures. West Sussex, England: Capstone Publishing Ltd.

Weitzman, E. A. (2000). Software and qualitative research. In N. K. Denzin & Y.S. Lincoln (Eds.), Handbook of qualitative research. Thousand Oaks, CA: Sage Publications, Inc.

Technical and Logical Issues Arising from Collaboration Across Multiple Organisations

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ABSTRACT

This paper discusses the technical and corresponding logical modelling issues arising out of Collaborative Business Process Engineering (CBPE). These modelling issues are based on the technologies of Service Oriented Architecture (SOA) and Web Services (WS). Business Process Modelling Notation (BPMN) is applied in this paper in order to present the proposed model of collaboration across multiple organisations. The uniqueness of this research, and the ensuing discussion, is that the collaboration between multiple organizations is envisaged through a 'yellow pages' and not through the known business-to-business (B2B) interaction. As a result, the collaboration discussed in this paper requires applications to publish, locate and communicate with each other across disparate technical platforms.

Keywords: Web Services, Service Oriented Architecture, UDDI Directory, Business Processes, Trust

INTRODUCTION

This paper describes how business processes of multiple organizations can successfully collaborate with each other. The ideas presented in this paper extend the now well-known concepts of B2B (Business-to-Business) collaborations, and apply them to multiple organizations that may not be known to each other and yet may want to get together electronically to satisfy a particular business demand.

B2B integration (or Business Integration) is a secured coordination amongst two or more known businesses and their information systems. It has dramatically transformed the way business is conducted between specific business partners, suppliers, customers and buyers. According to Microsoft, business process integration enables businesses to link their multiple business processes. Such integration of business processes results in what Gates (1999) has called a 'Digital Nervous System' or DNS. Building business-to-business (B2B) e-commerce systems presents many challenges to the system architect. Each company involved, stores its data and documents in formats that are likely to be different from the formats used by the other participating companies. There is, obviously, a need for companies to integrate what tend to be vastly different systems http://www.microsoft.com/technet/prodtechnol/biztalk/biztalk2000/evaluate/biztalka.mspx.

However, with the advent of Web Services (WS) and Service Oriented Architecture (SOA), it is now possible for businesses to offer as well as locate and consume services irrespective of the physical location of awareness of these businesses with each other. According to Hao (2003) SOA is an architectural style whose goal is to achieve loose coupling among interacting software agents. The SOA achieve loose coupling among interacting by employing a small set of simple and ubiquitous interfaces to all participating software agents. The interfaces should be universally available for all providers and consumers. Also descriptive messages constrain by an extensible schema delivered through the interfaces. A schema limits the vocabulary and structure of messages. An extensible schema allows new versions of services to be introduced without breaking existing services http://webservices.xml.com/lpt/a/1292.

This technical ability of businesses to collaborate with each other has lead to some interesting challenges in terms of both the technologies and the resulting logical interactions between businesses. These challenges emanate from the fact that in CBPE, we are attempting to model services that can be offered and consumed by organizations that may be unknown to each other electronically. This ability to offer services by publishing them on the Internet, and then locating and consuming them, results from the ability of web services to 'transcend' technological boundaries and environments, as discussed later in this paper.

As a part of the development of model for successful collaborative business process engineering, many important issues and challenges were identified and studied. Based on the three-dimensional process framework developed by Unhelkar (2005), these issues and challenges could be broadly categorised into technical, methodological and social challenges. Technically, the challenge is to study the simplicity of implementation of Web Services and their corresponding security and performance issues. These technical issues, revolving around Service Oriented Architecture (SOA) further expand into identifying the availability and management of the various channels of transaction capabilities between the collaborating organizations. Methodologically, the challenge is to identify, model, evaluate and investigate the impact of collaborative business processes on the structure and dynamics of the collaborating organisations. Socially, collaborations lead to challenges in terms of privacy, trust, legal as well as cross-cultural issues between the organizations.

The paper is presented as follows: Starting with a literature review in the area of business collaboration, the discussion deals with the web services technologies and models and the integrated collaborative business processes using a standardised business process management notation (BPMN). Finally, the impact of collaborative web based system on trust is discussed, and concluded with the potential for a successful CBPE model resulting in business integration across multiple unknown businesses.

LITERATURE REVIEW

The advent of the Internet and computer mediated communication has intensified the nature of collaboration between businesses. This is so because of the ever increasing ability of the Internet to enable business applications to interact with each other quickly. The resultant electronic collaborations (e-collaborations) are also broadly defined as collaboration among individuals engaged in a common task using electronic technologies http://cits.tamiu.edu/kock/pubs/journals/2005JournalIEEETPC/KockNosek2005.pdf.

The existing literature does not explain in sufficient detail how to extend the aforementioned electronic collaboration across many organisations that would enable them to share their products and services. We believe that such an extension is possible through the application of Web Services technologies. This belief also appears to be supported by Goethals and Vandenbulcke (2006), who mention that Web Services could be used for integrating system for collaboration even amongst unknown parties.

Fong (2006) describes the main challenge of the collaboration when the involved organisations have to make the investment necessary for replacing redundant or older system as well as building a dynamic platform that incorporates multiple standards. The challenge is further increased when, in unstructured e-collaboration (without prior contract), creating or exchanging of non-standard documents takes place.

Web Services are a suit of technologies that enable web applications to 'talk' with each other independent of their technical environments. Web Services are based on XML (), WSDL () and UDDI (). Web Services is a newly emerging distributed computing model for the web. S'duk and Unhelkar (2005) define Web Services as an attractive service model able to incorporate standards and open protocols for calling services and transmitting data. Web services make software functionality available over the Internet so that programs can request a service running on another server (a web service) and use that program's response in a website, WAP service, or other application. According to Unhelkar & Deshpande (2004), Web Services based technologies enable applications to "talk" with one another even across organisational firewalls, resulting in an opportunity for a cluster or group of organisations to simultaneously transition to Web-based entities.

Tilley, et al, (2002) describes the WS as a novel approach to engineer and deploy software solutions such as cooperative information systems. Snell and Tidwell (2002) define WS as a network accessible interface to application functionality, built using standard Internet technologies. Another definition by Cerami (2002) state that any services that are available over the Internet, uses a standardised XML messaging system, and are not tied to any one operating system. Thus we see that WS tend to offer opportunities that are way beyond the business integration that is commonly discussed and that merely talks about document exchanges. For example, it is very important from this research point to note the view of Kirda, et al, (2001), who declares that Web Services hold the promise of considerable gains for many organisations by giving them the opportunity to develop techniques to effectively integrate disparate applications by leveraging computer technology. Not only do integrated systems can provide better business value by sharing data, communicating results and improving overall functionality, but the mere ability to integrate systems opens up doors to synergise between systems of disparate organizations.

The ability to promote as well as locate services, however, is provided through Universal Data Dictionary Interface (UDDI). UDDI is a platform-independent, XML-based registry for businesses worldwide to list themselves on the Internet. Enterprise UDDI Services is a key element of Web Services infrastructure that provides a standards-based solution for discovery, sharing, and reuse of Web services, helping to maximize the productivity of developers and IT professionals. The purpose of UDDI is to allow users to discover available web services and interact with them dynamically. The process can be divided into three phases: Searching (discovery), Binding, and Executing.

Roy and Ramanujan (2001) states that UDDI specifications provide a mechanism to register and locate WS. It defines an electronic business registry where businesses can describe their business and register their WS as well as discover and integrate with other businesses that offer Web Services.

Considering, Goethals and Vandenbulcke (2006) emphasis that the UDDI is currently not the best means for realising Web Services discovery since they are accessible to anyone resulting the pollution of the registries. Hence, UDDI will allow companies to publish information about the Web Services they offer in a Universal Business Registry (UBR) that will be accessible by anyone. The solution would be to use the private UDDI or WSIL (Web Services Inspection Language).

The study of the existing literature brings us to the following questions as mentioned in the report by microsft.com. As the number of companies that offer Web-based services increases exponentially into the millions, how do buyers looking for a specific service find all of the potential sellers who can meet their needs?

Considering Pollock (2002) opinion that most problems contributing to the high failure rates of integration projects are not technical in nature, but logical, the following will recommend a technical/logical model to resolve already identified problems.

THE WEB SERVICE TECHNOLOGIES

The research is facing many challenges as it investigates the issues involved within the collaboration across multiple organisations. For example, there are the issues of how to create the proper channels of collaboration, what is the confidence level of these created channels and how these organisations could trust and collaborate when they do not even know each other?

As mentioned previously, it was realised some of the challenges such as the channels and their availability are technical issues. The issue of trust can be classified as a logical issue dealing with human factor. This study needs to investigate and identify a way for technology to solve the human related factor of trust. The study further revealed the need to put in place a mechanism in for organisations to define/publish and locate/consume each other's applications specifically when they are not even aware of each other's physical existence.

Figure 1 (Unhelkar, 2003), explains how Web Services are able to define and publish at the same time locate and consume services and applications. While the XML application is defined by WSDL and published by UDDI the same application is located by UDDI and can be consumed by WSDL. Therefore the application can talk even when the organisations are using disparate platforms.

The circle on the left hand side present that the Web Services, specifically WSDL define the XML application and the UDDI publishes the application. And, on the right hand side circle, the UDDI locate the original XML application that was submitted by left hand circle and the WSDL of the right hand side circle consume the application.

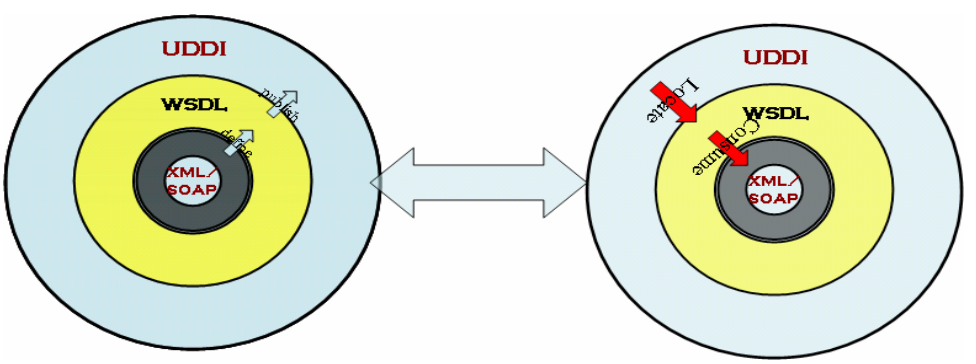
The literature review on the concept of the WS triggered the study by applying the existing technology of Web Services to propose a new model of Collaborative Web Based System (CWBS). The applications of the multiple organisations could be defined/published and located/consumed.

The literature review clearly explained how the WS specifically the UDDI could be applied to create entirely new channels of the collaboration that will not pollute the UDDI directory.

The study proposes two levels of the UDDI directories to register the organisation's information. The first level registers the industries while the second level registers organisation information such as name, address, products and services offered.

The channels of collaborations are illustrated in Figure 2, by identifying that UDDI directories can also publish and locate applications, the demonstrated model was automatically validated hence the different level of the UDDI's directories could also communicate with each other.

Figure 1. The Web services model (Extracted from Unhelkar (2003))



The level 2 directories would not be able to communicate with each other directly. The submitted applications can only published/located through level one directory for the better management of the CWBS.

Figure 2 will present the unique model of the collaboration amongst the multiple organisations that necessarily are not known to each other. These organisations might never have business agreement prior collaborations.

The red dotted line in the picture present a request entering the Collaborative Web Based System (CWBS), based on the request, the CWBS send the request to the first level to identify the industries involved. Then, the system will send it to level 2 in order to find the organisation capable of handling the request and submit the application. The proposed model will have the capability the send the application (request) to multiple organisations either in same or different industry until the process is competed and submitted back, informing the client of final result.

The system is also capable of performing another transaction by submitting the application back to the first level to find the related industry for further processing in the level 2. This classification places the industries as well as the organisations in the allocated place to make it very easy for their publication and location without polluting the directories.

The Figure 2 also illustrate how the organisations and the users not adapting the Web Services will remain outside of the model, unable to use or register in the system (Red organisations). However, if an organisation or a client using the systems facilities, but not registered, are allowed to use the system as long as they are using the Web Services. (Green organisations)

The application will return back to the client after completion, informing the finalisation of the request by supplying all the related booking and transactions numbers. The red dotted line shows existing channels of collaborations across the organisation and clearly shows how the participants could collaborate.

PROPOSED BUSINESS PROCESS MANAGEMENT NOTATION

In this section of the paper, the authors present the Business Process Management Notation (BPMN) designed for the software implementation of the proposed model in Figure 2. Business Process Modelling Notation (BPMN) will provide businesses with the capability of understanding their internal business procedures in a graphical notation and will give organizations the ability to communicate these procedures in a standard manner. Furthermore, the graphical notation will facilitate the understanding of the performance collaborations and business transactions between the organizations (http://www.bpmn.org/Documents/NWG-2001-09-01R4%20Charter.pdf).

Figure 3 depicts the process where a prospective member is ready to register in the system. It is very important to note that different prospective members such as user, person (`Doctor`, `Patient`) and organisations could connect to the Collaborative Web Based System (CWBS) to register. The CBWS does not classify them as a member until the registration is completed.

Prospective Member connects to the CWBS and requests to register in the system. The CWBS prompts the appropriate member registration form to the prospective member to enter the relevant details. If the information is insufficient or incorrect prospective member is asked to input correct details.

Then, CWBS prompts that the registrations form to be submitted and the prospective member submits the registration form. At the end, CWBS registers prospective member sending a unique registration number. The system recognises the prospective member as a member and allows the client to log out of the CWBS.

As depicted in Figure 3, the developed system is ready to accept registration of all prospective members. A prospective member could be any one of the following persons (user of the `system`, `doctor`, `Patient`) or an organisation such as police, insurance company, pharmacist, hospital, Health care system or any other organisations.

In Figure 4, the CWBS places the registration in the allocated directory in order to avoid the pollution of the directories. The CWBS identifies the relevant member industry from the registration form. The CWBS identify the industry's registration by informing the administrator for further direction if the industry does not exist. The directory level 1 will receive an identification number from that specific member and the CWBS register the member details of the member in directory level 2. Finally, the system stores the member details in the database. This is an automated process and only instance of human actor involvement will occur when the specified industry is not available in CWBS.

The Figure 4 illustrates how an automated process places the member details in the right place for the uncomplicated publish/locate process. The difference between the process shown in Figure 4, and a non-collaborative business process would be that the non-collaborative business process would *not* have the directories.

Figure 5 further illustrates the nature of CWBS. In Figure 5, channels of identifying a desired organisation are based on directories where the product and services they offer are stored. The process is triggered when a client submits a request (an inquiry) to the CWBS. It is very important that the user is using the Web Services. CWBS accept the request and identify the member's relative industry/industries based on the submitted request.

The CWBS prompts an optional form requesting details of registration if the Client is not a member. The CWBS prompts a message denying the request when there is no prior registry of the organization capable of handling the request.

The CWBS finalize the appropriate checks and submits the application to the directory level 1. The directory level 1 identifies the industry and submits the application to suitable level 2 directory to identify the organisation capable of

Figure 2. Proposed model of collaboration across multiple organisations

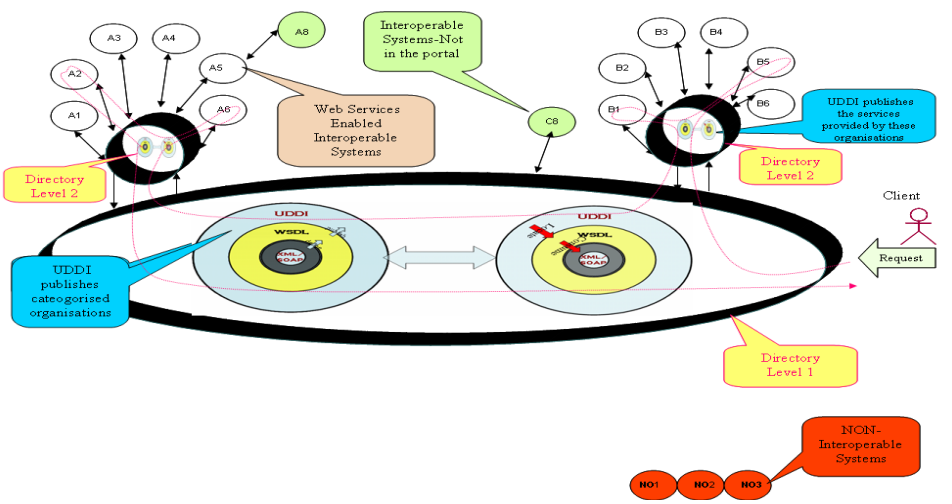


Figure 3. Registration of prospective members

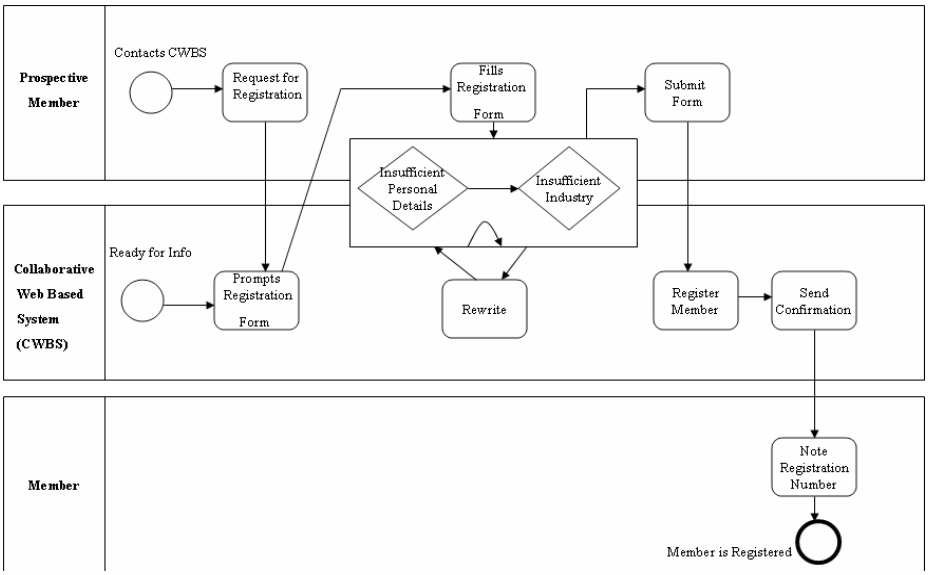
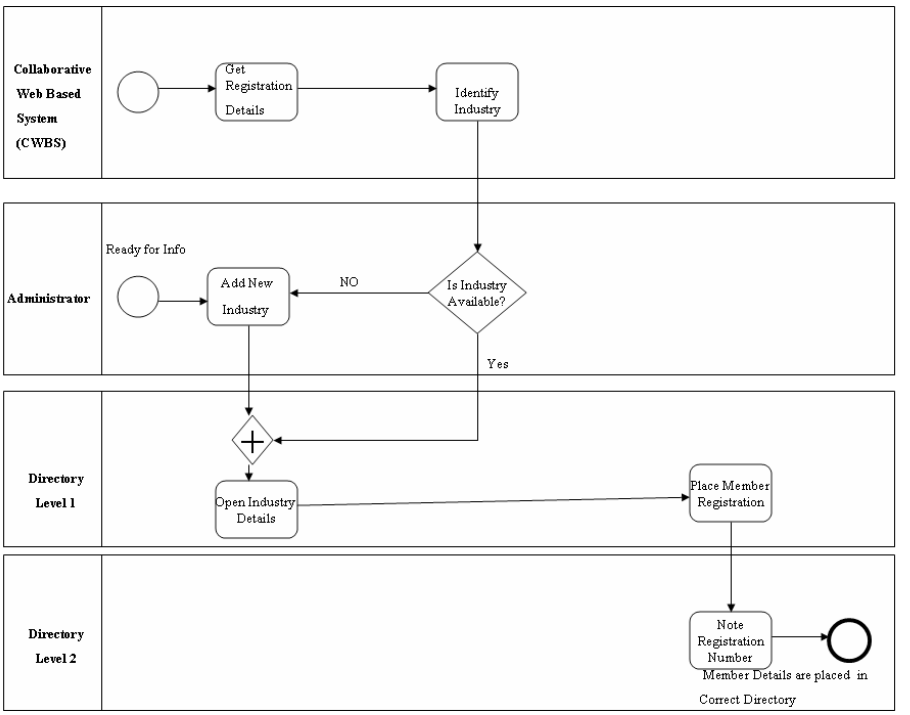


Figure 4. Place the registration in the directory



handling the requests. Then, CWBS eliminates the organisations that are not meeting the environmental boundaries (geographical, budget, member optional preferences).

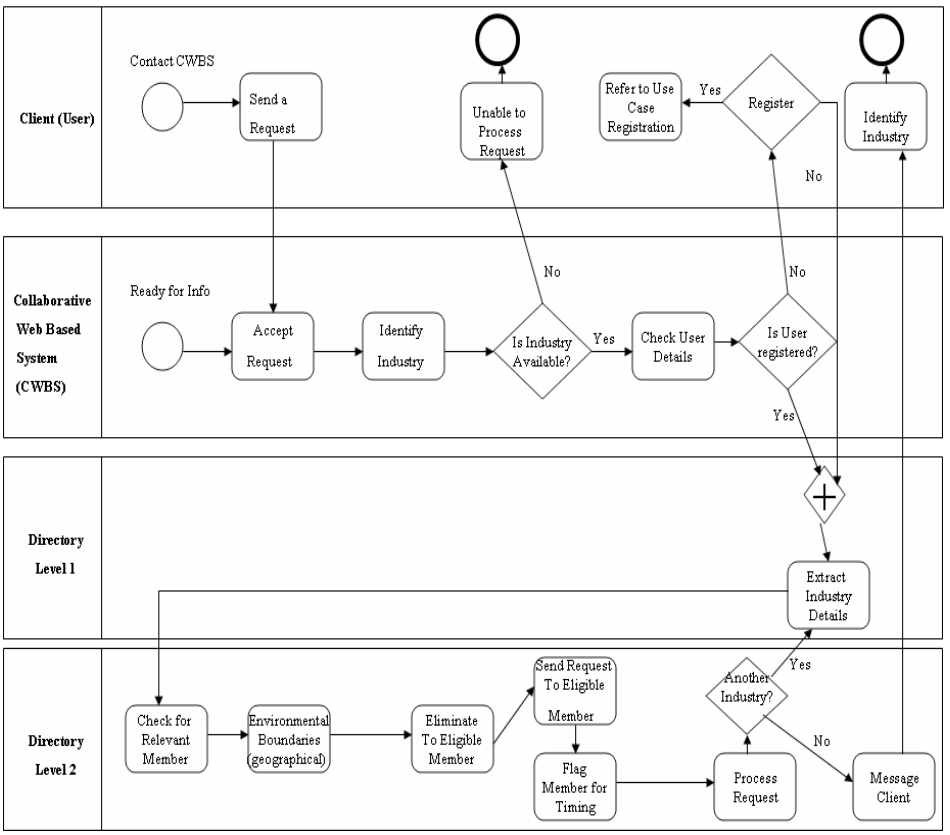
The CWBS follows eliminations of the capable parties who have received the most recent requests. In the next stage, the CWBS processes the client request and collaborates with selected members regarding request.

Right at this stage, the system flags the members involved in the process not to receive the next query. The application will return back to level 1 and if other industries should be involved in the request, the CWBS will go through the process of locating them in order to complete the request.

Finally, the CWBS prompts a message to client informing the outcome of the requested application and allows the user to log out.

Figure 5 above, illustrated the finalising of the processing a request that could be a classified as a very complex type. In this figure, the business process collaboration of multiple organisations is engineered. It is also clearly demonstrated how they collaborate without even knowing each other. The Web Services technology

Figure 5. Process service/product request



creates an opportunity for their application to process and progress regardless of the original platform used for their ordinary process.

IMPACT OF COLLABORATIVE WEB BASED SYSTEM ON TRUST ACROSS ORGANISATIONS

Having considered how the business processes of multiple organisations can be engineered in a way to collaborate, the study can focus on the trust issues amongst them. Jessup and Valacich (2006) outline three different relationships classified in the modern business world as basic, preferred and strategic. A basic relationship can be best described as buy products and services on the basis of price and convenience. Preferred relationship occurs when buyer and seller set preference and price to benefit each other and in strategic relationship both sides share risks and rewards.

The preferred relationship between the ***company*** and ***consumers*** takes place while the most influencing factor of ***trust*** is respected. Those factors are classified as positive customer service experience, length of the relationship with company, company or product reputation, brand familiarity and privacy policies. Therefore, the factors most damaging the trust could be classified as online security fears, telemarketing, company reputation by past incident, general suspicious of company and the disapprove of the company's business practice. http://www.clickz.com/stats/markets/professional/article.php/3312681#table2.

In the proposed environment, the organisations collaborate (work together) rather than compete (work against). The business processes (Applications) of the participated organisation work together to serve a customer request.

The system immediately identifies the industry/organisations involved in the process as soon as the original application is submitted. The application will be submitted to the relevant organisation in the order of priority. For example, if the client is a patient and submitting a request to appoint and see a doctor, the client is unable to purchase the medication online before the doctor submitting the prescription online.

In the given example, the application will be forwarded to the doctor for further process. The system then submits the application to the pharmacy for further processing. However, the doctor and pharmacy might not know each other, hence the system is locating the pharmacy there is really no issue of the trust involved since the client can actually carry the physical prescription to any pharmacy and purchase the medication.

This comparison shows the difference between the two processes – without and with CWBS – especially in the way in which it affects the roles played by people in the organizations and the role of the client. The application will be submitted to an organisation for further process and confidentiality of the involved organisations is indeed respected.

CONCLUSION AND DIRECTION

This research investigated the current collaboration (Business-to-Business) in order to look at possible solutions to enhance the collaboration across business processes of multiple organisations that are not necessarily known to each other. The business processes were studied in order to find the suitable channels of collaboration and evaluate the availability and the level of confidence of the proposed channels.

The paper explained how Web Services can facilitate engineer the collaborative business processes across multiple organisations. The logical challenge was also resolved by proposing a model of collaboration and the illustrated Business Process Management Notation (BPMN) illustrated the availability of the channels systematically and carefully under the guiding principles of the proposed directories.

As per Ghanbary (2006), when an organization undergoes electronic transition (e-transition), there is ample focus on the effect of the rapidly evolving technology on the dynamic environment as well as the structure of the organisation. Undoubtedly, transitions cause organizations to restructure and would introduce a new suite of business processes enabling them to remain in the market as well as grow by dealing with greater number of customers.

In the proposed model, the confidentiality of the participated organisations will be respected while the business processes will be fully collaborative. The research will need more investigation in order to study the actual impact of the collaborative business process on social (trust and legal) issues.

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REFERENCES

Cerami, E. (2002). "Web Services Essentials". O'Reilly and Associates.

Clickz Network Solution for Marketers. http://www.clickz.com/stats/markets/professional/article.php/3312681#table2. Retrieved 10/09/06

Fong, M. (2006). "E-Collaboration and Virtual Organisations". USA. Idea Group Publication. ISBN: 1-59140-285-9

Gates, B. (1999), Business@The Speed of Thought: Using a Digital Nervous System, Viking, Aus, 1999; also see www.Speed-Of-Thought.com

Ghanbary, A. (2006). "Evaluation of Mobile Technologies in the Context of their Applications, Limitations and Transformation". In B. Unhelkar (Ed.), Mobile Business : Technological, Methodological and Social Perspectives. New York: IDEA Gruop Publishing.

Goethals, F. & Vandenbulcke, J. (2006). "Using Web Services in Business-to-Business Integration" a book chapter in "E-Collaboration and Virtual Organisations" Edited by Fong, M. USA: Idea Group Publications. ISBN: 1-59140-285-9

Hao, H. (2003). "What Is Service-Oriented Architecture". http://webservices.xml.com/lpt/a/1292. Retrieved 25/09/2006.

Jessup, L. & Valacich, J. (2006). " Information System today". New Jersey, USA: Pearson Education Inc. Second Edition. ISBN: 0-13-145487-0

Kirda, E. & Jazayeri, M. & Kerer, C. & Schranz, M. (2001). " Experiencing in Engineering Flexible Web Service". IEEE Multimedia, January-March , 2001.

Microsoft Company.http://www.microsoft.com/presspass/features/2000/sept00/09-06uddi.mspx. Retrieved 8/09/06

Skonnard, A. & Laskey, B. (2000) "BIZTALK server 2000. Architecture and Tools for Trading Partner Integration". http://www.microsoft.com/technet/prodtechnol/biztalk/biztalk2000/evaluate/biztalka.mspx. Retrieved 25/09/06

N. Kock & J. Nosek (2005). "Expanding the Boundaries of E-Collaboration" http://cits.tamiu.edu/kock/pubs/journals/2005JournalIEEETPC/KockNosek2005.pdf Retrieved 8/09/06

Object Management Group/Business Process Management Initiative.http://www.bpmn.org/Documents/NWG-2001-09-01R4%20Charter.pdf. Retrieved 27/09/2006

Pollock, J. (2002). "Dirty Little Secrets: It's a Matter of Semantic" http://www.ebizq.net/views/download_raw?metadata_id=1707&what=feature. Retrieved 8/09/06.

Roy, J. & Ramanujan, A. (2001) " Understanding Web Services". IT pro. Novemebr, December 2001 issue. 1520-9202/01.

S'duk, R. & Unhelkar, B. (2005). "Web Services Extending BPR to Industrial Process Reengineering". Proceedings of Information Resource Management Association (IRMA). San Diego, California, USA.

Snell, J. & Tidwell, D. & Kulchenko, P. (2002). " Programming Web Services with Soap". O'Reilly & Associates.

Tilley, S. & Gerdes, J. & Hamilton, T. & Huang, S. & Muller, H. & Wong, K. (2002). "Adoption Challenges in Migrating to Web Services" Proceedings of Fourth International Workshops on Web Site Evolution. Washington, DC, USA. IEEE Computer Society. ISBN: 0-7695-1804-4

Unhelkar, B., & Elliott, Rodney, 2003, "The Role of Web Services in e-Business and Globalization", ***We-B Conference,*** (www.we-bcentre.com; with Edith Cowan University), Perth, 24-25 Nov, 2003.

Unhelkar, B., and Deshpande, Y., "Evolving from Web Engineering to Web Services: A Comparative study in the context of Business Utilization of the Internet", Proceedings of ADCOM 2004, 12th International Conference on Advanced Computing and Communications, Ahmedabad, India, 15-18 December, 2004.

Unhelkar, B. (2005), "Transitioning to a Mobile Enterprise : A Three-Dimensional Framework", Cutter IT Journal, August 2005, Vol. 18(8)

Scoring Systems and Large Margin Perceptron Ranking

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ABSTRACT

Perceptron learning is proposed in the context of so-called scoring systems used for assessing creditworthiness as stipulated in the Basel II central banks capital accord of the G10-states. The approximate solution of a related ranking problem using a large margin algorithm is described. Some experimental results obtained by utilizing a Java prototype are exhibited. From these it becomes apparent that combining the large margin algorithm presented here with the pocket algorithm provides an attractive alternative to the use of support vector machines. Related algorithms are briefly discussed.

1. INTRODUCTION

At least since the Basel II central banks capital accord of the G10-states, cf. e.g. [1], the individual objective rating of the creditworthiness of customers has become an important problem. To this end so-called scoring systems, cf. e.g. [12], [23], [17], [6] have been used for quite some time. Generally these systems are simple classifiers that are implemented as (linear) discriminants where customer characteristics such as income, property assets, liabilities and the likes are assigned points or grades and then a weighted average is computed, where a customer is judged "good" or "bad" according to whether the average exceeds a cut-off point or not. In an extreme case the attributes are just binary ones where 0 respectively 1 signifies that the property does not hold respectively holds. This situation frequently arises in practice. The weights can then either be computed using classical statistical methods or more recently employing artificial neural networks, cf. e.g. [19], provided that suitable bank records are available for training.

However, the use of only two classes for the classification of customers presents certain problems. The event of a credit default for example is not precisely defined, cf. [1], p. 92, so that banking records would almost certainly need at least one more class (e.g. "doubtful (?) customers"). This indicates that a finer distinction among customers could be useful. Indeed, after a computation of default probabilities (again usually based on two classes) banks divide customers into a larger number of classes. This, of course, seems rather counter-intuitive, since surely the division should (and could) be based on experience and be effected before probabilities are computed. Hence in this paper it is assumed that training data are available, where banking customers are divided into mutually disjoint risk classes $C_1, C_2, \ldots, C_k$. Here class C_i is preferred to C_j if $i<j$. It was shown in [8] how this preference relation may be learned employing a generalized version of the pocket algorithm to solve the associated ranking problem. Unfortunately this is not a large margin algorithm, cf. e.g. [11], and hence in this paper a large margin perceptron ranking algorithm based on the work of Krauth and Mezard, cf. [14], will be presented.

Note that the use of several classes has been investigated beforehand, see e.g. [2], p. 237. Moreover, the use of ranking functions has been recognized in an information retrieval context, cf, e.g. [25], for solving certain financial problems, cf. [15], and for collaborative filtering, cf. [20], [21]. However, at least in the banking business, ranking functions, as described in section 2 below, see also [7], [22], apparently have not been used before for the rating of customers. Note also that the fixed margin ranking algorithm described in [20] and [21] involves solving a quadratic and a linear programming problem successively whilst the algorithm presented below is obtained from a reduction of the ranking problem that allows a surprisingly simple albeit approximate solution using a modified perceptron learning algorithm.

2. REDUCTION OF THE RANKING PROBLEM

Suitable anonymous training data from a large German bank were available. In abstract terms then t vectors $\mathbf{x}_1, \mathbf{x}_2, \ldots, \mathbf{x}_t$ from $\Re^n$ (think of these as having grades assigned to individual customer characteristics as their entries) together with their risk classification (i.e. their risk class C_s for $1 \le s \le k$, where the risk classes were assumed to constitute a partition of pattern space) were given. Hence implicitly a preference relation (partial order) "$\rangle$" in pattern space was determined for these vectors by

$$\mathbf{x}_i \rangle \mathbf{x}_j \qquad \text{if } \mathbf{x}_i \in C_i \text{ and } \mathbf{x}_j \in C_j \text{ where } i < j.$$

It was then required to find a map $m_{\mathbf{w}}: \Re^n \to \Re$ that preserves this preference relation, where the index $\mathbf{w}$ of course denotes a weight vector. More precisely one must have

$$\mathbf{x}_i \rangle \mathbf{x}_j \qquad \Rightarrow m_{\mathbf{w}}(\mathbf{x}_i) > m_{\mathbf{w}}(\mathbf{x}_j)$$

If one now specializes by setting $m_{\mathbf{w}}(\mathbf{x}) := \langle \phi(\mathbf{x}), \mathbf{w} \rangle$, denoting the scalar product by $\langle .,. \rangle$ and an embedding of $\mathbf{x}$ in a generally higher (m-) dimensional feature space by ϕ, then the problem reduces to finding a weight vector $\mathbf{w}$ and constants ("cut-offs") $c_1 > c_2 > \ldots > c_{k-1}$ such that

$$\mathbf{x} \in C_1 \text{ if } \langle \phi(\mathbf{x}), \mathbf{w} \rangle > c_1$$
$$\mathbf{x} \in C_s \text{ if } c_{s-1} \ge \langle \phi(\mathbf{x}), \mathbf{w} \rangle > c_s$$
$$\text{for } s = 2, 3, \ldots, k\text{-}1$$
$$\mathbf{x} \in C_k \text{ if } c_{k-1} \ge \langle \phi(\mathbf{x}), \mathbf{w} \rangle.$$

The problem may then be reduced further to a standard problem:

Let $\mathbf{e}_i$ denote the i-th unit vector in $\Re^{k-1}$ considered as row vector and construct a matrix $\mathbf{B}$ of dimension $(m_1+2m_2+k-2)\times(m+k-1)$, where $m_1 := |C_1 \cup C_k|$ (here $|S|$ denotes the cardinality of set S) and $m_2 := |C_2 \cup C_3 \ldots \cup C_{k-1}|$, as follows:

$\mathbf{B} := \begin{bmatrix} \mathbf{R} \\ \mathbf{D} \end{bmatrix}$, dimension R = (k-2) ×(m+k-1), and the i-th row of $\mathbf{R}$ is given by the row vector $(0, \ldots, 0, \mathbf{e}_i - \mathbf{e}_{i+1})$ with m leading zeros. Moreover $\mathbf{D}$ is described by:

For every vector $\mathbf{x}$ in C_1 respectively C_k $\mathbf{D}$ contains a row vector $(\phi(\mathbf{x}), -\mathbf{e}_1)$

respectively $(-\phi(\mathbf{x}), \mathbf{e}_{k}-\mathbf{e}_{1})$, whilst for every vector $\mathbf{x}$ in C_s with $1 < s < k$ it contains the vectors $(\phi(\mathbf{x}), -\mathbf{e}_s)$ and $(-\phi(\mathbf{x}), \mathbf{e}_s-\mathbf{e}_1)$. The reduction of the problem to a system of inequalities is then proved by the following lemma.

Lemma 1: A weight vector $\mathbf{w}$ and constants $c_1 > c_2 > \ldots > c_{k-1}$ solving the ranking problem may (if they exist) be obtained by solving the standard system of inequalities $\mathbf{Bv} > \mathbf{0}$ where $\mathbf{v} := (\mathbf{w}, c_1, c_2, \ldots, c_{k-1})^T$.

Proof (see also [7]): Computation.

Of course, it must be admitted that the existence of a suitable weight vector $\mathbf{v}$ is by no means guaranteed. However, at least in theory, the map ϕ may be chosen such that the capacity of a suitable separating hyperplane is large enough for a solution to exist with high probability, cf. [4].

The price one has to pay for this increased separating capacity consists on the one hand of larger computation times. On the other hand, and perhaps more importantly, a loss of generalization capabilities due to a higher VC-dimension of the separating hyperplanes, cf. e.g. [24], must be taken into account. Hence it seemed advisable to employ fault tolerant perceptron learning using a generalized version of the pocket algorithm, cf. e.g. [11], [7]. In order to further improve the generalization properties here a large margin perceptron ranking algorithm based on the work of Krauth and Mezard will be presented. This may be be used to construct a separating hyperplane that has the large margin property for the vectors correctly separated by the pocket algorithm. The reader should compare this to the large margin ranking described in [20]: There the problem is solved using a (soft margin) support vector machine. Unfortunately computation of the complete set of cut-offs requires the solution of an additional linear optimization problem.

3. LARGE MARGIN PERCEPTRON RANKING

Here the minimal distance of any vector to the closest cut-off will be maximized. The reader should compare this to the fixed margin strategy in the sense of [20].

3.1 Pseudo Code for Perceptron Ranking

First note that the reduction of the ranking problem in section 2 immediately leads to an elegant perceptron ranking algorithm (where separability is assumed).

The **pseudo code** for this algorithm reads as follows.

Perceptron Ranking Algorithm

Input: Binary vectors $\mathbf{x}_1, \mathbf{x}_2, ..., \mathbf{x}_t$ (or vectors with integer entries) from Z^n with corresponding classifications $b_1, b_2, ..., b_t$ from $\{1, 2, \ldots, k\}$ (where the classes $C_1, C_2, \ldots, C_k$ for simplicity have been denoted by their indices) as training vectors, and a function ϕ: $Z^n \rightarrow Z^m$, where in general m>n.

Output: A weight vector $\mathbf{w}$ and k-1 cut-offs c_i satisfying $c_1 > c_2 > \ldots > c_{k-1}$ as vector $\mathbf{c}$ that solve the ranking problem.

Initialize $\mathbf{w}$, $\mathbf{c}$ arbitrarily.
Cycle through the t+k-2 vectors $\mathbf{e}_1-\mathbf{e}_2$, $\mathbf{e}_2-\mathbf{e}_3$, ... $\mathbf{e}_{k-2}-\mathbf{e}_{k-1}$, $\phi(\mathbf{x}_1)$, $\phi(\mathbf{x}_2)$, ..., $\phi(\mathbf{x}_t)$ and do until no further erroneous classifications occur
If $< \mathbf{e}_p-\mathbf{e}_{p+1}, \mathbf{c}> \leq 0$ then
  $c_p := c_p + 1$;
  $c_{p+1} := c_{p+1} - 1$;
End If
If $\mathbf{x}_p \in C_s$ & $<\phi(\mathbf{x}_p), \mathbf{w}> \leq c_s$ & $1 \leq s \leq k-1$ then
  $\mathbf{w} := \mathbf{w} + \phi(\mathbf{x}_p)$;
  $c_s := c_s - 1$;
End If
If $\mathbf{x}_p \in C_s$ & $<\phi(\mathbf{x}_p), \mathbf{w}> \geq c_{s-1}$ & $2 \leq s \leq k$ then
  $\mathbf{w} := \mathbf{w} - \phi(\mathbf{x}_p)$;
  $c_{s-1} := c_{s-1} + 1$;
End If
Return $\mathbf{w}$, $\mathbf{c}$

Remark: The restriction on the entries of the training vectors, which would be rather a nuisance for practical applications, can be removed fairly easily, cf. [18].

3.2 Correctness Proof for Perceptron Ranking

This follows immediately from the Perceptron Laerning Theorem, cf. [16] and [3] by observing that its application to the ranking problem as presented in section 2 leads to the update operations given in the pseudo code above. Note here that for perceptron learning under the assumed separability the monotonicity of the cut-offs is guaranteed already if the inequalities resulting from the block matrix $\mathbf{D}$ in section 2 are satisfied. Hence here the pseudo code could be shortened accordingly. However, if application of the pocket algorithm is envisaged, then the inequalities resulting from the block matrix $\mathbf{R}$ in section 2 constitute rules that must be fulfilled and hence cannot be ignored if a small number of faults is considered admissible. The reader may wish to consult [22], for a similar ranking algorithm. It is, however, given using a kernel version and its Novikoff bound will be somewhat worse in general as can fairly easily be seen.

3.3 Pseudo Code for Large Margin Perceptron Ranking

The work of Krauth and Mezard concerning large margin perceptron learning is described in [14]. Certain modifications were necessary in order to combine it with 3.1 and obtain a large margin algorithm, cf. [9]

The **pseudo code** for this algorithm reads as follows.

Input: Binary vectors $\mathbf{x}_1, \mathbf{x}_2, ..., \mathbf{x}_t$ (or vectors with integer entries) from Z^n with corresponding classifications $b_1, b_2, ..., b_t$ from $\{1, 2, \ldots, k\}$ (where the classes $C_1, C_2, \ldots, C_k$ for simplicity have been denoted by their indices) as training vectors, and a function ϕ: $Z^n \rightarrow Z^m$, where in general m>n. In addition a real number $\alpha > 0$ must be chosen.

Output: A weight vector $\mathbf{w}$ and k-1 cut-offs c_i satisfying $c_1 > c_2 > \ldots > c_{k-1}$ as vector $\mathbf{c}$ that approximate the maximal margin solution of the ranking problem. The approximation improves with increasing α.

Initialize $\mathbf{w}$, $\mathbf{c}$ with $\mathbf{0}$, $\mathbf{0}$.
Loop
For the given vectors $\phi(\mathbf{x}_1), \phi(\mathbf{x}_2), ..., \phi(\mathbf{x}_t)$ compute the minimumm of the following expressions:
  (i) $<\phi(\mathbf{x}_i), \mathbf{w}> - c_s$ if $1 \leq s \leq k-1$ for $\mathbf{x}_i \in C_s$, $1 \leq i \leq t$
  (ii) $-<\phi(\mathbf{x}_i), \mathbf{w}> + c_{s-1}$ if $2 \leq s \leq k$
Then m either has the form
  (a) $m = <\phi(\mathbf{x}_j), \mathbf{w}> - c_s$ for some j und $\mathbf{x}_j \in C_s$
  or
  (b) $m = -<\phi(\mathbf{x}_k), \mathbf{w}> + c_{s-1}$ for some k und $\mathbf{x}_k \in C_s$
If $m > \alpha$ then
  display $\mathbf{w}$, $\mathbf{c}$;
  stop;
Else
  If (a) then
    $\mathbf{w} := \mathbf{w} + \phi(\mathbf{x}_j)$;
    $c_s := c_s - 1$;
  Else
    $\mathbf{w} := \mathbf{w} - \phi(\mathbf{x}_k)$;
    $c_{s-1} := c_{s-1} + 1$;
  End If
End If

So in contrast to the ordinary perceptron ranking in the wide margin perceptron ranking the update operation is performed with the "worst" classified element as opposed to with an arbitrary misclassified element.

Note that for the case $\alpha = 0$ the original perceptron ranking as in 3.1 is obtained. Note also that a correctness proof of the algorithm follows from the correctness proof of the slightly modified Krauth/Mezard algorithm as given in [9] and the correctness proof in 3.2.

Perhaps it should also be pointed out that in analogy to ordinary perceptron learning kernel versions of both algorithms are readily deducible since in both cases only scalar products need to be computed to decide on the update operation.

3.4 Experimental Results

In order to test the large margin algorithm and with a view to further extensions a Java prototype was constructed. This was connected to an Access database via ODBC. In addition an Excel system with the Solver installed was employed for quadratic programming.

The experiments were carried out with 58 data vectors, which allowed perfect separation, provided by a German financial institution. The customers had been divided into 5 preference classes and the method by which the classes had been obtained was not disclosed (originally there were only 4 classes but six likely looking candidates were assigned to class 5 thus creating a slightly artificial situation). Each customer was characterized by 8 attributes where each attribute had been assigned a grade (from 1 to 5, where 1 is the best grade) based on evaluations by internal computer programs (again the details of this evaluation are not disclosed to outsiders). This led to an obvious reversal in some inequalities of the algorithm since the lowest weighted average grade was considered the best. The experiments were conducted on a standard laptop (1.47 GHz clock, 512 MB RAM). In order to test the quality of approximation measurements were conducted for various values of α (denoted by alpha in the Excel diagrams). For simplicity the function φ appearing in the algorithm was taken to be the identity. Moreover for comparison purposes the optimal large margin weights and cut-offs were calculated by solving the following quadratic programming problem employing the Excel Solver:

Minimize $\|\mathbf{w}\|^2$ subject to

$\langle \mathbf{x}_i, \mathbf{w} \rangle - c_{s-1} \geq 1$ for s = 2, 3, 4, 5

$\langle \mathbf{x}_i, \mathbf{w} \rangle - c_s \leq -1$ for s = 1, 2, 3, 4

where $\mathbf{x}_i \in C_s$ and i = 1, 2, 3, …, 58.

In this programming problem the entries of the vector **w** and the cut-offs were declared as variable to the Excel Solver so as to simultaneously get an optimal weight vector and optimal cut-offs

As a measure of the quality of approximation the distance of the "worst-classified" element to the nearest cut-off was computed. In diagram 1 the result for the optimal solution namely 0.0739745 is marked by a horizontal line. Note that the time measurements refer to elapsed time only and hence cannot be entirely accurate since for example cache effects have not been taken into account. However, for the puposes of the present paper this somewhat crude form of measurement was deemed adequate.

The results obtained were as follows in Diagrams 1 and 2.

As may be seen from diagram 1 the approximation to the optimal solution improves quite fast with increasing α up to about 80. Thereafter, however, only slow progress is made. Nevertheless, for practical purposes this approximation may be quite sufficient.

Clearly the time requirements increase linearly with increasing α as can be seen from diagram 2 (where times are given in milliseconds) and thus appear quite reasonable.

4. CONCLUSION AND OUTLOOK

A new large margin ranking algorithm has been presented. Encouraging experimental evidence has been obtained using "real life" data from a financial institution. The algorithm is based on a reduction of the ranking problem and a combination of the resulting ranking algorithm together with a result essentially due to Krauth and Mezard. In contrast to the wide margin ranking algorithm described in [20] it can be implemented with a surprisingly compact Java encoding. This is due to the fact that it can be seen as an extension of classical perceptron learning. On the other hand, of course, it gives only an approximate solution which may, however, as indicated by the experimental results, be quite satisfactory for practical applications. To clarify the situation additional experiments are needed and it is envisaged to perform these as soon as suitably large data sets become available.

In addition the algorithm only works for separable sets. However, it is intended to combine it with a modified version of the pocket algorithm by applying it to those data sets only that are correctly separated. This way an empirical risk minimization would be performed which is then followed by maximizing the margin. This seems attractive since that way certain approximations inherent to the soft margin support vector machine as utilized in [20] are avoided. Again it is intended to conduct suitable experiments as soon as possible.

Finally a few comments on related algorithms seem in order. The large margin algorithm in [20] has been briefly discussed already. The ranking algorithms in [5] and [13] appear inferior from the results given in [20]. In [26] large margin perceptron learning was introduced for the pocket algorithm. However, in spite of reasonable experimental evidence, the theoretical basis appears slightly shaky, for details see e.g. [10]. The ranking algorithm in [22] (soft margin version) appears to contain a gap since the monotonicity condition for the cut-offs seems to

Diagram 1

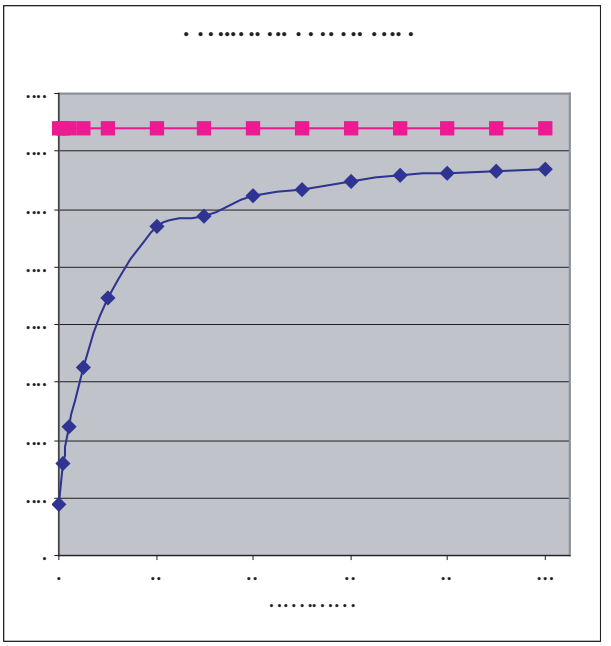
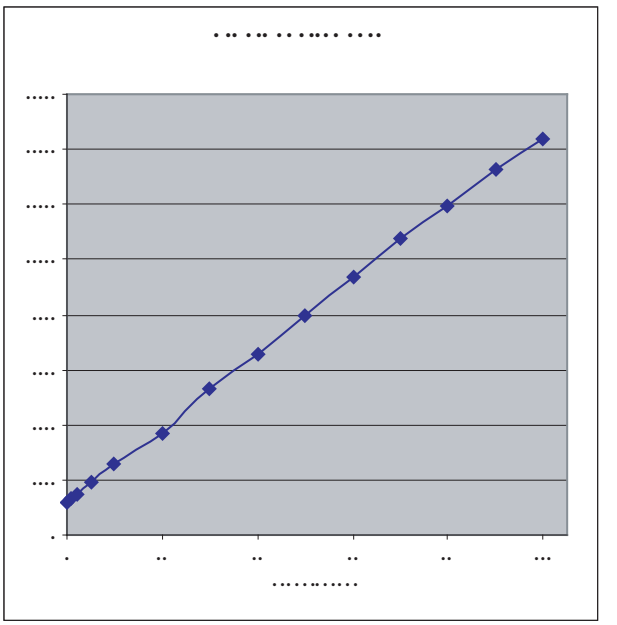


Diagram 2



be neglected. Moreover an additional vector is ignored without explaining the consequences. In short then the algorithm closest to the one presented here seems to appear in [20]. Of course, it has been tested in a completely different context and an objective comparison concerning the banking application envisaged here is still outstanding.

REFERENCES

[1] Banking Committee on Banking Supervision: International Convergence of Capital Measurements and Capital Standards, A Revised Framework, Bank for International Settlements, http://www.bis.org/publ/bcbsca.htm (June 2004)

[2] Bishop,C.M.: Neural Networks for Pattern Recognition. Oxford University Press, (1998)

[3] Block, H.D.; Levin, S.A.: On the Boundedness of an Iterative Procedure for Solving a System of Linear Inequalities. Proc. AMS, (1970)

[4] Cover, T.M.: Geometrical and Statistical Properties of Systems of Linear Inequalities with Applications in Pattern Recognition. IEEE Trans. on Electronic Computers, Vol. 14, (1965)

[5] Crammer, K.; Singer, Y.: Pranking with Ranking, NIPS, (2001)

[6] Episcopos, A.; Pericli, A.; Hu, J.: Commercial Mortgage Default: A Comparison of the Logistic Model with Artificial Neural Networks. Proceedings of the Third International Conference on Neural Networks in the Capital Markets, London, England, (1995)

[7] Falkowski, B.-J.: Lernender Klassifikator, Offenlegungsschrift DE 101 14874 A1, Deutsches Patent- und Markenamt, München, (Learning Classifier, Patent Number DE 101 14874 A1, German Patent Office, Munich) (2002)

[8] Falkowski, B.-J.: On a Ranking Problem Associated with Basel II. In: Proceedings of the 5th International Conference on Hybrid Intelligent Systems (HIS 2005). Eds. N. Nedjah, L.M. Mourelle, M.M.B.R. Vellasco, A Abraham, M. Köppen, IEEE Computer Society, (2005)

[9] Falkowski, B.-J.: A Note on a Large Margin Perceptron Algorithm, to appear in Information Technology and Control

[10] Falkowski, B.-J.: On Large Margin Pocket Algorithms, to appear in Proceedings of the IASTED International Conference on Computational Intelligence, CI 2006

[11] Gallant, S.I.: Perceptron-based Learning Algorithms. IEEE Transactions on Neural Networks, Vol. I, No. 2, (1990)

[12] Hand, D.J.; Henley, W.E.: Statistical Classification Methods in Consumer Credit Scoring: a Review. Journal of the Royal Statistical Society, Series A, 160, Part 3, (1997)

[13] Herbrich, R.; Graepel, T.; Obermayer, K.: Large Margin Rank Boundaries for Ordinal Regression. In: Advances in Large Margin Classifiers (Eds. Smola, A.J.; Bartlett, P.; Schölkopf, B.; Schuurmans, D.), MIT Press, Neural Information Processing Series, (2000)

[14] Krauth, W.; Mezard, M.: Learning Algorithms with Optimal Stability in Neural Networks. J. Phys. A: Math. Gen. 20, (1987)

[15] Mathieson, M.: Ordinal Models for Neural Networks. Neural Networks in Financial Engineering, Proceedings of the 3rd International Conference on Neural Networks in the Capital Markets, World Scientific, (1996)

[16] Minsky, M.L.; Papert, S.: Perceptrons. MIT Press, (Expanded Edition 1990)

[17] Müller, M.; Härdle, W.: Exploring Credit Data. In: Bol, G.; Nakhneizadeh, G.; Racher, S.T.; Ridder, T.; Vollmer, K.-H. (Eds.): Credit Risk-Measurement, Evaluation, and Management, Physica-Verlag, (2003)

[18] Muselli, M.: On Convergence Properties of Pocket Algorithm. IEEE Trans. on Neural Networks, 8 (3), 1997

[19] Shadbolt, J.; Taylor, J.G.(Eds.): Neural Networks and the Financial Markets. Springer-Verlag, (2002)

[20] Shashua, A.; Levin, A.: Taxonomy of Large Margin Principle Algorithms for Ordinal Regression Problems. Technical Report 2002-39, Leibniz Center for Research, School of Computer Science and Eng., the Hebrew University of Jerusalem, (2002)

[21] Shashua, A.; Levin, A.:Ranking with Large Margin Principle: Two Approaches, NIPS 14, (2003)

[22] Shawe-Taylor, J.; Cristianini, N.: Kernel Methods for Pattern Analysis. Cambridge University Press, (2004)

[23] Thomas, L.C.: A Survey of Credit and Behavioural Scoring: Forecasting Financial Risk of Lending to Consumers. International Journal of Forecasting, 16, (2000)

[24] Vapnik, V.N.: Statistical Learning Theory. John Wiley & Sons, (1998)

[25] Wong, S.K.M.; Ziarko, W.; Wong, P.C.N.: Generalized Vector Space Model in Information Retrieval. Proceedings of the 8th ACM SIGIR Conference on Research and Development in Information Retrieval, USA, (1985)

[26] Xu, J.; Zhang, X.; Li, Y.: Large Margin Kernel Pocket Algorithm. In: Proceedings of the International Joint Conference on Neural Networks 2001, IJCNN'01, Vol. 2. New York: IEEE, (2001)

Improving the Quality of Online Consumer Communities

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INTRODUCTION

Consumer-opinion websites enable consumers to voice their opinions on products, services and companies, read those others or and interact with other consumers on a website other than that of a manufacturer, retailer or auction. To consumers, these websites are sources of pre-purchase or post-purchase product information (Hennig-Thurau & Walsh, 2003). Consumers voicing their opinions on the Web are valuable sources of knowledge not only to other consumers but also to companies. They may learn about customer preferences and product defects (Nah et al., 2002), which they can translate into opportunities for product modification and development (Cho et al., 2002; Pitta & Fowler, 2005).

Previous research on consumer-to-consumer interactions on the Web has primarily focused on C2C auctions (e.g. Standifird, 2001; Dellarocas, 2003; Mollenberg, 2004), while communicative aspects of consumer interactions have not been paid much attention to. Relevant studies conducted in this area have looked at the persuasiveness of consumer-to-consumer communication on the Web (Xue & Phelps, 2004), the effect of positive and negative messages on consumers' brand evaluation (Chiou & Cheng, 2003), the use of online communities for marketing (Evans et al., 2001; Maclaran & Catterall, 2002), consumers' reasons for visiting C2C websites (Hennig-Thurau & Walsh, 2003), and their motivation to voice their opinion on C2C sites (Hennig-Thurau et al., 2004). These papers are anchored in the fields of marketing, information systems, but have not viewed consumer-to-consumer interactions as communicative exchanges. This paper is grounded in media richness theory, focusing on the interactional structures and tools available to participants in communicative exchanges on consumer-opinion websites. The goal of this paper is to identify mechanisms that render the information disseminated on consumer-opinion websites more valuable to both consumers and companies.

CONCEPTUAL FRAMEWORK

This study applies the concept of media richness to interactions on consumer-opinion websites. Media richness theory is well suited for this analysis, since there is a close link between website design, web usability and media richness (Palmer, 2002). Originally proposed as a theory in the realm of managerial communication, media richness theory suggests that media can be high or low in richness, which is defined as "the ability of information to change understanding within a time interval" (Daft & Lengel, 1986, p. 560). While leaner media suffice for unequivocal messages, task performance is expected to improve when richer media are used for complex messages (Daft & Lengel, 1986). Also, users perceive a medium as richer as they gain experience with it (Burke & Chidambaram, 1999).

Media richness theory argues that a medium's richness depends on its capacity regarding four parameters: the immediacy of feedback, the number of cues it can convey, language variety, and personal focus. Face-to-face communication is considered to be the richest medium, as its participants are able to give rapid feedback, communicate cues other than language (e.g. physical appearance, body language, tone of voice), use natural language to convey a wide range of meanings, and can communicate feelings easily. Richer media thus create a more positive affective state in the receiver, as they are capable of conveying information about the emotional state of the sender (Daft & Lengel, 1986; Daft et al., 1987; Lengel & Daft, 1988). Interactive media such as telephone or e-mail are considered to be leaner than face-to-face conversations but richer than static written communication, with telephone conversations being richer than e-mail messages (Lengel & Daft, 1988). The exact position of websites along the continuum between face-to-face and written communication is difficult to determine, since they may provide anything from mere textual information to multimedia applications (Palmer, 2002).

Examining websites in light of the four parameters of media richness, one can safely say that feedback in electronic media is always less immediate than oral communication—irrespective of whether synchronous or asynchronous—as typing a message causes a delay in transmission (Dennis & Kinney, 1998). The Web's capacity to convey social cues is lower than that of other channels, which entails that many of the social cues we are used to in the physical world are absent in online interactions (Donath, 1999). The parameter of language variety refers to how a medium serves to increase understanding among communicators by transmitting verbal and non-verbal information as well as signs and symbols (Daft & Lengel, 1986). Although in this sense written communication conveys less information than oral communication, web-mediated communication has means unavailable in conventional written communication, e.g. hyperlinks or animations, thus providing richer interactions than non-digital written formats such as letters or faxes. Ultimately, a sender who communicates feelings and emotions has greater presence in the exchange, since receivers tend to constantly monitor the sender's emotional expressions (Strongman, 1996). In the absence of nonverbal and visual cues, a writer in computer-mediated communication tends to lose in presence compared to the speaker in an oral conversation (Tanis & Postmes, 2003).

DATA COLLECTION AND ANALYSIS

Media richness theory provides a scheme for organizing and understanding the design features offered by C2C websites, which helps to identify ways of making them more suitable for the tasks they seek to perform. This study applies the techniques of content analysis to analyze features of websites (cf. Robbins & Stylianou, 2003; Zhou, 2004). The strengths of this approach lie in the unobtrusive, systematic, and replicable collection of data (Krippendorff, 1980).

The sample websites were found in the *Yahoo Directory* under "Consumer Opinion" (Yahoo Directory, 2006), which contains links to 28 sites. The *Google Directory* did not have a corresponding category containing chiefly consumer-opinion websites and was thus not considered for drawing the sample. From the 28 consumer-opinion websites found via the *Yahoo Directory*, nine had to be excluded, because they were not available at the time of data collection, contained only sponsored links, or were just alternative URLs to other sites listed in the directory. The resultant sample consisted of 19 websites (see Table 1 in "Results" section). A user account was opened with each site in order to gain access to all features offered.

A coding instrument was developed that makes for the systematic and unbiased collection of data from the sample websites by conducting a pilot study of the interactional structures of the first 9 websites from the alphabetically ordered list of sites. To develop this coding scheme, as many different features and tools as possible were identified that provide for feedback, multiple cues, language variety, and personalized messages. The scales used to measure these facts were nominal, taking into account the presence or absence of a particular feature. In content analysis, nominal scales do not require human judgment and interpretation to the same extent as, for example, ordinal scales and thus reduce coder bias. Subsequently, all 19 sites were examined for the presence or absence of the 25 features derived from the pilot coding. Since the study is exploratory in nature, the coding scheme was open for new codes that emerged throughout the coding process and sites already coded were then recoded for the presence or absence of these features (cf. Schultz, 1999; Ellison, Heino, & Gibbs, 2006). Overall, the coding scheme included 27 codes (see Appendix). All sites were revisited and re-coded as a check on intra-coder reliability (cf. Bauer, 2000; Stempel & Wesley, 1981), reaching an agreement of 99.61%.

Table 1. Basic interaction formats

	DI	CO	PR	RE	QU	RA	BL	WK	RG
AskAnOwner					•				
ComplaintBook		•							
Complaints		•							
ConsumerReview	•			•					•
Dooyoo				•					•
Epinions	•			•					•
JudysBook				•	•				•
MarketMarks		•	•		•				
My3cents	•	•	•	•			•		•
PlanetFeedback		•	•		•				•
Ratings				•		•			•
ReviewCentre	•			•		•			•
Riffs				•		•	•	•	
RipOffReport		•							•
SafetyForum	•								
SqueakyWheel		•							•
SyllasForum	•								•
TCCL	•	•	•						•
uSpeakOut	•								•
Total	**8**	**8**	**4**	**7**	**4**	**2**	**1**	**1**	**13**

RESULTS

As Table 1 shows, the sites enable consumers to express themselves in a variety of formats, including discussion threads (DI), complaints (CO), praises (PR), product reviews (RE), questions (QU), product ratings (RA), consumer blogs (BL), and wikis (WK). Further, Table 1 indicates how many sites require users to register (RG) in order to actively participate in such interactions. Reading contributions is possible without registration on all sites.

Feedback

The 19 C2C sites use almost exclusively asynchronous feedback mechanisms. In fact, *TCCL* and *Riffs* are the only websites facilitating synchronous feedback in the form of online chats. Asynchronous feedback on C2C websites includes comments on product reviews (n=12), e-mails (n=10), ratings of the usefulness of a product review (n=9), replies in discussion threads (n=8), company rebuttals to complaints (n=6), personal messages among registered users (n=6), replies to questions (n=4), and wiki collaborations (n=1).

Feedback facilities can also be looked at in terms of the parties involved. While only eleven sites offer one-to-one consumer communication (i.e. PM, e-mail, chat), 16 sites post one-to-many feedback from consumers (i.e. ratings, comments, replies in threads) and six sites enable companies to provide feedback on consumers' opinions in the form of rebuttals. Only one C2C website does not include any feedback mechanisms at all, confining interactions to message transmission and reception. To some extent, also the operators of the C2C sites give feedback to the contributors as well. While some of them merely claim that they reserve the right to remove inappropriate or offensive messages, two sites claim to approve all reviews before they post them online, and two websites automatically screen all messages for offensive words and censors them.

While the majority of sites rely on voluntary contributions, six sites offer financial or material incentives to contributors, which also function as a feedback mechanism. The incentives offered include cash rewards for every 100th review submitted by registered members or credit points which are redeemable for products or cash and are earned for each review or each time the review is read.

Multiplicity of Cues

Allowing members to provide information about themselves when they register is one way to remedy the Web's reduced capacity to convey social cues. Twelve sites enable users to make such information available in their member profiles, including for example location, gender, occupation, e-mail addresses, verbal biographies, hobbies, and links to personal websites. On ten sites, the user profiles also include statistics about the user's activities on the site. The data users are able to provide or the site provides about them include the number of contributions by the user, the join date, the number of credit points earned, the average rating s/he has received for his/her contributions, the number of visits, the date of the last visit, and the average response time.

C2C sites also provide cues regarding the status of individual users in C2C communities. Two sites provide rankings of their contributors either on the basis of the number of credit points they have earned or on the number of contributions they have made to the site. Six other sites award titles based on the quality (e.g. *top reviewer*) and quantity (e.g. *senior member*) of users' contributions. *ReviewCentre* does not award titles to users but to their contributions, labeling high-quality reviews as *expert reviews*. Similarly, registered members on *Dooyoo* can nominate reviews for inclusion in the site's *Hall of Fame*.

Another way of determining a user's status in a C2C community is by enabling registered members to indicate in their profiles which users in the community they trust in terms of expertise. These buddy networks people create when they add people to their list of trusted members may help others to decide whether or not to trust a reviewer. Overall, four sites offer such reputation systems. One C2C site merely lists a user's *Friends* but does not indicate how many users have added this user to their list of *Friends*.

Language Variety

All 19 C2C sites enable people to articulate their opinions publicly using natural language, e.g. discussion threads, blogs, chats, product reviews, comments, questions and answers, complaints and praises. The texts can be enhanced with active hyperlinks on six sites, e.g. to link to the sites of companies or products that writers are reviewing. Six sites also enable writers to paste pictures into their messages. Similar to hyperlinks, pictures may help people to provide evidence for their arguments for or against a company or a product. Three websites inviting verbal reviews offer a default structure that encourages readers to deal with positive and negative aspects of a product in the review.

Eight sites use categories in addition to verbal statements in the form of Likert-scale questions or closed-ended questions. These communication formats clearly

limit people's means of expression to a pre-defined set of answers and introduce a response bias as they suggest ideas and cannot account for qualifications to responses (*Blunch, 1984)*. Such ratings appear in two different formats. First, people can rate products or companies according to predefined criteria (e.g. customer service, ease of use, etc.). Second, they can rate the usefulness of other consumers' contributions, e.g. "Was this review very helpful / helpful / somewhat helpful / not helpful to you?". Although such data can be analyzed more easily than verbal product reviews, they provide only meaningful information if large numbers of users make use of these rating facilities.

Personal Focus

Six of the C2C websites enable people to use a selection of emotive icons to express sentiments such as fear, boredom or uncertainty, which sequences of ASCII characters do not convey as unequivocally as icons. Thus, such interactions are richer than those in which people can use either only ASCII-code emoticons in texts or no emoticons at all because opinions are to be expressed in the form of ratings. Another factor determining how much presence a writer has in computer-mediated communication is whether or not they post their contributions anonymously, use a screen name, or use their real names. On four sites people can voice their opinions anonymously, on three sites they are strongly encouraged to use their real names, and on twelve sites they can register any name. Consumers thus have the possibility to express feelings, emotions and attitudes when they select screen names. Avatars, which enable people to express emotions and attitudes, can only be used on five C2C sites. Thus, in the C2C interaction systems studied, interlocutors do not have much visual presence, although the medium has the capabilities to do so.

DISCUSSION AND IMPLICATIONS

Media richness theory argues that leaner media suffice to convey simple messages, while richer media should be used to convey complex messages. Messages on consumer-opinion websites have varying levels of complexity, depending on the writer's motives and on the reader's use of these messages. The tasks performed by users of consumer-opinion websites are threefold, including (1) passive information gathering (i.e. reading) before or after a purchase or as part of social interactions, (2) active information gathering (i.e. asking) before or after a purchase or as part of social interactions, and (3) information dissemination to share information after a purchase or as part of social interactions. Passive information gathering is complex, given that the relevant information has to be found first and then several or possibly many different viewpoints have to be processed. Reading stimulated by the need for social interaction is clearly less challenging, as an interactant will only respond to one message of his/her choice at a time. Writing, meanwhile, involves complex messages, if the writer seeks to produce a comprehensive and accurate product review, but uses less complex messages, if the purpose of writing is to vent emotions or interact with others. Thus, to be successful, consumer-opinion websites need to offer a high level of richness to those users producing or consuming complex messages, but at the same time they must not overwhelm those consumers exchanging less complex messages.

As the above results have shown, the websites examined have implemented a number of measures intended to render contributions to these sites more valuable. Table 2 summarizes these measures, indicating which parameter of media richness they belong to and how many sites have implemented them. Essentially, the measures listed in this table represent a non-exhaustive inventory of potential success factors for consumer-opinion websites, given that they enhance the richness of consumer-to-consumer interactions.

The quality of contributions in C2C interactions could be improved in a number of ways. Feedback mechanisms may impact quality, since writers might pay more attention to the quality of their contribution when site owners review contributions before they make them available publicly or may even decide not to post them. Similarly, people are likely to try harder when they know other people can rate them or comment on what they have written. However, readers may not be willing to provide feedback that rewards the writer but does not provide any rewards for themselves.

Quality is also closely associated with language, as opinions expressed verbally can account for both positive and negative views on a product or a company, unlike opinions expressed by answering multiple choice questions or closed-ended questions. When users rely on word-of-mouth communication, they consider negative information more helpful than positive information in distinguishing between high-quality and low-quality products (Herr, Kardes, & Kim, 1991). This suggests that website operators should encourage consumers to consider both positive and negative points when stating their opinion on a product, as is currently done by three C2C websites in the sample. When writers are guided by such a structure, their contributions may contain more valuable product evaluations rather than personal stories or venting of emotions.

Further, activated hyperlinks may enhance the quality of contributions in C2C interactions, as they enable the writer to loosely integrate information from other sources, giving a broader picture than the information posted on one C2C website can give. Ultimately, quality in C2C interactions can also be enhanced by offering emotive icons to writers, since words on a screen cannot always convey what people convey with facial expressions or intonation in face-to-face interactions. Conversely, the use of emotive icons may shorten or eliminate passages verbalizing emotions in consumers' contributions.

However, website operators wishing to enhance their sites need to be aware that not all features are valuable to all sites, in particular to those sites offering only one interaction format. For example, ratings of contributions add to the richness of general-opinion websites (e.g. product review sites) but are clearly of less value to pure complaint sites or discussion forums. Conversely, company responses would be a meaningful enrichment for complaint sites but not for discussion forums. Clearly, hybrid sites, facilitating more than one interaction format, provide richer interactions, as users can choose – depending on their experience with the medium – the format they perceive as the richest for the task they seek to perform.

The results also suggest that it is worthwhile for C2C websites to separate the tasks of information search/dissemination and social interaction. C2C websites could cater to both consumers' information and social needs but with different interaction facilities, for example by offering a discussion forum with member statistics and product-review facilities supported by trust networks. This separation would enable people to perform their information-oriented reading or writing tasks in a richer setting and social tasks involving less complex messages in a leaner setting.

REFERENCES

Bauer, M.W. (2000). Classical content analysis: A review, In *Qualitative researching with text, image and sound*, Bauer, M.W. & G. Gaskell, G. (Eds.), London: Sage, 131-151.

Blunch, N.J. (1984). **Position bias in multiple-choice questions.** *Journal of Marketing Research*, 21(2), 216-220.

Table 2. Improving the richness of online consumer interactions

Feedback	Cues	Language	Personal Focus
Company Responses [6] Ratings by Readers [9] Reader Comments [12] Screening/Reviewing [4] Credit Points [6]	Member Profiles [12] Trust Networks [6] Community Titles [6] Rankings [2]	Verbal Expression [19] Active Hyperlinks [6] Default structure [3]	Emotive Icons [6]

Burke, K., & Chidambaram, L. (1999). How much bandwidth is enough? A longitudinal examination of media characteristics and group outcomes. *MIS Quarterly*, 23(4), 557-580.

Bush, A.A. & Tiwana, A. (2005). Designing sticky knowledge networks. *Communications of the ACM*, 48(5), 67-71.

Chiou, J.-S., & Cheng, C. (2003). Should a company have message boards on its Web sites? *Journal of Interactive Marketing*, 17(3), 50-61.

Cho, Y., Im, I., Hiltz, R., & Fjermestad, J. (2002). An analysis of online customer complaints: Implications for Web complaint management. *Proceedings of the 35th Hawaii International Conference on System Sciences*, Los Alamitos: IEEE Press.

Daft, R.L., & Lengel, R.H. (1986). Organizational information requirements, media richness and structural design. *Management Science*, 32(5), 554-571.

Daft, R.L., Lengel, R.H., & Trevino, L.K. (1987). Message equivocality, media selection, and manager performance: Implications for information systems. *MIS Quarterly*, 11(3), 355-366.

Dellarocas, C. (2003). The digitization of word of mouth: Promise and challenges of online feedback mechanisms. *Management Science*, 49(10), 1407-1424.

Dennis, A.R., & Kinney, S.T. (1998). Testing media richness theory in the new media: The effects of cues, feedback, and task equivocality. *Information Systems Research*, 9(3), 256-274.

Donath, J.S. (1999). Identity and deception in the virtual community. In M.A. Smith & P. Kollock (Eds.), Communities in Cyberspace (pp. 29-59). London: Routledge.

Ellison, N., Heino, R., & Gibbs, J. (2006). Managing impressions online: Self-presentation processes in the online dating environment. *Journal of Computer-Mediated Communication, 11*(2), http://jcmc.indiana.edu/.

Evans, M., Wedande, G., Ralston, L., & van 't Hul. S. (2001). Consumer interaction in the virtual era: Some qualitative insights. *Qualitative Market Research*, 4(3), 150-159.

Hennig-Thurau, T., & Walsh, G. (2003). Electronic word-of-mouth: Motives for and consequences of reading customer articulations on the Internet. *International Journal of Electronic Commerce*, 8(2), 51-74.

Hennig-Thurau, T., Gwinner, K.P., Walsh, G., & Gremler, D.D. (2004). Electronic word-of-mouth via consumer-opinion platforms: What motivates consumers to articulate themselves on the Internet? *Journal of Interactive Marketing*, 18(1), 39-52.

Herr, P.M., Kardes, F.R., & Kim, J. (1991). Effects of word-of-mouth and product-attribute information on persuasion. *Journal of Consumer Research,* 17(4), 454-462.

Krippendorff, K. (1980). *Content analysis. An introduction to its methodology*. Beverly Hills: Sage.

Lengel, R.H., & Daft, R.L. (1988). The selection of communication media as an executive skill. *The Academy of Management Executive*, 11(3), 225-232.

Maclaran, P., & Catterall, M. (2002). Researching the social Web: Marketing information from virtual communities. *Marketing Intelligence & Planning*, 20(6), 319-326.

Mollenberg, A. (2004). Internet auctions in marketing: The consumer perspective. *Electronic Markets*, 14(4), 360-371.

Nah, F., Siau, K., Tian, Y., & Ling, M. (2002). Knowledge management mechanisms in e-commerce: A study of online retailing and auction sites. *The Journal of Computer Information Systems*, 42(5), 119-128.

Palmer, J.W. (2002). Web site usability, design, and performance metrics. *Information Systems Research*, 13(2), 151-167.

Pitta, D.A., & Fowler, D. (2005). Online consumer communities and their value to new product developers. *The Journal of Product and Brand Management,* 14(4/5), 283-291.

Resnick, P., Zeckhauser, R., Friedman, E., & Kuwabara, K. (2000). Reputation systems. *Communications of the ACM*, 43(12), 45-48.

Ridings, C.M., & Gefen, D. (2004). Virtual community attraction: Why people hang out online. *Journal of Computer-Mediated Communication*, 10(1), http://jcmc.indiana.edu/.

Robbins, S.S., & Stylianou, A.C. (2003). Global corporate web sites: an empirical investigation of content and design. *Information & Management*, 40, 205-212.

Standifird, S.S. (2001). Reputation and e-commerce: eBay auctions and the asymmetrical impact of positive and negative ratings. *Journal of Management*, 27, 279-295.

Stempel, G.H., & Wesley, B.H. (Eds.). (1981). *Research methods in mass communication*. Englewood Cliffs, NJ: Prentice-Hall.

Strongman, K. (1996). *The Psychology of Emotion*. 4th ed. New York: Wiley.

Tanis, M., & Postmes, T. (2003). Social cues and impression formation in CMC. *Journal of Communication*, 53(4), 676-693.

Xue, F., & Phelps, J.E. (2004). Internet-facilitated consumer-to-consumer communication. *International Journal of Internet Marketing and Advertising*, 1(2), 121-136.

Yahoo Directory (2006). *Consumer Opinion*, http://dir.yahoo.com/Society_and_Culture/ Issues_and_Causes/Consumer_Advocacy_and_Information/Consumer_Opinion/?b=0.

Zhou, X. (2004). E-government in China: A content analysis of national and provincial Web sites. *Journal of Computer-Mediated Communication*, 9(4), http://jcmc.indiana.edu.

APPENDIX: LIST OF FEATURES

Feedback	Asynchronous/synchronous, ratings, comments, threads, PM, e-mail, chats, rebuttals, wiki, feedback from site owner, credit points
Cues	Contents of member profiles, user statistics made available, link to personal site, picture of oneself, network of trust, ranking of contributors, titles awarded
Language	Ratings, verbal comments, pros and cons, activated hyperlinks, pictures
Personal focus	Registration, screen name, avatar, emotive icons

Business Process Analysis, Modeling and Simulation for Geo-Political Risks and Crisis Management

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ABSTRACT

The paper aims to present a real experience of designing a Control, Command, Communication, and Intelligence system to support crisis management through a three step business process. A better understanding of what is a crisis and a model of knowledge gathering appeared within the system development. We will explain this particular business process management through the successful example of the CHEOPS Project.

PAPER TEXT

When a company wants to offer a new tender for its clients in the geopolitical crisis management domain, it has to solve a dilemma. Firstly it has to build rapidly, a functional product in order to take a place on this well discussed market but on the long term this strategy isn't sufficient. An incremental design process is required in order to organize an architecture, to bring out functional and ergonomic specifications, and to structure an ontological application such as a multi-agent cooperation model.Furthermore a reflection on what a crisis is, on the values level which helps to make the model more accurate can be added.

We will explain this three step business process through the successful example of the CHEOPS Project. Firstly, we will describe its risk management system, then we will put the emphasis on its multi-agent cooperation model, and lastly, we will present a situation analysis as a constructive modelling process and we will finish with an analysis on the CHEOPS project business management and its possibilities of evolution.

1. TECHNICAL PROCESS

The CHEOPS Project is based on a fictive crisis simulation called CHEOPS-TCHAD, where Chad is involved in a civil war opposing the government and rebels supported by Libyans. The French Army has to protect the official government against Libyan's threat.

Before the CHEOPS-TCHAD Project, success in crisis management depended mostly on the Military's Attaché (AM) experience. The system was composed of two major parts: the Chadian operation field and the Military Intelligence Direction (DRM) located in Paris. Protocol constraints regarding communication between them were too important to define a cooperation model. In the project, each actor has a CHEOPS system and they are linked together. The AM provides its CHEOPS' database with geopolitical information. The DRM's CHEOPS system has a huge image, plan, map and document database. In addition the system is connected with a lot of information sources.

The constraint in such a multi-user system is that each user has a specific need in terms of information objects. The thematic layer concept allows each user to build his own vision of the geopolitical operation field selecting objects relevant to him.

In order to model crisis, it is essential to define the event, situation and scenario concepts. An event is a pool of facts; their identification and handling is the base of crisis situation analysis. A situation is a geographical operation field in a given moment and is composed of relevant objects essential for its analysis. A model situation is a situation which has been analysed and described. A scenario is a collection of model situations. When a scenario is encapsulated in a period, it becomes a crisis.

We can define the crisis concept showing differences between permanent and crisis states. In the crisis state, the situation analysis is made harder because human discernment is wasted by stress, importance of stakes and indeed cost. The crisis generates a temporal paradox because its analysis and linked tasks, like communication or justification of choices, need time incompatible with crisis resolution. One man can not manage a whole crisis by himself like in the Marc Aurèle time [Marc Aurèle 92]. Only virtual or real human groups working together can face a dynamic and complex situation, and so it is a typical multi-participant activity.

To meet this group working requirement is one of the main stakes of this domain. Crisis management gets it sense only if it is coordinated which adds a complexity level. This complexity is due to the fact that coordination should dispatch participant productivity without limiting their efficiency. Crisis analysis should be split in time, space, speciality, actions and functional roles of participants [Brugnot 01]. The crisis management Information and communication system (ICS) anticipation is important but is not always enough to avoid crisis and so it is essential to implement a three part operational crisis management:

- Anticipated operational management: to plan emergency action, to allocate needed resources and to optimize key parameters.
- Real time operational management: to update situation and decision parameters, and to make plans matching with reality.
- Back to normal operational management: to disengage efficiently allocated resources.

Therefore rules and constraint propagation techniques based planning modules have to be realised. In crisis management ICS, information of the situation is critical but documentary information is critical too. Commented past crisis files create a database which brings a comparison point, decisional argument and a base for innovation [Boyce & Barnes 06] In addition, on request data extraction can justify decisions and brings complementary information. An electronic document management system, based on indexed full text has to be realised.

In this ICS, the emphasis is put on heterogeneous systems interoperability, but in order to build a real multi-participant system, it is essential to develop a strong collaboration between experts who can have a different point of view and to be able to organize and deploy a crisis cell very rapidly. AI can be very interesting to help the decision process, particularly with new automatic learning techniques [Kodratoff & al. 87] like the Case Based Reasoning, which uses analogy mechanisms, and other learning techniques ([Michalski 86], [Michalski 93], [Mitchell & al. 83], [Kodratoff 86], [Rousseaux & Tecuci 87], [Dejong & Mooney 86], [Barès & al. 94]) which takes benefits of experts produced explanations in order to generalize problem resolution modes.

Some other problems which represent knowledge modelling constraints have to be taken into account:

- Databases for objects modelling in space and time, and uncertainty management and management of fuzzy.

- Attention management for relevant granularity scale in space and time: phenomena can be predictable only with a certain amount of prior spatial-temporal data.
- Decision help to take pictures of interesting situations, to compare and comment on them. But also to be able to model something which no longer exists.
- Ergonomics to detect the user's intentions from basic actions, to anticipate and solve ambiguity in concordance with user's supposed goals (GEOCOOP [Zacklad & Rousseaux 95]).

2. METHODICAL PROCESS

The CHEOPS-TCHAD simulation has demonstrated that in order to solve efficiently complex collective problems, a multi-agent cooperation model has to be designed [Van Peach 02]. It is what has initiated the MadeInCoop model. This one can be divided into four main principles:

- The knowledge level cooperative human-machine activity design, which describes users and system activities considering that artificial and human agents have goals and knowledge.
- The cooperation situations positioning in global organisational context, which describe organisation, tasks and characteristics of its agents, and especially which enables identification of agent sub-groups which are usually interacting.
- Cooperation dynamic description, which is based on agent interactions.
- Actor cooperative activities description, which models one actor activities in problem resolution, coordination and communication actions.

The Collective General Activity model in MadeInCoop can be divided into three sub models. The first one is the task model, which has to provide a general schematic which models main activity aims and the means used to reach these goals. It includes a chronological dependency description between aims. In this simulation, we can find two main tasks groups according to the situation: in normal phases, it consists of imagining all possible scenarios and following answers, and in crisis phases, it consists of following situations and its evolution feeding databases, to analyse events, to define goals and plan the means to reach them. The second one is the agent model. For each agent, the know-how, the responsibilities and the availabilities are defined. Finally the organisational model defines the negotiation rules between agents and tasks in order to respect characteristics coming both from agents and tasks. The result is the definition of some interaction situation between agents and general coordination principles between inter or intra agent groups.

There are six main agents. The Military Attaché (AM) collects information and sends argued reports on the situation (it is a human agent), the event database manager (GETEV) classify each event, the map database manager (GESTCART) manages different maps, provides zoom and can put in relief thematic layers , the messenger (MESSAG) transmits messages (it is a human agent), the news report analyst (ANALYS) translates text news reports into the database format, the tactical simulator (SIMUL) makes calculations and simulations in order to estimate current strength or necessary time to move units, and the arguer(ARGU) lets the user from tactical hypothesis to search corresponding events in the database and on the opposite, to analyse a pool of events in order to find strategic hypothesis.

In MadeInCoop, the general model draws the background, where the different cooperation situations will happen which will let agents solve the problems collectively. The shift, between the general model and the cooperation, changes the way to handle the situation in two ways. It is a shift from a static view to a dynamic view focused on the interaction between agents, and it is a shift for a more detailed view where problem resolution activities and coordination are handled more precisely.

Based on most of the activities on cooperation between human agents, we will use the Maieutic approach (Maieutic is Socratic Method that induces a respondent to formulate latent concepts through a dialectic or logical sequence of questions) where the cooperation can be modelled with high level dialogues between agents. Agents try to cooperate; they share a working memory where a history of their dialogues is recorded. This record can be used on 3 different processes: The first is the problem resolution process, which is the progressive exploration of the group "problem space ". The second is the coordination process; it's a record of the agent's progressive engagement. This process controls the first. The third is a communication process which enables us to follow the steps of a collective speech.

In order to illustrate this model, we will use an artificial problem resolution dialogue between local crisis management computer agents. In this scenario, the Chad is in a civil war context opposing the official government and the rebels

Figure 1. Inference structure

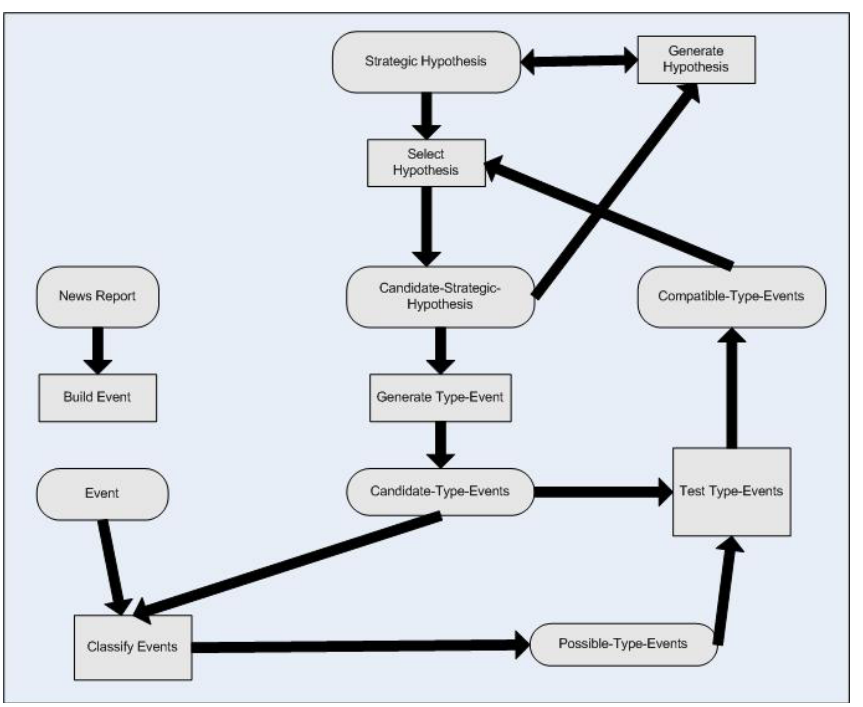
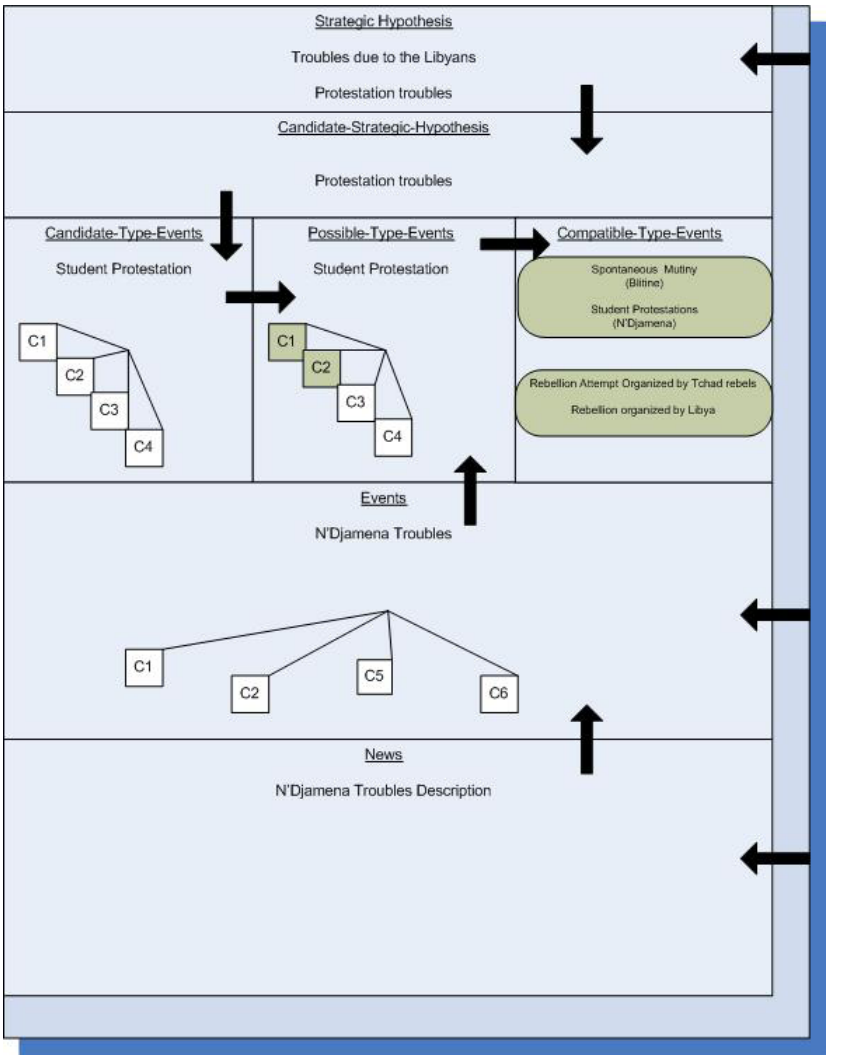


Figure 2. Virtual memory workspace of the local crisis management PC



helped by Libyans. The goal of the system is to help French military direction to take decisions, identifying if movements are spontaneous civil war movements, which do not need French intervention, or if these movements are due to the Libyans trying to invade the Chad area, which would need a French intervention because it would be an international law-breaking. The last events chronologically logged are the following:

- Troubles have appeared in the Biltine's barracks, which is near the north frontier without having the possibility to know the causes of these troubles.
- Street Fights have been signalled in Chad's capital N'Djamena near the national assembly, the consequence is that governmental troops have been sent from the north area to the capital.
- The airport of the Chadian capital has been bombed but the enemy fighter planes have certainly not been identified. Experts are analysing bomb impact pictures. Rebels have old Soviet planes which would not have permitted them to commit this bombing.

In MadeInCoop, the collective problem resolution method is based on a "structure induction" method [Simon & Lea74], [Hoc 87].

An event is built from a news report before being paired with candidate type events. The quality of these pairings selects possible type-events , of which compatibility with context is selected with confrontation with possible type events precedently identified.

In the following example, two strategic hypotheses have been generated and the AM tries to select the "protestation troubles" hypothesis. The process begins with extracting some properties of the news report (C1, C2, C5, and C6). From the candidate hypothesis, the AM generates a candidate type event with the C1, C2, C3, C4 properties. Comparing it with the capital's troubles, he is concluding that "student protestation" is a possible type event to model these troubles. The following step is to test the possible type event, to verify that it defines a compatible type events pool with other candidate type events. The conclusion of the test is not favourable because another interpretation of the events exists: "spontaneous mutinies" which are associated with "student protestation" is compatible with "protestation troubles".

Table 1 presents an extract from the virtual dialog between agents:

The actions of the coordination model are the same as those for the collective problem resolution (CPR) but different memory areas have to be reserved. A common group position area has to be reserved, where are recorded all the arguments and decision validated by the group and reflecting the "official" point of view of the group. An individual area has to be reserved to put the individual group members' decisions when they differ from the group decision. The imple-

Table 1

	Interpretation based on the problem resolution process	
1	AM: Did you receive the description of the N'Djamena events? It seems to be protestations organized by students near the opposition. This confirms that Biltine events are probably just the consequence of a problem linked with the soldiers' salaries and so it is interior troubles…	Build-Event Classify-Event Test-Type-Event Select-Hypothesis
2	ARGU: I disagree, the cause of Biltine events is unknown because the M'Boutoul ethnic group implicated is with the rebels.	Classify-Event
3	AM: Can you show that is it possible that rebels can be implied in recent events?	Test-Type-Event
4	ARGU: Yes I can demonstrate it. (Demonstration following)	Classify-Event Test-Type-Event
5	AM: What are the consequences?	Generate-Strategic-Hypothesis

mentation of coordination acts is mainly determined by group members' actions on virtual memory workspace. Its structure has four type: ACTION(OBJECT, PLACE,RIGHT,SEQUENCE).

3. EPISTEMOLOGICAL PROCESS

When we talk about crisis management intention interpretation, mission preparation or battlefield intelligence with militaries or civil servants, they have clear advice on the concept of an event. For them a fire or a bombing is clearly an event. For these operational actors the world is made of objects which exist in a reduced space and time and which have behaviours [Cauvet & Rolland 92] and of events which happen and which have to handle in order to control the situation. For them a decision helper system should be a representation of the operations field with plans, maps and pictures, a representation of real objects, with their associated properties, and a model, which enables the user to translate the real situation into a simulation where he can simulate the actions to take and their consequences.

The CHEOPS system has been designed and specified with operational officers. This representation could bring to an efficient digital representation only avoiding some aporias [Chaudron 94] [Poirel & Chaudron 94]. In a first time the event concept to be clearly defined: to be considered as an event in a crisis management context, an event has to gather some properties: it has to be linked with facts and so with environment objects to be localized in space and time, to be linked with a considered environment where the event is interpreted [Sperber 92] and to be linked with an intentional context [Sieroff 92]. We can wonder if in designing crisis management systems we try to rationalize and make a situation collectively understandable. This model is based on a deterministic concept: the same fact produces the same effects and if you understand the causes of a crisis you can avoid this crisis the next time that the cause will merge.

This project, which has succeeded in a military context with strong constraints, can be easily applied in a civil context. A lot of complex systems are multi-agent because it implies different actors working separately, but the solution of one subsystem has consequences on others and so a cooperative system like MadeInCoop should be useful. In addition most of these systems are based on people knowledge which could be integrated to the system making the other agent benefit from it.

4. APPLICATIONS

These risk management systems can be applied in a lot of domains: in ecology, in order to avoid ecological disasters, to preserve natural resources or to protect the endangered. In industry, these systems could be useful to avoid risks and crisis without affecting the production. For example, in a car production chain, a production stop costs a lot of money, these failures could be predicted and avoided with a risk management system. In transportation domain, these systems can increase the quality of services because one failure happened, it affects all the transportation network and the related activities, and so the crisis risk prediction is essential. In the health domain, such systems could avoid large epidemics, predict possible diseases and propose prevention actions to take. Finally, such risks and crisis management systems which work like a closed system could be linked together to make a meta-agent network where each risk management system would be considered as an agent taking part in a more global management system.

5. CONCLUSION

As a conclusion, we can say that this project, through the design of the CHEOPS collective crisis management system has contributed to a knowledge gathering method for ICS.

The goal was to adopt a global description on the knowledge level, without neglecting industrial organisational constraints.

We can see that this business process is cyclic and each iteration helps the system to become more accurate and more competitive. The business process management was a complete success and it enabled us to increase incrementally the experimentation field to other concrete cases adding a scientific goal to the technological objectives.

A lot still has to be done but the matter is scientifically rich enough to let a great deal of researchers in multidisciplinary domains to bring their contribution. This subject is a challenge for our societies because beyond technological and scientific aspects ICS invites us to collective intelligence.

REFERENCES

Aurèle M., « Pensées pour moi-même », Flammarion, 1992.

Barès M., Cañamero D., Delannoy J-F., Kodratoff Y., « XPlans: Case-Based Reasoning for Plan Recognition », Applied Artificial Intelligence, Vol. 8, N° 2, *Special Issue on Real World Applications of Machine Learning*, 1994.

Boyce G., Barnes P., « Anticipatory Risk and Crisis Management Systems: Conceptual Issues derived from Historical Experience », February 2006.

Brugnot G., « Gestion spatiale des risques (Traité IGAT, série aménagement et gestion du territoire) », *Lavoisier,* September 2001.

Cauvet C., Rolland C., « An Event-Driven Approach to the Dynamic Modelling of Objects », *Dynamic Modelling of Information Systems*, Noordwijkerhout, June 1992.

Chaudron L., « Symbolic formalization of the situation », Symposium SIC, Ecole SIC, *Campus THOMSON*, April 1994.

Dejong G., Mooney R., « Explanation-Based Learning: An Alternative View », *Machine Learning 1*, 1986.

Hoc J.M., « Psychologie Cognitive de la Planification », *PU* of Grenoble, 1987.

Kodratoff Y., « Leçons d'apprentissage symbolique automatique », *Cepadues*, 1986.

Kodratoff Y., Gheorghe T., Rousseaux F., « DISCIPLE; un Système Apprenti adapté aux domaines à Théorie Faible », COGNITIVA '87, Paris, May 1987.

Michalski R.S., « Inference-based Theory of Learning », *International Meeting on Advances in Learning*, Les Arcs, August 1986.

Michalski R.S, Ryszard S., « Multistrategy learning », *Tutorial T15* de l'IJCAI Chambéry, August 1993.

Mitchell T., Utgoff P.E, Banerji P.B, « Learning by Experimentation: Acquiring and Refining Problem-solving Heuristics », *Machine Learning*, Palo Alto, 1983.

Poirel O., Chaudron L., « ECOSIT : modèle d'élaboration coopérative de situation », *AI'94*, Paris, may 1994.

Rousseaux F., Tecuci G., « DISCIPLE; a Learning Apprentice Expert Systems », EXPERT SYSTEM '87, Brighton, December 1987.

SIEROFF, "L'attention sélective", Le courrier du. CNRS. , n°. 79. Sciences Cognitives, octobre. 1992

Simon H., Lea G., « Problem Solving and Rule Induction : A Unified View », In Gregg L-G. (ed.), *Knowledge and Cognition*, pp. 105-28, Lawrence Erlbaum, 1974.

Sperber D., « De l'attribution d'intention à la communication », *Le courrier du CNRS*, n° 79 Sciences Cognitives, october 1992.

Van Peach H., « Complexity and Ecosystem Management - The Theory and Practice of Multi-Agent Systems », *Edward Elgar Publishing*, January 2002.

Zacklad M., Rousseaux F., groupe COOP, « GEOCOOP ; conception d'une méthode d'acquisition des connaissances contextuelles et de modèles de coopération : application au développement d'un système d'aide à l'estimation du risque et à la gestion de crises », Rapport de Recherche de l'INRIA, N° 2052, programme 3 : IA, systèmes cognitifs et interaction homme-machine, October 1993.

ERP II System Vulnerabilities and Threats: An Exploratory Study

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ABSTRACT

Enterprise Resource Planning II (ERP II) systems integrate external entities into an organization's ERP system, primarily through integrating supply chain partners. This integration is facilitated through web services, a loosely coupled, platform independent way of linking applications within different organizations. Though many web services security standards exist, many organizations fail to implement these standards completely, therefore leaving the company vulnerable to security threats. This research study proposes a planning model for ERP II security. Some best practices related to managing and securing an ERP II system are gathered from extensive interviews with industry experts and government officials.

INTRODUCTION

Vendors recognized the significant opportunity for IT integration across departments, and robust ERP systems were developed out of more limited material planning packages for manufacturing. These systems modified the traditional processing paradigm of aligning the IT processes with department functions and instead created systems that tracked the workflow within the organization. This required management to coordinate with IT more closely and align job functions and training to the ERP system requirements. These ERP systems were purchased from major vendors and then customized to fit the particular needs of the organization with extensive help from outside vendors.

ERP systems arguably led to significant cost savings. However, original ERP systems were unable to accommodate the competitive pressures brought on by Just-In-Time (JIT) inventory management, supply chain integration and net-centric business models. These competitive issues led to a transformation of the ERP model into what is now called ERP II systems. These include linkages across the supply chain, and integration of customer relationship management (CRM) and logistics management software. The organizational boundary become diffuse, if not non-existent from the perspective of data flows. Suppliers are able to push transactions through the system with no real-time control by the receiving organization. In fact, network perimeters become obsolete since outside organizations are exchanging data with core business applications inside the organizations' trusted computing zone.

Darwin John, the former CIO of the FBI recently stated that "Security should be number two or three on any CIO's list of priorities" (Darwin John, personal communication, January 2006). While it is true that many vendors sell security solutions by creating a sense of fear, uncertainty and doubt, there is realistic reason to be worried. Carnegie Mellon's CERT Coordination Center's 2004 Annual Report states,

"In every way, the next twenty years will bring more of everything. More threats, more attacks, more resources at risk, more interconnection, more communication, more emergencies."

This highly pessimistic view of security appears to be warranted. The FBI/CSI annual crime report estimates that malicious software cost United States companies at least 170 billion dollars in 2004. This figure does not include loses from insider attacks, theft of intellectual property, or failed IT implementations. Symantec Corporation reports an unprecedented rise in malicious botnets and that malicious software is becoming more sophisticated, stealthy and polymorphic (Rob Clyde, VP of Research for Symantec, personal communication, November 2005).

More troubling than the proliferation of malicious software is the rise of extremely sophisticated and successful attacks on major United States companies, universities and government agencies seeking to steal defense and trade secrets. Though details are closely held by the Federal Bureau of Investigations, it has been widely reported that an active investigation is underway on network intrusion by agents of the Chinese government into highly sensitive United States government agencies under the case name Titan Rain (Espiner, 2005). Individuals associated with the National Security Administration have reported to the researchers that the Chinese government has over 3,000 professional information warfare agents actively attempting to steal United States government secrets, weapons plans and corporate trade secrets.

Many companies engage in routine business practices, which if details about them were discovered, could be used in launching attacks. For example, an attacker would be interested in knowing the shipping schedule of toxic chemicals through populated areas. A foreign agent may attempt to discern the intentions of our military through gaining information about supplies going to certain defense depots or shipping ports. A potential enemy would be very interested in design documentation regarding our weapons systems, and may attempt to counter our force superiority through exploitation of weaknesses in these systems.

Also, corporate espionage is a serious threat to large corporations, and these agents often seek similar information as intelligence agents: intellectual property, trade secrets, marketing plans, R & D proposals, merger and acquisition plans, etc. (Crane, 2005). Many foreign corporations actively seek to steal United States companies' trade secrets through placement of agents inside of their IT shops who can install malicious code to circumvent security restrictions, or to allow the agent to directly access the data from the servers.

RESEARCH METHODS

The researchers conducted a literature review regarding ERP II system vulnerabilities; though there is surprisingly little in the academic literature about these issues; after the initial review the researchers reviewed hacker websites and postings regarding these vulnerabilities. These initial reviews revealed that very little information is available on the net about ERP vulnerabilities.

The researchers also conducted a series of interviews with senior executives, IT security professionals, government officials, Big-4 IT security specialists, and other experts to using s a grounded theory approach to qualitative research (Strauss, 1990) to develop an initial model of planning ERP II security based on senior IT executives understanding of IT security in ERP II systems. These interviews were also undertaken to determine what the vulnerabilities are in these systems and to investigate the process of securing organizations in ERP II linkages.

The researchers then reviewed the XML/web services security literature to document security challenges that need to be addressed in ERP II projects (Anzbock, Dustdar, & Gall, 2002; Cremonini, De Capitani di Vimercati, Damiani, & Samarati, 2003; Damiani, De Capitani di Vimercati, & Samarati, 2002; Nadele, 2003). In order to

better understand the issues facing IT staff during ERP deployments, a series of interviews with IT professionals in the process of an ERP implementation were conducted. Based on these investigations, the researchers developed an initial best practices guide and a planning model for ERP II Security.

Subjects in the Study

Given the qualitative and exploratory nature of this research, it is important to describe the subjects in some detail. Over a process of several months, telephone and face-to-face interviews were conducted with:

- The former CIO of the Federal Bureau of Investigations
- The current CIO of the Bureau of Alcohol, Tobacco and Firearms
- The Senior Security Consultant to the United States State Department and author of many NIST standards
- A State Chief Information Security Officer
- The CIO of a large multinational corporation
- Current and former federal agents/information security professionals who were/are employed by the FBI, NSA, and DIA
- Hackers
- One of the authors of original Rainbow series who was also one of the authors of the HIPAA legislation
- Two ERP vendors
- Three Big-4 accounting firm information security specialists
- Several faculty members from two of the three universities with the best reputation for IT security training
- ERP managers for two very large organizations
- Project managers for two ERP implementations

Limitations of Methods Used

A number of limitations on the methods used must be acknowledged. First, the sample of subjects was an extended convenience sample with snowballing. The researchers then approached individuals with whom they had contacts, and followed the chain of referrals for subsequent interview subjects. Second, the researchers attempted to contact a number of ERP vendors, IT consulting companies, Big-4 consultants, and companies known to the researchers to be involved with an ERP deployment. Unfortunately, corporations refused to grant access to their systems or discuss specifics about security implementation of their systems. It became apparent that vendors control dissemination of information about system vulnerabilities through Non-Disclosure Agreements and most corporations would not cooperate with this research.

Furthermore, discussions about ERP systems with hackers were not fruitful. Gaining entrance to the hacker community is essentially a "community of practice" process, where one is slowly invited to the community as one develops relationships and demonstrates competency (Wenger, 2002). Given that the subject of discussion is a felony under several provisions of the United States Code, it is understandable that the hackers approached by the researchers were less than forthcoming.

The initial model for ERP II security planning should not be considered a valid model, as it has not been empirically validated. Future work needs to be done to establish the accuracy of this model by testing its usefulness in an actual ERP II implementation.

FINDINGS

In the following section a brief overview of several ERP II security vulnerabilities is reviewed. Then a model is introduced which shows a matrix of polices and best practices which should be implemented to secure ERP II systems.

ERP II SECURITY VULNERABILITIES

Inherent Security Vulnerabilities in ERP II Systems

Vendors have done a good job creating secure ERP systems. Most have robust access control, auditing, and user authentication features. Their security architecture in general is sound. While early systems had significant weaknesses, no well-known ERP system on the market has a reputation for inherent weaknesses.

However, ERP systems are extremely complex pieces of software, and as with all code, there are going to be vulnerabilities. These systems are also vulnerable to weaknesses in the underlying databases. SAP R/3 had a known vulnerability that allowed users to gain super-user access to the ERP (Net-Security.org, 2001). With this privilege, an attacker could access or corrupt any data. In one sense, the incredible complexity of these systems facilitates security since their users will only have knowledge about a limited set of the system's functions. Their opportunities to launch attacks will necessarily be limited by their incomplete knowledge of the system architecture. This complexity also exposes the essential design flaw in these systems, and the need for custom configuration of thousands of options to ensure security. While auditing standards exist for ERP II systems, no known methodology allows enterprises to ensure that their customization conforms to the security policies of the organization (Magklaras & Furnell, 2005).

From a usability perspective one concern is that some ERP II systems still have a look and feel reminiscent of the old main-frame environment. Systems may require users to remember the names of screens for input and provide no contextual cues to guide the user. Usability research shows that users will circumvent security that they believe to be onerous or to interfere with their ability to accomplish work (Cranor, 2005). Thus, if users are not able to remember screen names or navigation sequences, they will augment their memory with reminders. These reminders become vulnerabilities themselves, as they often contain detailed guidance on accessing the systems and can include user IDs and passwords for screen access.

Vectors of Attack

Experts agree that the most likely vector of attack on ERP system will be through privilege escalation by an insider. Given that the data contained in the ERP II relates to customers, suppliers, vendors and employees, there is little data in the system of interest to a casual hacker seeking systems that can be compromised. Most professional hacking today is done for monetary gain. Much of it is related to identity theft and online fraud. Again, these forms of computer crime do not lend themselves to attacks on ERP II systems. However, an insider may attack the ERP II system through sabotage of key files, modifying passwords on accounts to halt the work flow, or by modifying DTDs or XML schemas to block the exchange of data (Polivy & Roberto, 2002).

A professional attacker will study the system for vulnerabilities and attack the system at the point where his skill, training and experience tells him that he is most likely to gain access without detection. This is one of the reasons why focusing on the security of the ERP II system alone cannot provide for effective security. For example, an attacker could access the network through a compromised web server and then install sniffing software on that machine to monitor the network for passwords. With a username and password combination, the attacker could then log directly into the ERP II system. This highlights the key roles that continual auditing and patch management play in maintaining the security of these systems.

Competitive Intelligence Threats

Inference is a well-known problem in access control (Morgenstern, 1987). Essentially, a user can submit a series of queries to a database with his access permissions. Using logic, the attacker is then able to identify specific attributes about one subject in violation of the access control policies. This issue is of paramount importance in the planning of an ERP II deployment. Most security features within ERPs are created in reference to specific screen views. An employee is granted access to particular screen, usually based on their role. While many ERP IIs use a form of RBAC, the need to customize thousands of screens leads to many unintended consequences that violate the organization's security policies.

Aggregation is the threat of unintended disclosure that arises from the combination of many items of data that allow deductions about some process or event about which the attacker has no other information (Jaeger, 2001). For example, if an attacker knew that the US Military had requisitioned air transport to Central Africa, had ordered lightweight summer clothing for 5,000 troops, and that vaccinations for malaria had been ordered for the third week of July, he could surmise that approximately 5,000 troops are being sent to Central Africa. If the attacker also had knowledge of the cargo being shipped ahead of time, one could make conclusions about the nature of the mission. This same form of intelligence gathering occurs in attacks on large corporations. In an insider is able to access many parts of the ERP II system, she may be able to determine true costs of products, discounts offered to particular vendors, marketing plans, R&D budgets, or financial issues that have not been released to the public. Many of the security experts interviewed stated that most ERP II systems have significant vulnerabilities related to unintended access control combinations, and that insider will exploit these vulnerabilities to gather specific confidential information.

Supply Chain Partnership Model Weaknesses

One threat from opening up your system to supply chain partners is that once inside your system, it is possible for partners to "explore" the rest of your corporate data (Domke, 2001). Unisys Vice-President Peter Regent cautions companies that "You'll have to reengineer your processes to align with security. Otherwise, you won't get any return on your investment [in supply chain systems]" (Paul, 2004). Unfortunately, most ERP II systems are not engineering around security. The usual model is for the supply chain partners to agree on data exchange formats and to identify their common business processes. Security features are then added onto whatever existing mechanisms allow for the exchange of data.

Another serious concern that is often ignored in the implementation of ERP II systems relates to planning for the dissolution of the supply chain partnership. Too few organizations plan how to protect their data once they decide to remove an organization from the supply chain. An explicit procedure needs to be implemented to protect the confidentiality of data once the decision is made to remove someone from the chain. This can require extensive modifications to code when using web services.

Many of the consultants interviewed for this research caution that most supply chain linkages allow access to too much data by the parties. Essentially, organization A will be granted permission to access company B's ERP II system, but company B will not invest the resources needed to ensure that the data accessible by agents of organization A is minimally sufficient. Many organizations place the outside organization into an existing role. However, this can lead to the outside partner having access to information about true prices, marketing strategies, etc. that can give them competitive advantage. Research is underway at Purdue University to address how to arrange for encrypted exchanges of pricing and cost data so that both parties can gain maximum advantage through the relationship (Clifton, 2004). Essentially, organizations in an ERP II linkage still do not entirely trust the other participants, so the data on costs, production, shipping, etc., may be altered or otherwise obfuscated to protect the party releasing the data. This leads to an erosion of the potential value for all participants in the supply chain partnership.

Lastly, from a network security perspective, the creation of linkages with supply chain partners has two significant effects. First, the organization loses its network perimeter. In effect, the IT systems are merged into a unified system and each party allows outside organization access to the internals of its IT system. Second, everyone connected in a supply chain is exposed to whatever vulnerabilities exist in every partner's systems (Bragg, Rhodes-Ousley, & Strassberg, 2004). Thus, despite an organization's best efforts at protecting its systems, if one of its partners is compromised by malicious software, that partner's system can infect other organizations' system or introduce significant vulnerabilities into their IT architecture.

A MODEL FOR ERP II SECURITY PLANNING

The researchers developed the following model for ERP II security planning based on the seminal Information Assurance Model and the results of the interviews. See Figure 1.

This model is based on three components:

1. Security Services
2. Management Considerations
3. Targets of Security Planning

Each of these components is represented by an axis in the model. There are forty-five cubes within this model, and the researchers propose that effective ERP II security planning requires organizational effort to address each of these thirty-six cubes. For example, Database Security x Audit Methodology x Integrity would require that the organization define an audit methodology to ensure the integrity of data in the database through an analysis of existing database security measures.

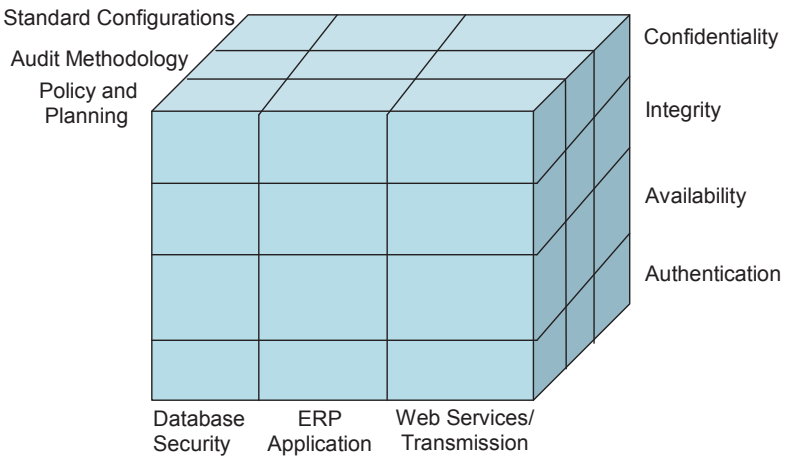
Security Services

The original IAM model proposed the well-known CIA triad for information security: confidentiality, integrity and availability. These are the security services that any system can provide. There is an inherent tension between these services, as ensuring the integrity and confidentiality of data often interferes with the availability of data. This model was later expanded to include authentication of users and non-repudiation of transactions (Schou, 2004). Accordingly, this planning model requires all participants in an ERP II enabled supply chain to address confidentiality, integrity, availability, authentication and non-repudiation of transactions. These services are provided by the ERP II system, but planning needs to ensure that the features of the systems are fully implemented.

Management Considerations

The second axis of the ERP II Security Planning Model discusses the three broad areas for management attention: standard configurations, audit methodologies, and policies and planning. The best practices portion of this paper will address specific issues related to standardized configurations which are suggested in order to reduce the complexity of the security planning process, to enable better patch and configuration management, and to reduce the overall vulnerability of the system through reducing the types of operating systems and applications. Audit methodologies will also be discussed in detail in the best practices guide. Senior executives report that reliance of the existence of third party IT audits does not guarantee the security of a system. Each firm has its own audit methods. This issue becomes even more crucial when considering international partnerships. ITIL, ISO 17799, and Control Objectives for Information and related Technology

Figure 1. The ERP II security planning model



(COBIT®) (ITIL, 2006) COBIT are three widely used IT audit frameworks, but they vary greatly in their focus, level of detail, and scope of review. Effective security demands that all partners agree ahead of time on a standardized audit methodology to ensure that vulnerabilities are discovered and addressed in all partner organizations. Lastly, there needs to be a formal process, a well-managed project to plan the policies that will guide users of the ERP II system. This process must be conducted internally, and cannot be wholly delegated to the ERP II implementation consultants.

Targets of Security Planning

Throughout this project, ERP II managers emphasized the critical interdependencies between the underlying databases and the ERP II applications. It was also discovered that all major ERP II vendors are using web services to facilitate inter-company communication. Accordingly, we have defined three areas that require management attention in planning. First, the database must be secured. In most ERP II systems, the ERP II appears to the database as a single user. However, the ability to connect to the database exists outside of the ERP architecture. An attacker may be able to sabotage the ERP II or steal data via unauthorized access to the database. The configuration of the ERP II is also a critical challenge as there are literally thousands of possible configuration options and screens to address. An effective ERP II implementation requires a minimum of 5% of the resources to be dedicated to planning access control models and searching for security policy violations that could occur (West, B., personal communication, March 2006). Lastly, there are significant weaknesses in the implementations of most web services projects. These weaknesses occur through using only a limited set of the web services standards, which results in providing only part of the CIA triad.

FUTURE RESEARCH

The researchers realize that perhaps the most important piece of this research may be missing. Currently we are working on mapping the collected qualitative data, essentially a list of best practices to the model developed in this paper. We hope to demonstrate a systematic approach to securing ERP II implementations.

REFERENCES

Anzbock, R., Dustdar, S., & Gall, H. (2002). Software configuration, distribution, and deployment of web-services. Paper presented at the Twelfth International Software Engineering and Knowledge Engineering, Ischia, Italy.

Bragg, R., Rhodes-Ousley, M., & Strassberg, K. (2004). Network Security: The Complete Reference. New York: McGraw Hill.

Clifton, C. (2004). Privacy-preserving data integration and sharing. Paper presented at the ACM SIGMOD workshop on Research issues in data mining and knowledge discovery, Paris, France.

Crane, A. (2005). In the company of spies: When competitive intelligence gathering becomes industrial espionage. Business Horizons, 48(3), 233-340.

Cranor, S. G. (2005). Security and Usability : Designing Secure Systems that People Can Use Sebastapol, CA: O'Reilly Media.

Cremonini, M., De Capitani di Vimercati, S., Damiani, E., & Samarati, P. (2003). An XML-based approach to combine firewalls and web services security. Paper presented at the ACM Workshop on XML security 2003, Fairfax, VA.

Damiani, E., De Capitani di Vimercati, S., & Samarati, P. (2002). Towards Securing XML Web Services. Paper presented at the ACM Workshop on XML Security 2002, Fairfax, VA.

Espiner, T. (2005). Security experts lift lid on Chinese hack attacks [Electronic Version]. ZDNet News. Retrieved March 11, 2006 from http://news.zdnet.com/2100-1009_22-5969516.html.

ITIL. (2006). IT Infratstructure Library.

Jaeger, T. T., Jonathon E. . (2001). Practical safety in flexible access control models. ACM Transactions on Information and System Security 4(2), 158-190.

Magklaras, G. B., & Furnell, S. M. (2005). A preliminary model of end user sophistication for insider threat prediction in IT systems. Computers & Security, 24(5), 371-380.

Morgenstern, M. (1987). Security and inference in multilevel database and knowledge-base systems. Paper presented at the ACM SIGMOD international conference on Management of data, Proceedings of the 1987 ACM SIGMOD international conference on Management of data.

Nadele, M. (2003). Standards for XML and Web Services Security. Computer, 36, 96-98.

Net-Security.org. (2001). SAP R/3 Web Application Root Compromise. Retrieved February 5, 2005, from http://www.net-security.org/vuln.php=853

Paul, L. G. (2004). Keep it moving. Retrieved February 5, 2005, from http://www.csoonline.com/read/093004/moving.html

Polivy, D. J., & Roberto, T. (2002). Authenticating Distributed Data Using Web Services and XML Signatures. Paper presented at the ACM Workshop on XML Security, Fairfax, VA.

Schou, C., Frost, J., Maconachy, WM. (2004). Information assurance in biomedical informatics systems Journal of Organizational and End User Computing, 23(1), 110-118.

Strauss, A., & Corbin, J. (1990). Basics of qualitative research: Grounded theory procedures and techniques. Newbury Park, CA: Sage.

Evaluating Relationship Implementations Performance in Object-Relational Databases

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ABSTRACT

In this work an evaluation of an object-relational schema implementation representing different relationships of an UML class diagram against the relational approach was made. To perform this test we have implemented both object-relational and relational schemas from a UML class diagram in a commercial database leader in the market. The main goal has been to prove the competitiveness of the object-relational technology. The methodology used for this work was to present several schema implementations of association, composition, aggregation and inheritance relationships, propose a set of representative queries to evaluate their behavior, compare the results and make an analysis based on response times. Four alternatives implementations of the schema diagram were made for a composition relationship presented in the proposed UML class diagram. The queries have been executed with no flush to the database buffer pool among runnings to simulate a real situation. In some object-relational queries several built-in functions and operations have been used. As a consequence of this work we are proposing some extensions to the relational schema diagram to add the object-relational alternatives (references, arrays, multisets, etc.) proposed by the SQL:2003 standard.

Keywords: Performance test. Object-relational schema. SQL:2003. Array. Multiset. Scoped references.

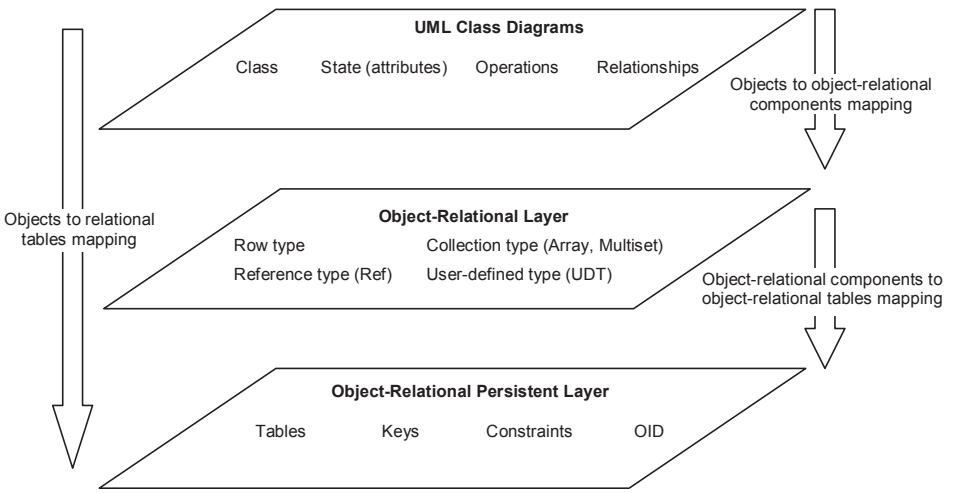
INTRODUCTION

Object-relational database management systems (ORDBMS) based on the SQL:2003 standard offer several new capabilities to implement inheritance, association, aggregation and composition relationships among objects, comparing to the relational approach based on the SQL'92 standard. These novel capabilities are based on the use of user-defined types (UDTs), references and collections. A reference is a logical pointer to a row object that is constructed from its object identifier (OID). In the object-relational (O-R) approach association and aggregation relationships can be implemented by means of single references or collection of references, depending on the relationship cardinality. Composition relationship which is a stronger whole-part relationship than aggregation can be implemented by including a single object or a collection of them into other objects, again depending on the relationship cardinality. Collections can be implemented by two different structures: array and multiset; the main difference between them is the prediction of a given maximum size (the array) or not (multiset).

In relational database management systems (RDBMS) relationships are implemented via tables, foreign and primary keys. Depending on the relationship degree and cardinality a join table is defined in order to hold it. A join table must contain at least a foreign key column for each primary key of the entities participating in the association.

In this work we evaluate the implementation of inheritance, association, aggregation and composition relationships over Oracle 10g to prove the competitiveness of the object-relational technology. We have used this ORDBMS for both object-relational and relational implementations. The reason for choosing Oracle 10g is because it is leader in the database market and includes many of the SQL:2003 features. To perform the implementation evaluations several queries have been selected considering the use of special built-in functions applied to references (REF, DEREF) and collections (TABLE). Those queries were executed and compared to their relational equivalent, which take the form of join operations.

Figure 1. Layers involved in mapping objects into ORDBMS



The results obtained in terms of the elapsed time and execution plans proposed by the optimizer are given.

Two important works are found in the literature about the study of the ORDBMS performance [1, 5]. They were done several years ago, when the O-R technology did not offer the nowadays features. At that moment arrays and multisets were not implemented and scoped references were not supported. We used them as a reference for this paper. Furthermore, [6] was taking into account in our research since it refers to the benefits and contributions of the O-R technology in the software development process and [7] where some concepts about O-R mappings are proposed.

MAPPING LAYERS OF ORDBMS

In [4] we have defined three layers involved in the transformation of UML class diagrams into ORDBMS persistent objects. The first one corresponds to the UML class diagram, the second is the object-relational layer composed of the O-R elements proposed by the SQL:2003 standard [8] -UDTs, arrays, multisets, references, row types-, and the third is the object-relational persistent layer composed of typed tables which are defined from the elements of the second layer containing keys, constraints and OIDs, among other things. Unlike the relational model the additional layer of the object-relational model adds a greater complexity.

The layers involved in the transformations and the elements composing them are presented in Figure 1. It shows that the relational transformations complying with SQL'92 standard are made in one step from UML to relational tables; while O-R transformations take two steps from UML to object-relational components and from the latter to persistent object tables.

DATA MODEL EXAMPLE

We have used a book case model of a purchase order administration in a business company whose UML class diagram for the schema implementations is shown in Figure 2. This model contains many of the relationship types needed to perform the evaluation. It should be noted that no aggregation relationships are presented, this gap was overcame by implementing the composition relationship in a "weak" manner treating it as an aggregation as will be shown later in this paper.

The UML class diagram was translated into an object-relational schema compliance with the SQL:2003 standard and into a relational schema designed under the SQL'92 standard and following the normalization rules. This was done in order to compare the performance of both technologies.

RELATIONAL SCHEMA DEFINITION

The UML class diagram mapping into a relational schema is based on the definitions made on [3].

For the inheritance hierarchy of classes, three ways are presented in the literature [2, 3]: flat, vertical and horizontal. We have implemented the three methods but in this paper it is only shown the flat model by creating one single table for all classes (super and subtypes) in the hierarchy. In the hierarchy it is assumed that Person and Company sets are disjoints and the three object types (customers, persons and companies) must be represented, then in the table where those attributes not corresponding to the type stored in a row, contains NULL values.

Figure 2. Class diagram for a purchase order application

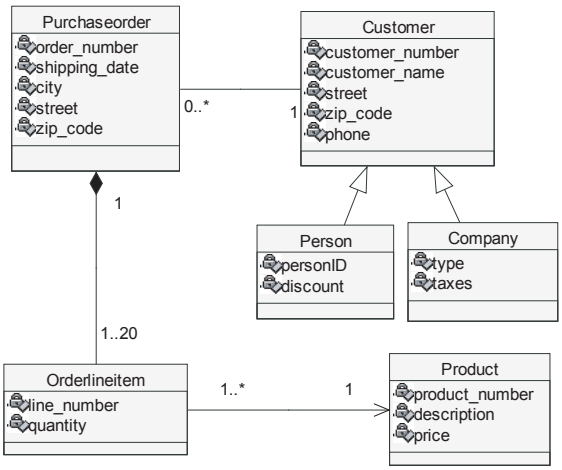


Table 1. Object-relational mapping layers

UML layer components	Object-Relational layer components	Persistent layer components
Customer class	Customer UDT	Customer type table with substitutability property
Person class	Person UDT under Customer	
Company class	Company UDT under Customer	
Purchaseorder class	Purchaseorder UDT	Purchaseorder type table
Orderlineitem class	Orderlineitem UDT	
Product class	Product UDT	Product type table
Customer - Purchaseorder association	Purchaseorder reference multiset (attribute of Customer UDT) Customer reference (attribute of Purchaseorder UDT)	
Purchaseorder - Orderlineitem composition	1. Orderlineitem object array (attribute of Purchaseorder UDT)	
	2. Orderlineitem reference array (attribute of Purchaseorder UDT)	Orderlineitem type table
	3. Orderlineitem reference multiset (attribute of Purchaseorder UDT)	Orderlineitem type table
	4. Orderlineitem object multiset (attribute of Purchaseorder UDT)	
Orderlineitem - Product association	Product reference (attribute of Orderlineitem UDT)	

Association, aggregation and composition relationships are implemented by means of primary and foreign keys.

OBJECT-RELATIONAL SCHEMA DEFINITION

The O-R schema is generated by using references, arrays and multisets and/or a combination of them according to the definitions made in [4].

In Table 1 we present the elements composing the three layers involved in the O-R schema definition. Observe that Purchaseorder-Orderlineitem composition relationship has been implemented in four different ways:

- The first one (1.) is by defining an Orderlineitem type array of dimension 20 in Purchaseorder type table, this is the most natural implementation according to the relationship defined in the UML class diagram. We included the objects of the "part" into the "whole" due to it's a strong relationship where the part life depends on the whole life. We used an Orderlineitem type array into Purchaseorder type table because the multiplicity of the part is well known having a maximal number of 20.
- The second one (2.) is by defining an array of references to Orderlineitem objects in Purchaseorder type table, implemented by the orderline_va attribute. This implementation was made in order to use references within the composition relationship so that it can be treated like an aggregation relationship. It is important to note that if the "whole" is deleted some procedure to eliminate the "parts" must be implemented in order to maintain the integrity of the references. This is not a natural implementation of a composition relationship, it is done in this case in order to evaluate this relationship type. Although for some cases and depending on the nature of the relationship this can be an alternative for a composition.
- The third (3.) and fourth (4.) alternative implementations include a multiset of references and a multiset of objects respectively. The difference between these two and the previous two is that for multiset it is not known the maximum size of the collection. The considerations made about using references or objects are the same than the previous paragraphs.

The relationship between Orderlineitem and Product is an unidirectional association, so we have included a reference to Product as an attribute in Orderlineitem UDT.

Observe that the persistent layer is composed of fewer elements than the O-R layer, depending on the way the composition is implemented three or four tables are defined.

Considering that there are no symbols proposed to represent the O-R elements in a database schema diagram we introduce a graphical notation for this purpose which is shown in Table 2.

Table 2. Object-relational extensions to the relational schema diagram

Graph	Element
→	Reference (single arrow)
⇉	Array of references (double arrow)
⇉	Multiset of references (quadruple arrow)
▭	Object array
▦	Object multiset
▭→	Object array containing references to other object
▦→	Object multiset containing references to other object

According to the graphical elements proposed, the resultant object-relational schema diagram corresponding to the first implementation of the composition relationship is shown in Figure 3. The other schemas of the remainder implementations of the composition relationship are shown in Figures 4 to 6.

In Fig. 3, the Customer class has a multiset of references to Purchaseorder class. The Purchaseorder class has a single reference to the Customer class and an array of Orderlineitem objects containing a reference to Product class.

Figure 4 shows that the Customer2 class has a multiset of references to Purchaseorder2 class. The Purchaseorder2 class has a single reference to the Customer2 class and an array of references to the Orderlineitem2 class. Orderlineitem2 class contains a single reference to Product2 class.

In Fig. 5, the Customer3 class has a multiset of references to Purchaseorder3 class. The Purchaseorder3 class has a single reference to the Customer3 class and a multiset of references to the Orderlineitem3 class. Orderlineitem3 class contains a single reference to Product3 class.

Figure 6 shows that the Customer4 class has a multiset of references to Purchaseorder4 class. The Purchaseorder4 class has a single reference to the Customer4

Figure 3. Schema diagram for the object-relational implementation. Composition relationship implemented using an array of objects

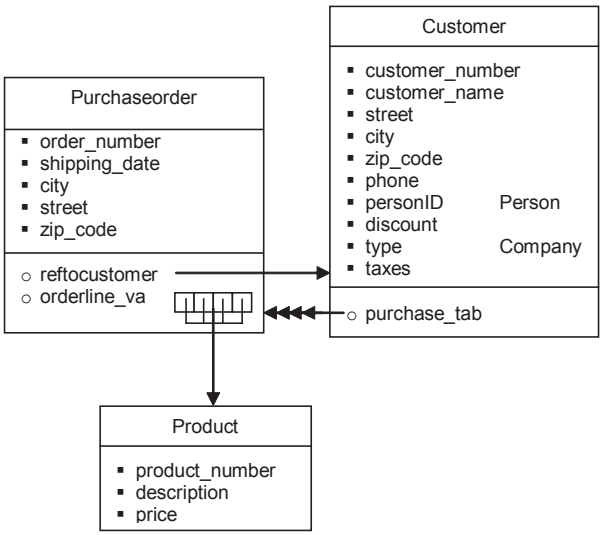


Figure 4. Composition relationship implemented by means of an array of references

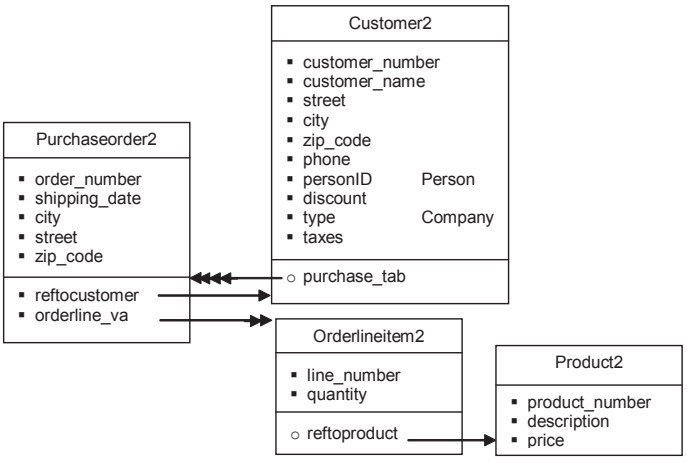


Figure 5. Composition relationship implemented by means of a multiset of references

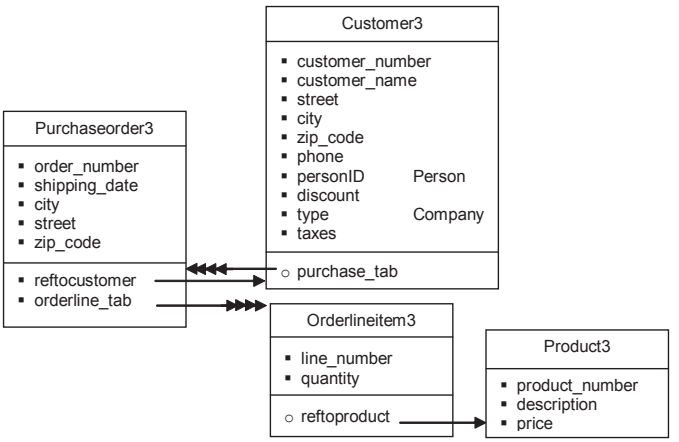
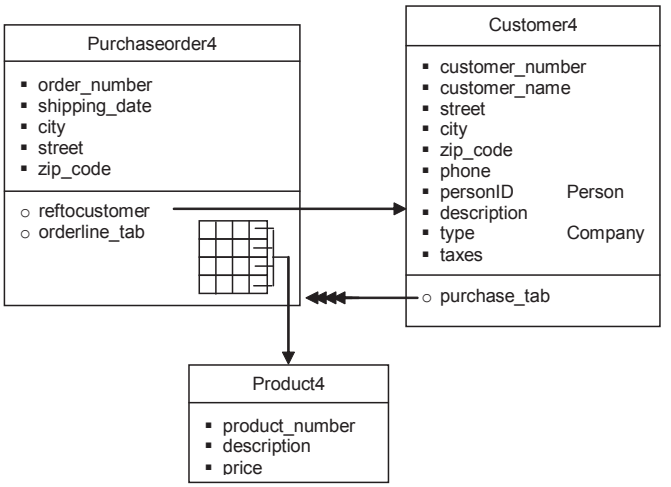


Figure 6. Composition relationship implemented by means of a multiset of objects with references to other object



class and an embedding multiset of Orderlineitem4 objects with single reference to Product4 class.

DATABASE IMPLEMENTATION

In order to make a proper evaluation among the different implementations the tables of the database were populated with thousands of object/tuples using store procedures written in the programming language provided by the ORDBMS containing random values generation functions for the data.

In the object-relational schema every row object in an object table (type table) has an associated OID that uniquely identifies it. The OID allows the corresponding row object to be referenced by other objects. A built-in data type called REF is used for such references. We have used scoped REF to constrain that only references to a specified object table can be implemented, because they are stored more efficiently than unscoped REFs. In the relational schema every row in a table has a primary key that uniquely identifies it allowing table joins.

The number of generated instances of each class is shown in Table 3.

Table 3. Number of objects of each class in the data model

Class	Number of instances
Company	451
Customer	1,000
Orderlineitem	63,578
Purchaseorder	10,000
Person	320
Product	10,000

EVALUATION TEST BETWEEN THE SCHEMAS

We have defined several relational and object-relational queries to compare the performance of the schemas proposed. As can be seen the selected queries explore the use of collections (array and/or multiset) of objects and references, single references and inheritance hierarchy. These queries have been selected due to collections and references make the difference between the O-R approach and the relational one, and the reason of the performance comparison made.

We have executed each one 10 times in different moments and we have calculated the average elapsed time for them. We decided not to flush the database buffer pool among runnings because in real life users execute several applications at the same time all of them consuming system resources. The hardware used for the implementation and testing is an Intel Pentium IV CPU 3.00 GHz, with 1 GB of main memory, running the Microsoft Windows XP operating system.

The goal of the comparison among the queries is to make a relative evaluation of the proposed implementations and analyze the use of references, arrays and multiset of the object-relational technology against the joins of the relational approach. In this analysis we considered the response times and the execution plans defined by the optimizer.

Query 1. Find the order numbers and the detail of line numbers and quantity ordered.

In this query we are analyzing the behavior of the four implementations of the composition relationship in order to find out the most convenient alternative in terms of the response time.

1.1 Array of objects

```
SELECT p.order_number, o.line_number, o.quantity FROM purchaseorder_t p,
TABLE(p.orderline_va) o;
```

1.2 Array of references

```
SELECT p.order_number, o.column_value.line_number, o.column_value.quantity
FROM purchaseorder2_t p, TABLE(p.orderline_va) o;
```

1.3 Multiset of references

```
SELECT p.order_number, o.column_value.line_number, o.column_value.quantity
FROM purchaseorder3_t p, TABLE(p.orderline_tab) o;
```

1.4 Multiset of objects

```
SELECT p.order_number, o.line_number, o.quantity FROM purchaseorder4_t p,
TABLE(p.orderline_tab) o;
```

1.5 Relational model

```
SELECT p.order_number, o.line_number, o.quantity FROM purchaseorder p,
orderlineitem o
WHERE p.order_number = o.order_number;
```

The results obtained are shown in Table 4.

Table 4 shows that the use of a multiset of objects (query 1.4) has the same response time than the join (query 1.5) proposed for the relational query; in this case both

Table 4. Results of the query 1

Query	Rows selected	Response time (hh:mm:ss)
1.1	63578	00:00:03
1.2		00:00:07
1.3		00:00:07
1.4		00:00:02
1.5		00:00:02

technologies are competitive. The use of collections of references (queries 1.2 and 1.3) have the worst response time, the explanation for this behavior relays on the size of the references, which are more than 40 bytes long requiring an extra time to solve it. Looking at the execution plans the use of arrays requires a collection iterator operation (PICKLER FETCH) that is not present for multisets, it is traduced in a higher cost and number of bytes involved.

Query 2. Find the customers, their order numbers together the line numbers and quantity ordered.

This query is similar to query 1 but in this case we are starting from the customer typed table adding an extra multiset of references. When the composition is implemented like an aggregation two hop references are employed. For this case we are using the traversal of two collections.

2.1 Multiset of references + Array of objects

```
SELECT c.customer_number, c.customer_name, p.column_value.order_number, o.line_number, o.quantity
FROM customer_t c, TABLE(c.purchase_tab) p, TABLE(p.column_value.orderline_va) o;
```

2.2 Multiset of references + Array of references

```
SELECT c.customer_number, c.customer_name, p.column_value.order_number, o.column_value.line_number, o.column_value.quantity FROM customer2_t c, TABLE(c.purchase_tab) p, TABLE(p.column_value.orderline_va) o;
```

2.3 Multiset of references + Multiset of references

```
SELECT c.customer_number, c.customer_name, p.column_value.order_number, o.column_value.line_number, o.column_value.quantity FROM customer3_t c, TABLE(c.purchase_tab) p, TABLE(p.column_value.orderline_tab) o;
```

2.4 Multiset of references + Multiset of objects

```
SELECT c.customer_number, c.customer_name, p.column_value.order_number, o.line_number, o.quantity
FROM customer4_t c, TABLE(c.purchase_tab) p, TABLE(p. column_value.orderline_tab) o;
```

2.5 Relational model

```
SELECT c.customer_number, c.customer_name, p.order_number, o.line_number, o.quantity
FROM customer_plano c, purchaseorder p, orderlineitem o
WHERE c.customer_number = p.customer_number AND p.order_number = o.order_number;
```

The results obtained are shown in Table 5.

Looking at the results shown in Table 5 the relational approach is more efficient in terms of response time than the O-R technology. The cause is that the multiset of references implementing the association between Customer and Purchaseorder add an extra time for solving the query as was mentioned before. The multisets used for the composition relationship consumes much more time than the arrays. Looking at the execution plans the operations, cost, number of bytes and the other variables of the plans gave us no clue about this behavior. What it is clear in this case is that when two collections are involved in a query is better to implement it by means of arrays if possible.

Arrays perform much better than multisets in the case that the entire collection is manipulated as a single unit in the application because the array is stored in packed form and do not require joins to retrieve the data, unlike multiset, using Oracle 10g.

Query 3. Find the products ordered by the customers.

In this query we are using two collections plus single references to retrieve products information, that is to say it were employed three hop references.

3.1 Multiset of references + Array of objects + Single references

```
SELECT c.customer_number, c.customer_name, p.column_value.order_number, o.reftoproduct.product_number
FROM customer_t c, TABLE(c.purchase_tab) p, TABLE(p.column_value.orderline_va) o;
```

3.2 Multiset of references + Array of references + Single references

```
SELECT c.customer_number, c.customer_name, p.column_value.order_number, o.column_value.reftoproduct.product_number
FROM customer2_t c, TABLE(c.purchase_tab) p, TABLE(p.column_value.orderline_va) o;
```

Table 5. Results of the query 2

Query	Rows selected	Response time (hh:mm:ss)
2.1	63578	00:00:05
2.2		00:00:10
2.3		00:01:14
2.4		00:01:14
2.5		00:00:03

3.3 Multiset of references + Multiset of references + Single references

```
SELECT c.customer_number, c.customer_name, p.column_value.order_number, o.column_value.reftoproduct.description
FROM customer3_t c, TABLE(c.purchase_tab) p, TABLE(p.column_value.order-line_tab) o;
```

3.4 Multiset of references + Multiset of objects + Single references

```
SELECT c.customer_number, c.customer_name, p.column_value.order_number, o.reftoproduct.product_number
FROM customer4_t c, TABLE(c.purchase_tab) p, TABLE(p.column_value.order-line_tab) o;
```

3.5 Relational model

```
SELECT c.customer_number, c.customer_name, p.order_number, pr.description
FROM customer_plano c, purchaseorder p, orderlineitem o, product pr
WHERE c.customer_number = p.customer_number AND p.order_number = o.order_number
AND o.product_number = pr.product_number;
```

The results obtained are shown in Table 6.

As it can be noted queries with the third added hop have the same performance than query 2.

Query 4. Find customer information for all customers of person type.

In this query we are using the inheritance hierarchy of Customer obtaining the supertype information of person subtype. The substitutability property allows the storage of any subtype in the supertype table.

4.1 Object-relational

```
SELECT p.customer_number, p.customer_name, p.street, p.city
FROM customer_t p WHERE VALUE(p) IS OF (person_ob);
```

4.2 Relational

```
SELECT customer_number, customer_name, street, city
FROM customer_plano WHERE type = 'P';
```

The results obtained are shown in Table 7.

The response time for both queries is similar; due to the few rows involved in the query the time is very low. Analyzing the execution plans both are very similar, and no differences can be found. The advantage of the O-R approach is that the model evolution can be easily implemented, subtyes can be added to the hierarchy and can be stored in the supertype table.

Query 5. Find customer and person information for all customers of person type.

The difference between this query and query 3 is that in this case we are treating supertype instances as subtype instances.

5.1 Object-relational

```
SELECT p.customer_number, p.customer_name, p.street, p.city, TREAT(VALUE(p) AS person_ob).person_id, TREAT (VALUE(p) AS person_ob).discount FROM customer_t p WHERE VALUE(P) IS OF (person_ob);
```

5.2 Relational

```
SELECT customer_number, customer_name, street, city, person_id, discount
FROM customer_plano WHERE type = 'P';
```

The results obtained are shown in Table 8.

The result analysis made for query 4 is the same for this one. Due to in both queries (4 and 5) the flat model is used, so the optimizer makes a sweeping of the entire tables.

Table 6. Results of the query 3

Query	Rows selected	Response time (hh:mm:ss)
3.1	63578	00:00:10
3.2		00:00:12
3.3		00:01:13
3.4		00:01:11
3.5		00:00:07

Table 7. Results of the query 4

Query	Rows selected	Response time (hh:mm:ss)
4.1	320	Less than 1 second
4.2		Less than 1 second

Table 8. Results of the query 5

Query	Rows selected	Response time (hh:mm:ss)
5.1	320	Less than 1 second
5.2		Less than 1 second

CONCLUSIONS

In this work we have evaluated the implementations of relationships of different type into an object-relational schema and have made the comparison of them against a relational approach. Oracle 10g was used for the implementations. We started with a UML class diagram of a book case example. In order to define the O-R schema we have transformed the class diagram into O-R elements of an intermediate layer and then they were transformed into persistent typed tables. These tasks are more complex than the relational model which involves a more direct mapping. Several O-R schemas have been defined involving different alternatives for the implementation of composition relationship. Arrays and multiset of references and objects have been used for this purpose. We have proposed graph elements to support object-relational extensions for the relational schema diagram. Those elements are very useful for database developers since the complexity of the object-relational model can be represented graphically facilitating their interpretation.

The evaluation of the O-R implementations against the relational approach has been driven by a set of queries, their response time and execution plans. As a result of this study, comparing the use of arrays, multiset, objects and references, for the implementation of composition and aggregation relationships, no general conclusion of which one is better can be made. Each case can be analyzed according to the business rule to be implemented, several alternatives for them are open, and it is worthy to make some evaluations before making a final decision. The performance of the inheritance hierarchy is the same in both technologies analyzed, having the O-R technology more flexibility for type evolution.

Even though the relational technology threw the best results, the object-relational technology had good ones in some cases, not so far the relational behavior. In the future work our plan is to implement the mappings in an OO language such that it is possible to evaluate if the O-R technology can reduce the impedance mismatch existing between the OO programming languages and the relational approach. A priori, the expectation is to get certain advantages from the O-R technology regarding to this issue.

REFERENCES

1. Carey, M., DeWitt, D., Naughton, J., Asgarian, Brown, P., M., Gehrke; J. and Shah, D.: The Bucky Object-Relational Benchmark. In Proc. of ACM SIGMOD International Conference on Management of Data, pp. 135-146 (1997).
2. Carey, M., Chamberlin, D., Narayanan, S., Vance, B., Doole, D., Rielau, S., Swagerman, R. and Mattos, N.: O-O, What Have They Done to DB2?. In Proc. of 25th International Conference on Very Large Data Bases. Edinburgh, Scotland (1999).
3. Elmasri, R. and Navathe S.: Fundamentals of Database Systems, Third Edition. Addison Wesley. (2000).
4. Golobisky, M.F. and Vecchietti, A.: Mapping UML Class Diagrams into Object-Relational Schemas. In Proc. of the Argentinian Symposium of Software Engineering (ASSE 2005). ISSN: 1666-1087. Pág. 65-79. 34 JAIIO, Rosario, Santa Fe, Argentina (2005).
5. Lee, S.H, Kim, S. J. and Kim, W.: The BORD Benchmark for Object-Relational Databases. In Proc. of the 11th International Conference on Database and Expert Systems Applications (2000).
6. Mahnke, W.: Towards a modular, object-relational schema design. In Proc. of the 14th International Conference on Advanced Information Systems Engineering (CAiSE'2002) (2002).
7. Marcos, E., Vela, B., Cavero, J.M. and Cáceres, P.: Aggregation and Composition in Object-Relational Database Design. In Proc. of the Fifth East-European Conference on Advances in Databases and Information Sytems, Vilnius Lithuania (2001)
8. Melton, J. ISO/IEC 9075-2:2003 (SQL/Foundation), ISO standard. (2003).

Knowledge Support for Software Projects

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ABSTRACT

The unpredictable nature of software projects and the need for effective communication within project teams requires a framework for social interaction and feedback that results in better decision-making. This paper analyses the creation and capture of knowledge within software development projects and discusses the central role of decision making in the development process. The paper views how the knowledge generated within a software project can be provided greater visibility and communicated effectively, and to achieve this, presents a framework to facilitate social interaction and feedback during the development process.

1. INTRODUCTION

The use of knowledge is expected to result in better decision-making, innovation and competitive advantage within software projects. Software development projects are life-cycle driven and are organised around teams that are assembled specifically for the limited duration of the project. The software development process relies on the knowledge and creativity of individuals and teams, and the formation of these teams requires the involvement and participation of all team members in the development process. There is also an increasing need to involve users early in the software development life-cycle since designing software requires extracting detailed knowledge of the users. Effective communication is the basis for discussion between users and developers during the requirements definition process that is essential to provide an understanding of the software requirements. However, problems of communication occur due to the diversity of professional expertise and organisational roles that confer users' different views and expectations of the system to be developed.

The unpredictable nature of software projects and the need for effective communication within project teams necessitates a framework for social interaction and feedback that results in better decision-making. This paper analyses the creation and capture of knowledge within software development projects. The paper discusses the central role of decision making in the development process and how the effective use of knowledge helps to improve decision-making during the development process. The knowledge created and decisions implemented need to be effectively communicated across the entire process. Social interaction and feedback are key factors that facilitate the effective use of knowledge within software projects. The paper views how the knowledge generated can be provided greater visibility within the projects and communicated effectively, and also presents a framework to facilitate social interaction and feedback during the development process.

2. KNOWLEDGE

Knowledge is the capacity for effective action. Alavi and Leidner (1999) define knowledge as 'a justified personal belief that increases an individual's capacity to take effective action.' While 'personal' implies the contextual nature of knowledge, action requires competencies and know-how, and implies the dynamic nature of knowledge. Knowledge is fluid and formally structured, and it exists within people, processes, structures and routines, (Davenport and Prusak 1998). Polanyi (1967) suggests that knowledge exists as tacit and explicit. Tacit knowledge comprises an individual's mental models, and while it is personal and in the mind of an individual, it is also context specific and difficult to articulate, formalise and verbalise, and is therefore hard to communicate and share. The factors that influence an individual's mental model include the individual's education, expertise, past experiences, perceptions, biases, prejudices and environment. Explicit knowledge can be easily articulated and codified and therefore transmitted and communicated. Polanyi (1967) contends that human beings acquire knowledge by actively creating and organising their own experiences and sums it up by stating that "we can know more than we can tell."

The importance of knowledge is increasing as organisations recognise that they posses knowledge and increasingly learn to view this knowledge as a valuable and strategic asset. Knowledge assets include knowledge which resides within the individuals, systems, processes, documents and structures of the organisation. Davenport and Prusak (1998) recommend that to remain competitive, organisations must efficiently and effectively create, capture, locate and share their organisations knowledge and expertise, and have the ability to bring that knowledge to bear on problems and opportunities.

2.1 Knowledge Management

The American Productivity and Quality Center (1996) defines knowledge management as "a conscious strategy of getting the right knowledge to the right people at the right time and helping people share and put information into action in ways that strive to improve organisational performance." Knowledge management, therefore, requires that it is imperative to identify what knowledge needs to be managed, how, when, where, by whom, and for whom. Consequently, the key elements of KM are collecting and organising the knowledge, making it available through knowledge infrastructure, and then using the knowledge to improve decision making and gain competitive advantage. Alavi and Leidner (1999) refer to knowledge management as a systematic and organisationally specified process for acquiring, organising and communicating both tacit and explicit knowledge of employees so that other employees may make use of it to be more effective and productive in their work and decision-making while improving product and process innovation.

3. THE NEED TO MANAGE SOFTWARE PROJECT KNOWLEDGE

Compared to organisations which are permanent structures and have routines, projects are temporary by nature and their implementation requires creative actions, practitioner's experience, and the ability to apply knowledge to development problems. Projects are designed to achieve specific objectives within a predetermined time frame, budget and resources. Projects involve planning for non-routine tasks to be conducted in several phases, and can be characterised as unique, goal-oriented and complex undertakings steeped in uncertainty, which aim to produce a meaningful product or service in order to satisfy a need, (Dalcher 2003).

Software projects are life cycle driven and follow the sequence of going from concept through definition and development, to testing and delivery. However, unlike other projects, the requirements of software projects are subject to frequent change. As a product, software can be changed, and it is therefore assumed that this change is possible at even the later stages of the development process. Such change and uncertainty make software projects more unpredictable than other projects, and are therefore organised around teams, relying upon the knowledge and creativity of the individuals and the teams. Software projects are typically implemented by teams assembled specifically for the project and often disbanded upon its completion. Requirements evolve and team members often change during the course of projects, while feedback from one phase of the project to another rarely provides team members with an opportunity to learn from their good decisions or mistakes. Team members often come together for the first time at the outset of the project and therefore it is difficult to create the right knowledge culture and locate the knowledge assets. Moreover, project implementation effort is often

focused on immediate deliverables with no emphasis on how the experience and insights gained would help and benefit future projects.

The amount of knowledge required to manage a project depends upon the novelty and uniqueness of the required outcome. Love et al (1999) argue that even though a project is unique, the processes involved in delivering the final outcome are similar in projects and, therefore, most projects do not need to start from scratch as they can utilise existing processes and learn from the experiences acquired from previous projects. Projects are required to be completed within a specific schedule and budget, which makes the reuse and harnessing of knowledge desirable. Without the reuse of existing knowledge or the ability to create new knowledge from existing solutions and experiences, project organisations have to create new solutions to every problem they encounter, potentially leading to delays and inefficiencies. With the reuse of knowledge, projects can be planned more efficiently to be delivered within budget and on time. Koskinen (2004) suggests a metaphor of a project tree to visualise the entire knowledge required by a projects, and states that the types of knowledge that a project may require are tacit, explicit, additive or substitutive. Koskinen (2004) further refers to additive and substitutive knowledge as knowledge that is new to the project and is either invented internally or acquired from external sources. This is similar to Bredillet's (2004) view that project teams need to know what knowledge is available to complete the project based on past experience, and what knowledge needs to be acquired or will emerge as a result of the unique nature of the project tasks, especially within software projects.

The implementation and outcome of projects depends upon a large extent on the knowledge of individuals, their access to local and global knowledge resources, and recognition and integration of existing knowledge. Problem solving within unique project instances generates further knowledge, and the knowledge assets thus created, combined with the experience gained by implementing the project, can benefit subsequent projects. Certain software process improvement approaches, for example the Capability Maturity Model, suggest that the development process be optimised to deliver the most of the software organisation's capability. Such approaches often suggest that knowledge be managed or leveraged, but do not bring it down to an operational level. However, the knowledge requirements make it imperative to identify what knowledge needs to be managed, how, when, where, by whom, and for whom. Consequently, the key requirements for managing knowledge within software projects are collecting and organising the knowledge, making it available through knowledge infrastructure, and then using the knowledge to improve the execution of projects.

The knowledge that is created requires a strategy or model that facilitates the cross leveling of this knowledge across the software development process, and globalises the knowledge created within the software project. Process models for software development depict sequential, incremental, prototyping or evolutionary approaches. Developmental models help simplify and reduce the complexity within software projects by providing a perspective to organise the different stages or phases of the development process. The following section presents and discusses the Dynamic Feedback Model, which underlines the relationships and interactions between the various entities and phases of the software development process.

4. THE DYNAMIC FEEDBACK MODEL

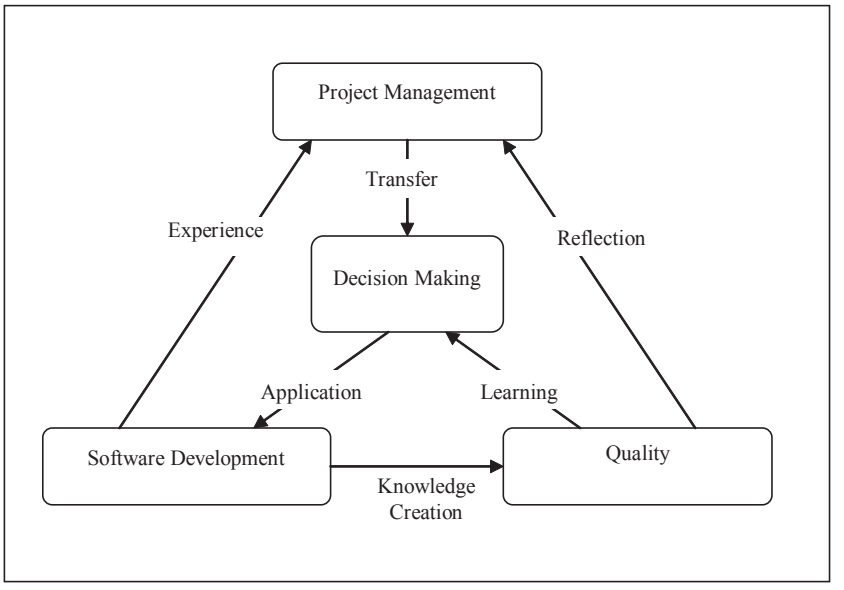
Complex and uncertain software development situations require a model that can account for the knowledge needed to plan and implement decisions within the development process. An example of such a model is the Dynamic Feedback Model (DFM) that underlines the relationships and interactions between the entities by depicting the feedback loops operating between them. The model, as depicted in Figure 1, focuses on four different functional areas that are intertwined throughout software development. The DFM models the relationships in a non-linear fashion amongst the functional areas and allows a continuous view of the development process. The four areas are management, technical, quality and decision-making.

4.1 Functional Areas

The management area involves the planning, control and management of the software development process. It also pertains to the strategy and operation of the project. Key concerns revolve around identifying performance gaps, assessing progress, and allocating resources to accomplish tasks. As technical development and knowledge creation are on going activities, the management area also takes on a continuous view. It does not limit its focus to delivering a product, but to the continuous need for generating and maintaining an on-going flow of knowledge required for continuous development.

The technical area deals with the creation and continuous improvement of the software system. The area recognises the changing needs and perceptions of the development process. The activity in this area includes evolution and maintenance of the software, while also maintaining its functionality and utility. Experimentation, learning and discovery take place as the software goes from inception to evolution. The development and design of the software form the basis for interac-

Figure 1



tion between team members, and the knowledge created through the interaction provides the raw material for decision making within the process.

The quality area is perceived as a dynamic dimension, which continuously responds to perceived mismatches and opportunities reflected in the environment. It is concerned with assuring the quality of the product developed and the process used to develop it. Being an area of assessment, it provides the basis for learning.

The decision-making area lies at the core of the model as software development is described as a decision making process (Dym and Little 2000). This area attempts to balance knowledge, uncertainty and ambiguity with a view to maximise the expected returns on an on-going basis. Knowledge acquired from implementing decisions is used within the process either as background knowledge available to support future decisions, or as a formalised part of an integral body of knowledge which can be used to optimise the decision making process. Decision-making helps manage opportunity and risk and therefore this area can also be considered the risk management area. Risk assessment and planning are key activities within this area, which also ensures the implementation of decisions and the monitoring of their execution on a continuous basis. The knowledge required for the implementation, execution and monitoring of decisions is provided by the interaction and feedback loops of the model.

4.2 Feedback Loops

The DFM is in essence a set of interactions and feedback loops governing and controlling the development of software form a continuous perspective. The decision making perspective of the DFM ensures that rational and reasoned choices are made from the alternatives available during the development process.

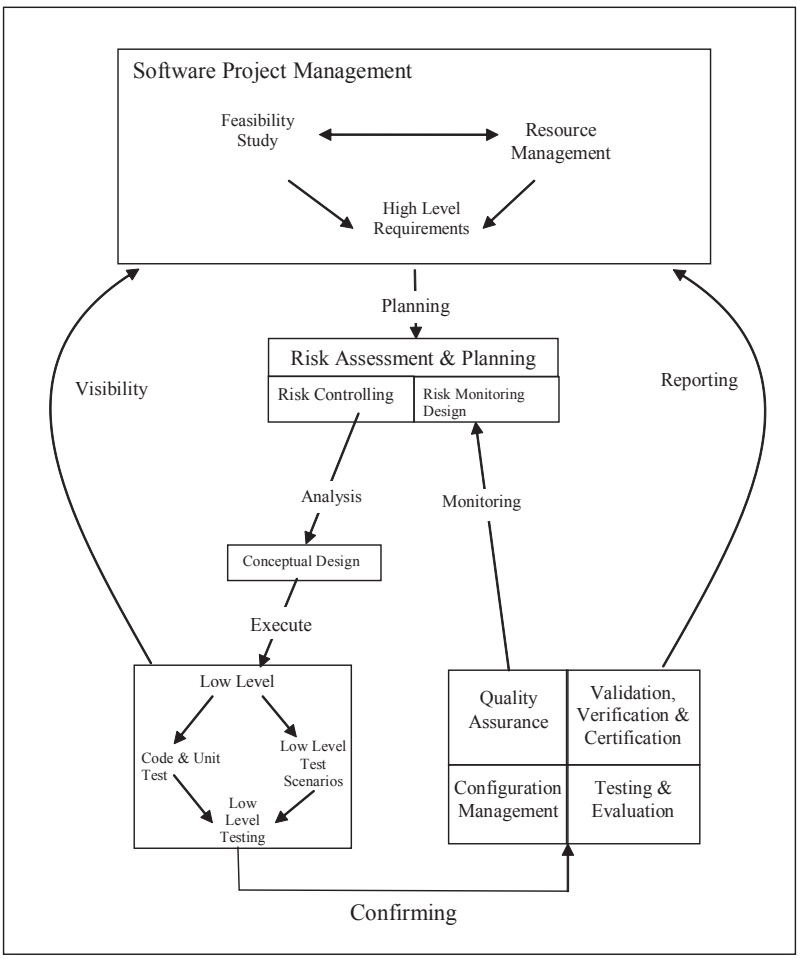
The basic loop in the dynamic system is the knowledge transfer-application-experience loop. This loop helps to plan and control the production, evolution and growth of the software in association with project management and decision making. The loop enables the continuous generation of new information as well as feedback knowledge and experience gained while executing the project. The use of this knowledge is crucial in changing plans to adapt to reality and opportunities, modifying the decisions and re-examining the assumptions. The visibility of this basic feedback loop provides a continuous process to ensure the system remains relevant with regard to its objectives.

The knowledge creation loop links the knowledge created and learning with effective application. The knowledge generated during the design process within the decision-making area is applied to help develop the software. The knowledge created in the technical area helps in quality assurance, while the learning that emerges from identifying and correcting mismatches is fed back to the decision making area for use in subsequent development.

The reflection-transfer loop provides visibility to the project management area regarding the opportunities and mismatches present in the quality area, and also those provided by the implementation and execution of the decisions made.

The above mentioned loops depict relationships between the different functional areas. The DFM can therefore be used as a framework for understanding the dynamic nature of the interactions between entities in software development, and the knowledge that flows between them. The model moves away from linear thinking and offers a continuous perspective for understanding and implementing relationships, and the role these relationships play in software development. The model achieves this through the on-going feedback and interactions of the

Figure 2



loops, which present the framework to provide the knowledge flow required for software projects. The following section examines the feedback and interactions between the different phases of software development projects.

4.3 The DFM Process

The phases of the software development process can broadly be categorised as problem definition, requirements analysis, design, implementation and maintenance. The DFM views knowledge as a key asset in the development of software and focuses on its feedback within the functional areas of development. In doing so, the DFM encourages thinking about software development in terms of the different phases and their interactions. The feedbacks within the functional areas of the DFM are depicted in Figure 2, and the use of knowledge for decision making within the various activities of software projects.

The project management area facilitates project planning and execution, and is also where the user requirements are elicited and the problem defined. Planning involves resource management where the skills and competencies required to execute the project are identified and teams are formed. Proper requirements analysis and specification are critical for the success of the project, as most defects found during testing originate in requirements. In order to understand the customer requirements, the developers require insight into the domain of the business system and the technical concepts of the system to be developed. Knowledge is created while understanding the requirements by the interaction of the different team members, and also between the users and the developers. This knowledge provides the perspective for decisions made to implement the project. The project management area is where discussion takes place between the users and developers as software development requires that users are involved in the development of the software. A clear understanding is needed between the users and developers to build the software, and this understanding is established through dialogue and communication. The formalisation of such an understanding usually results in the form of proposals and contracts. The feasibility of the project and the cost involved in executing the project are the basis for the proposals and contracts. The project management area addresses the need to assess the feasibility of the project and its cost analysis.

Based upon the decisions made and the outcome of planning within the project management area, an analysis of the impact the project will have on the business and technical environment is made along with the possible risks involved in implementing the project. The analysis views the goals, scope and functionality of the system being developed and how they fit or respond to the existing processes with which they are required to interact. Risk assessment and planning are conducted and feature the two traditional components of risk identification and prioritisation. Identification tries to envision all situations that might have a negative impact on the project, while prioritisation involves analysing the possible effects and consequences of the risk in case it actually occurs. The project also requires crucial decisions to be made in the design stage. High level design is the phase of the life cycle that provides a logical view of the development of the user requirements. Design involves a high level of abstraction of the solution, through which requirements are translated into a 'blueprint' for constructing the software, and provides the architecture of the application and its database design. Decision making at this stage of the process helps transform the requirements into a set of software functions and a physical database structure. Scenarios are developed to test the acceptability of the design with relation to the requirements.

The technical activities of design, code generation and testing are performed in the technical area. The area includes the detailed design phase where the high level design is converted into modules and programs. A unit test plan is created for the conditions for which each program is to be tested. The required programs are coded or translated into the programming language, and the programs are tested using the unit test plans. The technical area ensures that the integration plan is implemented according to the environments identified for integration. The area also ensures the maintenance, functionality and utility of the software apart from its creation and evolution. The decisions made in this area relate to the technical activities and provide confirmation of the design and suitability of the requirements. The decisions made are verified during system testing within the quality assurance area.

Pressman (1997) states that quality assurance consists of the auditing and reporting functions of management, and that its goal is to provide management with the data necessary to be informed and assured about product quality. The quality assurance area involves system testing which validates that the software developed meets the requirement specification. This phase identifies the defects that are exposed by testing the entire system. A series of tests are performed together, each with a different purpose, to verify that the system has been properly integrated and performs its functionality and satisfies the requirements. The quality assurance area thus provides verification of the decisions made and tasks performed in the technical area while confirming the decisions made during the design phase, and validating the requirements.

The different phases of the process are validated and given visibility by the feedback loops. Controlling the execution of decisions generates knowledge (Dalcher 2003a). The feedback loops globalise this knowledge within the process and ensure that knowledge is available for decision making. The decisions made in the decision making area during design and risk analysis receive confirmation during technical development and quality assurance. Technical development provides the project management area visibility of the software being developed to meet the requirements. Quality assurance further reports and validates to project management the decisions made during design and technical development. The project management area is able to assess the feedback and incorporate it in planning to help address some of the change and uncertainty inherent within the software development process.

5. CONCLUSIONS

Software projects require knowledge to implement projects effectively. Software projects are organised around teams and rely upon the knowledge, creativity and competence of the individual team members. Effective knowledge management helps provide timely and required knowledge to team members, which results in better productivity and quality of the software processes and product. The DFM adopts a long-term perspective of software development that enables it to address the issues of uncertainty and ambiguity, and therefore benefit from the decisions made and knowledge created during the development process. The long-term perspective also enables the DFM to look beyond a single project and use the knowledge generated towards improvements in future software projects. The DFM is receptive to changes in the environment and tackles them by feeding acquired knowledge back into the decision making process. As software development becomes more integrated in management practices the importance of continuous learning, knowledge, and skill acquisition as underpinned by the DFM will remain central to improved control, visibility and management. The availability of a long-term view justifies the adoption of multiple perspectives, the reuse of knowledge and the utilisation of a decision making perspective, which underpin feedback and improvement.

The DFM provides a framework that facilitates social interaction and feedback, which further enhance the use of knowledge within the software development process. The feedback loops help facilitate the flow of knowledge created and insights gained within the processes and developmental activities of the functional areas. The continuous view of software development provided by the DFM enables the knowledge, both tacit and explicit, to be globalised through-out the software project organisation. In the domain of software development, the DFM provides software project organisations with an approach that focuses on the non-technical aspects, and the knowledge required to support the developmental effort. The DFM helps identify how and where knowledge is created, shared, transferred, applied and assimilated within the software project organisation. In doing so, the DFM provides a framework and culture that views knowledge as a valuable resource, and supports the effective implementation of software projects. Future work includes validating knowledge support provided by the DFM for software development projects.

6. REFERENCES

[1] Alavi M and Leidner DE (1999) 'Knowledge Management Systems: Issues, Challenges and Benefits,' Communications of the Association for Information Systems, Vol 1, Article 7.

[2] American Productivity and Quality Center (APQC) (1996), Knowledge Management: Consortium Benchmarking Study Final Report; Available from http://www.store.apqc.org/reports/Summary/know-mng.pdf

[3] Bredillet CN (2004) 'Projects are Producing the Knowledge which are Producing the Projects……' Proceedings of IPMA, Budapest.

[4] Dalcher D (2003) Computing Project Management, Middlesex University Press, London.

[5] Dalcher D (2003a) 'Software Development for Dynamic Systems.' Developments in Metainformatics. LNCS, Springer Verlag, Peter J Nurnberg (ed): pp 58-75.
[6] Davenport TH and Prusak L (1998) 'Working Knowledge,' Harvard Business School Press, Boston.
[7] Dym C L and Little P (2000) 'Engineering Design: A Project Based Introduction.' John Wiley, New York.
[8] Koskinen KU (2004) 'Knowledge Management to Improve Project Communication and Implementation,' Project Management Journal, Vol 35, No 1, pp 13-19.
[9] Love, P.E.D, Smith, J and Li, H, (1999) 'The Propagation of Rework Benchmark Metrics for Construction,' International Journal of Quality and Reliability Management, Vol 16, No 7, pp 638-658.
[10] Polanyi M (1967) 'The Tacit Dimension,' Routledge and Keon Paul, London.
[11] Pressman RS (1997) 'Software Engineering – A Practitioner's Approach,' The McGraw-Hill Companies, Inc.

Information Security Policy: Taxonomy and Development Issues

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ABSTRACT

The content of this paper aims at defining what an Information Security Policy (ISP) is, what are the possible ISP formats, and what parts of the ISP are of particular importance. Special emphasis is put on the presentation of methods for the reduction of effort needed for the development of a good ISP.

INTRODUCTION

The answer to the question: *What is an Information Security Policy?* is not so simple. There are many opinions about this, so let's look at what some researchers have considered:

Karen Forch (1994) stated that all organizations should develop a security policy statement and train all employees on its contents. A policy statement should include main checkpoints that are directed specifically at an individual organization's operations including: Avoidance, Deterrence, Prevention, Detection, Recover, and Correction.

DPMA Model Corporate Computer Security Policy Statement (2006) concludes that it is the policy of a company to protect its proprietary information assets and allow the use, access and disclosure of such information only in accordance with corporate interests and applicable laws and regulations.

The Generally Accepted Information Security Principles (GAISP), (2006) draws upon established security guidance and standards to create comprehensive, objective guidance for information security professionals, organizations, governments, and users. The use of existing, accepted documents and standards will ensure a high level of acceptance for the final GAISP product, and will enable a number of benefits to be achieved.

Finally, Ross Anderson (2001) stated:

By security policy I mean a succinct statement of a system's protection strategy (for example, "each credit must be matched by an equal and opposite debit, and all transactions over $1,000 must be authorized by two managers"). A security target is a more detailed specification, which sets out the means by which a security policy will be implemented in a particular product-encryption and digital signature mechanisms, access controls, audit logs, and so on.

The content of this paper summarises a research aimed at defining what an Information Security Policy (ISP) is, what are the possible formats, and what parts of the ISP are of special importance. The content of the paper will therefore include the following parts:

- What is and what is not an ISP,
- What are the possible formats of an ISP,
- Possible approaches used for the development of an ISP
- Important issues regarding the content of an ISP.

The paper terminates with conclusions and suggestions for future research of these issues.

THE BASIC DIFFERENCE

To some extent the authors quoted in the introduction illustrate the basic difference in the approach to what an ISP is. ISP could be a term used for defining:

- Management's point of view about the protection of the information resources of an organization,
- Results of a project aimed on the development of facilities, procedures, and awareness to protect company's information resources,
- Implementation of a project defined above,
- A document distributed to all employees (or to their subset) informing them of information security arrangements.

In this paper we define an ISP as an internal or generally accessible document produced or endorsed by senior management. This document defines policies deployed or to be deployed within the organization to protection the information resources of the organization and that all staff should follow it.

INFORMATION SECURITY POLICY FORMATS

There are many forms of such a document ranging from a one page document, to an extended 200 page long volume. Janczewski & Colarik (2002) defined these basic differences:

- *General ISP*
  This may be a very short document (less than one page) stating that the security of information is of importance for the company, and that all staff are responsible for assuring that data will be accessible only to those authorised, and not changed without authorization. It is an ISP mission statement.
- *Practical ISP*
  This is a collection of basic rules on how to handle company documents and resources to maintain a high level of security. These rules are top level concepts of security do's and don'ts. For instance, it could contain a statement that all the company files need to have backups performed at the end of each working day, or that no staff member is allowed to disclose their password to anyone. A practical ISP is usually a few pages long. This document is presented to every employee and they are asked to sign an acknowledgement.
- *Detailed ISP*
  This document is an extension of the Practical ISP and contains details of all the procedures mentioned in the Practical ISP document plus a detailed instructional breakdown of those rules, such as how to do a proper backup. Obviously, the development of such a document can have a significant initial cost in being established. Once it is created it can provide for employee training and consistency. Detailed ISPs can be over 200 pages long.

The names of these different policies may varies from organization to organization, and may be quite different from the above, yet it is easy to classify given document to any of these three groups.

GENERAL ISP

As mentioned before the general ISP is usually very short and outlines the wish of the top management to protect information resources of the organization. Below is an example of such a policy introduced at the University of Auckland, New Zealand (2006):

By proactively managing information security, the University can reduce the likelihood and/or the impact on our information systems from a wide range of threats. These threats include:

- Theft of physical IT assets,
- Theft and exploitation of information,
- Deliberate disclosure of sensitive information by University people, agency or contract employees,

- Accidental disclosure of information by University people, agency or contract employees through careless talk (social engineering) or poor document control,
- Destruction or corruption of information stored on computers whether deliberate or accidental,
- Prosecution because of non-compliance with legislation e.g. the New Zealand Privacy Act,
- Concerted attacks on our networks and information by highly organised and computer literate groups; e.g. hacking, denial of service attacks, worms and viruses.

As it was shown in this example the objective of the General ISP is only to indicate the wish of management to protect their information resources. General ISPs does not say how to do this or what consequences would be imposed on those who do not follow it.

PRACTICAL ISP

This is a publication, which contains a number of headings with short (one or two sentence) blurbs. For instant it could be titled as "The Quick Reference Guide to Information Security" and cover issues such as:

1. Access to Information
2. Password Generation & Control
3. Notebook & Laptop Security
4. Viruses
5. Work From Home, etc

Each entry is summarised by a short instruction. For example (from an original company document) the issue of "Destruction of Computer & Telephony Hardware" was followed by: "Information Services are responsible for computer & telephony hardware assets and will determine the method of disposal for each individual item".

More extended version could be represented by a 50 page long document labelled "Information Security Policy" including such parts as:

- *Scope of the Policy*
  General introduction on what the policy covers, applicability, etc
- *Assets Classification and Control*
  This is one of the most important security policy aspects: the definition of access rights to all of the organization's assets which are not freely available and methods of managing these privileges
- *Personnel Security*
  All measures necessary to have trustworthy staff and methods of verifying this trust.
- *Physical and Environmental Security*
  Every real company uses office space and owns/uses office and ICT equipment. This space/equipment should be protected and that part of the ISP addresses these requirements.
- *Computer and Network Operation and Management*
  All protection measures related to computer hardware/ software and networks. This may include the firewall settings, protection against viruses and SPAMs.

Each chapter outlines specific group policies. For instance the "Personnel Security" chapter could contain several Objectives, followed by Policy and Guidelines like:

- *Objective*
  To minimise the damage from security incidents and malfunctions, monitor and learn from such incidents.
- *Policy*
  Channels for reporting security incidents and malfunctions shall be established and all staff made aware of them.
- *Guidelines*
  Staff should be made aware of the purpose and use of the channels for reporting security incidents

A disciplinary process should be instituted for dealing with security breaches.

The above is a quote from an anonym company document.

In many cases the Practical ISP is printed as a short document and staff are asked to read and follow it. For instance, the University of Auckland Practical ISP (2006) warns the staff and the students: "Users who do not comply with mandatory IT policy will be subject to the provisions of the appropriate statute".

DETAILED ISP

A detailed ISP is an extension of the Practical ISP. Not only does it define what needs to be protected but also states how it could be done. For instance while the practical ISP may imply that each employee should back up files, the detailed ISP would instruct the user on how this should be done. This policy may also define how often this needs to be carried out plus how to retrieve backed up data. Such a document could be well over 200 pages long.

It is obvious that an effort to produce such a document is usually significant and that only large organization can afford to do this. Janczewski and Tai (2006) stated (in relation to the practical ISP within accounting Small and Medium Enterprises, (SME)):

All respondents seem to have an information security policy in their organizations. However, a more careful analysis reveals that what they have might not be a real "information security policy" as some of the respondents said they have "IT policy" (or something to that effect). While IT policy might govern what employees can or cannot do with the IT system, an information security policy should go beyond the IT system and include policies on operational or procedural matters. So even though the respondents have policies in place, the policies might not be of good enough quality.

This implies that in practical terms none of those SMEs developed a detailed ISP.

On the top of the large costs related to producing such a document the maintenance effort spent on it could be equality prohibitive. It is clear that such a policy may only make sense if it is properly updated.

The author of this paper recalls a case of auditing a branch office of an international bank where the branch IT manager produced a copy of their detailed ISP. One of the points there was the definition of a procedure for handling of faulty computer equipment. The regulation stated how to report a fault and prepare the equipment for repair. Further, it was indicated that a specific company is authorized to service the equipment. It looked faultless. But in the meantime the bank had changed the repairer making the name in the ISP not valid. One could imagine the consequences of shipping faulty equipment containing sensitive information to an unauthorized service dealer!

IS STANDARDIZATION OF ISPS POSSIBLE?

There are several, sometime conflicting parameters:

- Companies differ in every possible aspect: domain, objectives, size, and IS technology implemented.
- The business environment is usually based on a LAN-type network spanning desk top machines, mainframes and servers with connection to the outside word. This connection may be of the many types including VPN, dial up, and WEB based.
- The application and system software used could be different, however one element is common: no application is perfectly separated from the rest of the world. Through CD ROMs and USB devices even standalone machines are able to exchange data.
- The law in each country is different and may impose different constraints on a company's information systems in terms of the security of their and other's data and software. However, there is a noticeable world trend to standardise law. A company wishing to benefit from international trade must abide with other country's regulations. This puts pressure on local law to follow other international regulations.

This means that security mechanisms & procedure descriptions must be set up to guard information assets from destruction or unauthorised modification. This forces each company to set up their own data security policies which should have

a common denominator. Is a generic ISP such a common denominator? In the author's opinion the answer is a qualified YES, due to the following reasons:

- Internationally ICT has become highly standardised. The trend is similar to the automobile industry where cars are produced by different companies that look relatively similar but:
  - o They are assembled in many countries and shipped internationally,
  - o Driving methods are practically the same,
  - o Main subassemblies work on the same or similar principles.

  The same applies to the ICT industry.
- The growth of the international trade is significant. Each supplier must be prepared to co-operate with a wide range of customers. This puts pressure to adjust their own structure to that of their customers.
- The production/trade methods around the world have become standardised. During the writing of this paper tensions between the USA and Iran are high. But despite what these two countries represent in terms of the political doctrines or culture models, it is obvious that the ICT equipment used in both countries is more or less compatible and is used in a similar way.

Despite all of these compelling reasons many companies, especially SMEs, have not developed a full ISP set (Tai, 2006). The main reason for this is due to the relatively high demand for financial and human resources to develop and maintain such a set of documents. There should be a way of reducing these costs and the next section explains how this could be possible.

APPROACHES TO ISP DEVELOPMENT

The most elaborate approach to setting up an ISP is to develop it as a part of a waterfall methodology suggested by many authors. One of the best examples of this was presented by Whitman and Mattord (2005). In this case the ISP is a part of the whole process starting at the decision to develop an information security system and concluding with system implementation, maintenance and update. If done correctly, such a procedure would lead to the best results; however the costs would be enormous.

The other approach is to take into consideration the most popular international security standard, the ISO 17799 *Code of practice for information security management* (2005) and use it as a framework to develop a company ISP. This way the quality of the resulting ISP would be very high while the effort would be significantly lower than using the fully sized risk analysis and development process. This was well proved by Tai (2003).

Probably the most robust and quickest way of developing an ISP is to use a *Toolkit*, or a *Toolbox* (von Solms, 2001) developed at the Nelson Mandela Metropolitan University, Port Elisabeth, South Africa (former Port Elisabeth Technikon). The concept of the toolbox is based on using the ISO 17799 standard as a foundation stone of the software package guiding the ISP developers though the process of constructing an ISP document.

The Toolbox is an integrated software driven tool. It is based on a very sound theoretical foundation. However its "intelligence" helps novice security officers in setting up the ISP quickly and efficiently. It also may be used as a support tool for experienced consultants.

Each of the above presented methods has advantages and drawbacks. The first method allows the development of a custom-tailored ISP, which is the best for the given conditions, but the cost would be substantial. On the other hand, the last approach allows the quick development of a basic (yet practical) ISP.

Many authors have presented examples of ISP, such as Janczewski & Colarik (2004) or comprehensive instruction how to setup an ISP (Kaon, 2006).

NEGLECTED ISP ISSUES

A well developed ISP contains sections addressing issues such as:

- Organization of Information Security
- Asset management
- Human Resources Security
- Physical and environmental security
- Communications and operations management
- Access control
- Information systems acquisition, development and maintenance
- Information security incident management
- Business continuity management
- Compliance

This list makes up the foundation of the ISO 17799 standard.

Regulations are required for the areas addressed in the list above. However, some of these issues are not receiving proper attention and may result in significant security breaches and considerable losses. The issue that will be addressed in this paper is the issue of the ownership of documents or files and authorised access to them.

Almost all security models define security levels and categories. The lattice theory is based on this (Amoroso, 1994). The introductory step in there is definition of possible security levels and categories. In a military institution such a listing may look as it is presented in the Table 1.

Table 1. Example of security levels and security categories

Security levels		Security category
Top secret		HQ
Secret		Navy
Confidential		Army
Limited circulation		Air forces
No restriction		

It is possible for the number of security levels to differ from the number of security categories. Also, it is not important (apart from the psychological point of view) what terms are used to name each of the security levels. The security categories are usually associated with different units of an organization.

Now, a number of interesting questions should be made:

- How many security levels are needed?
- How strictly should we determine the borders between these levels?
- Are the assigned levels and categories strict or can they change over time?

The number of security levels must have an optimum. One security level does not make any sense. This would imply that all the documents are available to anybody and few would follow this principle. Therefore two levels is an obvious minimum but may not provide proper protection of information. On the other extreme, many security levels, like, say 20 or 30 does not make sense as this would make it impossible to manage such a system.

All this implies is that any organization embarking on the introduction of a security classification system must decide how many levels should be generated. In saying that there are limitations:

- The initial most obvious choice is the introduction of 3 levels, which could be labelled as:
  - o No restriction (the document is accessible for anybody)
  - o Internal use (the document is accessible for employees only)
  - o Confidential (the document is accessible to a restricted number of employees)
- In military and governments usually there are at least 4 security levels: "general", "internal circulation only", "confidential", and "top secret". The "top secret" is for use by a limited number senior management.

Generally speaking the choice of the number of security levels is a function of two variables:

- The security needs of the organization (more security levels allow the better tailoring of security systems to the desired needs).
- The economy of the system (more security levels cost more to implement and maintain)

The next issue is the strictness of the division between security levels. Janczewski & Portougal (2000) studied this specific issue. They came to the conclusion that it is worth making the borders fuzzy. Sometimes shifting an item up or down the confidentiality scale could have noticeable economic effects.

Table 2. Standard security label

Security level	Security category
Secret	Human resources

Table 3. Improved format of a security label

Security level	Security category	Expire date	Owner
Secret	Human resources	12 March 2008	Smith

Starting from the Bell LaPadula security model (1973) through the Orange Book (1985) and culminating on the previously mentioned ISO standard 17799, all sources advocate the development of security labels attached to all subjects and objects. The security label is a record of the security level and security category of the object to which is attached. One should note that the security category is sometimes referred to as the "security compartment". A security label could look similar to this in the Table 2.

An obvious question must follow: is such a security label adequate for a typical business environment?

Imagine the following situation: A company is preparing a marketing plan and the plan is considered as a top secret and a *top secret* security level is attached to it. The CEO of the company then appears on national TV and announces the new marketing strategy. What would you think reading such a document later seeing the "Top security" label still attached to the document?

The other important aspect of the label is that what should be done if changes are made to the document?

The obvious solution to this problem is to nominate a person as an owner of the document and authorise only this person to introduce changes to it. These changes could relate not only to the content of the document itself but to the content of the label.

Hence, it seems sensible that a security label of any document or file should have a format presented in the Table 3.

This security label was extended to include fields describing the date of the document expiring and an indicator of who the owner is. Such a label has significant advantages especially in the case of electronics processing. A system validating all the classified documents would inform the owner of a document about it's expiry date and ask for a decision on what to do next with the content of the security labels and the document itself. As a result an appropriate change could be done such as like removing it from circulation or changing its security level.

CONCLUSION

All the above allows us to formulate the following conclusions related to the ISPs:

1. Each company should develop a set of documents relating to Information Security management that includes a brief guide, full policies and detailed procedures. Emphasis should be placed on the full policy (or the Practical ISP).
2. These documents should contain a set of major clauses regarding such issues as assets classification and control, personnel security, physical security, computer operations, network operations, system access control, and risk management.
3. The development of an ISP could be the result of a full risk analysis but without noticeable decrease of the quality of the final document other methods offer similar products with significant costs and time reduction.
4. A generic ISP documents forms the foundations stone of these methods.
5. Development of a good ISP should be preceded by establishing rules of handling sensitive information/documents, such as the establishment of the security levels and the handling limited circulation information. One can imagine the confusion resulting from the introduction of security labels within an organization which did not set before these rules before.

Hence future research should be aimed at developing a methodology of evaluation of company information systems from a security point of view. Such evaluations could include the analysis of:

- Procedures of handling company customers and suppliers,
- Structure of the telecommunication system
- Internal flow of information, etc.

REFERENCES

Amoroso, E., Fundamentals of Computer Security Technology, Prentice Hall, 1994

Anderson, R., Security Engineering, Wiley, 2001

Bell, D., LaPadula, L., Secure Computer Systems: Mathematical Foundations ESD-TR-73-278, Vol1, Mitre Corporation, 1973

DPMA Model Corporate Computer Security Policy Statement, quoted after: DPMA Model Corporate Computer Security Policy Statement, http://accounting.uwaterloo.ca/ccag2001/6CHAP97.htm, reviewed 2006

Forch, K., Computer Security Management, Boyd & Fraser, 1994

The Generally Accepted Information Security Principles, http://www.issa.org/gaisp/_pdfs/overview.pdf, reviewed 2006

ISO 17799 Code of practice for information security management, ISO, Second edition, 2005,

Janczewski, L., Colarik, A., A Managerial Guide to Cyberterrorism and Information Warfare, IDEA Publishers, 2003

Janczewski, L., Tai, V., Security Status and Model for Mid-size Accounting Firms in New Zealand, Proceeding of the 2006 IRMA International Conference, May, 2006

Janczewski, L., Portougal, V., „Need-to-know" principle and fuzzy security clearance modelling, Information management & Computer Security, No 5, 2000

Kaon Technologies, Information Security Policy, http://www.kaonsecurity.com/html_pages/policy_main.htm, reviewed 2006

National Computer Security Center Department of Defence Trusted Computer Security Evaluation Criteria, DoD 5200.28-STD, 1985

Tai, V., Development of Information Security Policy with use of Information Security Standards", A research essay, The University of Auckland, January 2003

Whitman, M., Mattord, H., Principles of Information Technology, , Thomson, Second Edition, 2005

The University of Auckland: Why do we need to manage information security?, http://www.auckland.ac.nz/security/FAQ.htm, reviewed 2006

The University of Auckland, Compliance with policy, reviewed 2006, http://www.auckland.ac.nz/security/compliance.htm

Von Solms at all, The Information Security Management Toolbox, Proceedings of the 1st Annual Information Security for South Africa Conference, ISSA2001, 2001

Issues and Challenges Facing E-Entrepreneurship and E-Innovation

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ABSTRACT

This paper explores key issues and challenges facing e-entrepreneurship and e-innovation through case studies. The case studies draw mainly upon interviews with senior managers of the case companies and documentary research of the companies' publications. One of the key issues facing e-entrepreneurship and e-innovation today, as demonstrated by the case studies in this paper is that e-business needs to respond closely to market needs and gain market credibility. Another key issue is that there should be credibility built within the e-business marketplace before inception of the business. In addition, the intangibility of an online service needs to be addressed in order to build brand awareness. The discussion of the issues as such provides readers with both theoretical and practical guideline for a further study.

Keywords: E-business, entrepreneurship, innovation, case study

1. INTRODUCTION

The dotcom crash and the following three-year economic downturn saw hundreds of Internet entrepreneurial startups closed down or sold. However, many of the innovations and technologies created by them "live on and play important roles in the future either via acquisitions, in new startups, or through copycatting by the industry's giants" (Hamm, 2003, p.52). Blogger.com was a troubled startup that hosted 200,000 Weblogs, personal websites where people could share insights and web links with all comers. It was bought by Google in 2003 and has since become part of Google's information storehouse. Another example was Liquid Audio, a digital music pioneer subsequently acquired by Anderson Merchandisers, a major distributor of music CDs to help create profitable online music distribution.

Despite the many failures caused by the dotcom crash, it presented new challenges as well as new opportunities to entrepreneurs of e-business. This author argues that a combination of entrepreneurship and innovation will be a crucial factor to the long-term sustainability of e-commerce and e-businesses. For the purposes of this paper, the terms of e-entrepreneurship and e-innovation refer to broadly entrepreneurship and innovation in the context of e-business activities and operations.

This paper aims to explore key issues and challenges facing e-entrepreneurship and e-innovation through case studies. The case study draws mainly upon interviews with senior managers of the case companies and documentary research of the companies' publications. In the following sections, the paper starts with a review of the concepts of entrepreneurship and innovation in the e-business context and then moves on to discuss generally key issues and challenges facing entrepreneurial and innovative e-business companies. After that, two case studies of the business models of two dotcom companies engaged with entrepreneurship and innovation were presented to illustrate the specific issues and challenges facing them. This is followed by a discussion of future trends of e-businesses and their implications for e-entrepreneurship and e-innovation. The paper winds up with conclusions.

2. THE CONCEPTS OF E-ENTREPRENEURSHIP AND E-INNOVATION

2.1 E-Entrepreneurship

E-entrepreneurship describes entrepreneurship in e-business. The e-dimension of entrepreneurship incorporates all the key elements of entrepreneurship including risk-taking, proactivity, and innovation in building, running and managing e-business. The concept of e-entrepreneurship is not limited to small e-businesses but includes corporate e-intrapreneurship which is embedded in establishing e-infrastructure to do e-business in large organizations. E-business operates in a fast-moving, highly uncertain, unknowable and unpredictable context, and as such entrepreneurship in e-business by necessity exceeds the traditional concepts of entrepreneurship. For example, the traditional notion of entrepreneurship of being or becoming an expert or finding and protecting a unique knowledge in a niche market, clashes with the fact that e-business knowledge is often short-lived and available to everyone, anytime, and anywhere (Steinberg, 2003, 2004).

Empirical studies demonstrate that the concept of e-entrepreneurship has changed in the wake of the dotcom crash, presenting new challenges to e-entrepreneurs. In 2003, Steinberg (2003) conducted a multiple-case study on e-entrepreneurship in the Greater London business area, which provided intriguing findings about the changes in the social meaning of e-entrepreneurship since the dotcom crash. The study used a sample of 42 dotcom entrepreneurs who had started a small business in the wake of the dotcom crash in 1999/2000 or who had business which survived the crash. In the view of the entrepreneurs surveyed, entrepreneurship in e-business was different to classic entrepreneurship. In terms of skills and knowledge, e-entrepreneurship requires not only basic business skills and expert knowledge, but also the social skills necessary to be able to relate to other disciplines and sectors. In this regard, relationship and partnership with other sectors and businesses are crucial to e-entrepreneurship. The study also found that the dotcom crash had proven to be a positive turning point for a new generation of entrepreneurship which would open up e-businesses and endeavour to establish a new professional identity within e-business. E-business networks also played a central role within the new e-entrepreneurship. This e-entrepreneurship community was made up of business people who had previously been working in other sectors or in other firms and had moved into the e-business field to pursue a new personal and professional challenge. Traditionally, expertise in entrepreneurship was limited, by and large, to one specialist discipline, however, unlike the traditional entrepreneurship, the new sense of entrepreneurship in e-business was determined by the ability to creatively combine different sets of expertise to accommodate the wide range of needs of e-businesses powered by rapidly evolving and complex new digital technologies. The very character of e-business thus shaped the fundamental construct of e-entrepreneurship, that is, constantly engaging in, and developing innovative information and communication technologies in one way or another.

2.2 E-Innovation

E-innovation can be broadly defined as innovation that is related to e-business. Technological innovations in e-business have significantly changed inter-firm communications and have the great potential to revolutionize the efficiency and effectiveness of inter-firm relationships and their governance. Take Cybersettle.com for example. The company was founded in the mid-1990s by a pair of attorneys, and has not only survived the dotcom crash but attracted more customers and partners. The dotcom does what most do not and has created a thriving e-business model through e-innovation. Customers can use the website to settle a wide variety of commercial disputes online quickly and inexpensively. By August 2003, it had handled more than 75,000 transactions and over $US500 million in settlements (Winston, 2003).

The common and most important functionalities of the e-business technological innovations are standardization, centralization and formalization to facilitate inter-firm collaboration. However, technological e-innovation is only one aspect of e-innovation. It may include establishing and/or implementing innovative processes, operations, service, strategy, structure, technology, etc. in relation to e-

business. For example, e-innovation may represent an innovative strategy enabling customers to do what best serves their purpose via information communications technology (Martin, 2004). In order to implement an e-business innovation strategy and realize the commercial value of the innovation, companies often resort to partnerships which provide complementary resources and advantages in order to get things done.

3. ISSUES AND CHALLENGES FACING E-ENTREPRENEURSHIP AND E-INNOVATION

Today's e-business operates in a highly competitive marketplace where sustainable competitive advantage is almost impossible as there are minimal barriers to new entrants and competitors in the marketplace. Innovation faces constant challenges of imitation and erosion. There have been different views in the literature about the benefits of first movers in e-business marketplace. Mellahi and Johnson (2001) asked the question "does it pay to be first to market or should e-commerce firms wait for first movers to make an investment and then cannibalize the idea with lower entry cost?" The cause of the concerns are raised by a general belief that it is safer and less expensive to imitate the first mover in the e-business environment, where there is a higher level of technical uncertainties and rapid rate of technological innovation. For instance, many new dotcoms rushed to build an e-marketplace and chose imitation as a business strategy rather than innovation. This author argues that it is the lack of a combination of innovation and entrepreneurship capacity that has caused the demise of many imitators in the dotcom industry. The essence of innovation and entrepreneurship is taking a new idea to market, not imitating a new idea without taking into account the special needs of local markets, and being innovatively and proactively responsive to environmental changes by introducing a new product, process, service or implementing a distinctive business model as did the case companies studied in this paper.

In the early days of e-business, it was likely that most businesses could be applied differently online and offline. "Irrational exuberance" was prevalent within the market and venture capitalists were prepared to take on much more risk. However, since the dotcom crash, the market appears to have reverted to traditional models and methods. More attention has been given to the fundamental structural components of e-business, such as flow of revenue. E-business, to many companies, is now just seen as another channel to market (rather than signalling the demise of offline business as originally prophesized). Likewise, many senior managers interviewed for the present study indicated that there was no difference in the concepts of entrepreneurship online and offline. Traditional business models are here to stay. For new e-businesses to succeed, they need an innovative idea incorporated into a sound business model which is viable economically and which is facilitated by knowledgeable and experienced people.

As such, those entrepreneurial and innovative e-business activities which genuinely have utility for the customer (e.g. e-banking) are more likely to be successful. For example, the difference between retailing and banking is that while one is seen as an emotive and/or social activity, the other is perceived to be a chore. Therefore, offering an electronic channel to facilitate the latter is more likely to succeed than the former – people want convenience and speed when they bank but they are more likely to value other factors which an online channel may not necessarily be able to offer when they shop for goods and services. In this respect, dotcom companies should endeavour to enhance customer experience by offering tools on their Websites which enable customers to personalize the shopping process, and provide more personalized business services such as those offered by the bicycle company of the case study 2 of this paper.

3.1 Case Study 1: SpeakerDirect

SpeakerDirect (www.speakerdirect.com.au) is a young Melbourne (Australia) based dotcom, providing an online speaker portal. The online speaker portal business idea was developed in Dec 2003, and the portal was formally launched in March 2004, illustrating the fact that the founders believed that speed to market was one of the essential elements of their strategy, and a characteristic of the e-market. The Website system was developed from scratch with the premise that the company wanted a corporate friendly, and comprehensive tool for both speakers and speaker-seekers. SpeakerDirect is actually a business resource as well as a promotional platform. SpeakerDirect.com.au provides a free service for corporations to search and select corporate speakers. However, unlike their competitors, the company does not take engagement fees. The company has an ambitious goal of becoming the number one global speaker portal within five years and to connect up the entire business community. The company philosophy is one that aims to offer both speakers and seekers a personalized service alongside the electronic service, although the emphasis of their efforts is on the latter (e.g. they might meet with a major corporate and maintain communications by telephone on a frequent basis).

The founders and current directors of the company came from marketing and public relations background and also have experience in introducing an online tool in a market traditionally run by agencies. During their time within the corporate world, they identified a need and a business opportunity for a comprehensive search tool for corporate speakers. Under the traditional model, speaker-seekers were required to contact individual agencies who would provide a list of their registered speakers. The agency would then charge a fee on top of the speaker cost. However, this model is administration-heavy, for both the agency and the speaker-seeker, therefore the company's founders came up with the idea for an online speaker portal. This essentially is an online database of corporate speakers and entertainers which is free to search and provides a profile of each speaker, online show reels and indicative fees. Searchers can then contact speakers through the company's online system to arrange bookings etc. Speakers pay an annual fee to be listed on the Website, and in return, they are given their own personal Website (they can also link to their own Website), and an email inbox to receive and respond to inquiries. This is complemented by regular reporting functions (such as the number of searches the speaker has been displayed on, personal website hits received etc). The success of the model is evident, and only six months after the formal launch of the portal, SpeakerDirect.com.au has around 300 speakers, and 12,000 hits a day.

From the perspective of the Company's founders and directors interviewed for the present study, entrepreneurship and innovation mean risk (financial, emotional and personal):

"Entrepreneurship is taking control and action on a concept or a dream in the face of adversity. The tangible aspect of making that happen is where innovation comes in. For example, I want people to communicate with each other over long distances (the dream), therefore I am going to do something about it and invest time and dollars to do it even when everyone is saying it cannot be done/I am mad/it is too risky (entrepreneurship/the risk) and a phone is designed to achieve this (the innovation to achieve the dream). A combination of both is the 'big picture' that requires tenacious and passionate people to turn an idea into reality by being independent and in control" (Interview Data, 2004).

The business model that the company has developed is in itself an example of a combination of entrepreneurship and innovation – it is the first of its kind, replacing the idea of the client having to deal with many agencies separately, by creating a one-solution portal. Another example of entrepreneurship and innovation is the system behind the website. This was designed to be multi-functional (but streamlined) and very user-friendly for both speakers and seekers. One of the most innovative features is a bulletin board where companies can advertise an event for which speakers can express an interest in being engaged for – this would be a useful tool for anyone who is time-pressed or needs a speaker at short notice.

Another key e-dimension of entrepreneurship and innovation that the case company demonstrates is responsiveness to client and market needs. For example, SpeakerDirect.com.au is seeking to position itself as a media tool (e.g. by providing a service whereby speakers are available to journalists for "expert comment", gaining valuable and credible exposure, but without actually being engaged on a fee basis). In the directors' words, they have "flipped the agency concept on its head", and as a result, many seeker clients believe the free service is "too good to be true".

The company's initial success relies not only on its entrepreneurial and innovation capacities but also its active partnering program which includes developing existing relationships with corporations, and building strategic alliances with trade associations and other dotcoms. Evaluation of the partnerships is done upfront (e.g. with speakers, how to position themselves and with clients, what their needs are and how they can be met). For example, the company has developed a strategic alliance with an online talent agency located in the same premises, and has become part of the agency's network. The two directors of this agency also sit on the company's board, complementing the company's experience with their own eight years' experience in international Website development and with

actors and entertainers. The company has also engaged in developing working partnerships with corporate speakers.

According to the directors of the company, a plan has been made to develop a systematic procedure and structure for selection of speakers and monitoring of their performance. At this early stage of the process, all speakers are accepted. However, it is likely that after 12 months, those speakers who have not received engagements because, for instance, they are unsuitable, will not re-list themselves. Speakerdirect have however developed a reporting tool for speakers who want data in order to assess their relative successes, which details speakers' personal Website hits, enquiries, engagements etc.. Speakers are also encouraged to contribute to the marketing and public relations effort themselves by directing people to the Website and through self-promotion, because those who do not are likely to be less successful than those who do. Speakers do, however, have an initial consultation in which they can discuss their positioning. Subsequent evaluation by the company may include assessment of the speaker's fee, testimonials, their show reels and general credibility. On the client's side, key organizations and associations who may use the service are identified, and contacted in order to explore their needs and promote the online portal.

However, there are some issues relating to the company which may warrant attention. In terms of management of speakers, there needs to be people behind the system driving it and a commitment to the partnership between speakers and clients (seekers) on both sides. There is a corresponding need to be fluid, dynamic and responsive to needs, adapting to clients. Non-responsiveness or a slow turnaround and/or delivery of solutions are key problems which may damage the partnerships. In an online context, the intangibility of the service provided may also lead to customer dissatisfaction. The company has however tried to counter this with more tangible solutions, such as by producing company literature to give to speakers and seekers and through personal contact. The business model of SpeakerDirect is innovative in a sense that it is not an agency and takes no engagement fees, and it takes clients directly to speakers with the specific skills and areas of expertise they are looking for. However, the financial viability of the model remains a question, which inevitably reminds readers of the key lessons learned from the dotcom crash in 1999/2000.

There is also an issue of acceptance and credibility facing this young and innovative company. It has found that corporations have often been sceptical about the online speaker portal service, because they have been conditioned to think and work according to how the market worked previously: e.g. dealing with numerous agencies, or believe that they should be paying a fee for the service. In this respect, they think the online speaker portal concept may be *too* entrepreneurial. However, the company addresses these concerns with education, personalization of the service (e.g. telephone contact), and by evidencing its credibility within the corporate world. The founders also experienced difficulties in strategizing and implementing their idea, and believe that more education and funding for small businesses are required in order that e-commerce does not appear to be too elusive for startups.

3.2 Case Study 2: Bicycle Exotica

Bicycle Exotica was formed in 1999, after the owner-manager experienced frustrations while attempting to purchase a high-end bike for himself. Prior to this he had been employed by a bicycle wholesaler, and therefore had some expertise in the area. The case company imports a range of high-end ($AU5,000+) bicycles and components and sells them direct to the public in Australia, unlike the traditional supply model where wholesalers sell to bike shops. The company employs one other full-time staff member and gets part-time support from the owner-manager's partner. Specific activities such as book-keeping and web site development are outsourced. Turnover was around $AU750,000 in 2003.

The direct-selling business model is non-traditional and risky, as bikes (especially high-end models) are an emotive product and customers prefer to 'see before they buy'. However, the owner/manager's earlier experiences of trying to buy a high-end bike convinced him that not only could he improve access to the products for customers, but he could 'cut out the middle man' and so offer the bikes at a more competitive price than the traditional model of selling through shops. The Bicycle Exotica Website provides an online 'shop front', although the owner/manager encourages customers to contact him directly. He likes to offer a personalized service (he might speak to a customer five times before a sale), and in this way he overcomes the intangible element of his business. The Website specifically does not offer a 'shopping cart service', again because of the product characteristics.

The company's business model obviously has advantages and disadvantages compared to the traditional bricks-and-mortar model. Australians often buy high-end bikes from the United States, because it has a smaller number of supply steps than the Australian market and therefore bikes can be offered at a cheaper price. However, Bicycle Exotica's business model means they can compete with the global market.

Bicycle Exotica has consciously tried to maximize the advantages of their business model, and minimize its disadvantages by using innovative methods. For instance, rather than using a print catalogue, the company developed a CD which comprehensively showcases its products. In addition, the company's Website has a level of detail higher than the standard amongst bike sellers. Most important of all, the Website is a core part of the business rather than an 'add-on'. The company has also developed a 'bike fit' program whereby customers can send their body measurements to ensure they get the right size bike, which again, is a departure from the traditional method whereby it is done in person. The owner/manager frankly admitted that he had "stuck his head out" by selling direct to the public because the bike industry is traditionally quite protective. Furthermore, the owner/manager's offering of a personalized service to customers provides for the emotive element of the sale. The company can sell high-end bikes at a similar price to lower-end bikes sold through shops. However, this philosophy has not been embraced by everybody. For example, one competitor applied pressure to an Australian bike magazine in order to prevent the company advertising within the magazine. Nonetheless, the company tries to maintain good relationships in the industry by offering bike shops discounted bikes for them to resell to their customers.

It is likely that the business model would not succeed if the company did not maintain good partnerships with other bike sellers, suppliers, Website developers and other Web technology providers. To enhance customer services and minimize the disadvantage of online sale, the case company has developed a tentative 'clicks and mortar' partnership with a Sydney bike shop in relation to one of the bike brands it sells. Customers can view the range at the bike shop and purchase them through them. The company will sell the products to the bike shop at such a price that they can offer them at the company's prices (ordinarily, although shops would buy the company's products to resell to their customers at a favourable price, the resale price would still be higher than what the company would sell it for). Customers are hence getting the 'best of both worlds' whereby they can view the products they want to buy, at a favourable price, although the profit margins would be lower for both the company and the bike shop than if the bike was sold direct.

Although the e-business model is working well, there are serious challenges the company has to address. The bike industry is a typical cottage industry, where many businesses are owner/manager or run by bike riders, but not business people. To this extent, entrepreneurship and innovation are still relatively new concepts. According to the owner/manager interviewed for the present study, at present the Internet is hardly being utilized effectively by the industry in Australia and most Websites are superficial. B2B electronic supply chains hardly exist in the bike industry (although he claims, they would be welcomed!). The market is also fairly small, with many competing products, which means that no one business has a big enough share that they can invest in innovative ideas. Nevertheless, the case company has survived the worldwide dotcom crash and is profitable, thanks to its innovative and entrepreneurial business model and good working relationship with its brick-and-mortar partners.

4. FUTURE TRENDS OF E-BUSINESS AND THEIR IMPLICATIONS

As the key premise of e-entrepreneurship and e-innovation lies in a thriving e-business environment, their future development is tightly bound with, and determined by, the future of e-business. The author speculates possible development trends in e-commerce and e-business in the near future on the basis of current development patterns and discusses the implications of the trends for e-entrepreneurship and e-innovation.

E-commerce and e-business practices will continue to grow. Industry analysts and renowned research groups such as Gartner Group projected a strong growth in e-commerce and e-business, estimating that the market would be worth $US7.3

trillion worldwide in 2004, and will continue to grow in the next few years. But, unlike some of the present examples, e-business will be more mature (rather than experimental) in nature, in terms of the scope, quality and credibility of online customer services and products. Participating in e-business will be part of every executive's job in the near future. Despite its success, the recent initial public offering (IPO) of Google's shares saw them fall below the price range set by its executives, suggesting that many investors were still very cautious about e-business in the wake of the disastrous dotcom crash in which millions of shareholders around the world were badly burned. The response to Google's IPO indicated that the public expectation for high-tech e-business ROI tends to be normal now, and views e-business and e-commerce as the same as other businesses. The implication of this trend is an opportunity for growth as well as challenges of succeeding in a relatively mature market where quality and credibility of products and service count.

The collaboration of e-businesses is, and will continue to be, the key to sustained business success. An e-business strategy will be ineffective without an integrated e-partnership strategy, because the ability to leverage collaborative relationships becomes essential in today's competitive e-business world. Consumer/purchaser power will dominate the e-business world and propel smaller e-entrepreneurs to bind together to provide customers with an ever-widening array of products and services, real-time and rich information, and speedy and quality transactions. Moreover, collaborative e-partnerships help to streamline the product-to-market process through collaborative planning and design, improve efficiency from the channel network by reducing inventories, and ultimately generate profitability. However, alarmingly, many e-business alliances failed, or did not achieve their goals. How to make e-partnership work requires more than the navigation of technological hurdles and complexity. Human, organizational and cultural factors become more crucial as e-business moves towards maturity. The biggest challenges to managers include conflict in different organizational and country cultures, taxation, financial and commercial risks, and legal risks concerning on-line intellectual property, national and international on-line trade and law (Zhao, 2006).

Lee and Whang (2002) maintain that the future of e-business lies in intelligence. They believe that the next trend of e-business is intelligence at the supply chain level. Intelligence refers to the capacity for processing, accessing, controlling and managing information and knowledge. If this view holds true, the implications for future entrepreneurship and innovation are profound. To enhance the intelligence will be the main business line and the focus of e-entrepreneurial and e-innovation businesses.

In terms of e-marketplaces, it would appear that a trend has developed whereby the current highly successful mega e-marketplaces such as Amazon.com, eBay and the like increasingly drive smaller players out of markets and limit competition, thus turning e-marketplaces into oligopolies (Murtaza, et al., 2004). However, the ubiquity of the Internet is and will continue to be a strong counter force to the formation of oligopolies as there are actually no barriers to market entry in the cyber world, and the Internet provides constant opportunities to engineer new types of entrepreneurial business and innovation. Future e-marketplaces will require a whole range of quality services and innovative products, and alliances to deliver supreme value to customers. Thus, deals based only on price will be obsolete in future e-marketplaces.

Although the concept is as old as the manufacturing process, quality management will gain momentum in e-business management. The failure of many e-businesses and the dotcom crash have on the whole been caused by poor quality customer services and support, problems with Website security and technologies, and weaker change management (Janenko, 2003). The key principles of quality management will be the fundamental cornerstone to e-business success, which include:

- Customer focus;
- Continuous improvement and measurement to achieve customer satisfaction;
- Acquiring customer and market knowledge;
- Mutual respect, mutual trust and mutual benefit of all stakeholders;
- Consistent and precise performance to high standards in all areas of the organization;
- Striving for excellence through benchmarking, etc;
- Measurement of quality using data and tools;
- Improving quality and efficiency of decision-making;
- Better use of resources to achieve effectiveness and efficiency;
- Results focus;
- Management by facts and processes;
- Effective leadership and team commitment;
- Teambuilding and collaboration;
- Valuing employees & human and intellectual capital;
- Employee training/education/development;
- Empowerment and involvement; and
- Opening channels of communication.

These familiar components of quality management undoubtedly offer an essential guide for the quality operations of e-entrepreneurial and innovation businesses. It is a wide-spread fallacy that a good quality Web site design and a high volume of hits or traffic are good indicators of quality and will lead automatically to e-business success (Janenko, 2003, Ross, 2003). Indeed, it is this misconception that turned the "dotcom boom" into "dotcom doom". The primary fundamental quality management constructs therefore still have appeal in current and future e-business management.

5. CONCLUSIONS

In this frenetically changing competitive landscape, entrepreneurship and innovation enable organizations to gain competitive advantage and hold the key to their e-business success. The fast growth and business success of companies such as eBay, Amazon.com, travel.com and priceline.com, along with the bankruptcy of numerous dotcom firms worldwide in 2000 hold potent management implications for IT innovation and entrepreneurial organizations worldwide. As such, e-entrepreneurship and e-innovation have become emerging disciplines for proactively responding to changes in the e-business world.

This paper identifies and studies issues and challenges facing e-entrepreneurship and e-innovation. One of the key issues facing e-entrepreneurship and e-innovation today, as demonstrated by the case studies in this paper is that e-business needs to respond closely to market needs and gain market credibility. Another key issue is that there should be credibility built within the e-business marketplace before inception of the business. In addition, the intangibility of an online service needs to be addressed in order to build brand awareness. The discussion of the issues as such provides readers with both theoretical and practical guideline for a further study.

REFERENCES

Hamm, S. (2003). Startups may die, but not their bright ideas. *Business Week*, March 10, 2003, 52-53.

Janenko, P. M. (2003). E-business: the illusion of automated success. *The TQM Magazine.* 15(3), 180-186.

Lee, H. L. & Whang, S. (2002). Supply chain integration over the Internet. In J. Genunes et al. (Eds.), *Supply chain management: models, applications, and research directions* (pp. 3-18). Bordrecht: Kluwer Academic Publishers.

Martin, L. M. (2004). E-innovation: Internet impacts on small UK hospitality firms, *International Journal of Contemporary Hospitality Management*, 16(2), 82-90.

Mellahi, K. & Johnson, M. (2001). Does it pay to be a first mover in e-commerce? The case of Amazon.com. *Management Decision*, 38(7), 445-452.

Murtaza, M. B., Gupta, V., & Carroll, R. C. (2004). E-marketplaces and the future of supply chain management: opportunities and challenges. *Business Process Management Journal,* 10(3), 325-335.

Ross, D. F. (2003). *Introduction to e-supply chain management: engaging technology to build market-wining business partnerships.* Boca Raton: St. Lucie Press

Steinberg, A. (2004). Entrepreneurship and success in e-business: on changing meanings of expertise and community in e-entrepreneurship. London: The London School of Economics and Political Science. Retrieved April 21, 2004, from http://www.mariecurie.org/annals/volume3/steinberg.pdf.

Steinberg, A. (2003). *The re-definition of expert knowledge in e-entrepreneurship: a study on the sense-making of success and decision-making amongst e-entrepreneurs in the wake of the dotcom crash.* London: London School of Economics.

Winston, P. (2003). Cybersettle Inc. www.cybersettle.com . *Business Insurance*, November 3, 2003, 37(44), 12.

Zhao, F. (2006), Maximize Business Profits through E-partnerships, Hershey, NJ: IDEA Group Publishing.

Dimensions of Autotelic Personality in the Context of Mobile Information and Entertainment Services

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ABSTRACT

Autotelic Personality represents an important individual construct in flow theory yet little is known about its underlying dimensions. Csikszentmihalyi (1988) suggested that the higher the autotelic nature of an individual, the more likely for him/her to experience flow. This study explores autotelic personality, its underlying dimensions and its relationship with perceived playfulness in the context of Mobile Information and Entertainment Services (MIES). This study found Autotelic Personality to be an important quality in order for users to experience perceived playfulness in the MIES context. Several underlying dimensions of Autotelic Personality were identified, including personal innovativeness, self efficacy and control.

INTRODUCTION

Autotelic Personality characterizes a person "who is able to enjoy what he is doing regardless of whether he will get external rewards from it and who thus is more likely to experience flow for a given activity" (Hoffman & Novak, 1996). Csikszentmihalyi (1988) in his study of happiness identified what an 'autotelic' personality is – a person who sets their own goals, whether short-term or long-term, and then has great fun in achieving them. As Csikszentmihalyi stated:

"...the complexity of a flow activity is limited by the degree of challenge it can provide, and by the willingness and "creativity" of the person to create challenges in an activity. A person who can do this well, or who has the ability to enter a flow state relatively easy, is said to have an "autotelic personality"

Although Autotelic Personality is identified as an essential part of the Flow model by Csikszentmihalyi, very little research explored the underlying dimensions of Autotelic Personality (Finneran and Zhang, 2005; Nakamura and Csikszentmihalyi, 2002).

The convergence of mobile commerce and internet technologies has promised users unprecedented convenience and greater enjoyment. In recent years, mobile information and entertainment services (MIES) has been gradually gaining popularity among mobile phone users (Garcia-Macias, 2003; Baldi and Thaung, 2002; Van de Kar et al. 2003). Research into mobile internet to date has by and large focused on extrinsic use of these services, for example, productivity and usefulness and has largely ignored important end-user characteristics. To better understand users' acceptance of MIES, we argue that it is equally important to examine an intrinsic motivator "Perceived Playfulness", defined as:

"The extent to which the individual perceives that his or her attention is focused on the interaction with the World-Wide-Web; is curious during the interaction; and finds the interaction intrinsically enjoyable or interesting" (Moon and Kim, 2001)

This construct was proposed by Moon and Kim (2001) based on the theory of flow and its importance verified by Chung and Tan (2004). However, some researchers have recently pointed out that individual differences have been ignored in many flow related studies (Finneran and Zhang, 2005; Nakamura and Csikszentmihalyi, 2002).

Therefore to gain a better understanding of the role of Autotelic Personality in MIES, it is important to identify those individual differences likely to make up Autotelic Personality and which contribute to the emergence of Perceived Playfulness.

INDIVIDUAL DIFFERENCES AND PERCEIVED PLAYFULNESS

Individual differences refer to factors such as personality, situational, and demographic variables that influence user's beliefs about and use of information technology. In the context of Flow, Webster and Martocchio (1992) studied microcomputer playfulness and suggest microcomputer playfulness act as an individual' tendency to interact spontaneously, inventively and imaginatively with microcomputers. It is a situation specific individual characteristics represents a type of cognitive playfulness. Moon and Kim (2001) considered Perceived Playfulness as an intrinsic belief or motive, which is formed by an individual's subjective experience with IS/IT. Hence, identifying those individual characteristics that lead to Perceived Playfulness may provide insight into this (stable) individual belief construct.

This study examines the pattern of relationships between Perceived Playfulness and those individual differences that lead to its occurrence. We are also keen to know whether these individual differences are likely to be the dimensions of Autotelic Personality. This study draws upon previous research on Flow as Perceived Playfulness is fundamentally based on Flow. Prior work related to the state of flow with information technologies has adopted alternative conceptualizations, often with different terminology of the major dimensions related to Flow construct (Siekpe, 2005; Finneran and Zhang, 2005). Most research tends to use these individual differences (except Focused Attention) as antecedents of flow instead of underlying dimensions as shown in Table 1.

Personal Innovativeness and Flow

The flow experience usually occurs in structured activities such as games, ritual events, sports, artistic performances, etc. (Csikszentmihalyi 1988). It does not normally occur in everyday life because challenges and skills are rarely balanced. However, even if skills and challenges are balanced, it does not guarantee a flow experience occurring. This is due to the fact that activities only provide the challenges; it is still up to the individual to recognize the challenge, provide the skills, and extract enjoyment from the activity. Therefore, challenge is more related to the perceived complexities *provoked by* the activity rather than the individual per se. As Csikszentmihalyi (1988) stated; the complexity of a flow activity is limited by the degree of challenge it can provide, and by the willingness and "creativity" of the person to create challenges in an activity. Because of this reason, Personal Innovativeness introduced by Agarwal and Prasad (1998) was deemed important in the context of our study. Personal Innovativeness in the domain of information technology is conceptualized as an individual trait reflecting a willingness to try out any new technology. Furthermore, Agarwal and Karahanna (2000) provide

Table 1. Different conceptualizations of personal innovativeness, self efficacy, control and focused attention

Individual Difference	Construct	Dimensions	Antecedents
Personal Innovativeness	Cognitive absorption; Flow	Flow-Finneran and Zhang (2003)	Cognitive absorption-Agarwal and Karahanna (2000)
Self Efficacy/Skills	Flow		Koufaris (2002); Ghani et al. (1991); Hoffman and Novak (1996); Novak et al. (2000)
Control	Flow; Perceived Playfulness	Trevino and Webster (1992); Webster et al. (1993); Koufaris (2002)	Chung and Tan (2004); Ghani and Despande (1994); Ghani et al. (1991); Webster and Ho (1997); Chen (2000);
Focused Attention	Flow; Perceived Playfulness	Trevino and Webster (1992); Webster et al. (1993); Koufaris (2002)	Hoffman and Novak (1996); Novak et al. (2000); Chung and Tan (2004);

empirical support of its influence on cognitive absorption, which is a construct similar to flow. In this regard, Pagani (2004) suggests individual innovativeness can be seen as willingness to adopt 3G multi-media services.

Self Efficacy and Flow

Self Efficacy is similar to Skill which has been well studied in research on Flow (Koufaris, 2002; Ghani et al. 1991; Hoffman and Novak, 1996; Novak et al. 2000). Recall that the most important condition for a Flow state to occur is when the challenges of a situation match the skills of the participant. Past researches have drawn distinction between general self-efficacy and computer self-efficacy (CSE). While the former being an overall judgement of an individual on efficacy across multiple computer application domains, the later represents the judgement on specific task in the domain of general computing. Agarwal et al. (2000) pointed out that there is a significant support for a relationship between self efficacy and individual beliefs about IT. Their result suggests software specific self-efficacy will have a stronger effect than the initial general self-efficacy due to the "carryover" effect, i.e. the accumulated application specific self-efficacy will eventually displace the effects of initial belief with the passage of time. Because of this reason, Computer Self Efficacy (CSE) is preferred over Skill as the latter may convey the meaning of general competency on everyday tasks.

Control, Focused Attention and Flow

Hoffman and Novak (1996) developed a theoretical mode of Flow within the hypermedia context. In this model, Challenges, Skills and Focused Attention have been modeled as the primary antecedents of flow. Other secondary antecedents (Interactivity and Telepresence) were also added in accordance to the literature of hypermedia. The consequence of flow leads to increased learning, perceived control, exploratory behavior and positive experience. However, their earlier work is exploratory in nature therefore all the hypothesized relationships were not empirically tested. Novak et al. (2000) later revised the original model and changed Control as a primary antecedent of flow. The revised model was then tested and results showing all these four antecedents exert positive and significant on flow. A somewhat interesting finding is that they model Control and Skill together as a higher order construct (i.e. Skill/Control) However, a distinction should be made between these two, control capturing an individual's perception that he/she exercises control over the interaction with environment (Webster et al.. 1993) whereas Self Efficacy (Skill) is the judgement on specific task in a specific domain prior to that interaction. Chung and Tan (2004) in their study also proposed Focused Attention and Control as two individual cognitive aspects that lead to Perceived Playfulness.

DEVELOPMENT OF THE RESEARCH HYPOTHESES

From the literature review, several limitations were identified. It was noted that there was a lack of focus on the individual side in the literature on intrinsic motivation. It has also been found autotelic personality as an important personality construct has not been well examined in previous studies. The hypotheses to be explored in this paper therefore are:

H1: Personal Innovativeness, Focused Attention, Self Efficacy and Control are positively related to Perceived Playfulness
H2: Autotelic Personality is a second order reflective structure formed by Personal Innovativeness, Self efficacy, Control and Focused attention
H3: Autotelic Personality is positively related to Perceived Playfulness

RESEARCH METHODOLOGY

Sampling

The sample consisted of university students who attend information system and business lectures at Auckland University of Technology. Participants were a total of 149, who volunteered to participate in the study. The participants were 99 males and 55 females. In terms of phone categories, about 60% of all the respondents specified they have WAP-enabled mobile phone or GPRS phone. Respondents holding a 3G mobile phone came second in the list, with a significant proportion of 12% among the respondents. Users of the CDMA mobile phone are relatively few, only 7% compared to other phone categories. At the same time, 21% of all the respondents are not sure about the phones they are using. When asked whether their phone provides a feature with which to access MIES services, 83% of the respondents answered "Yes" to this question. This indicates the wide availability of mobile internet capable phones in the New Zealand market.

Research Design

Data was collected via personally-administered questionnaires in class. This study aims to explore the antecedents of Perceived Playfulness in the context of mobile information and entertainment services (MIES). It explains the relationships among variables and constructs in a theoretical model and examines the differences between two groups. Therefore, the purpose of this research is hypothesis testing, based on our extensive knowledge of the variables and their relationships in the theoretical framework. A questionnaire was used to collect the data. A participant information sheet was also given to each respondent. The data collection was conducted in November 2005 at Auckland University of Technology. Students from six classes were invited to do the questionnaires. A total of

Table 2. Measurements items

Variable	Source
Personal Innovativeness	*Agarwal and Prasad (1998)*
Self Efficacy	*Hung et al. (2003)*
Control	*Agarwal and Karahanna (2000)*
Focused Attention	*Webster et al. (1993)*
Perceived Playfulness	*Moon and Kim (2001)*

186 questionnaires were returned. Incomplete questionnaires were discarded, leaving 149 usable samples.

In terms of measurement, all items were constructed as agree-disagree statements on a seven-point Likert scale. Since the variables in interest have been previously validated under different contexts, mirroring the same items in a new context is straightforward. To ensure measurement reliability, items validated in previous research have been used (see Table 2). The measures for Personal Innovativeness, Self Efficacy, Control, Focused Attention and Perceived Playfulness were taken from or based on previous IS research and were modified to suit the MIES context. Adopting the same measures as others instead of creating new measures may enhance the comparability of the paper with others, specifically when existing measures already become a field standard (Churchill et al. 1999).

DATA ANALYSIS AND RESULTS

The data analysis technique employed in this study is Partial Least Squares (PLS). PLS is a recent technique that generalizes and combines features from principal component analysis and multiple regressions (Thompson et al. 1995). The PLS approach provides a means for directly estimating latent variable component scores. It is a technique comprised of measurement and structural models (Gefen et al. 2000). The aim of testing the measurement model is to specify how the latent variables are measured in terms of the observed variables, and how these are used to describe the measurement properties (validity and reliability) of the observed variables. The structural model investigates the strength and direction of the relationships among theoretical latent variables. Autotelic Personality as a second order factor can be approximated using various procedures. One of the easiest to implement is the approach of repeated indicators known as the hierarchical component model suggested by Lohmöller (1989, pp. 130-133). In essence, a second order factor is directly measured by observed variables for all the first order factors. This procedure works best with equal numbers of indicators for each construct.

Measurement Validation

To measure internal consistency of a given block of indicators, internal composite reliability (ICR) scores were obtained through PLS-GRAPH to assess the reliabilities of each latent variable. Where the internal consistency of any latent variable exceeds 0.70, this indicates tolerable reliability (Fornell and Larcker, 1981). All latent variables in our model have internal consistencies greater than 0.7, this indicates all constructs have high reliabilities. Two validities need to be captured in the measurement model: convergent validity and discriminant validity. Essentially, they estimate how well the measurement items relate to the constructs. PLS performs confirmatory factor analysis to establish factorial validity regarding these two validities (Gefen and Straub, 2005). To test convergent validity of the measures associated with each construct, the loadings and cross loadings of each indicator on the latent variables must also be examined. Convergent validity is shown when the *t-values* of these loadings are above 1.96 (Gefen and Straub, 2005). The results (Table 3) indicate almost all measurement items exhibit very high convergent validity on their measured latent variables.

However, it has been noticed that the first measure of Focused Attention (FoA1) and the second measure of Perceived Playfulness (PP2) exhibit very low loadings. The way to establish discriminant validity is to examine the square root of the AVE of each construct to the correlations of this construct to all other constructs.

Table 3. Convergent validities

	PI	SE	FoA	Ctrl	*PP*
PI1	**0.774**	0.257	0.190	0.331	*0.177*
PI2	**0.869**	0.410	0.261	0.417	*0.438*
PI3	**0.816**	0.492	0.104	0.412	*0.443*
PI4	**0.826**	0.372	0.213	0.357	*0.364*
SE1	0.410	**0.880**	0.041	0.443	*0.468*
SE2	0.408	**0.877**	0.012	0.443	*0.477*
SE3	0.475	**0.959**	0.045	0.470	*0.488*
FoA1	-0.021	0.017	**0.456**	0.123	*0.025*
FoA2	0.067	-0.058	**0.698**	0.168	*0.088*
FoA3	0.225	0.052	**0.866**	0.379	*0.281*
Ctrl1	0.401	0.430	0.304	**0.846**	*0.459*
Ctrl2	0.281	0.344	0.256	**0.769**	*0.329*
Ctrl3	0.442	0.415	0.369	**0.818**	*0.532*
PP1	0.152	0.076	0.300	0.226	***0.434***
PP2	0.107	-0.063	0.218	0.093	***0.105***
PP3	0.432	0.357	0.290	0.453	***0.779***
PP4	0.316	0.418	0.278	0.404	***0.775***
PP5	0.291	0.483	0.208	0.404	***0.768***
PP6	*0.379*	*0.488*	*0.230*	*0.498*	***0.846***

Table 4. Discriminant validities

	PI	SE	Ctrl	FoA	*PP*
PI	**0.824**				
SE	0.496	**0.934**			
Ctrl	0.468	0.498	**0.822**		
FoA	0.267	0.074	0.412	**0.808**	
PP	*0.486*	*0.534*	*0.557*	*0.316*	**0.739**

In the PLS-GRAPH, the AVEs can be easily obtained by performing a bootstrap re-sampling. Fornell and Larcker (1981) suggest that the square root of AVE should be greater than the corresponding correlations among the latent variables. The results shown in Table 4 demonstrate all latent variables exhibit high discriminant validities. The diagonal cells in the correlation matrix shown in Table 3 are the square root value of AVE for each latent variable.

The initial test of the measurement model using confirmatory factor analysis indicated that some construct revisions were needed. The loadings and cross-loadings of indicator FoA1 and PP2 in Table 3 showed relatively low correlations on the latent constructs they were meant to describe. Essentially this result presents a need to re-specify the instruments. The approach described in Churchill (1979) is to purify the measures. Items that do not share equally in the common core should be eliminated. As suggested by Straub et al. (2004), this approach can be applied to PCA, PLS and covariance-based SEM. As a result, FoA1 and PP2 were eliminated in the revised model.

The Structural Model

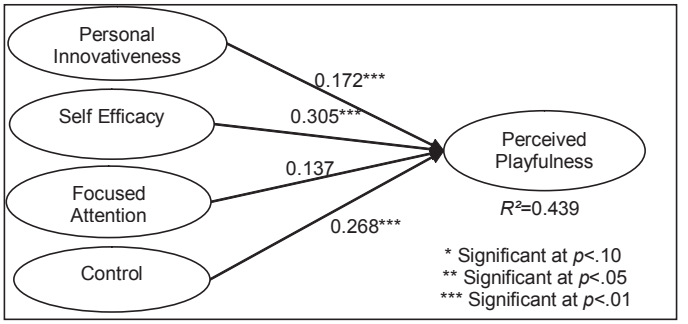
Testing Individual Differences on Perceived Playfulness

We first test the proposed four individual differences and their influences on Perceived Playfulness in the context of MIES. The results indicate all factors except Focused Attention exert significant influence on Perceived Playfulness as shown in Fig 1.

Testing Second Order Factor

When testing second order constructs, the percentage of the paths should be at 0.70 or above to establish the convergent validities of the first order factors (Chin, 1998). As shown in Fig 2, the correlations between Personal Innovativeness, Self Efficacy, Control and Autotelic Personality are highly correlated because the 0.70 threshold has been met. Since a reflective model would assume the first and

Figure 1. Individual differences as antecedents of perceived playfulness



second constructs are extremely highly correlated, a formative model seems less likely for Autotelic Personality. The low loading from Autotelic Personality on Focused Attention (after measurement revision) casts further doubt on its role in reflecting Autotelic Personality. Next, a mediation test was performed to see if the second order construct fully mediates the relationship between the first order factors and the theorized dependent variable (Chin, 1998). Autotelic Personality is used as a more parsimonious second order factor and it shows significant correlation its first order factors. As a surrogate of its first order factors, Autotelic Personality strongly influences Perceived Playfulness and is highly significant (β=0.647, t=11.2900). This aggregate measure is the only significant predictor of Perceived Playfulness when all first order factors are controlled for.

All items have large and significant loadings on their corresponding factors indicating evidence of good construct validities (Doll et al. 1994). For the latent variables, with *t-values* above 2.0 being considered significant, all factors except Focused Attention have large and significant structural coefficients, indicating good construct validity. The *R-square* values (0.627~0.672) showing three of the four first order factors (Personal Innovativeness, Self Efficacy and Control) can be reliably explained by Autotelic Personality. Based on these results, Hypotheses 1, 2 and 3 were supported.

DISCUSSION AND CONCLUSION

Chin and Gopal (1995) suggest the relative importance of the reflective model is established by contrasting the loadings from the overall latent belief with each of the individual beliefs. Each belief represents a separate attitudinal dimension which reflects an existing overall attitude. Our findings suggest all underlying factors (Personal Innovativeness, Self- Efficacy, Control and Focused Attention) significantly correlated with Autotelic Personality. The loading of Focused Attention indicate it is not an important underlying belief in reflecting Autotelic Personality compared to other factors. According to Buchanan et al. (2001), navigate the mobile internet via mobile phones can be a daunting experience given the constraints of small screen display and cumbersome input mechanisms. A common criticism of early WAP sites was that they involved too many selections and moves between menus and submenus, for the user to achieve their desired contents. Therefore, user's Focused Attention is likely to be affected by the screen size of mobile phones (Buchanan et al. 2001; Sweeney and Crestani, 2006).

Our findings suggest all underlying factors (Personal Innovativeness, Self- Efficacy, Control and Focused Attention) significantly correlated with Autotelic Personality. On the other hand, only Personal Innovativeness, Self Efficacy and Control significantly determine Perceived Playfulness. High correlations were also identified between these three factors and Autotelic Personality. This is consistent with Asakawa (2004) that autotelic students are those felt more in control of the situation and positive about challenges as compared to their non-autotelic counterparts. Acknowledging that an autotelic person perceived challenge situation differently from non-autotelic person, this study integrated Personal Innovativeness as one of the underlying dimension of Autotelic Personality (Agarwal and Karahanna, 2000). The higher loading of Autotelic Personality on Personal Innovativeness and Control indicates both constructs are important dimensions of Autotelic Personality. This study also provides empirical evidence that Self Efficacy is a significant dimension of Autotelic Personality in the context of MIES.

In summary, the important dimensions of Autotelic Personality are: Personal Innovativeness, Self-Efficay and Control. These dimensions are positively related to Perceived Playfulness. This study thus empirically proves the existence of this important construct and the predisposition of its core dimensions to lead to the occurrence of Perceived Playfulness in the context of MIES. Our findings suggest individuals with Autotelic Personality are more likely to experience Perceived Playfulness in relation to these services. In terms of practice, it is possible to use these dimensions to address the unique needs of different user groups. For example, it might be a possibility to categorize MIES users according to the importance of Personal Innovativeness, Self Efficacy and Control when designing marketing strategies for service offerings. As Hoffman and Novak (1996) suggest, this has crucial implications for market segmentation of the mobile marketplace.

REFERENCES

Agarwal, R., Sambamurthy, V., & Stair, R. (2000). Research report: The evolving relationship between general and specific computer self-efficacy - An empirical assessment. *Information Systems Research*, 11(4), 418-430.

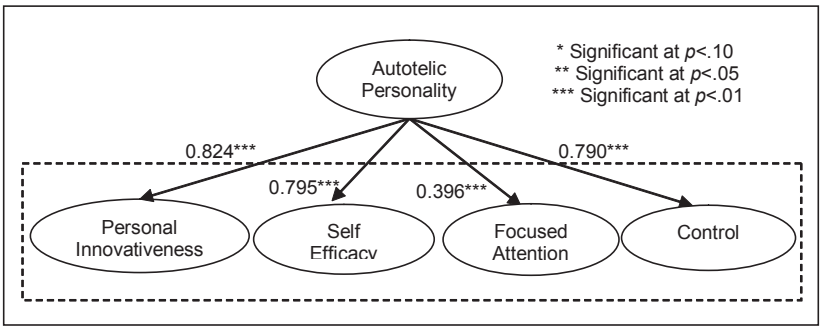
Agarwal, R., & Karahanna, E. (2000). Time flies when you're having fun: Cognitive Absorption and Beliefs about Information Technology Usage. *MIS Quarterly*, 24, 665-694.

Agarwal, R., & Prasad, J. (1998). A Conceptual and Operational Definition of Personal Innovativeness in the Domain of Information Technology. *Information Systems Research*, 9(2), 204-215.

Asakawa, K. (2004). Flow experience AND autotelic personality In Japanese College students: How Do They experience challenges In Daily life?. *Journal of Happiness studies*, 5(2), 123-155.

Buchanan G, Jones M., Thimbleby H., Farrant S. & Pazzani M. (2001). Improving mobile Internet usability. *Proceedings of the 10th International Conference on World Wide Web*, Hong Kong, May 2001, pp 673-680. ACM Press.

Figure 2. Second order reflective construct



Chen, H. (2000). Exploring Web Users' On-line Optimal Flow Experiences. Unpublished PhD Dissertation, School of Information Studies, Syracuse, NY: Syracuse University

Chin, W. W., & Gopal, A. (1995). Adoption intention in GSS: Relative importance of beliefs. *The Data Base for Advances in Information Systems*, 26(2/3), 42-64.

Chin, W. W. (1998). Issues and Opinion on Structural Equation Modeling. *MIS Quarterly,* 22(1), pp. vii – xvi.Chung, J., & Tan, F. B. (2004). Antecedents of Perceived Playfulness: An Exploratory Study on. User Acceptance of General Information-Searching Websites. *Information & Management,* 41(7), 869-881.

Chung, J., & Tan, F. B. (2004). Antecedents of Perceived Playfulness: An Exploratory Study on. User Acceptance of General Information-Searching Websites. Information & Management, 41(7), 869-881.

Churchill, G. (1979). A paradigm for developing better measures of marketing constructs. *Journal of Marketing Research*, 16**,** 64-73.

Churchill, G. (1999). *Marketing Research: Methodological Foundation*. New York: The Dryden Press.

Csikszentmihalyi, M. (1988). The Future of Flow. In Csikszentmihalyi, M., & Csikszentmihalyi, I. S. (Eds.), *Optimal Experience*: *Psychological Studies of Flow in Consciousness* (pp.364-383). New York.

Davis, F. (1989). Perceived Usefulness, Perceived Ease of Use, and User acceptance of Information Technology. *MIS Quarterly*, 13**,** 318-339.

Doll, W.J., Xia, W., & Torkzadeh, G. (1994). .A Confirmatory Factor Analysis of the End-User Computing Satisfaction Instrument. *MIS Quarterly*, 18, 453-461.

Finneran, C. M., & Zhang, P. (2005). Flow in computer-mediated environments: Promises and challenges. *Communications of the Association for Information Systems*, 15, 82-101.

Fornell, C., & Larcker, D. F. (1981) Evaluating Structural Equation Models with Unobservable Variables and Measurement Error. *Journal of Marketing Research*, 18, 39-50.

Garcia-Macias, J. A., Rousseau, F., Berger-Sabbatel, G., Toumi, L., & Duda, A. (2003). Quality of Service and Mobility for the Wireless Internet. *Wireless Networks*, 9, 341-352.

Gefen, D., & Straub, D. (2005). A Practical Guide to Factorial Validity Using PLS-Graph: Tutorial and Annotated Example. *Communications of the Association for Information Systems*, 16(5), 91-109.

Gefen, D., Straub, D., & Boudreau, M.C. (2000). Structural Equation Modeling and Regression: Guidelines for Research Practice. *Communications of the Association for Information Systems*, 4(7), 1-80.

Ghani, J., & Deshpande, S. (1994). Task Characteristics and the Experience of Optimal Flow in Human-Computer Interaction. *The Journal of Psychology*, 128, 381-391.

Ghani, J., Supnick, R., & Rooney, P. (1991). The Experience of Flow in Computer-Mediated and in Face-to-Face Group. In Degross, J., Benbasat, I., DeSanctics, G., & Beath, C. (Eds.), *Proceedings of the Twelfth International Conference on Information Systems* (pp. 229-238). New York.

Hoffman, D. L., & Novak T. P. (1996). Marketing in Hypermedia Computer-Mediated Environments: Conceptual Foundations. *Journal of Marketing*, 60, 50-68.

Hung, S. Y., Ku, C. Y., & Chang, C. M. (2003). Critical factors of WAP services adoption: An empirical study. *Electronic Commerce Research and Applications*, 2, 42-60.

Koufaris, M. (2002). Applying the technology acceptance model and flow theory to online consumer behavior. *Information Systems Research*, 13(2), 205-23.

Lohmoller, J. B. The PLS Program System: Latent Variables Path Analysis with Partial Least Squares Estimation. *Multivariate Behavioral Research* (23), 1989, pp. 125-127.

Moon, J. W., & Kim, Y. G. (2001). Extending the TAM for a World-Wide-Web context. *Information & Management,* (38)4, 217-230.

Novak, T. P., Hoffman, D. L., & Yung, Y.-F. (2000). Measuring the Customer Experience in Online Environments: A Structural Modeling Approach. *Marketing Science*, 19(1), 22-42.

Nakamura, J., & Csikszentmihalyi, M. (2002). The concept of flow. In C.R. Snyder & S.J. Lopez (Eds.), *Handbook of positive psychology* (pp. 89-105). New York: Oxford University Press.

Pagani, M. (2004).Determinants of Adoption of Third Generation Mobile Multimedia Services. *Journal of Interactive Marketing*, 18(3), 46-59.

Siekpe, J. S. (2005). An Examination of The Multidimensionality of Flow Construct in a Computer-Mediated Environment. *Journal of Electronic Commerce Research*, 6(1), 31-43.

Straub, D., Boudreau, M.-C., & Gefen, D. (2004). Validation Guidelines for IS Positivist Research. *Communications of AIS*, (13)24, 380-427.

Sweeney, S., Crestani, F. (2006), Effective search results summary size and device screen size: Is there a relationship? *Information Processing & Management*, 42(4), 1056-1074

Trevino, L. K., & Webster, J. (1992). Flow in Computer-Mediated Communication. *Communication Research*, 19(5), 539-573.

Webster, J., & Martocchio, J. (1992). Microcomputer playfulness: Development of a measure with workplace implications. *MIS Quarterly*, June, 201-226.

Webster, J., Trevino, L. K., & Ryan, L. (1993). The dimensionality and correlates of flow in human-computer interactions. *Computers in Human Behavior*, 9(2), 411-426.

Business Process Management for Collaborative Businesses

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ABSTRACT

Business process management is established for improving business processes within an enterprise. However, the concept could also be applied to enhance collaborative business processes spanning over multiple enterprises. In contrast to the intra-organizational case, management of cross-organizational collaborative processes imposes several organizational and technological challenges that result from the variety of independent actors in the environment of collaborations. This paper focuses on these challenges, presents a conceptual solution for the different management tasks, and demonstrates how a realized concept which supports networked enterprises in the management of collaborative business processes could look like.

1. INTRODUCTION

Nowadays, economic organizations are dramatically changing towards networked structures [ÖsFl00]. These are characterized by core competence specialized value units [PrHa90] that intensively interact along the added value in order to together generate the intended product. This intensification of exchanges leads to strong collaborative relationships (also called collaborative business, cf. [RöSc01], [Cama02]). So the ground is prepared for enterprise networks and virtual organizations [DaMa92]. Such collaborations are mainly driven by the intention to generate added value, which is achieved through synchronized execution of associated business tasks. This sequencing of activities constitutes a collaborative business process and implies special properties that strongly differ from the regular case [Wert06]. First, the activities are spanning over multiple organizations, because the generation of added value is performed through cross-organizational division of labour. Second, each of the individual business activities that compose the process clearly belongs to a unique organization. The collaborative business process can be partitioned in several parts, each of which contains one or more activities, distinctly associated with an organization and fully controlled by her. Therefore those parts of cross-organizational business processes, which strongly differ from intra-organizational ones, can be characterized as autonomous fragments. Consequently concepts and solutions developed for the intra-organizational case are mostly not suitable for cross-organizational purposes. This article investigates the Business Process Management concept in such collaborative environments. After explaining the intention of the concept, we propose a platform which is apt to support the idea for cross-organizational business processes. In the following sections the conceptual and technical basics of this platform are presented. In contrast to other approaches, e.g. [GrAb01], not only bilateral processing of business processes is focused, but end-to-end processes. Therefore, we will step through the three phases of the cross-organizational Business Process Management and show the concepts we developed for every phase. Afterwards we will show how the concept is realized so far and finish with a short outlook.

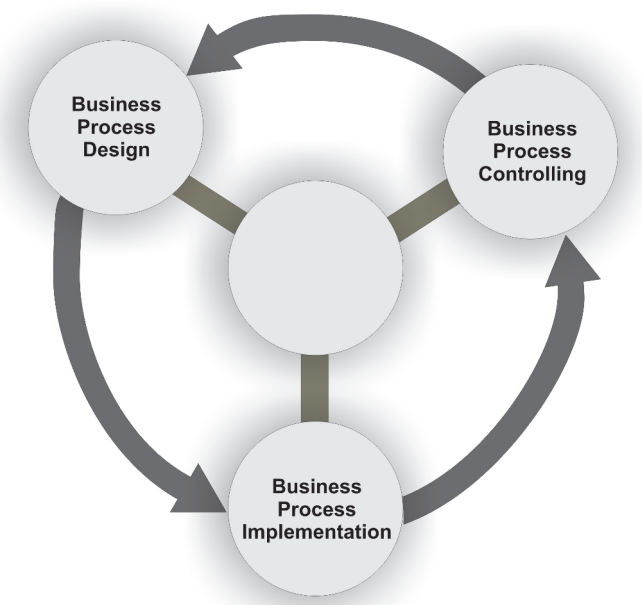
2. BUSINESS PROCESS MANAGEMENT IN COLLABORATIONS

A continuous and successful business strategy must not simply cover the design of business processes, since the design solely results in static models of the considered processes which do not allow for process changes. However, execution of these static models usually yields improvement potential over time, e.g., because the execution context changed or certain execution aspects were not reflected in the model. To realize and quantify these improvement potentials, it is necessary to measure execution of the models, i.e., perform controlling of them, which allows for identifying weaknesses and changing the models accordingly.

These three steps are integrated in the Business Process Management concept: business process design, business process implementation and business process controlling [ScJos02]. The basic lifecycle concept can be found in the House of Business Engineering [ScNü95; Sche96]. Business process design refers to modelling of existing as-is or intended to-be processes. This can be accomplished using modelling languages (e.g., EPC [KeNü92], BPML [Arki02]) and the respective modelling tools. Business process implementation summarizes all operative steps that are necessary to execute a process which was modelled before, including IT systems for execution as well as human interaction. Research effort is currently put into the exploration of mechanisms to minimize the need for human interaction in business process implementation. Business process controlling denotes all actions that aim towards measurement and examination of running and finished processes with the goal of discovering optimization potentials. Once found, such a potential can be realized by changing the process model in the next modelling phase.

This lifecycle is conceived for a single organization. In the design phase, each process model is changed by a single modeller at a time. During the execution phase, the process is handled by a single execution system within a single organi-

Figure 1. Business process lifecycle



zation. Consequentially all controlling information can be gathered "indoor", i.e., within the organization. However, in environments with multiple organizations acting cooperatively, collaborative processes cannot be regarded as monolithic anymore, since different parts of them are designed, executed and controlled by multiple different organizations [LuBu99]. Consequently the lifecycle abruptly gets very complex and difficult to handle:

The *design (respectively modelling)* task comprises multiple autonomous modellers that act independently and follow different goals. This results in self-contained parts of the collaborative business process. Therefore the process design can rather be characterized as an assembly task of autonomous process parts.

The *execution* is distributed over different enterprises. Consequently there is no central processing engine. Instead each autonomous process part has its own independent processing engine, so classic workflow concepts and technologies have to be extended to match the new cross-organizational requirements [Schu02].

Controlling means monitoring of running and finished processes and comparing them with set values. However, monitoring in the sense of determining unique process states is impossible for collaborative workflows, because their state is hidden in the autonomous workflow engines. They only disclose virtual state information that clouds the real procedures. Moreover, the controlling comprises the aggregation and calculation of valuation functions. However, these functions contain information on business structures (esp. cost factors). Such information is considered business-critical and inaccessible to third parties, even if they are partners.

Having revealed these gaps, we will step through these three phases and show the concepts for collaborative business processes in the next section.

3. CONCEIVING A CROSS-ORGANIZATIONAL BUSINESS PROCESS MANAGEMENT

Transferring the concept of business process management for single organizations to cross-organizational environments characterized by the involvement of multiple actors in the different phases requires the shift from a centralized paradigm to a support for distributed environments. For these actors a collective behaviour cannot be supposed. Thus each phase requires new techniques that are different to those of the classical business process management and that incorporate the split activities. Therefore we do not focus on bilateral processing of business processes, but on end-to-end processes with potentially a huge number of contributors.

Distributed Business Process Modelling

The design of business processes is considered one of the fundamental management tasks. In order to document the design, a specification medium is needed. On the conceptual level models have raised as the primary medium for business process specifications (e.g. EPC, BPML, BPEL, etc.). Thus the design task can be summarized as the creation of business process models. With regard to cross-organizational business processes, this actually comprises the model generation for an original that spans over multiple organizations. In principle this can be performed in a centralized and a decentralized way:

Supposing a centralized model creation, a single actor (that may also be incorporated by a group of collectively acting individuals) is in charge of the whole process model. This implies detailed knowledge and unrestricted access to all aspects of the process through all organizations. Due to the individual demand of protection, real-world organizations usually do not agree to fully expose their knowledge and their processes to a third party. So this case can be considered implausible.

Assuming a decentralized model creation, this implies the existence of different modelling individuals, each of which generates only parts of the process. Within this procedure they may follow different modelling paradigms, methods and languages. Therefore this approach requires both a technique for assuring the consistent individual model creation and a technique for the integration of the partial models.

Another dimension to cope with is the direction of the model creation procedure. In this sense, the differentiations are if a model is created in more and more detailing an abstract description of the model object or if the model builds up by adding more and more aspects to it and aggregate it afterwards.

Although from a theoretical perspective, such an approach has to cope with all potential permutations of modelling techniques, our approach is limited to a homogeneous approach, i.e., we presume the use of a single modelling language. Even in this scenario there are sufficient degrees of freedom for the modelling subject. In our implementation we use the event-driven process chain (EPC) language, which is one of the most common process model languages in Europe.

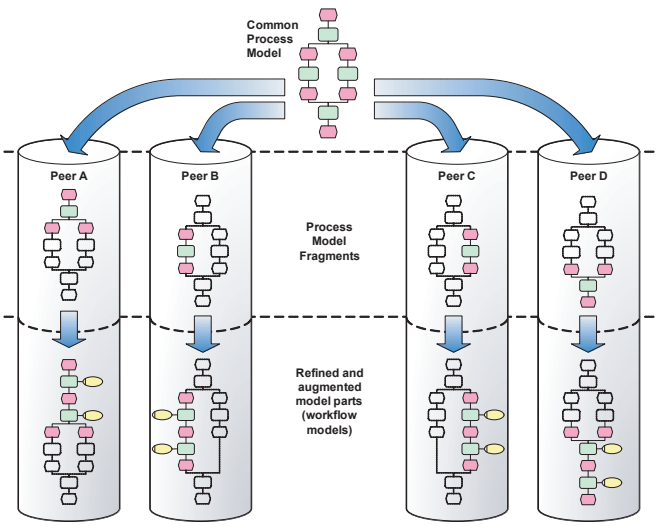
More precisely, our design procedure comprises four steps:

1. *Definition of process modules:* We start with the assessment of the status quo of the different organizations involved by specifying their capabilities. In our case they have to express their ability to produce output using process models that describe their possible processing sequences. The results are component-like models that can be assembled together and that incorporate process interface descriptions specifying interaction points.
2. *Definition of process intentions:* The composition of the process modules has to follow certain business objectives. In order to construct an objective-adequate process model, the intention of this process must be defined. This especially addresses the output the process has to deliver as well as the organizational constraints (e.g., the whole process has to be performed within the EU).
3. *Process module composition:* The composition itself is performed by analyzing compatibility of process interface pairs. That yields pairs of matching interfaces through which process modules can be connected. Based on those modules which are able to produce the intended outcome, a network of modules is successively constructed and generates the final product. Thus the composition is directed by the matching assignments of the process interfaces. The set is filtered by the organizational constraints of step 2 and rated by a common target function. The best rated result is the final one and describes a common cross-organizational business process model for all participants.
4. *Process model consistency analysis:* To avoid contradictions within the overall process model, the composition phase closes with a consistency analysis during which the model is analyzed with respect to flow logic consistency. Such a test is described for example in [SaOr99]. Having passed this test, the cross-organizational business process model can be realized within all involved organizations.

Distributed Business Process Execution

The distributed execution of a business process starts with a common process model that all participants share and that is business oriented, i.e., its content is mainly conceptual and its purpose is organizational management. From this model every participant extracts those parts that he has to execute and augments them with arbitrary information he needs for execution, e.g., refinements of process sub-parts or execution context parameters (cf. Figure 2). Thus the business model is transformed into an IT-oriented workflow model, the main purpose of which is the execution of the contained process. The following section introduces the steps from the common process model to the execution of the workflow model:

Figure 2. Distributed business process execution



1. *Splitting Up the Common Process Model:* All activities in the common process model are annotated with the executing organization unit ("Company X"), or with an organization unit role ("Customer") that can be mapped onto a concrete actor within the execution context. So the common model disaggregates in disjoint process model fragments that are executed by exactly one actor each. As the process modules were composed to the common process model during the modelling phase they have interface descriptions. So it is possible to define exactly which goods and which information must be transferred from one actor to another.
2. Apart from goods and information, the execution of the whole process devolves from one actor to another at an interface. Therefore it is necessary to define how the control of the process is transferred. At process junctions it may be even possible to split up process control or join multiple execution threads again.
3. *Augmenting the Process Fragments:* Execution of a process fragment usually requires considerable prearrangements on the part of the executing actor. Therefore the process fragment is first transformed from the modelling language into an executable language. Since the business process model is business oriented, it usually does not contain information about execution parameters, e.g., an IP address of an interface or authentication credentials for an ERP system. So it must be augmented with these missing execution parameters during or after transformation to the executable language. After that, the process fragment is contained in an executable workflow model.
4. Usually the common business process model disaggregates into multiple process fragments, each of which is transformed into a single workflow model. These workflow models are deployed to the respective IT systems then, which are finally configured with the contained information.
5. *Executing the Process:* Figure 2 shows how the whole top-level process is implemented by executing the workflow models of the process fragments which it consists of. After configuration of all involved systems this happens automatically, i.e., without interaction with individual process instances.

Since the whole process is executed fragment-wise by multiple separate systems, there must be transition points from one system to another where execution is finished or suspended at the source system and perpetuated at the target system. This transition has two different aspects: data flow and control flow. Data transfer between separate IT systems is widely used already, e.g., between departments within a single organization. However, the transfer of process execution control and context via push and pull mechanisms is not common. Especially in split and join situations, e.g., when a simultaneous execution of multiple process parts on multiple systems begins or finishes, the process context must be duplicated and merged accordingly. During execution, performance data is gathered as a means for the next step: the controlling phase.

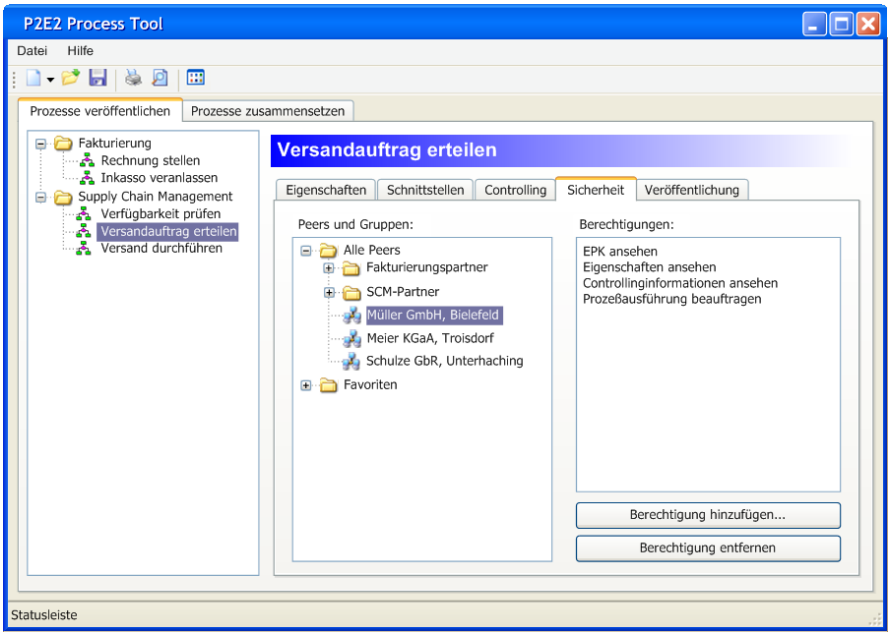
Distributed Business Process Controlling

From the management perspective, the ability to execute a business process is not sufficient. In order to improve the design and the way of execution it is essential to measure the target object, i.e., to reveal performance indicators of the cross-organizational business process. In the intra-organizational case, this means to extract historical execution information from a single process execution system and to calculate the performance indicators from them. In contrast to that, the cross-organizational case is rather complicated. On the one hand there are multiple execution systems, each of which holds only partial information about the execution of a single cross-organizational business process. Thus the challenge is not only to compose performance data from multiple sources, but also to identify linked process chunks and to reconstruct the complete structures of historical cross-organizational business processes under the side condition of heterogeneous keeping of data and system ownership. On the other hand this information on the reconstructed process not necessarily leads to performance indicators for the whole process, because their calculation requires the valuation of process execution data. However this valuation (e.g., the cost function) is usually considered a business secret, so an overall indicator processing cannot be performed without exposing individual business knowledge. Therefore we propose to calculate distributed performance indicators in a way equivalent to the execution data processing: each organization transforms the process information gathered from the execution systems into its individual (partial) performance indicators. These figures will then be used to compute the overall indicators. Following this procedure, the organizations are not obliged to publish their calculation scheme and only communicate the resulting values.

4. TECHNICAL REALIZATION

In this section the realization of the concepts described above will be presented. Within the research project P2E2 – Peer-to-Peer Enterprise Environment[1], a platform has been developed that prototypically implements the distributed Business Process Management principles.

Figure 3. Screenshot of PDDT



The basic idea is to form a network of actors ("peers") which are all equal with respect to rights and what they are able to do [ScFi02]. The network is dynamic, i.e., peers may enter and leave the network at any time. The peer-to-peer principle guarantees equal opportunities for all participating parties. Every party distributes models of the processes that it offers to perform. A customer peer can reassemble these process fragments to the model of a complete process and buy the execution of it (or parts of it) from other peers. Thus the P2E2 network structurally corresponds to the organizational network of the collaborating organizations and therefore provides a wide set of advantages as a technological base for enterprise networks [KuWe04].

Distributed Business Process Modelling

First, the processes offered in the network must be modelled, aggregated, assembled and so on. The top-level modelling language used in the P2E2 prototype is the event-driven process chain (EPC). Modelling is performed using the ARIS Toolset by IDS Scheer AG. However, the P2E2 meta-model explicitly supports other modelling languages, too.

In the first step, every peer designs his own processes in any desired detail, thus obtaining a "private" model which can contain arbitrary (even secret) information about the process and therefore is not shared with other peers. Then he generates a "public" view to the model by reducing the contents of the private model to the minimum that is necessary for other peers to comprehend the modelled process and its interfaces.

In the next step, all public models by all actors are distributed among the network. For this purpose we developed the Process Distribution and Discovery Tool (PDDT), a peer-to-peer software which is based on the JXTA peer-to-peer framework and supports distributing, versioning, searching and transferring models (see Figure 3). With the shared information about the available process fragments, any peer can construct a complete process from the fragments. Using the PDDT again, this common process model is shared with all peers that participate in its execution.

Distributed Business Process Execution

Figure 4 shows the architecture of a P2E2 peer along with the controlling and configuration applications which are not an integral part of the peer itself. This subsection about execution starts with the output of the modelling tool in the lower left corner of the figure.

In P2E2, the execution part of the Management concept is simplified compared to the scenario outlined in Section 2, because the common process model is composed from several process fragments. So the responsibilities for the execution of the process parts are ex ante established and partitioning. Besides, the augmentation of the process fragments with execution information benefits from the fact that the private model with all execution details already exists. Therefore the common process can be omitted. So it is sufficient that every peer augments its process fragments once and reuses this information in every execution.

Another part of the augmentation phase is the conversion of all models into a common execution model language, i.e., XPDL in our case: finally, all P2E2 process fragments exist as executable XPDL models. To obtain them, a multi-stage conversion and augmentation is performed. First, the EPC models are automatically converted into XPDL format using the modelling tool. Then the attributes of all XPDL model elements are filled in with data necessary for execution using another tool developed within the project, which is named "augmentation tool" in Figure 4.

Execution in P2E2 is finally performed using workflow engines by Carnot AG and abaXX Technology AG ("WFMS" in Figure 4). Whenever necessary, communication between executing peers is performed by calling BAPI methods using Wf-XML.

Distributed Business Process Controlling

During execution, every engine records performance data and stores it for the third phase: controlling. The most basic performance data gathered during execution is stored in the audit trails of the workflow management systems (see Figure 4). However, mainly due to business secrecy, their content is not exposed directly. Instead, every peer processes its performance data to its liking and exposes the results or parts of the results over a specific web service interface exclusively. Of course, this information only refers to the execution of a process fragment, not the process as a whole.

The reassembly from fragments to the whole process is achieved using a specific controlling tool (see Figure 4). It first fetches performance information about process fragments from all participating peers using the web service described above. Then the information how the whole process is composed from process fragments is used to aggregate per-process information from per-fragment data.

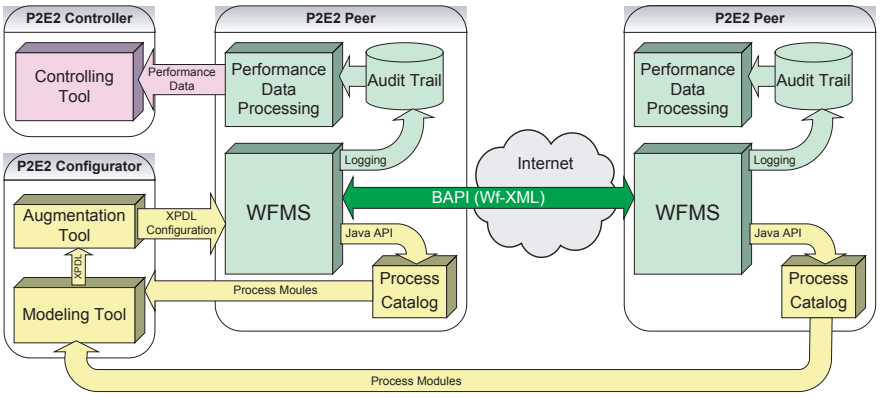
5. CONCLUSION AND OUTLOOK

In this paper, we have presented a concept for the cross-organizational business process management, including distributed modelling, execution and controlling, that is already widely-implemented. In particular we addressed and ensured the continuous IT support of all three phases, the decision autonomy and secrecy demand of the participating organizations during the process, and the technical and conceptual feasibility of our approach (which will be finally verified when the entire prototype is completed).

Currently, two business scenarios are evaluated with our concept. One of them is taken from the financial services sector and deals with factoring, the other one deals with supply chain management in international and national product distribution.

This concept was developed at the Competence Centre Business Integration (CCBI), Institute for Information Systems (IWi) at the German Research Centre for Artificial Intelligence (DFKI), Saarbruecken. It addresses current research problems in the area of process integration and networked businesses by bring-

Figure 4. P2E2 technical architecture



ing together the business-oriented and the IT-views. The work is performed by clustering national and international funded research projects (esp. ArKoS, ATHENA, INTEROP, P2E2), intending the development of solutions for a better interoperability in business networks.

REFERENCES

[Arki02] Arkin, A.: Business Process Modelling Language-Business Process Management Initiative. 2002.

[Cama02] Camarinha-Matos, L. M.: Collaborative Business Ecosystems and Virtual Enterprises. Kluwer Academic, Norwell 2002.

[DaMa92] Davidow, W. H. & Malone, M. S.: The Virtual Corporation - Structuring and Revitalizing the Corporation for the 21st Century. Harper Collins, New York 1992.

[GrAb01] Grefen, P., Aberer, K., Hoffner, Y., & Ludwig, H.: CrossFlow: Cross-organizational Workflow Management in Dynamic Virtual Enterprises. In: International Journal of Computer Systems, Science and Engineering 15 (2001) 5, pp. 277-290.

[KeNü92] Keller, G., Nüttgens, M., & Scheer, A.-W.: Semantische Prozessmodellierung auf der Grundlage "Ereignißgesteuerter Prozeßketten (EPK). In: Veröffentlichungen des Instituts für Wirtschaftsinformatik, A.-W. Scheer 1992.

[KuWe04] Kupsch, F.; Werth, D.: Process-Driven Business Integration Using Peer-to-Peer Technology. In: Mehdi Khosrow-Pour (ed.): Innovations Through Information Technology., 2004, pp. 1294-1300.

[LuBu99] Ludwig, H., Bussler, C., Shan, M., & Grefen, P.: Cross-Organizational Workflow Management and Co-ordination - WACC99 Workshop Report. In: ACM ASIGGROUP Bulletin 20 (1999) 1.

[ÖsFl00] Österle, H., Fleisch, E., & Alt, R.: Business Networking - Shaping Enterprise Relationships on the Internet. Springer, Berlin et al 2000.

[PrHa90] Prahalad, C. K. & Hamel, G.: The core competence of the corporation. Springer, Berlin et al. In: Harvard Business Review 63 (1990) 3, pp. 79-91.

[RöSc01] Röhricht, J. & Schlögel, C..: cBusiness. Erfolgreiche Internetstrategien durch Collaborative Business. Addison-Wesley 2001.

[SaOr99] Sadiq, W.; Orlowska, M.E: Applying Graph Reduction Techniques for Identifying Structural Conflicts in Process Models. In: Proceedings of the 11th International Conference on Advanced Information Systems Engineering (CAiSE '99). Springer, 1999, pp. 195-209.

[Sche96] Scheer, A.-W.: ARIS-House of Business Engineering: Von der Geschäftsprozeßmodellierung zur Workflow-gesteuerten Anwendung ; vom Business Process Reengineering zum Continuous Process Improvement. In: Scheer, A.-W. (ed.): Veröffentlichungen des Instituts für Wirtschaftsinformatik, No. 133, Saarbrücken : Universität des Saarlandes, 1996.

[ScNü95] Scheer, A.-W.; Nüttgens, M.; Zimmermann, V.: Rahmenkonzept für ein integriertes Geschäftsprozeßmanagement. In: Wirtschaftsinformatik 37 (1995), No. 5, pp. 426-434.

[ScFi02] Schoder, D.; Fischbach, K.: Peer-to-Peer : Anwendungsbereiche und Herausforderungen. In: Schoder, D.; Fischbach, K.; Teichmann, R. (eds.): Peer-to-peer: ökonomische, technische und juristische Perspektiven. Springer, 2002, pp. 3-21.

[Schu02] Schulz, K.: Modelling and Architecting of Cross-Organizational Workflows, PhD Thesis. University of Queensland 2002.

[Wert06] Werth, D.: Kollaborative Geschäftsprozesse - Integrative Methoden zur modellbasierten Deskription und Konstruktion. Saarland University 2006.

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Complexity and Dynamism in the Information Systems Domain

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ABSTRACT

This paper argues that the emergence of the network economy and network society extends the boundary of the Information Systems (IS) domain, and that complexity science offers the apposite concepts and tools for incorporation into a General Conceptual Framework (GCF) and Methodological Base (MB) for IS. The paper is structured in the following way. The next section outlines the imperative for a paradigm shift –from dealing with IS as discrete systems to dealing with IS as components of the interconnected world. Section 2 outlines the complexity science concepts for articulating the dynamism, adaptation and co-evolution observed in the interconnected world, and Section 3 discusses the way in which the complexity science concepts connect with existing philosophical movements in the IS domain, and reflects on how they may contribute to the development of a GCF and MB for IS.

1. INTRODUCTION

The IS and IT landscape is characterised by network dominance and increasing complexity. As shown elsewhere (Merali and McKelvey, 2006), the network motif is one that we can see at play at many different levels in the evolution of the IS field, for example,

- the potency of discrete advances in hardware and software capabilities to generate significant change in business and society is realised through the mobilisation of network effects;
- technological advances escalate the potency of network effects by continually enhancing the connectivity and bandwidth of networks;
- the growth of IT-enabled socio-economic networks is accompanied by globalisation and an increase in the number and heterogeneity of players who can affect the dynamics of networks.

Recent work on small world and scale-free networks (Newman, Barabási & Watts, 2006) shows that small changes in network connectivity can bring about major, almost costless changes in the characteristics and behaviour of the socio-economic players and milieu. The net effect of this is a perception that individuals and organisations have to deal with a world that is increasingly dynamical, complex, and uncertain, and that their actions may have unintended consequences that impact on other parts of the world.

The network form of organising is the signature of the internet-enabled transformation of economics and society. Management literature has shifted from focusing solely on the firm as a unit of organisation to focusing on networks of firms, from considerations of industry-specific value systems to considerations of networks of value systems, and from the concept of discrete industry structures to the concept of ecologies. The labels "network economy" and "network society" (Castells, 1996) have become integrated into the management lexicon. In the strategy literature the network economy is characterised by competition in high-velocity environments, speed of technological change and uncertainty (Eisenhardt, 1990. Organisations, needing to shape and redefine their own competitive arena are confronted with the need to continually innovate (Hayton, 2005). This brings with it the challenges of working towards radical and incremental innovation, whilst dealing with resource constraints to achieve an efficacious balance of risk and return. From the IS perspective, an interconnected world that is comprised of technologically mediated networks of networks can be conceptualised as

- a complex multidimensional network which
- connects a diversity of agents (individuals, groups, institutions, nations, computers, software components etc.) through
- multiple and diverse communication channels

IS and IT underpin the realisation of this networked world. Strategy, OD and IS research have converged on issues of connectivity, co-ordination, competition and collaboration, learning and transformation at multiple levels of analysis in the networked world.

These developments have two important consequences for IS scholarship and methodology development: IS methodologies need to offer the requisite ontological and epistemological constructs for enabling us to

- deal explicitly with dynamism, complexity and continuous change, and
- engage with the trans-disciplinary discourse

characteristic of the emergent networked world, in which many heterogeneous components (social, institutional, technological and informational) are connected in a dynamic fashion.

Complexity science is viewed as a source of concepts for enabling the trans-disciplinary exploration of complex organisation in the networked world, and for explaining the dynamics of networked systems at different levels of description ranging from the micro- to the macro. It offers a powerful set of methods for explaining non-linear, emergent behaviour in complex systems (Anderson, 1996, Merali, 2004 have overviews for OD and IS). There are three special issues dedicated to applications of complexity theory[1], [2], [3] in the IS domain.

The systemic level IS capabilities underpinned by the network form of organisation that are of particular interest in the "New Economy" include:

- intelligence (sensing internal and external contextual characteristics, developing representations of the environment and formulating and implementing appropriate strategies and responses).
- coordination (particularly dynamic co-ordination and recombination of distributed resources, processes and capacity to act),
- robustness (the ability to reconfigure, self-repair and renew, and to maintain integrity in the face of changes in and attacks from the environment),
- efficiency (of co-ordination, transaction and resource development within and across organisational boundaries, and
- flexibility (adaptive capability and transformational capacity).

The next section highlights concepts from complexity theory for articulating IS phenomenology and dynamics of the networked world.

2. COMPLEXITY CONCEPTS

2.1 Complex Systems and the Network Form of Organising

Complex systems are non-linear systems, composed of many (often heterogeneous) partially connected components that interact with each other through a diversity of feedback loops. Their complexity derives from the partially connected nature and the nonlinear dynamics which make the behaviour of these systems difficult to predict (Casti, 1997). The non-linearity of these systems means that small changes in inputs can have dramatic and unexpected effects on outputs, affording possibilities ***both***, *for maintaining the steady state* ***and*** *for transformation*: small changes in topology can make a big difference to what is possible and what is not. The particular network dynamics and possibilities for adaptation and transformation of the network at any given time are emergent manifestations of the non-linear interactions in the particular network context. The context may support a heterogeneous combination of:

- types of links
- properties of the nodes
- types of information and knowledge flows through the links
- types of information and knowledge content and processes of nodes
- degree of connectivity and density of connections in the network
- patterns of connectivity.

The language of complexity science allows us to use network dynamics as the explanatory mechanism for linking micro-level diversity with the emergence of coherent macro-level phenomenology of the networked world.

2.2 Complexity Concepts and Networks

Complex adaptive systems (CAS), *emergence, self-organisation* and *co-evolution* in complex systems are complexity concepts developed the most in organisational literature, and are of particular interest to us in our project of developing a GCF for extending the IS domain into the management field.

The concept of CAS (open, dynamical systems that adapt and evolve in the process of interacting with their environments) serves to characterise the phenomenology of IS in the networked world (Merali, 2004). CAS are non-linear systems embodying self-organisation and emergence and have the potential (capacity) for adaptation *and* transformation.

The pattern of interactions that underpins the dynamics of CAS is explained in terms of the network of interconnections. A CAS is made up of multiple, interconnected components ("agents"). The resulting network connectivity allows for the generation of feedback loops.

A system regulated by negative feedback loops would characteristically display stability, whilst a system dominated by positive feedback loops would be subject to the "runaway" escalation of a particular trajectory. CAS embody the potential for simultaneous existence of *both* negative *and* positive feedback loops. Hence a diversity of feedback cycles may be interlinked in a variety of ways, with different consequences. – The interlinked cycles may maintain a homeostatic organisation (as in the Maturana and Varela's 1973 account of autopoietic organisation of stable living organisms) or they may spontaneously generate new, more complex forms of organisation under certain critical conditions (Prigogine, 1987; Langton, 1991; Kauffman, 1993).

Emergence refers to the phenomenon whereby the macroscopic properties of the system arise from the microscopic properties (interactions, relationships, structures and behaviours) and heterogeneity of its constituents. The emergent macroscopic "whole" displays a set of properties that is distinct from those displayed by any subset of its individual constituents and their interactions.

At the microscopic level, the behaviour of an individual constituent is contingent on the precise state of that constituent and conditions in its local environment *at that instant*. For constituents on the boundary of the system, the local environment will constitute "internal" and "external" components. The collective behaviour of the individual constituents at the microscopic level will manifest itself as the behaviour of the "whole system" visible at the macroscopic level.

Self-organisation is the ability of complex systems to spontaneously generate new internal structures and forms of behaviour. This *generative* aspect takes the complex systems concept of self-organisation beyond the early cybernetics concept of self-organisation which focused on the self-regulatory and control aspects of organisation. In the self-organisation process, the components *spontaneously* re-orientate and restructure their relationships with neighbouring components giving rise to the emergence of structures that embody an increased level of internal complexity. The constituents are partially connected: the behaviour of each one depends on the behaviour or state of some subset of all the others in the system. Each acts on local information only derived from the others with which it is connected. Thus the *system* self organises: no single component dictates the collective behaviour of the system. Network connectivity is critical in defining and maintaining the ordered state, with most components receiving inputs from only a few of the other components so that change can be isolated to local neighbourhoods. Self-organisation is not the result of a priori design, it surfaces from the interaction of system and the environment and the local interactions between the systems components.

The existence and persistence of the system is thus a relational phenomenon, predicated on the relationship of the constituents of the system to each other and to constituents of the environment in continuous time. Local, contingent, neighbourhood interactions and adjustments at the micro-level are at the same time detectable as a coherent pattern of properties constituting the "whole" system.

The classical separation of *"becoming"* from *"being"* does not advance our understanding of complex systems. In order to identify how emergent properties are produced we need to be able to access descriptions of the system at multiple scales from the micro to the macro *at the same time*. This presents us with a problem of representation in the classical mode of top-down refinement. Typically, complex systems representations are either developed as mathematical models or as computer simulations.

At the micro-level, system and environment components interact in a contiguous space, and, depending on the nature of particular relationships, can to a lesser or greater degree be considered to be mutually effective. Thus the dynamic definition of a system is contingent on the dynamic definition of its environment, and system constituents are an integral part of the landscape in which they exist. The concepts of systems adaptation and evolution are thus extended to the dynamics of the ecosystem within which systems are situated and thus to *co-evolution* of system and environment.

These characteristics require us to redefine the way that boundaries are conceptualized: from the classical view of fixed boundaries, towards a more dynamic view of boundaries as relative and relational phenomena, linking system and environmental elements through differential coupling.

The emergence of the macro level phenomenology from micro level interactions and the mutually defining relationship between the system and its environment are defining characteristics of our information network dynamics. The question of how to deal with boundaries in this context remains a non-trivial one.

To summarise, CAS are sensitive to initial conditions and hence embody path dependency, in the sense that history matters. However the heterogeneity of network nodes (i.e. we can have nodes that are defined by different sets of characteristics) and their connectedness (i.e. not all nodes are connected to the same number of other nodes) coupled with the possibility of dynamically reconfiguring network topology (by activating/deactivating links, and/or adding/removing nodes) affords a level of micro-diversity and a combinatorial potential that makes it impossible to predict with any certainty the future state of the macro-level system.

In face of this escalating computational complexity and mathematical intractability, complexity science offers agent-based modelling as a way to explore the possibilities and characteristics of the unfolding dynamics of complex adaptive systems. The next paragraphs highlight the characteristics of the agent-based approach that are useful for looking at the network dynamics of the interconnected world, suggesting the need to develop conceptual frameworks for defining the parameters to be modelled.

2.3 Agent Based Modeling and Multi-Scale Descriptions

Agent-based computational modeling has features that are particularly relevant when studying socially embedded systems, and it is displacing conventional mathematical theorizing approaches (Carley, 1995, Axtell, 2000).

It is possible to model diverse agents, capable of acting with local information and noisy pay-offs (Axtell 2000). Genetic algorithms (Holland, 1998) provide the means to explore adaptive behaviour, learning, evolution and fitness in dynamic landscapes. Running such models furnishes us with an *entire* dynamical history of the process under study. This is important when exploring processes of emergence and self-organisation in complex adaptive systems. Complex systems have many degrees of freedom, with many elements that are partially but not completely independent, with ambiguous system-environment relationships. There is a greater diversity of local behaviours than there is of global outcomes. In order to achieve an effective representation of the dynamics of the processes connecting the local (micro-level) and global (macro-level) characteristics we need to develop a multi-scale description of complex systems, and agent-based modeling provides a mechanism for doing so.

For social systems the specification of the components (agents) for the construction of agent based models is itself often a challenging prospect. With the escalation of available computational power it will be possible to build models with a million agents of reasonable complexity.

The diversity of social relationships and the idiosyncrasy of individuals makes it difficult to develop models that are both, sophisticated enough to capture the essential features of the social interactions and characteristics, and simple enough

to make visible the dynamics of the system. The difficulty lies in identifying what constitutes the requisite set of attributes for defining social systems – and *this* is a matter that necessitates a discourse with the sciences of sociology, philosophy and psychology amongst others (Merali 2004).

From a methodological perspective, we need ontological and epistemological frameworks to guide the utilisation of complexity concepts in studying and dealing with social systems. However the science of complexity does not offer the requisite frameworks, nor do the social sciences. Turning to philosophy and the social sciences we find that there are a number of existing philosophical perspectives that we may be able to draw on in order to explore the possibility of developing the requisite frameworks

3. PHILOSOPHICAL OPENINGS

Our exploration of complexity concepts brings us to some openings that invite a further investigation of several philosophical positions, and these are highlighted below for future speculation.

To assimilate and accommodate the phenomenology of emergence and CAS we need to identify a philosophical position that enables us to deal with

- inseparability of *being* from *becoming*
- "fluidity" between system and context,
- *potentiality* of the emergent system and its constituents given that emergent phenomena are non-deterministic, path-dependent and context sensitive, and
- assimilation of the present and persistent with the possible and transient.

Heidegger's *Being in Time* (Heidegger, 1962) offers us a number of enabling concepts for this endeavour. Heidegger's *Dasein* (*being-there*, or *being-in-the-world)* gives us the articulation of individual and collective *being* and its relationship with past, present and future time.

Dasein (*being-there* or *being-in-the-world)* is the wholeness of being that includes the context and assimilates objects of the world into itself. This is an affirmation of *Dasein* in the present. However *Dasein* in the present is in, and open to, a space of *possibilities* of the (collective) world (this is articulated in Heidegger's concept of *clearing*) and it is pressing *forward* into the possibilities (of the future). This pressing forward has a general direction (Heidegger's *towards-which* or *for-the-sake-of-which*), but no specific conscious goal – as Dreyfus (1987) puts it,

Dasein is simply oriented toward the future, doing something now in order to be in a position to do something else later on, and all this makes sense as oriented towards something that the person is finally up to but need not have, probably cannot have, in mind.

So, *Dasein* embodies the past, present and future: The "pressing into the future" of *Dasein* in the *past* is the passage into *Dasein* in the *present* which is already pressing into *Dasein* in the *future*.

In attempting to locate complexity concepts in relation to the map of established philosophical positions, Heidegger's existential phenomenology offers a promising starting point for our ontological framework: the notion of *Dasein* articulates the qualities of emergence (in the unfolding of *Dasein*), the contiguity of *being* with *becoming,* and the spontaneous organisation of *being* (incorporating the context, assimilating objects in the environment into dynamics of being).

Turning to the social sciences, we find that Critical Realism (Bhaskar, 1986) also articulates path dependency, emergence and transformation in social systems: it does so in terms of *causal mechanisms*, tracing the emergence of the experienced world from the existence of possibilities in the actual world, realised through generative mechanisms of the real world. In *Complexity theory and the social sciences* David Byrne develops the proposition (Reed and Harvey, 1992), that Critical Realism constitutes the philosophical ontology complementing complexity as the scientific ontology.

With regard to the epistemological dimension, defining and studying the being of particular complex systems-in-the-world, presents us with another problem. The moment we speak of being, it is interpreted (Eco, 1997). Interpretations are grounded in the system of interpretation or perspective of those who generate them. It is therefore possible to generate a diversity of interpretations from the observation or experience of any particular event or state of affairs. Similarly, the possibilities of being are transcendental, extending beyond articulated experience existence and imagination of any person. We are thus confronted with the problem of appreciating the potential (of being) beyond articulated accounts, representations or speculations about the past, present or future.

The problem of exposing that which lies behind and beyond language-based interpretations and descriptions of the world constitutes an opening for the exploration of Derrida's deconstructionist (Derrida, 1978) philosophy. This opening is explored in Paul Cilliers' Complexity and Postmodernism. Cilliers draws on Derrida to develop an excellent exposition of the parallels between the complexity of language systems (and the possibilities of meaning emerging from the relationship between language-based descriptions of the world and the world itself) and connectionist accounts of the complexity of social systems.

To summarise, whilst the science of complexity does not directly offer us ontological and epistemological frameworks for the application of complexity to social systems, complexity concepts resonate very strongly with several existing philosophical movements, highlighting a number of openings for future investigation in the development of GCF and MB for IS.

4. POSITIONING IS IN THE MANAGEMENT FIELD

The exposition of the information network-in-use in this paper accentuates the existence of the information network as an integral, constitutive element of the network society and economy. The information network both, serves, and shapes the networked world.

As illustrated above, conceptualising the networked world as a CAS transcends the traditional boundaries between disciplines in the management field. This has two important implications for future IS research:

- the travail of IS in the interconnected world is a trans-disciplinary one, and demands the active development of a discourse with the other disciplines. The adoption of complexity science concepts would speak for a discourse not only across the management field, but also across the natural and human sciences
- the centrality of IS in the network economy and society places the IS domain at the heart of the management field, and we should, as a discipline, re-cognise our responsibilities for informing the discourse pertaining to information networks-in-use in other management disciplines.

5. CONCLUSION

To summarise, this paper has shown that the complexity and dynamics of systems are not readily treated with traditional research approaches that simplify the world with high level generalisations predicated on macro-level observations of structural persistence and assumptions of Gaussian statistics. Complexity science furnishes us with the concepts and tools for building multi-level representations of the world and for making sense of the dynamics of emergence. The dynamics of emergence is predicated on micro-diversity, and fine grained representations are essentially descriptive models of the detailed complexity of the world and its dynamics. Thus it is through exploratory modelling that we discover how the complex world works, and how macro-level properties and behaviours of systems emerge from micro-level diversity and dynamics. Consequently, modelling is the principal research tool for complex systems, and sensemaking is a legitimate research goal. This implies a significant shift in the established thinking about what constitutes knowledge and how it is best obtained. This is the challenge for traditional research and in particular for the hypothetico-deductive school.

REFERENCES

Anderson, P. (1999). Complexity theory and organization science, Organization Science 10: pp216-232.

Axtell, R, (2000) Why Agents? On the Varied Motivations for Agent Computing in the Social Sciences. Center on Social and Economic Dynamics Working Paper No. 17, November 2000, The Brookings Institution, Washington.

Bhaskar,R. (1986) Scientific Realism and Human Emancipation. Verso. London

Byrne, D. (1998) Complexity Theory and the Social Sciences: An Introduction. Routledge, New York.

Carley, K. (1995) "Computational and and mathematical organization theory: Perspective and directions" Comput. Math Organ Theory 1 (1) 39-56.

Castells, M. (1996) The Rise of the Network Society, Oxford: Blackwell Publishers.

Casti, J. (1997) Would-be worlds: How Simulation is Changing. Wiley: New York.

Cilliers, P. (1998) Complexity and postmodernism: Understanding Complex Systems. Routledge, New York.

Derrida, J. (1978) Writing and Differerence. Routledge, London.Dreyfus, R. (1987) in The Great Philosophers, Magee, B.,Oxford University Press, p. 265.

Dreyfus, R. (1987) in The Great Philosophers, Magee, B.,Oxford University Press, p. 265.

Eco. U. (1997) "On Being"in Kant and the Platipus. 9-56. Seeker and Warburg. London

Eisenhardt, K. M. (1990). Speed and strategic choice: How managers accelerate decision making. Sloan Management Review, 32(3), pp. 39–54.

Hayton, J. C. (2005). Competing in the new economy: The effect of intellectual capital on corporate entrepreneurship in high-technology new ventures. R&D Management, 35 (2), pp. 137–155

Heidegger, M., Being and Time, (1962) (translated by Macquarrie, J. and Robinson, E.), Blackwell, Oxford

Holland, J. H. (1998). Emergence: from chaos to order. Oxford University Press, Oxford.

Kauffman, S. A. (1993). The Origins of Order: Self-Organization and Selection in Evolution, Oxford: Oxford University Press.

Langton, C.G. (1991) Computation at the Edge of Chaos:Phase-Transitions and Emergent Computation. PhD dissertation, University of Michigan.

Maturana, H. and Varela, F.J. (1973) Autopoiesis: The Organization of the Living, in Autopoiesis and Cognition: The Realization of the Living, Maturana, H.R. and Varela, F.J. ,Boston Studies in the Philosophy of Science 42. D. Reidel Publishing Company, Dordecht, Holland.

Merali Y. (2004) Complexity and information systems. In: Mingers J, Willcocks L, (eds.) Social theory and philosophy of information systems. London: Wiley; 2004. pp. 407-446.

Merali, Y, and McKelvey. B. "Introduction To The Special Issue:

Using Complexity Science To Paradigm-Shift Is Into The 21st Century", 21 (4) in press

Newman, M., Barabási, A.-L., & Watts, D. J. (2006). The Structure and Dynamics of Networks, Princeton, NJ: Princeton University Press.

Prigogine , I. (1967) "Dissipative Structures in Chemical Systems", in Fast reactions and Primary Processes in Chemical Kinetics, S. Claessons (Ed), Interscience, New York.

Reed, M. and Harvey, D.L. (1992) "The new science and the old complexity and realism in the social sciences",Journal for the Theory of Social Behaviour 22 356-79.

ENDNOTES

1 *Communications of the ACM*, 2005, 48 (5): Special Issue on Adaptive Complex Enterprises.

2 *Information Technology and People*, 2006, **19 (**1): Special Issue on Complexity in IS Research.

3 *Journal of Information Technology* 2006 **21** (4) *forthcoming*

Evaluation of Web Services Resource Framework for Virtual Organization

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ABSTRACT

The organization of resources in communities is an efficient way for resource discovery. The effectiveness of proposed communities depends on the technologies selected, their interoperability, platform independence and compliance with standards. This paper outlines the role of different available technologies to sustain the effective working of the community and to provide the general middleware for the community formation. Main focus of this paper is to evaluate the Web Services related specifications particularly Web Services Resource Framework and Web Services Distributed Management; and their effectiveness in the community formation.

1. INTRODUCTION

Emerging distributed computing paradigms, such as Grid Computing [4] and Virtual Research Environments [7] comprise of services/peers which collaborate in one way or another to improve their effectiveness – this cooperation leads to the formation of a "Virtual Organization". Virtual Organizations already exist in e-commerce, science, research and engineering projects – whereby a collection of organizations or scientists come together to solve a single large problem. Enormous development in Information and Communication Technology (ICT) has changed the requirements and expectations of consumer/user leading to tense competition (economically), composite and complicated services (scientific), and demand for diverse and dispersed resources (Grid environment). Extensive collaboration in every aspect in every possible way is required to meet these high user expectations. A Virtual Organization is one such strategic approach to building strong but flexible links to partner organizations with similar interests [6].

The effectiveness of a Virtual Organization relies on the technology selected for the middleware, adherence to standards, and built in support for managing the diverse resources. In our understanding, the middleware provides basic features for community formation; defines protocols for coordination among resources and peers; the mechanism to advertise the capabilities of the resources, the discovery of suitable services and the management of these dynamic resources.

The community formation process and different types of communities are discussed previously and can be found in [1], [2] and [3]. The 'Section 2' discusses the requirements of the VO and suitability of emerging specifications in the Web Services. The 'Section 3' evaluates Web Services Resource Framework (WS-RF) [5, 13] and Web Services Distributed Management (WSDM) [14] for Virtual Organizations and different collaborative environments. The last section explains the existing and proposed implementation details for the community.

2. REQUIREMENTS OF VIRTUAL ORGANIZATION

A Virtual Organization "VO" defines a logical group of members within the grid, which can be geographical distributed. Usually all members have a common interest, for example one institute, a group of scientist or a commercial enterprise. Within these VO's all resources are shared and the use is strictly defined by policies. Selection of any technology to simulate VO requires thorough consideration and analysis of its built in support not only for the formation of VO but its management and functionality. In the following section we will discuss different requirements of VOs in the context of features available WS-ServiceGroup and WSDM. Technical details of WS-ServiceGroup and WSDM are based on the GT4 [8] implementation of WS-RF and Apache implementation of WSDM [9].

2.1 Bootstrapping Service

Virtual Environment provides essential information to a peer on joining the network to discover enough network-based and other resources to sustain itself. Each container hosting Web Services manage

ContainerRegistryService and DefaultIndexService which collects data from various sources and provides a query/subscription interface to that data. Resources are added in the ContainerRegistryService and DefaultIndexService at the time of initialization.

2.2 Maintaining Membership Policy

Each community needs to keep appropriate membership criteria, thus members of community should have resources, capabilities and competencies compatible with the rest of the members. VO manages the membership requirement of community by restricting membership according to a set "Membership Policy". Membership Policy is constrained in the ServiceGroup as MembershipContentRule below is the example:

```
<wssg:MembershipContentRule MemberInterface="ns2:X" ContentElements=""/>
<wssg:MembershipContentRule MemberInterfaces="ns3:Y" ContentElements="ns3:RP1 ns3:RP2" />
```

MembershipContentRule in the first statement expects members to implement "ns2:X" portType; where as second MembershipContentRule expects not only implementation of "ns3:Y" but also exposing two ResourceProperties.

2.3 Lease Time

The membership of any ServiceGroup is for specific duration set at the joining time. After membership duration ceases, peers can apply to renew their membership, the outcome of which can be linked to the effectiveness of a peer and its historical effectiveness within the community. VO makes strategic alliances to achieve set goals and there is no need for long term contract which is contrary to the purpose of Virtual Organizations.

2.4 Access Control

Different members enjoy different access rights for different resources available within the community. Nature of access rights depends on the effectiveness and activeness of specific member within the community and relevance of resources to a particular member. Access rights granted to different peers depends on their role within the community and nature of resources; Each Resource has its own access and security policies which are controlled in the form of Grid Map file in GT4.

2.5 Resource Monitoring Service

Optimized usage of resources means maximum productivity of the resources; which boosts overall performance of the community. Overloading resources or minimum usage of resources with respect to their capacity results in declined standards, which can be achieved by better governance and scheduling. ServiceGroup implementation provides QueryResourceProperties operation which can be used to search members matching certain criteria i.e. CPU with 50% load, resource with 1 GB memory etc. Resource monitoring leads to fault detection, performance analysis, performance tunneling, performance prediction and scheduling.

2.6 Performance Controller Service
The WSDM-MUWS describes the manageability of the resources. The manageability capability is best thought of as an interface to the internal workings of the Service. The role of the manageability capability is to list the available operations on a resource so that management software can get a list of the available operations. These capabilities are defined using XML and can be aligned with ServiceGroup membership content rules by including ResourceProperties essential for monitoring and management in the membership content rules.

2.7 Scheduling Manager Service
The combination of WS-ServiceGroup and WSDM-MUWS provides best Resource Querying and Monitoring mechanisms; on top of which any level of complex scheduling service can be implemented. Scheduling of tasks involves co-ordination between member peers and co-operation with other communities, which leads to complex and demanding workflows. Both WS-ServiceGroup and WSDM-MUWS subscribe to the changes in the Resource Properties of the members through Web Services Notification (WSN) and effective use of WSN provides real time monitoring capabilities to schedule tasks to member peers either in parallel or series.

2.8 Security Manager Service
The Community provides a secure environment to its members for co-ordination. The community as a whole ensures the protection of data through its unique ability to adapt, resist and protect data by scattering the multiple copies within the community boundary. Members can access local resources and communicate with other members without any additional authorization and authentication once they are known to the local authentication authority. Most of WS-RF implementation provides different level of security, message level and transport level security along with delegations of credentials.

2.9 Community of Communities
In WS-ServiceGroup each VO itself is a stateful Web Services with ResourceProperties encapsulating the member's details. WS-ServiceGroup can be arranged in hierarchical manners to create communities within community as long they all full membership criteria. Community of Communities is essential to pool similar services within the community and group different communities to from super VO according to the requirement of workflow.

3. WS-RF AND COMMUNITY FORMATION

The community formation is to achieve the relevance of resources and services with respect to each other or according to the business requirements. The suitability of resources and services is the basis of different type of communities, which is crucial for the collaboration among participants from business, commercial or academic domains can be achieved. The services are units of work that map closely to the activities in a business or scientific process, such services are immediately relevant to analysts who can readily participate in their creation and use them to define complicated new processes thus enabling Service Driven Environment. The architectural implementation of the community based on WS-RF ServiceGroup has many advantages and some are listed below:

3.1. Governance
Sharing of services/resources offered by participating Peers is central to our Community approach and is fundamental of VO. The ability to rapidly assemble the applications or orchestrate the processes based upon the availability of services from participating members. The sharing of different resources, by definition requires efficient governance. Monitoring and Discovery System (MDS) in Globus Toolkit 4, is a suite of Web Services to monitor and discover resources and services on the Grid. The implementation of MDS allows resource discovery and monitoring in the standard way. The query and subscription interfaces in MDS to arbitrarily detailed resource data can be configured with trigger interface for appropriate actions under specific conditions.

3.2. Reusability
Conventionally developers are geared to tackle each application as an independent problem to be solved, with little possibility of the code reuse. Web Services based communities are all about application development with reuse in the mind, both in term of the existing code and in terms of planning new code to be used in future applications. Different service/s provided by different members, can be reused by other members to support their services or to develop composite services i.e. workflow.

3.3. Rapid Application Development
Peers are categorized in Communities based on the service/s they tend to share; these services are reusable fragment of code, which can be assembled in many different ways to develop bigger and sophisticated applications. The community focus on each activity as a service, which can be useable in different applications and applications are no more isolated code with limited applicability outside their problem domain. These services are orchestrated through a "workflow" based on the available resources, competencies, strengths/weaknesses of members; which may require collaboration among communities to "buy in" services missing within the community.

3.4. Manageability
Sharing of service/services offered from different resources even when these resources are in different Communities leads to endless possibilities. Thus development of any complicated applications is more or less orchestration of independent services, resulting in more manageable application development process with respect to time and development cost. Modular software is designed to avoid failures in large systems, especially where there are complex user requirements. The possibility to replace similar services particularly at run time under un-predictable circumstances gives new dimension to the management of final goal according to the user requirements.

3.6. Improved Quality
MDS monitors the status of different registered resources and service/s with "self-cleaning", each resource has a lifetime and is removed from the Index of available resources if it is not refreshed before it expires. Monitoring capability can be coupled with set of conditions to control the Quality of Service (QoS) [17] of individual resource i.e. advertise only those resources with processor load less than 50%, resources with memory size of at least I Gig. Tools can discover similar type of services and select any service from the pool of similar services according to the Quality of Service (QoS) constraints and the requirements of final goal. The module design of services means they can be replaced at run time without compromising the quality. The replacement of semantically equivalent services can be automatically initiated by the community (in case of Co-Operating community) or can be manually done by the client.

3.7. Diversity
Very few applications can survive in the isolation. Most often applications have to be integrated with other applications inside and outside the enterprise. This integration is usually achieved using some form of "middleware". Middleware provides the "plumbing" for data transport, data transformation, routing etc. [15]. No sizeable IT organization operates with a single programming standard, and with emergence of Web Services as the de-facto standard the architecture of the applications is changing with no reliance on single programming modal. Modular applications developed by integration of different of services deployed on variety of platforms and environments can exploit the specialization of individual programming language to achieve maximum quality. This Technology-to-Technology" (T2T) gives new dimension to integration of application development, which requires changes in programming style and our understanding to the problem.

4. SEMANTIC AND COMMUNITY MANAGEMENT

The recent trends in industry connected with enterprise integration demand solid technology to provide effective Knowledge Management within and across industrial enterprises [16]. Combination of Semantic Web and Peer-to-Peer technologies provides many attractive and powerful features for this domain, but these great possibilities are not yet fully explored. There is a strong interest in the development of reliable platform for support of cooperative knowledge management and flexible integration of various applications, Web Services and industrial resources in the Grid Environment.

WS-RF is described as a set of protocols for manipulating WS-Resources, and deals with application data (resource properties) in the form of the XML. Additional data is defined within WS-RF itself –e.g. TerminationTime in WS-ResourceLifetime and service group entry WS-Resources in WS-ServiceGroup. It is easy to attach semantic information with the service through optional resource. Any service can work on multiple resources and one resource can be managed by multiple services, adding additional resource declaring the semantic information related to the service, data types and operation is more feasible. Tools can query the semantic resource of the service, if it exists before integrating the service in the workflow. WS-Resources can have reference to other WS-Resources in the form of EPR, which gives an alternative possibility of keeping the semantic information separate from the WSDL and integrating it with the service as a WS-ResourceProperty. WS-RF mandates the use of XML Schema for the application specific data and use of languages like XPath or XQuery for querying purposes. The application data can be anything in XML format and WS-RF doesn't constrain the XML Schemas used to describe the data which make it possible to annotate the data with semantics.

Different implementations have different mechanism to collect the information which can be from different sources. GT4 has three different possibilities to populate Index Service (i) to get information from resources, (ii) through subscription/notification mechanism and (iii) through any external program. WS-RF is described as a set of protocols for manipulating WS-Resources, and deals with application data (resource properties) in the form of the XML. Additional data is defined within WS-RF itself –e.g. TerminationTime in WS-ResourceLifetime and service group entry WS-Resources in WS-ServiceGroup. External program provides maximum flexibility to collect the data and apply local Knowledge Base to extend the WS-ResourceProperties. This approach requires the flexibility in the data set with attached semantic, to organize the services based on the semantic nature of the data consumed by the service and semantic information related to the operations in the form of pre and post-conditions.

The WS-ServiceGroup specification can express group, membership rules, membership constraints and classifications using the resource property model from the WS-ResourceProperties. Groups can be defined as a collection of members that meet some constraints as expressed through resource properties. Membership Policy is constrained in the WS-ServiceGroup as MembershipContentRule defined either in the form of WSDL portType or WS-ResourceProperties. The use of XML Schema and WS-ResourceProperties facilitates further elaboration the membership policy by coupling semantics with MembershipContentRule. Thus WS-RF communities can be formed on the basis of semantic defining the application data, application operations or both of them without any additional support from the WS-RF engines. The default reliance of WS-RF on XPath as query language and adding the semantic in the form of WS-ResourceProperties make it easier to query the semantic information and relate it to the local knowledge base.

5. PROTOTYPE

Currently available P2P systems tend to use protocols which are proprietary and independent of other networks, incapable of leveraging their services. For example, Gnutella [20] defines a generic file sharing protocol and Jabber [21] defines an instant messaging protocol, but none of these protocols are interoperable. Each system creates its own P2P community, duplicating efforts in creating software primitives required by P2P systems, such as managing underlying physical network. Initial prototype for community formation [3] is developed in JXTA [23]. Details and result of our initial prototype are discussed in [3].

For later release we have re-designed the architecture to accommodate Web Services due to broader acceptance of Web Services and WS-* supporting specifications in the Grid Community. WS-RF was the automatic selection for the community formation due to its build in support for VO in the form of WS-ServiceGroup and WS-Resources. The Globus Toolkits has Monitoring and Discovery System (MDS), which defines and implements mechanisms for service and resource discovery and monitoring in distributed environments. MDS extensively uses interfaces and behavoiors defined in the WS-RF and WSN specifications and can be easily integrated with other standard implementations. MDS architecture and the relevant Web Services interfaces allow users to discover resources and services, monitor their states, receive changes in the status and visualize monitoring results. MDS can be used to implement large-scale distributed monitoring and distributed systems. MDS manages ContainerRegistryService and DefaultIndexService; and when new instance of Resource is created through Factory/Instance pattern it is added in the DefaultIndexService. Each Resource itself decides the amount of information it wants to expose; and this information is usually the subset of ResourceProperties in the WS-Resource.

The key issue in selecting the ResourceProperties to be advertised in the VO; is the one which are aligned with the WSDM-MUSE requirements. WSDM-MUSE provides uniform interface for similar WS-Resources; to query their properties and management operations. Each member within the community fulfills the membership requirement and exposes identical ResourceProperties therefore they all can be managed by single WSDM-MUSE interface which is the case with Competing Community. It is also possible that within the community their can be different type of Resources; this is the case when VO has multiple membership criteria in the form MembershipContentRule for Co-operative Community and multiple WSDM-MUSE interfaces are required for each type of resource/service.

WSDM-MUSE operations are specific to the nature of resource; due to varying nature of the resources it was not possible to have generic operations for every resource/service; although it is possible to have single WSDM-MUSE monitoring other management interfaces in a limited fashion. Standard manageable resource definitions create an integration layer between resources (Resources may be using different protocols and programming languages) and users/administrators. WSDM creates a free agent Web services proxy capable of communicating with multiple resources, breaking the classic model of the proxy being a wholly dedicated to single resource/service.

The main benefit of using WSDM is its "Co-relatable Properties" which defines the properties that together determine if two manageable resources with different identities are still the same resource. Concept of "Co-relatable Properties" helps to manage same resource/service which can be in different VO's and is managed by multiple independent policies. Each ResourceProperty itself is the Notification Topic; and VO and management interface subscribe for notification for any update in the state. In case of Community of Communities top level VO gathers information from constituting VOs at regular intervals (retrieving information from its local index); it also subscribes to the changes in the local index. In MDS and WSDM information related to each resource/service is kept as ResourceProperties; which makes it possible to utilize notification mechanism for dynamic discovery and monitoring leading to soft state nature of registration, indexing and monitoring. The extensive use of XML Schema to declare data makes WS-ResourceProperties as the ideal candidate for attaching the semantic to the resource and service. Semantic information is coupled with the service as WS-ResourceProperties means possibility to manage/update the semantic at run time through general purpose WS-ResourceProperties operation life add, update and delete. In the prototype flexibility in the WS-ResourceProperties is achieved by heavy use of data type "xsd:any", to bind any type of data with the WS-ResourceProperties for semantic information.

6. CONCLUSION

In this paper we have presented the concept of categorizing peers in communities on the basis of their expertise and interests. We have suggested Web Services based Community formation due to its broader acceptance, platform independence and interoperability. Vanilla Web Services lack the notion of state and stateful interactions, resource lifecycle management, notification of state changes, and support for sharing and coordinated use of diverse resources in dynamic 'virtual organizations' [4]. WS-RF specifications are designed on top of Web Services specifications to provide missing components. WS-RF along with the WSDM makes the best combination not only for community creation but for community management. Community creation and community discovery is addressed by WS-ServiceGroup Specifications and WSDM provides the missing bit of monitoring and management. WS-ServiceGroup and WSDM is powerful tool to manage dispersed resources; but their effectiveness relies on the other WS-RF specifications and Web Service Notification.

7. REFERENCES

[1] Asif Akram, Omer Rana, Structuring Peer 2 Peer Communities. The Third IEEE International Conference on Peer-to-Peer Computing. (2003) 194-195

[2] Asif Akram, Omer Rana: Organizing Service Oriented Peers Collaboration. The First International Conference on Service Oriented Computing. (2004) 451- 466

[3] Asif Akram, Omer Rana and Rob Allan: Organization of Grid Resources in Communities. First IEEE International Conference on e-Science and Grid Computing (2005) submitted
[4] Ian Foster, Carl Kesselman, Jeffrey M. Nick, Steven Tuecke, The Physiology of the Grid: An Open Grid Services Architecture for Distributed Systems Integration. Downloadable as http://www.globus.org./research/papers/ogsa.pdf, 2002
[5] Web Services Resource Framework, Available at http://devresource.hp.com/drc/specifications/wsrf/index.jsp
[6] H.V.D. Parunak: Distributed Artificial Intelligence, in Manufacturing Experience With the Contract Net, pp. 285-310, Research Notes in Artificial Intelligence. Los Altos, CA: (Morgan Kaufmann Publishers, 1987)
[7] Rob Allan, Alison Allden, David Boyd, Rob Crouchly: Roadmap for a UK Virtual Research Environment, Report of the JISC JCSR VRE Working Group (2004) http://www.jisc.ac.uk/index.cfm?name=programme_vre
[8] Globus Toolkit, Available at http://www.globus.org/toolkit/
[9] Apache Apollo, WS-RF Project, Available at http://ws.apache.org/wsrf/
[10] GNUTELLA Web: Gnutella Home. http://www.gnutella.com/
[11] JABBER SOFTWARE FOUNDATION Jabber IM http://www.jabber.org/about/overview.html
[12] JXTA http://www.jxta.org/
[13] S. Graham, I. Robinson, and et al. Web Services Resource Framework Primer, Draft 5. Available at http://www.oasis-open.org/committees/wsrf, 2005.
[14] Web Services Distributed Management (WSDM), Available at http://devresource.hp.com/drc/specifications/wsdm/index.jsp
[15] O. Kaykova, O. Kononenko, V. Terziyan, and A. Zharko: Community Formation Scenarios in Peer-to-Peer Web Service Environment, Databases and Applications, Innsbruck, Austria
[16] Semantic Web Services Resource Framework (WSRF-S) report available at www.wsmo.org/TR/d31/v0.1/d31v01_20050808.pdf
[17] Omer Rana, Asif Akram, Rashid Al-Ali, David W.Walker, Gregor von Laszewski, Kaizar Amin: Quality of Services Based Grid Communities. In Web Services and Agent Systems. (Kluwer Academic , 2004)

Host Based Intrusion Detection Architecture for Mobile Ad Hoc Networks

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ABSTRACT

Mobile ad hoc network is a collection of mobile hosts, which can communicate with each other using wireless interfaces and can also dynamically form a network topology where each node can act as router to forwarding the packets to other nodes. These networks are in high demand due to the ease and speed in setting up such networks. Due to the inherent vulnerabilities of wireless medium and node mobility make such network highly susceptible to malicious attacks. Things are getting worst when some nodes getting hijacked or compromised and make this network to stop from the smooth workings. This paper proposes the host based intrusion detection architecture to identify the malicious node and provide security support to continue the smooth workings of this network.

Keywords: HAR, ACM, ARP, CM, ADM, MDM, HDD, SCM etc.

1. INTRODUCTION

Mobile ad hoc network (MANET) has become an exciting and important technology in recent years because of the rapid development of wireless devices. MANETs are highly vulnerable to attacks due to the open medium, dynamically changing network topology, lack of centralized monitoring and management point and lack of clear line of defense. Since mobile nodes are autonomous devices that are ready to capable of roaming independently and due to roaming, network topology changes dynamically. The nature of the mobile nodes makes the network very vulnerable to an adversary's malicious attacks. First of all the use of wireless links renders this network susceptible to attacks ranging from passive eavesdropping to active interfering. Second, the nodes with inadequate physical protection are receptive to being captured, compromised and hijacked. Since identifying a particular mobile node in a large scale network cannot be done easily, and attacks by a compromised node from inside the network are far more damaging and much harder to detect. Therefore, all the nodes in this network must be prepared to provide its own security to operate in a mode that does not have any centralized administration and trust no peer. Due to decentralized nature of decision-making, many network algorithms rely on the cooperative participation of all the other nodes in the network, which creates a great problem for this network. Since any adversaries can capture any node to exploit this vulnerability for new types of attacks designed to break the cooperative algorithms. Further packet routing creates vulnerability in the ad hoc network, because most of the ad hoc routing protocols are also co-operative in nature. Since the nodes are acting as router, unlike with a wired network, where firewall and extra protection can be placed on routers and gateways to provide extra security. So an adversary who hijacks an ad hoc mobile node could paralyze the entire wireless network by injecting false routing information and intentionally dropping the packet so that false routing information conclude in messages from all the nodes being fed to the compromised node and it can dropping the packet to waste the valuable resource of this network. In summary, history of security research for mobile ad hoc network provide intrusion prevention measures, such as encryption and authentication, can be used to minimize the intrusion, but cannot eliminate them. For example, above measures cannot defend against compromised mobile nodes, which act as master for several slaves in a clustered network architecture, which carry the private keys of other slaves in that cluster. The dynamic nature of the ad hoc network also means that trust between the nodes in the network is virtually non-existent. Without trust, preventive measures are unproductive and measures that rely on a certain level of trust between nodes are susceptible attacks themselves. Further no matter how many intrusions prevention measurers are inserted in a network there are always some weak links that one could exploit to break in. Intrusion detection presents a second wall of defense and it is a necessity in any high-survivability of this type of network.

2. SURVEY OF INTRUSION DETECTION ARCHITECTURE

Since fixed network based computer system there are several points where the monitoring activity can be performed to protect the devices which becomes the target of an intruder. An intrusion can be defined as "any set of actions that attempt to compromise the integrity, confidentiality, or availability of a resource", when it takes place, intrusion prevention techniques, such as encryption and authentication are usually the first line of defense. But the scalability and complexity of the ad hoc network address exploitable weakness in the system due to design and programming practice of various autonomous nodes. Such as vulnerabilities like buffer overflow, static buffer flows and memory leakages can waste significant amount of electrical power and intensive processing drains. So we have to avoid the situation whereby the device has to do more routing in the ad hoc network. The primary assumptions of intrusion detection are the node activity in terms of user and program activities are observable via system auditing mechanism during a particular session of the node activity and differentiate between normal and intrusion activities. So intrusion detection therefore involves capturing audit data of the session and reasoning about the evidence in the data to determine whether the system is under attack. Based on the session audit data of the host, which supplied by the operating system or maintaining the audit data by special mechanism, IDS can analyze and monitor the events to find that whether the activity is belonging to any normal behavior or not. Though each node in the network act as router but this paper does not consider any network level examination of the packet.

3. CATEGORIZATION OF IDS MODEL

intrusion detection model can be categorized into misuse detection and anomaly detection. Misuse detection model: - detection is performed by looking for the exploitation of known weak points in the system, which can be described by a specific pattern or sequence of events or data (the" signature" of the intrusion).

Anomaly detection model: - detection is performed by detecting changes in the patterns of utilization or behavior of the system. This is the type of intrusion detection described in [1]. It is performed by building a statistical model that contains metrics derived from system operation and flagging as intrusive, if any observed metrics that have a significant statistical deviation from the model. Conceptually, an intrusion detection model, i.e., a misuse detection rule or a normal profile, has major two components:

- The features extraction (or attributes, measures), e.g. "the number of failed login attempts", "the number of opening of Vi editor", the manipulation of bash_profile file ", etc, that altogether describe a logical event, e.g. user manipulation of system files and environment variables.
- The modeling algorithm, e.g. rule –based pattern matching, that uses the features to identify intrusion.

The main advantage of misuse detection is that it can accurately and efficiently detect instances of known attack that is already specified in the system but unable to detect newly (truly innovative) attacks. Anomaly detection systems, for example, IDES [2], flag observed activities that deviate significantly from the established normal usage profiles as anomalies, i.e. possible intrusions. The main advantage of anomaly detection is that it does not require prior knowledge of intrusion and can thus detect new intrusion, but it may not be able to describe what the attack is and may have high false positive rate. Since defining a set of

predictive features that accurately capture the representative behaviors of intrusive or normal activities and extracting abnormal features from the data that quickly identify the intrusive activity in the system is the most important step in building an effective intrusion detection model which can be independent of the design of modeling algorithms.

4. PROBLEMS OF THE EXISTING IDS TECHNIQUES AND ITS LIMITATION

Since ad hoc networks neither have any centralized administration, nor have any traffic concentration points where the IDS can collect audit data for the entire network. Therefore, at any one time, the only available audit trace will be limited to communication activities taking place within the radio range, and the intrusion detection algorithms must be made to work on this partial and localized information [3].

A scenario of this problem can be seen in the following. Suppose IDS on a mobile ad hoc network are communicating with a certain encryption algorithm. Once an attacker compromises the security of one node in the network, it can send a message to all of the neighboring nodes conveying the need to change the encryption algorithm because due to an attack the attacker gain control of the network. Since the compromised node is communicating with the authorized encryption algorithm, the other nodes in the network trust the compromised nodes decision, and change the encryption algorithm for the network. This could lead to a type of availability attacks on the network. Since the nodes are busy trying to change the encryption keys by using intensive processing power, the IDS takes up a lot of the communication bandwidth between nodes, making the other, regular communication between nodes very slow. Further scalability is limited because distributed data collection can also cause problems with excessive data traffic in the network. Further it is also difficult to reconfigure or add capabilities to the IDS when network is fully operational. In summary, it must be needed to answer the following research questions in developing an ideal intrusion detection system for the mobile ad hoc networks

1. What architecture of the system is necessary for developing intrusion detection and response systems that fits in the mobile nodes and run continually with minimal supervision?
2. What are the suitable appropriate points to collect audit data of the nodes?
3. How to find out anomalies which depends on the partial, local audit traces –if they are the only acceptable audit sources?
4. How do we impose a minimal overhead on the system where it is running, so as to not interfere with its normal operation and run independently?
5. What is a good model of activities in a wireless communication environment that can separate anomaly when the nodes under attacks from the normalcy?
6. Finally due to resources constraints on the mobile nodes, IDS should not consume too much resource including power, processing time; therefore IDS should increase the run-time efficiency?

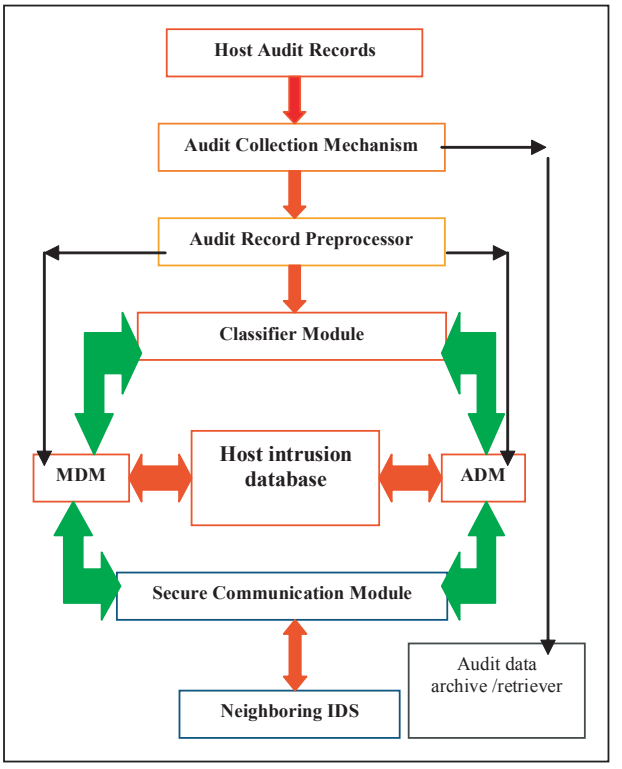
Considering the above all issues it can be found that if the design of IDS architecture are standalone for each host then they can detect attacks independently to decrease the co-operation between nodes and also takes the major decision locally. In order to provide protection to the individual nodes in the ad hoc networks it is required to constantly monitor the activity performed on the individual host so that unnecessary communication with other nodes can be minimized.

5. PROPOSED ARCHITECTURE

Host based system architecture are concerned with what activity is happening on each host. This architecture is ideal if it is able to detect actions and other activities with high confidence. In order to function properly, IDS has to be installed on every node in the network to processes and perform analysis on the audit data gathered locally, at the expense of the already limited resources on the hosts. The below architecture takes care to ensure that the IDS running on each host does not drain resources more than necessary. Here all the modules work collectively at the same time to provide the necessary support for the intrusion detection in the network.

The proposed architecture has eight parts, a) Host Audit Records (HAR), b) Audit Collection Mechanism (ACM), c) Audit Record Preprocessor (ARP), d) Classifier Module (CM), e) Anomaly Detection Module (ADM), f) Misuse Detection Module (MDM), g) Host Intrusion Database (HID) and h) Secure Communication module (SCM).

Figure 1. Graphical representation of a proposed host based IDS



a) Host Audit Records (HAR)

each operation of a host should be recorded to check that whether an intrusion is taking place. The local host audit record will consist of specific items out of the network traffic as well as user commands of the node. HAR is responsible for collecting useful information to minimize the volume of the audit data, responsible for gathering and storing not to processing it.

b) Audit Collection Mechanism (ACM)

This module usually passes the audit records to both the modules, one is Audit data archive/retriever, for the session duration storage, and to the Audit Record Preprocessor. The audit data archive /retriever can support as a simple buffer that writes the session oriented raw audit data into audit files or as sophisticated as a custom database management system used to store and retrieve audit data.

c) Audit Record Preprocessor (ARP)

This refers to one or more individual preprocessors used by IDS to isolate and format certain audit records prior to inputs into the other modules. Some records of the ongoing activity of the users must be maintained to provide as input to the intrusion detection system. In this module detection specific audit records are created from the host audit records. Each record contains the fields like subject, actions, object, exception-condition, resource-usage, time-stamp etc. This formatted audit records are providing structured and system specific useful information, which are passed below to the three individual module (MDM, CM, ADM) of the IDS. These individual modules are independently process the each audit records to determine any new intrusion has occurred or any malicious activity is performed by the host or not [4].

d) Classifier Module (CM)
Classification algorithms have attracted considerable interest both in the machine learning and data mining research areas [5]. In this architecture the classifier module basically concentrates on the decision tree approach. Objective is to use learning algorithm such that it is good if it produces hypotheses that do a good job of predicting the classification of unseen attacks. Audit record preprocessor (ARP) module provides structured and system specific set of records. Each record has the structure, consisting of a number of attribute value pairs. One of these attributes represents the category of the record. Basic approach is to determine a decision tree that on the basis of answers to questions about the non category attributes predicts correctly the value of the category attributes which takes only the values {attack, Don't attack}. From the tree construction, this module in the IDS properly does classification and finding new attacks. The use of the decision tree-learning algorithm is to test the "most important" attribute first, which makes the most difference to the classification of an example. That way, it can be hoped to get to the correct classification with a small number of tests, meaning that all paths in the tree will be short and the tree as a whole will be small so that it will provide faster approach to detect attacks on the node.

e) Anomaly Detection Module (ADM)
Each ADM is responsible for detecting a different type of anomaly. There can be many ADM modules based on the complexity of the IDS architecture. Each working separately or co-operatively with other ADM modules based on the processing load, e.g. .one is looking for file access frequency, while another might watch user input speed. In this architecture ADM will analyze data, compare with known profile which already defined, run the statistical analysis to determine if any deviation is significant, and flag the events as a true attack state, false attack state, or normal state. If it finds a false positive, then profile must be updated to reflect the results. Since in that case it making bridge with the classifier module (CM) to identify new types of attack occurred in the node. ADM's activity is to update profiles and checks for anomalous behavior whenever an audit record is generated or a session terminates. If abnormal behavior is detected, an anomaly record is generated having three components <Event, Time-stamp, and Profile>[6]. These generated records are compared with the audit record preprocessor input to conclude for an attack and then matches with the classifier module. If an ADM can identify an anomaly based on the data in the Host intrusion database, then it can initiate a local and global response to the intrusion. An example of a local response could be to stop communication to the identified node, rendering it useless to an attacker. A possible global response would be to use the secure communication module to alert other nodes in same cluster or in the other cluster, allowing them to configure a new network topology by excluding the designated compromised node. If the amount of data in the HID and CM is not sufficient to determine if the present activity should be as an intrusion, then it is possible for ADM to use the secure communication module to query the other nodes in the network to get help in identifying an intrusion [7].

f) Misuse Detection Module (MDM)
Detection is performed by looking for the exploitation of known weak points in the system, which can be described by a specific pattern or sequences of events or the data (the "signature" of the intrusion). Here the collections of signatures (representative patterns) define the known attacks [8]. The primary purpose of MDM is only to identify the known patterns of attacks that are specified in the local intrusion database. It also gathering sufficient information from the CM module about the specification of new attacks, accordingly it can update the rule sets. MDM takes the audit data for analysis and compares the data to HID for attack signatures. The attack signatures are normally specified as rules with respect to timing information and are also referred to as known attack patterns. If any comparison made between ADM and MDM, then it can be find that MDM'S job is to only identify known patterns of attacks that are specified in the host intrusion database. If MDM needs more information from the other neighboring nodes then it should use the Secure Communication Module to interact with them. Using the information provided by neighboring nodes IDS, then MDM might be able to predict an intrusion with more accuracy.

g) Host Intrusion Database (HID)
HID is a database maintaining in the nodes that warehouses all the information necessary for the IDS, such as the signatures of known attacks, the established patterns of users and resource usage and the normal volume of data flow in the network. The ADM and MDM communicate directly with the HID to determine if an intrusion is taking place.

h) Secure Communication Module (SCM)
SCM is providing necessary communication with other IDS on the network. It will allow the MDM and ADM to use co-operative algorithms to detect intrusion [9]. This module initiates a global response when an IDS of a node or a group of IDS of several nodes detects an intrusion. Basically, to provide security in a wireless medium it is required any communication that must be occurred from one node to another will use the SCM. Since Buttyan et.al. [10] discuss the problems regarding any public-key based security system to make each user's public key available to others in such a way that its authenticity is verifiable. In ad hoc networks, this problem becomes even more difficult to solve because of the absence of centralized services and possible network partitions [11]. Since data communication via SCM will need to be encrypted in order to ensure the data received by another IDS is accurate and has not been modified in any way. This module is only used by the IDS to exchange security related information between nodes and also share the necessary bandwidth that mobile devices uses for normal data transmission. So it is required to be efficient and fast, and can only use the amount of bandwidth it needs when transmission required. Efficiently managing the bandwidth for normal data transmission for mobile devices is another issue for IDS design also [12].

6. CONCLUSION
This paper has discussed several new issues and ideas that must be addressed when designing intrusion detection systems for mobile ad hoc networks. Even if the prevention schemes are perfect and implemented correctly, there are still internal and insider attacks that utilizes software vulnerability. A compromised node is an insider, with all the necessary cryptographic keys, and if it elected as a cluster head then it can launch many attacks. Thus, intrusion detection system should be designed in such a way that it can provide a necessary level of protection to the node and network and work independently without minimum human supervision. Through continuing investigation, it can be shown that this architecture is well suited for better intrusion detection in wireless ad hoc network that are distributed and co-operative in nature. Furthermore, the modular characteristics of the architecture allow it to be easily extended, configured and modified, either by adding new components, or by replacing components when they need to be updated. Such as it is possible to modify the audit record preprocessor module to provide more structured format of output. Application of this architecture might prove helpful in networks that are dynamic in nature, such as a group of tanks roaming in the desert, emergency response teams, and law enforcement etc.

7. FUTURE WORK
Future work includes implementation of such IDS architecture and testing its effectiveness in mobile ad hoc networks environments. Further enhance the capability of classifier module, so that it detect the attacks with minimal amount of time and provide useful information to the ADM and MDM module, to increase the effectiveness and scalability of this proposed architecture.

8. REFERENCES
1). Dorothy .E. Denning. An Intrusion- Detection Model. IEEE transaction on software Engineering, 13 (2); 222-232, February 1987.
2). T. Lunt, A. Tamru, F. Gilhan, R. Jagannathan, P. Neumann, H. Javitz, A. Valdes and T. Garvey. A real-time intrusion detection expert system (IDES) –final technical report, computer science laboratory SRI International, Menlo Park, California, February 1992.
3). Zhang, Y. W. Lee, 2000 Intrusion detection in wireless ad hoc networks. In proceedings of the sixth international conferences on Mobile computing and networking (Mobicom 2000). Boston, MA. August 2000.
4). Lee, W., S. Stolfo. A framework for constructing features and modules for intrusion detection systems. In processdings of the 1999. IEEE symposium on security and privacy.
5). J.R. Quinlan, C4.5: programs for machine learning, Morgan Kaufmann, san mates, CA 1993.

6). Andrew .B. Smith, An examination of an Intrusion Detection Architecture for wireless Ad hoc networks, department of computer science, Mississippi state university, MS.39762.

7). Z. Hou, L., J. Zygmunt 1999. Securing ad hoc networks. IEEE networks November /December 1999.

8). K. Ilgun, R.A Kemonerer and P.A Porras , State transition analysis : A rule based Intrusion detection Approach , IEEE transaction on software engineering , vol .21 .no 3. March 1995. Pages 181-199.

9). Wu, H., S. Yang, Y. Lin 2000. The sharing session key component (SSKC) algorithm for End-to-End secure wireless communication. In Proceedings of the IEEE 34th annual International Carnahan Conference on the security Technology. Pp.242-250.

10). S. Capkun. Levente Buttyan. Self-organized Public key management for mobile ad hoc networks, IEEE Transactions on mobile computing, vol.2.No.1: 52-64; January –March 2003.

11). Y. hung and W. lee, A. cooperative Intrusion Detection System for Ad hoc networks.

12). Y. Zhang and W. Li, An Integrated environment for testing mobile ad hoc networks. In proceedings of the Third ACM international symposium on mobile ad hoc networking and computing (Mobihoc ’02), Lausanne, Switzerland, June 2002.

ICT for Higher Education in Sudan: Issues and Perspectives

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ABSTRACT

Educational development and reform for any nation have always been characterized by the government's efforts to adapt education to national development needs. The heart of educational development and reformation, as in for developed and developing countries, has always been basic and technical education development with an aim to provide quality education for human resource development to meet the needs of the social, economic and political development of the country. The first section will conceptualize the role of ICT in developing economy and the global trends in ICT Practices, while the second section will give a brief of country profile, economic profile along with the impact of the peace agreement in Sudan, and will also highlight the present education system in Sudan stressing on the state of higher level education.

Keywords: ICT, Higher Education, Developing Countries & Education System.

INTRODUCTION

Information and communication technology (ICT) has become, within a very short time, one of the basic building blocks of modern society. Many countries now regard understanding ICT and mastering the basic skills and concepts of ICT as part of the core of education process, alongside reading and writing. Within the past decade, the new ICT tools have fundamentally produced significant transformations in industry, agriculture, medicine, business, engineering and other fields. They also have the potential to transform the nature of education-where and how learning takes place and the roles of students and teachers in the learning process.

ICTs have changed the nature of work and the types of skills needed in most fields and professions. While they have, on the one hand, created a wide array of new jobs, many of which did not even exist ten years ago, they have also replaced the need for many types of unskilled or low-skilled workers. These trends pose new challenges to educational systems to prepare students with the knowledge and skills needed to thrive in a new and dynamic environment of continuous technological change and accelerating growth in knowledge production.

ROLE OF ICT IN DEVELOPING SOCIETY

Information technology presents tremendous challenges and opportunities to society. The manner in which the country meets the challenge of information technology will largely shape its economic and social future into this century. A spectacular array of knowledge and information interchanges and processes lies at the heart of the information age. The capability of peoples and communities to be educated and trained in these new technologies is central to the appreciation and mastery of this new age.

The role of education and training aspects of ICT in capacity building & developing economy:

The challenges of the information age are not confined to any one sector but pervade all sections of society. Technological changes are leading to pressures on politics, work, education and social organizations. And these changes are going to force change as profound as that shaped by the industrial revolution, but at a much far faster pace. The question is not whether profound change will happen, but how our existing social structures will adapt themselves to these inevitable changes. The use of training and education will largely determine how these structures can deal with today's rapidly changing society.

Third World Nations need to develop an effective science, technology and innovation policy to spearhead this drive. Such a policy must be directed at specific actions such as research and the transfer, diffusion, rapid absorption and application of technology, with particular emphasis on the greater use of information technologies. In addition to the broad, societal needs outlined above, there are a number of specific sectoral needs of the information age.

Education it is clear that any society wishing to capitalize on information technology must invest heavily in education. Educational institutions must not only gear their efforts towards enabling people to master the complex and rapidly changing technologies themselves but also need to explore how such advances can be linked to, and influence, the wider business and commercial world. Degree, Diploma and specialized certificates programs, in particular, have a vital role to play in meeting the challenge ahead.

Training is a fundamental requirement of the information age. Countries coming to grips with competition and change in a dynamic and external environment should emphasize on more training. New entrants to the labor market must be trained in the skills and technologies associated with information technology, and existing public and private sector staff must be moulded to perform different tasks in a more flexible and innovative manner.

EDUCATION AND TRAINING FOR TECHNOLOGY

It has been argued by educationists and reformists that in striving to meet the wide ranging needs of IT, country's higher education system must maintain a strong diversity. Even vocational higher education is not that far inferior to university education. Society needs a broad continuum of graduates with different mixtures of knowledge and skills. It is required to have variety and flexibility in form, context, length, access and output. In this context, many students are taking the Private Technical College route specializing in areas of ICT and computers, which commands a very strong job opportunities in this sector.

Tertiary education can play a vital role in helping Third world Nations to exploit new opportunities in the information technology sector. Innovation, based on the application of science and technology, is now the mainspring of international economic competitiveness for any developing economy of the world.

Training should be seen as an investment rather than a cost and should be the focus of strategic planning like in most of the competitive economies. Training initiatives undertaken by developed nations bring many spin-off benefits to the wider economy, those having abundant natural resources and scope for development. The information age also requires emphasis on technical training to ensure that the labor force has the right skills balance.

GLOBAL TRENDS IN EDUCATIONAL ICT PRACTICES

As mentioned clearly by Middlehurst (2003) in his study on challenges and choices for Higher Education Institutions that increasing faith in the power of technology has seen an enormous increase in the use of ICT in education institutions world wide. This trend has further led the emergence of a number of non-traditional

HE providers competing for the student population among themselves, and with the traditional university.

Nowadays, the traditional university no longer has hegemony over the provision of higher education. In rising to the new challenge, it is turning to ICT to improve the quality of its operations, and also to reach for students in destinations beyond the traditional physical boundaries. At the same time the increasing use of ICT in higher education institutions is set within a context of wider economic, social, and political changes affecting countries worldwide.

Thus, the rationales and choices made by institutions for their ICT applications are influenced by a variety of macro and micro environments, and consequent perceptions of competition and the need for collaboration. Issues such as the digital divides, literacy limitations, financial constraints (largely developing countries), changes (increases) in student enrolment numbers (which is a global phenomenon), global technological developments, and competition between and among HE institutions and the emergent providers of higher education (global phenomena), are examples of the forces that drive change contexts (Middlehurst, 2003).

We can give examples from some countries that are also in process of implementing ICT in the higher education system for nation's growth:

AFGHANISTAN

Currently undergoing a large scale restructuring effort, Afghanistan has neglected its educational system because of recent wars and political instability. In this effort of gaining a centralized educational system, television sets are being sent to various villages across the country, and the aim is reaching students with educational broadcasting.

NEPAL

Nepal is an agricultural country that has an income per capita of less than US$ 250. More than four fifths of the population depends on agriculture as the main economic activity. The major ICT investment is the scholarships granted by the Ministry of Science and Technology to the unemployed youths

SUDAN: COUNTRY PROFILE

With an area of 2.5 million km^2, Sudan is the largest of African countries. Its vast size permits considerable variations in relief and vegetation: the north is a rainless desert; in the center there are wooded Savannah lands receiving monsoon rains ranging between 500 and 1500 mms annually; thick equatorial forests cover southern parts where precipitation reaches 1800 mms.

With strategic position in Africa, neighboring nine countries, and huge natural resources including the new discovered oil and gold and with the settlement of the southern Sudan conflict and the signing of peace agreement, the country became viable to receive financial and technical support from various donors.

ECONOMY OF SUDAN

Sudan's primary resources are agricultural, but oil production and export are taking on greater importance since October 2000. Although the country is trying to diversify its cash crops, cotton and gum Arabic remain its major agricultural exports. In recent years, the GIAD industrial complex introduced the assembly of small autos and trucks, and some heavy military equipment such as armored personnel carriers.

Extensive petroleum exploration began in the mid-1970s and might produce all of Sudan's needs. Significant finds were made in the Upper Nile region and commercial quantities of oil began to be exported from October 2000, reducing Sudan's outflow of foreign exchange for imported petroleum products. There are positive indications of significant potential reserves of oil and natural gas in southern Sudan, the Kordofan region and the Red Sea province.

In recent times, the government has worked with foreign partners to develop the oil sector, as a result of increased oil export, Sudan earnings from this sector have gone up from $500 million in 2000–01 to $1500 million at the end of 2005.

Some of the economic indicators of Sudan in recent years are presented in Table 1.

It can be observed from the above table that the economy of Sudan has improved over the years and with the recent peace agreement it will continue to stride in the areas of development.

SUDAN PEACE AGREEMENT

The government of Sudan and the Sudanese People's Liberation Movement (SPLM) in the South has signed a permanent peace accord, ending Sudan's 21-year civil war. This is a final comprehensive peace agreement. It is the culmination of a more than two years of intensive negotiations which was mediated by the regional Intergovernmental Authority on Development (IGAD). This peace agreement marked the end to 21 years of civil conflict that has claimed the lives of more than two million people and displaced four million more from their homes. A peaceful Sudan would serve as an engine for growth and breadbasket for East Africa once oil revenues and other resources are used for rebuilding infrastructure, economic development, and education.

EDUCATION IN SUDAN

Education is envisaged to equip recipients with knowledge and skills and assist to constitute human capital that empowers them to promote new values and to bring about change in their lives and in their communities. The educational system in the country therefore exercises a determining influence on the socio-economic and cultural development in the country.

On the other hand education promotes labor productivity growth and social development and spreads value and solidarity, tolerance social justice and environmental awareness for women, education in addition to its high private rates

Table 1. Sudan economic indicators

Indicators	1995	2000	2003	2004	2005
Current account balance (Billion US$)	-1.475	-1.84	-1.457	-1.366	-1.089
GDP based on (Purchasing Power Parity) per capita GDP (US$)	1295.69	1779.91	2025.334	2127.666	2220.681
GDP per Capita, current price (US$)	257.192	391.978	529.726	586.46	643.31
GDP current prices (Billion US$)	7.189	12.191	17.793	20.211	22.747
Inflation (Index, 1995=100)	100	501.05	613.142	652.996	692.176

Source: International Monetary Fund, World Economic Outlook Database, September 2005

of return, is found to be inversely connected with fertility and to increase child survival rates and better health.

The provision of basic education for all depends on political commitment and political will backed by appropriate fiscal measures public, private and voluntary.

As for higher education in a development setting:

As the nature and dimension of socio-economic and cultural factors have significant bearing on the quality of life of people, the search for solution for bringing about desirable improvement has been a continuing process in which the role of human resources development through education is duly emphasized.

The impact of development of human resources is intense and pervasive on all sectors of growth and is closely associated with the system of providing education and training. The effectiveness of the educational system is, however, primarily dependant on the availability of adequate finance to meet the requisite costs of the provision for the development of higher education and research.

The system of higher education, being chiefly responsible for preservation, generation and dissemination of knowledge and skills of the highest order, exercises a determining influence on the socio-economic and cultural development in the country. A World Bank report identified universities in developing countries as having three major roles:

a. Producing high level manpower to fill scientific technical, managerial and teaching job.
b. Carrying out research to generate knowledge and innovation relevant to the country's development.
c. Providing advisory services to assist development.

Noting that the principal output of higher education, are high level manpower, knowledge and innovation (research) and development advisory services, the World Bank identified number of hypotheses which can be reformulated in the context of Sudan. Higher education in Sudan had mirrored the different phases of economic and social change in the country.

The institutions of higher learning in the country, particularly specialized universities and colleges, have to use non traditional higher education infrastructures with a view of availing more efficient modes of learning. The installation of adequate infrastructures and intensive training of and the setting of knowledge information storage servers and date bases and e-learning platforms are mechanisms to serve that purpose.

HIGHER EDUCATION SYSTEM IN SUDAN

Higher education plays an important role in providing the generation with the necessary knowledge, values and skills to shoulder the responsibility of the overall development and to play their roles in different walks of life. Higher education provides the society with the intellectual, professional, scientific, educational, political, cultural and administrative personnel for development. It is considered the main tool for development and the more vivid source for scientific research.

Higher education is provided by universities, both public and private, and institutes and colleges of technical and professional education. The National Council of Higher Education is the government body responsible for higher education. Since 1990, many government universities have been created, mostly in the provinces. A few private tertiary institutions have also opened.

I. ***Main laws / decrees governing higher education:***
Decree: 1991 Higher Education Act Year: 1991
Concerns: Higher Education

II. ***Languages of instruction:***
Arabic, English

III. ***Stages of studies:***

- **Non-university level post-secondary studies.**
  University studies
  a) University level first stage: Bachelor's Degree.
  b) University level second stage: Master's Degree.
  c) University level third stage: Doctor of Philosophy.
  d) University level fourth stage: Higher Doctorate.

The National Comprehensive Strategy in the education domain:

In the field of higher education, the National Comprehensive Strategy has got concerned with realizing the resolutions of Education Revolution with the objective of achieving the following:

1. Revising higher education legislation and laws.
2. Increasing the number of higher educational institutions.
3. Qualifying of teaching staff.
4. Authentication of knowledge.
5. Encouraging scientific research related to the solution of the country's development, economic and social problems and linking the higher education with the environment and society.

EXPANSION OF HIGHER EDUCATION

The first half of the decade of the nineties witnessed the expansion of higher education through out the Sudan. The number of universities has increased from 10 in 1990 to 54 universities in 2005. Also public higher Institutions have increased from 7 in 1990 to 27 in the year 2005. The government of Sudan believe in the necessity of expanding higher education to meet the community demands and to reach international rates which in some countries reach 60 % of those in the age group 18 - 24.

ICT FOR HUMAN DEVELOPMENT & EDUCATION IN SUDAN

Despite the high tide of expansion in the field of ICT that shaped the international relations in today's economic and social life, resulting in unprecedented human advancement though out history of mankind, yet the benefits of putting to use ICT is not evenly realized by developing countries especially in Africa. This is attributed to a number of reasons, to mention a few, the non-preparedness of most of the countries in terms of institutional and operational capacities for running ICT system.

Sudan experience of the last two decades in building and capitalizing on ICT as a gateway for sustainable development is a landmark in Sudanese history. The experience tells how the institutional, legal and regulatory frameworks were reformed to advance ICT as tools for integrating the economy into the global market spheres. Moreover, staging a country, long been isolated and burdened by foreign debt, to new development horizons.

It is worth mentioning here that still the roles and functions of teachers in the standard classroom setting has not changed due to the traditional instruction methods used. The students are still taught through verbal instruction, and do not have the chance of autonomous hands-on execution of ICT possibilities. Moreover, as the curriculum undergoes frequent changes, the available software becomes insufficient, and the teachers are limited in terms of exploration possibilities.

Development in ICT in Sudan is represented by a gallant expansion of infrastructure and capital investment including management systems and human capital. Still areas pertaining to expanding the ICT markets in terms of product, distribution, quality of ICT products measured by their suitability to broader use, and affordability of the services.

Importantly establishing the link and measures with the economic and employment opportunities for individuals as well as society at large. These poses stubborn challenges to ICT advancement that would really support its expansions and reduce the risks of unguided competition that would probably lead to diminishing returns on investments and ultimately lead to crowding out effect of the actors adopting supply led strategy rather than demand pull strategies.

In view of the above, the UNDP is intervening to assist the government through its ICT institutions to collectively part sharing the interventions that promote ICT for human development and education. A process, which will assist formulating national strategy involving all stakeholders within the UN ICTD programme framework.

DEVELOPMENT STRATEGY TO NARROW THE DIGITAL GAP

ICT investment requires a tremendous amount of resources, particularly in the current period after the oil exploration in 2000. The program to narrow the digital gap should, therefore, carefully design and implemented. At least two primary concepts should be taken into account in developing the strategy.

Table 2

Program	Projects
Informatics Polices & Legislations	1- Drafting & ratifying Informatics & related Financial Legislations.
Establishment of a National Information Network	1- Drafting & ratifying National Information Network Law. 2- Design of Database and its Operating System. 3- The Interconnection of Local Networks. 4- Training.
Infrastructure Development	1- Creating the National Committee. 2- Development of Human Resources. 3- The Feasibility Study Model. 4- Network of National research Center. 5- Hardware Industry. 6- The Super Gateway. 7- Sudanese Silicon Valley.
Content & Electronic Publishing	1- An exploratory project in education content delivery. 2- A model Sudanese Cultural content.
Informatics Services	1- The program of the Digital Library. 2- Assessment of size of the present Information Services.

Source: Ministry of Higher Education and Scientific Research, January 2004

The first basic strategy is to make use as much as possible the existing domestic capacity, human resources as well as hardware infrastructure. For domestic connectivity, the strategy should be designed to capitalize from the existing communication infrastructure (fiber optic, copper, satellite, and microwave). Such concept will protect the higher education sector, as one of the social sector, from the technology's high obsolescence rate.

The higher education sector, collectively, is a large market for any domestic providers. Although the population who can afford using the ICT infrastructure is mostly between 40-50 years old, a substantial proportion of it does not possess adequate IT skill. Investing in younger generation, as a potential customer for the future is, therefore, imperative for ICT service providers. The future is not too distant either, since within 3 to 5 years they will be graduates and become an individual user, or even representing their employer to become institutional users.

The second basic strategy is to rely on the new paradigm concept, which has been chosen as the strategy for the national higher education development. The concept that rely on merit based tiered competition, user participation through proposal based competition, and higher accountability, is considered as the best suited strategy for higher education.

CURRENT DEVELOPMENT PROGRAMS

Knowing the fact that ICT capacity is an essential part of the future knowledge economy [World Bank, 2001], the Ministry of Higher Education considers ICT development at high priority. Within the auspices of the Ministry of Higher Education there are a few ongoing programs being carried out.

CONCLUSION

The Information and Communication Technologies (ICT) provide very forceful instruments to bring higher education to the Third World. However, as has been pointed out in several of the studies reviewed, "technology by itself is not a solution to any development problem; it only provides an opportunity." Further, "a thorough and wide-spread development in Third World countries requires "not only electronic communication policies and regulation but also social aspects.

In order to avoid being marginalized in the future knowledge economy, human development has to be a top priority for the nation [World Bank, 2001]. The ICT could significantly contribute to the nation in providing opportunity to conduct efficient, and yet quality, higher education. Although the peace agreement and the economic development has a tremendous impact to the national capacity to reduce the digital division, a careful, selective, and well-targeted ICT investment program for higher education is well justified.

The ICT could play an important role in higher education sector, particularly by providing the necessary infrastructure for improving quality in the institutions in the country. In addition to the domestic collaboration, collaborative activities among the neighboring countries could also boost efficiency. The higher education sector in these countries has many similar problems that collaboration in solving common problems is strongly recommended. The ICT could play an important role in providing support for the collaboration to happen.

One important and general conclusion is therefore that in order to get a sustainable impact upon the development process of Third World societies, the development of ICT in these countries must be supported both by technical and non-technical applications of relevance to the situation in which people in the country concerned live. Only then will the ICT structures created, contribute towards a development that will benefit the people of the countries in which the ICT is implemented.

REFERENCES

Bowers, C.A. (1998: 113). The Paradox of Technology: What's Gained and Lost? The NEA Higher Education Journal, Spring, 1998, P113.

Daniel, 1997, Daniel, J.S., Mega University and knowledge media: technology strategies for higher education, Kogan Page, London.

Dertouzos, M. (1997), "What will be: How the New World of Information will change our lives, New York, NY, Harpercollins Publishers.

Harvey, L and Green, D (1993:10): Defining Quality; Assessment and Evaluation in Higher Education.

Ingegerd Palmér (2001), "The Challenge of ICT in the Arctic (An overview of the use of Information and Communication Technology in Education), Luleå University of Technology, Sweden.

Joseph Intsiful (2003), "Use of ICT for Education, Research and Development in Ghana: Challenges, Opportunities and Potentials", Italy 2003.

Ministry of Higher Education and Scientific Research Directory

Middlehurst, Robin (Prof). (2003); Competition, Collaboration and ICT: Challenges and Choices for Higher Education Institutions; University of Surrey, UK

Rosswall, Thomas (1999). "The role of ICT in higher education at the beginning of this new millennium".

The comprehensive National Strategy (1992-2002) Vol I. Center for strategic studies September 1998.

The statistical yearbook 2003-2004 FMOE.

World Bank, 2004, World Development Indicators database, 2004

The Interface Design for Learning Environments via Web Using the Multiple Intelligences Theory and the Ergonomic and Usability Criteria

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ABSTRACT

Nowadays, the success of distance learning environments via web depends mainly on a well-designed interface for the user because teachers and learners are physically in different places and time. So, the instructional interface development process is a great challenge for distance education courses offered in these environments. The goal of this paper is to propose planning and methodology strategies to develop interfaces using the Multiple Intelligences Theory according to ergonomic recommendations and usability. It is also presented an application of the proposed methodology in the Natural Sciences in Education I course-discipline of the Pedagogy Undergraduate, Program, one of the six bimodal undergraduate courses offered by CECIERJ Foundation/CEDERJ Consortium. This Consortium is a partnership between the government of Rio de Janeiro State, Brazil, and six Public Universities located at Rio de Janeiro city.

INTRODUCTION

In a computer-based training environment, instructional interface elements should be those that are specifically designed to facilitate the learners´ access and participation. Fundamentally, their learning process once teachers and learners are physically in different places and time. This means that the success of the learning process in these environments depends on a well-designed user interface to help learners to guide themselves through instruction (Lohr, 2000). For this reason, ergonomic recommendations and usability in a design project should be considered.

On the other hand, the Information and Communication Technologies (ICT) progress are helping teachers to follow individually the learning process of their students. The ICT can also make possible to elaborate interfaces for web environments which can provide the student comprehension throughout symbol systems (linguistic, numerical, musician, graphic etc.), facilitating learning process for different cognitive styles. So, ICT are perfect to apply the Multiple Intelligences (MI) Theory approach defended by Howard Gardner (2001).

The goal of this paper is to propose a methodology to develop distance education interfaces for courses offered via web using the MI Theory according to the ergonomic recommendations and usability. It is also presented an application of the proposed methodology in the *Natural Sciences in Education I* course-discipline of the Pedagogy Undergraduate Program offered by CECIERJ Foundation/CEDERJ Consortium.

THEORETICAL FOUNDATION

Some important concerns (as ergonomic recommendations, usability of instructional interfaces) and the MI Theory that were fundamental to elaborate the methodology proposed in this paper will be developed now.

Ergonomic Recommendations and Usability of Instructional Interfaces

Hackos et al (*apud* 1998) and Marchionini et al (1995 *apud* Lohr 2000) showed that:

"The user interface is formally defined as the communication link between an environment (a product or system) and an user. It consists of objects or elements designed to communicate the function of the environment. An instructional interface by this definition can be thought as the elements that assist the user, a learner, in the task of learning. In a computer-based training environment, instructional interface elements are those that are specially designed to facilitate access to, and participation in, instruction and instructional support."

In agreement with Lohr (2003), the project of an educational interface is a challenging effort that requires instructional design and educational project knowledge as long as human and psychological factors, ergonomic research, computer sciences and publishing project. Many recommendations are available to attend the designer professional, but many among them do not fulfill with the specific necessities for educational environment. Nilsen (2000) says that "*many of the existing environment interfaces present problems in the information architecture, visual elements organization, interactivity and functioning"*.

Hall (2000 *apud* Silva , 2006) detaches that education based on web depend on the target public, the communication context and the virtual environment. Although designers must face these questions, a web-based course should consider the learning objectives which are the most important factors in guiding the entire creation process of the project development.

In this way, Fleming (1998) proposes to observe how people study in the internet and how are their expectations when using the learning environment. The interface should provide the knowledge of how a student should answer questions related to the browsing and to the learning.

Finally, it is important to understand that the interface design project for learning environments via web have to consider the target public identification (user), his/her objectives and tasks. Then, when the ergonomic and usability criteria are applied the quality of the interaction is guaranteed due to the teach-learning process.

The Multiple Intelligences Theory

The MI Theory (Gardner, 2001) can help a teacher to organize his work and to know well his students. This fact will be possible through a set of categories used to describe strong and weak characteristics of the students, within a special recommendation to avoid prejudices and/or stereotyping them [p.185, 186]. Using the MI Theory is easier to assign subjects, teaching methods, hardware, software and ways of evaluation in order to considerate the most strong intelligences that are revealed by the students.

At the beginning of the Eighties, Gardner has initially identified seven different human intelligences: the *linguistic intelligence* (sensitivity to spoken and written language, the ability to learn languages, and the capacity to use language to accomplish certain goals); the *logical-mathematical intelligence* (capacity to analyze problems logically, carry out mathematical operations, and investigate issues scientifically); the *musical intelligence* (skill in the performance, composition,

and appreciation of musical patterns)*;* the *bodily-kinesthetic intelligence* (potential of using one's whole body or parts of the body to solve problems); the *spatial intelligence* (potential to recognize and use the patterns of wide space and more confined areas); the *interpersonal intelligence* (capacity to understand the intentions, motivations and desires of other people)*;* the *intrapersonal intelligence* (capacity to understand oneself, to appreciate one's feelings, fears and motivations).

From 1997 and on, Gardner (2001, p. 63-79) has been identifying more three "new" possible *intelligences:* the *naturalistic intelligence* (applied to people who demonstrate great recognition and the classification of its environment); the *spiritual intelligence* (spiritual human predispositions) and the *existential intelligence* (capacity of pointing out the meaning of the life, the direction of the death, the final destination of the physical and psychological worlds).

There are some meaningful works in Education using the MI Theory. The SUMIT (Schools Using Multiple Intelligence Theory) Project, for example, was a 3-year national investigation which has involved 41 schools in the United States. It sought to identify, document, and promote effective implementations of MI. After this study, 78% of the schools have declared positive results in standardized tests; 63% have associated this success to the pedagogical practices used and based on the MI Theory; 78% have declared that there was an improvement in the learning process of the students with learning problems; 80% have declared an improvement in the participation of the parents and 75% of them have attributed the improvement to the MI Theory; 81% have declared that the students were more disciplined, and 67% of them have attributed this improvement on the students' behaviour to the MI Theory. Although these numbers can reflect an emphasis positive, it is also important to say that they were based on empirical data, that cannot be refuted by anyone.

Vicari (2005) has developed an experiment at Paulista University in São Paulo State, Brazil, which involved the application of learning activities with undergraduate students of Production Engineering. The MI Theory was applied as a pedagogical strategy on the learning process. The experiments have the intention to verify whether learning contents presented, according to the student profile, could facilitate the learning process, and whether learning contents not adjusted to the student profile could make the learning process more difficult. 92 experiments were taken: 41 according to the student profile and 51 in contrast. The percentage of consonant contents was higher than the percentage of conflicting contents. The conclusion of this case study was that in distance learning, when there is a previous knowledge of the student profile and individual learning styles based on the MI Theory, it is possible to present an adequated way in order to obtain better results in learning process.

The VLSM is an adapted model aligned with the philosophy of Saskatchewan Education University (Boulton, 2002). The virtual teacher´s task is to scaffold learning to support the learner in the use of VLSM design elements: layer 1- Instructional Strategies; layer 2- Multiple Intelligences, layer 3- The Organization Models; layer 4- ICT Genre. The layers of VLSM demand online instruction to utilize many different combinations of the four layers in order to meet different intelligences and learning styles (Witfelt, 2000 apud Boulton 2002). In the second layer (Multiple Intelligences), teachers will need to examinate their pedagogical beliefs and take into consideration the theory of Multiple Intelligences (Witflet, 2000; Bisho et al, 2001 *apud* Boulton 2002). The MI Theory suggests several other ways in which the subject material may be presented to facilitate effective learning. Meeting individual learning needs can be accomplished through the use of eight potential individualized instruction pathways.

CONTEXT OF THE CASE STUDY

CEDERJ Consortium (Distance Undergraduate Education Centre of Rio de Janeiro State, Brazil) is connected to SECTI (Innovation, Technology and Science State's Secretary of Rio de Janeiro) and associated to six Public Universities located at Rio de Janeiro city (UENF, UERJ, UFF, UFRJ, UFRRJ and UniRio). Since 2001, some bimodal undergraduate courses are offered: Computer Science, Biological Sciences, Mathematics, Pedagogy (Initial series of K12), Physics and Administration. The main goal of these courses were to socially include the students who can not study in a local University. In 2007, it will be offered some other courses: Chemistry, Geography, Pedagogy (complete course) and Modern Languages. Actually there are 14.000 registered students and 20 (twenty) regional centres spread all over Rio de Janeiro State prepared to assist the students during the course. The contents of these courses are developed by teachers who work at the associated Public Universities and edited by the CEDERJ staff to adapt the written pedagogical material to be presented in two ways: publishing and web-based material. Specifically for the web-based instruction, there are four multidisciplinary departments and each one responds for Biological Sciences, Mathematics, Physics and Pedagogy developing material (Silva, 2006).

The Pedagogy Program of CEDERJ was created to be completed in 3 years learning period, along 30 and 60 hours course-disciplines. There are mandatory courses-disciplines and others which are eligible by the student, according to the teaching methodology. The course-disciplines are offered to the learner through didactical printed material, digital material and web classes at CEDERJ e-Learning platform (http://www.cederj.edu.br). The students have presential and also long distance tutors to help them on the learning process. Long distance tutorial can be accessed through a public telephone, fax or at CEDERJ plataform. The tutors can use didactical printed material and web classes during tutorial meetings.

THE DESIGN OF WEB-BASED INTERFACES USING THE MI THEORY

This item describes planning and methodology strategies to develop distance education interfaces for web courses using the MI Theory accounting as also ergonomic recommendations for usability. It is also presented an application of the proposed methodology in *Natural Sciences in Education I* course-discipline of the Pedagogy Undergraduate Program of CEDERJ Consortium.

Planning Strategies to Design Web-Based Interfaces Using the MI Theory

In traditional "face-to-face" classrooms the teacher conducts, helps and promotes educational and learning process. On web classes, however, the interface should transmit the idea of being in an environment built especially for the student with an appropriated design. Moreover, the instructional interface design should offer a rich learning context minimizing the loneliness feeling, a frequent complain of distance education learners. Thus, a distance education interface via web should offer several resources in order to accomplish the learners-target needs, according to their individuality, their real life environment and also the aims of the learning activities. For planning and using learning strategies in the interface's design of a course-discipline, it must be considered (Silva, 2006):

- Target public (learners): identification of the system's user;
- Contents: what is accosted by each discipline/course and its pre-requisites?;
- Strategies: the relation between the course-discipline aims and daily matters;
- Concepts: which concepts have to be given to the target public (learners)?;
- Function: the course-discipline function related to the program;
- Mission (goals): course-discipline goals related to the program;
- Tasks: activities which have to be accomplished by students using the interface;
- Cognitive styles.

These eight elements above should be considered in order to create a metaphor conception that will be used in the hole interface design to construct the course-discipline environment for the web. The web designer should concern about the text language of each screen, so that the interface will not function only as a background. In this way, it is important to create a context and a visual identity that enables the discipline contents' organization and the insertion of learning activities inside the designed interface.

Resources or situations such as, for example, a video sample, are organized or included in the interface to promote the learning of a content / subject / theme. The function of this survey for the metaphor creation is to enrich or to propose an interface with interesting learning situations that help the student to attend a video, read a text, to participate on a debate about some subject with his classmates. These situations should be associated to different learning styles of the students and should contemplate all the multiple intelligences.

For Fleming (1998), it should be given opportunities for visual learners to view pictures or diagrams, for verbal/textual learners to hear and read explanations, and for active learners to learn through discovery or experience. It sounds quite daunting, but it's not as hard as it seems. Providing these different opportunities will make learners feel more at ease right from the start and will help ensure that they are not turned away by an approach that does not address their needs.

The ICT progress was made to become real the MI approach defended by Gardner. It is already possible to create computer programs or software directed toward different intelligences, programs that offer a variety of entry points allowing the students to demonstrate their understanding in various symbols systems (linguistic, numerical, musical, graphical etc.) (Gardner, 2001).

Applying the Strategies to the Interface Design of the Pedagogy Program of CEDERJ Consortium

The Education web staff is a multi-disciplinary team, composed by a coordinator and an instructional designer, both undergraduated in Education. There are also web designers, animators, illustrators and programmers.

The coordinator assembles the printed educational material of a particular course-discipline of the Pedagogy Program and selects a group composed by an instructional designer, a web designer and an animator/illustrator to work on the contents. Then the work starts in order to implement 15, 20 or 30 course-discipline classes, according to the hours required on the program. These groups are selected considering the qualification and individual features of the components.

After the planning stage described above, it is necessary to create a script to be followed by the workgroup, guided by the steps to elaborate and to implement the interface design or the web classes of a course-discipline as seen next:

Step 1. Workgroup meeting to define the discipline's web design;
Step 2. Meeting with the instructional designer, responsible for writing the texts of the web classes;
Step 3. Elaboration and implementation of the course-discipline design/environment;
Step 4. Teacher's approval;
Step 5. Applying usability tests for the evaluation of the course-discipline interface by the students and tutors (Silva, 2006);
Step 6. Final design and course-discipline implementation;
Step 7. Upload of the web classes on CEDERJ platform allowing the students´ access.

IMPLEMENTED INTERFACES

The interfaces are elaborated/designed by the illustrator/animator responsible for the discipline using Adobe Flash software. Each layout corresponds to a .fla file. The instructional designer is responsible for the content elaboration of the web classes which are based on the text of the published material. Therefore, he/she has to select videos, internet sites, games etc., to include them in the interfaces. When the instructional designer has finished the content elaboration of the web classes, the web designer will implement them by producing .swf files. Finally, these .swf files will be published in a .php page at CEDERJ platform. This platform is a framework which corresponds a distance education environment known as a CLMS – Content Learning Management System.

The implemented interfaces of the course-discipline *Natural Sciences in Education I* are static due to the specifications of CEDERJ platform. It does not allow a frequent interface update because it has been attended by a great and crescent number of users. However, in the second semester of this year, a new version of the platform will be implemented and it will be possible to receive dynamic interfaces.

It will be showed now some implemented interfaces using the planning and the script already described for web classes elaboration related to the course-discipline entitled *Natural Sciences in Education I* of the Pedagogy Program. The TV interface has been designed to associate each channel to an special intelligence proposed by Gardner. Then, each channel tries to show the discipline content in a way that stimulates the cognitive style of the individual student that is associated to an intelligence type.

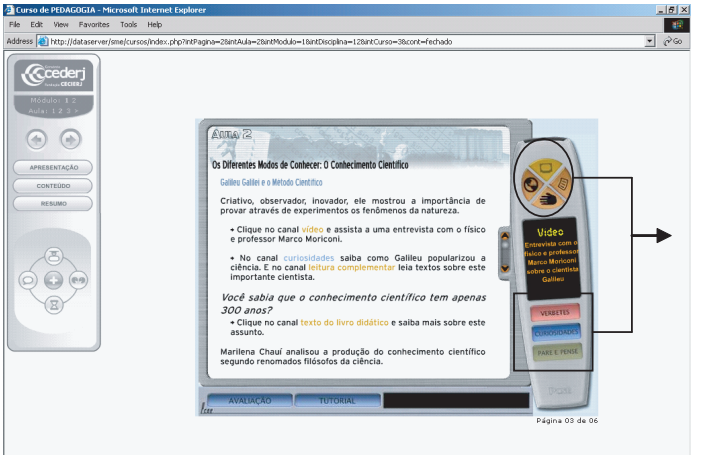
As long as the design and the implementation of interfaces stimulate many intelligences types, it allows the student to access pedagogical activities that are more related with their cognitive style facilitating the learning process.

The dynamic of this course-discipline in the web is a TV program with two characters: "Gil Terra" and "Ana Soe". The content of the lesson is presented in a TV screen inviting the student to guide him/herself by choosing TV channels.

Figure 1 presents the text with questions regarding the subject presented in the lesson, and guides the student towards TV channels where he/she may access videos, published didactical material, linkage, suggestion of activities etc., all intended to be carried throughout their professional career as teachers.

To Access the complementary video of the classroom, the student should click the video channel (Figure 2), where is possible to attend interviews, news, and documentaries related to the subject presented in class. This type of Learning Activities (LA) is for verbal and textual learners to listen and read explanations (Fleming 1998). For Gardner, this LA stimulates the *linguistic intelligence.* For the practical activities it is necessary to click on the channel entitled "practicing in the classroom" (Figure 3). For Gardner, this LA stimulates the *bodily-kinesthetic intelligence* because it invites the student to use his/her body (as the hand or the mouth) to solve problems or to create products. This LA also stimulates the

Figure 1



The TV Screen
< http://www.cederj.edu.br/cecierj/> Retrieved September 26th, 2006

Figure 2

The screen with the video channel – *linguistic intelligence*
< http://www.cederj.edu.br/cecierj/> Retrieved September 26th, 2006

Figure 3

"Practicing in the classroom" screen– *bodily-kinesthetic and naturalist intelligences* < http://www.cederj.edu.br/cecierj/> Retrieved September 26th,

naturalist intelligence as the student can build some instruments to study Nature. To access the internet sites that are recommended in the class, the student should click in the channel entitled "complementary reading" which, in agreement with Gardner, should stimulates the *linguistic intelligence*, the *musical* and the *logical-mathematical intelligences* too.

At the "stop and think" channel (Figure 4) active learners will learn through discoveries or activities (Fleming 1998) by accessing animations, videos, texts or games, synchronized to the *logical-mathematical and the intrapersonal intelligences* (Gardener 2001). Finally at the "Comments" channel (Figure 5) the learners can discuss the themes presented in the course-discipline to improve their *interpersonal intelligence* (Gardner 2001).

CONCLUSIONS

The educational interfaces should be developed to enhance a new knowledge acquisition, academic abilities and attitudes which are necessary for their career. In consonance to this, it is fundamental to know the learners´ cognitive style because from this stage it is possible to decide about the curricula, the pedagogy and the evaluation methods. Another important aspect is that the educational decisions will be taken based on a up to date student profile. The application of the MI Theory and the ergonomic and usability criteria during the planning and design of the interfaces for learning environments based on the web can facilitate the settlement of an enriched environment that: 1) present learning situations where the information organization will reach the interests and the preferences; 2) minimize learners´ troubles; 3) identify the experiences and the objectives of each learner; 4) reach the educational objectives established at the beginning.

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REFERENCES

Aldridge, D. (1991). Spirituality, healing and medicine. *British Journal of General Practice, 41,*425-427.

Boulton, Jeff. (2002). Web-Based Distance Education: Pedagogy, Epistemology, and Instructional Design. Retrieved July, 10, 2006, from Educational University of Saskatchewan Communications and Technology, Web site: http://www.usask.ca/education/coursework/802papers/boulton/index.htm

Figure 2

"Stop and Think" channel – Game - *logical-mathematical intelligence*
< http://www.cederj.edu.br/cecierj/> Retrieved September 26th, 2006

Draft Standard for Learning Object Metadata (2002). Learning Technology Standards Committee. Retrieved September 26, 2006, from http://ltsc.ieee.org/wg12/files/LOM_1484_12_1_v1_Final_ Draft.pdf.

Fleming, J.(1998) Web Navigation the User Experience. Ed. O'Reilly.

Gardner, H. Inteligência: um conceito reformulado. Editora Objetiva. Rio de Janeiro. 2001.

Hall, R.H., Watkins, S.E. & Eller, V.E. (2003). *A model of Web Based Design for Learning*. Retrieved August 10, 2006, from In *The Handbook of Distance Education*, edited by M. Moore and B. Anderson, Mahwah, NJ: Erlbaum, 367-376. Web site: http://medialab.umr.edu/papers/handbook_2003_hall.pdf .

Lohr, L. *Designing the instructional interface*. Elsevier Science Ltd. Computers in Human Behavior, Univerity of Northern Colorado, USA, 16, p.161-182, 2000.

Nielsen, Jacob. (1995) Advances in Human Computer Interaction - vol.5. Ablex Publishing.

Perrenoud, P. (2000) *Pedagogia Diferenciada*. Artmed Editora. Porto Alegre. RS..

ZERO Project at the Havard Graduate School of Education (Schools Using Multiple Intelligence Theory) (n.d.). Retrieved September 3, 2006, from http://www.pz.harvard.edu/

Silva, S. de P. (2006) Ergonomic evaluation of Usability Interface in E-learning Projects. 7º Congresso Brasileiro de Pesquisa e Desenvolvimento em Design, Paraná.

Silva, S.P. (2006) *Strategies for the Web-Based Instructional Design in Distance Education.* 22nd ICDE World Conference on Distance Education. Rio de Janeiro. Brasil.

The encyclopaedia of informal education (ínfed). (n.d). Howard Gardner, Multiple Intelligences and Educatio. Retrieved 8 september, 2006, from http://www.infed.org/thinkers/gardner.htm

Vicari, L.M. (n.d.) Distance Learning, Yes... But How? Presentation of the results from the application of learning actions on Production Engineering students, based on the student profile. UNIP. S.Paulo. Brazil. Retrieved September 21, 2006, from http://www.tidia.fapesp.br/portal/eventos/folder.2006-06-21.4513988865/14885.pdf#search=%22Luci%20Maria%20Vicari%22.

What is a Learning Object? (n.d.). Retrieved September 21, 2006. Wisconsin Online Resource Center from (http://www.wisc-online.com/Info/FIPSE%20-%20What%20is%20a%20Learning%20Object.htm).

Why Analysts Draw: The Effect of Diagrams Supporting UML Use Cases

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ABSTRACT

An experiment was undertaken to compare effectiveness of use cases with and without supporting use case diagrams. The Cognitive Theory of Multimedia Learning is used to hypothesize diagrams improve the effectiveness of use cases by providing visual cues aiding model viewers in selecting and integrating relevant information. The level of understanding developed by participants viewing either uses cases or use cases with a use case diagram was measured using comprehension, retention and problem solving tasks. Results support the hypothesis that participants developed a significantly higher level of understanding when viewing UML use cases with the support of a use case diagram. This suggests practitioners should consider combining a visual representation with use cases to achieve higher levels of understanding in persons viewing these descriptions.

Keywords: UML, Use Case Modeling, Conceptual Modeling, System Analysis

1. INTRODUCTION

Use cases in the unified modeling language (UML) are a popular modeling technique for system analysis and design (Burton Jones and Meso, 2006; Siau and Loo, 2006). The application of use cases by practitioners varies (Dobing and Parsons, 2006). However, use cases remain primarily text-based descriptions that provide a structured sequence of processes within a system (Jacobsen et. al., 1994). While text is a rich, familiar and expressive modeling language, text can also be ambiguous and difficult to conceptualize. It seems reasonable, given the popularity of use cases, to consider whether use case diagrams provide a significantly more effective method for communicating system analysis information than text-based use cases alone.

An experiment was undertaken to compare the effectiveness of use cases with and without supporting use case diagrams. The Cognitive Theory of Multimedia Learning (Mayer, 2001) is used to hypothesize that diagrams improve the effectiveness of use case delivery by providing visual cues aiding model viewers in selecting and integrating relevant domain information into effective cognitive representations. We take the view that techniques should be compared on how well they support the development of an understanding of the domain they represent (Gemino and Wand, 2003). To test understanding, we use a problem solving task (Bodart et. al., 2001; Gemino, 1999) that requires reasoning about the domain and focuses attention on higher levels of understanding.

2. BACKGROUND

Use Case Modeling

A Use Case is a description of a sequence of events in a system that produces a result as understood from a user's perspective. A use case presents the actions associated with a person's "use" of the system (Jacobson et. al., 1994). The use case is often an important part of object-oriented analysis methods (Dobing and Parsons, 2006; Siau and Cao, 2001).

Researchers that support the UML suggest the simplicity of the use case method is an asset. Kobryn (1999) suggests that use cases are simple and natural notations that are easy to understand for stakeholders, analysts and designers. While the use case is primarily text, the UML has developed an assortment of diagramming techniques that can potentially integrate with use case information. A key for the use case remains the lack of formalism (Jacobson et. al., 1999).

Previous UML Research

UML modeling has attracted significant research attention (Agarwal, 2003; Burton Jones and Meso, 2006; Evermann and Wand, 2005; Fedorowicz and Villeneuve, 1999; Siau and Cao, 2001; Siau and Loo, 2006). While much has been said about expected benefits of Use Case modeling (Jacobson et. al., 1999; Kobryn, 1999), little empirical research has been directed at these claims. Dobing and Parsons (2006), for example, found little empirical research on the effectiveness of Use Case modeling.

The UML approach is genrally accepted, however, it has critics. Douglass (1998) argued UML is large and overly complex. Halpin and Bloesch (1999) suggested UML models are designed for software engineering and are less suitable for validation of conceptual models. Dori (2003) has suggested that UML has difficulty in integrating structural and process elements of system designs. Dobing and Parsons (2006) suggested Use Case modeling faces two significant challenges. One challenge is that Use Cases tend to isolate stakeholders from object class models. This results in a lack of information on classifications and categories within the system. They argue that information in the Class Diagram is valuable in developing understanding and is not provided by Use Cases. A second challenge is the lack of formalism, which allows Use Cases to mix conceptual, design and implementation details in the same description. This mixture of design and conceptual elements may cause confusion for stakeholders and reduce the effectiveness of the stakeholder/analyst communication.

Separating Conceptual Modeling from Requirements Engineering

To understand how uses cases can be used, it is important to outline the system development process. The information system development process can be viewed as a series of increasingly formal representations ending in machine executable code (Wand and Weber, 1993).

Three generic roles in this development process include stakeholders, analysts and developers. The least formal representations of the system are the concepts held by stakeholders. In a standard development process, analysts interact with stakeholders to develop more formal representations of the system, often called conceptual models (Wand and Weber, 2002). These conceptual models are shown to stakeholders to validate analysts' perceptions of the system.

Conceptual models are a foundation for the development of formal functional requirements. Analysts develop functional requirements primarily to communicate system details with developers. In an ideal world, developers could use the formalized functional requirements to develop the eventual machine code for the systems (the system artefact).
Throughout the development process, the system representation grows increasingly formal and precise. The role of the analyst is to communicate system details in such a way as to develop a common understanding of the system between developers and stakeholders.

Analysts are involved in two distinct processes. The first involves interacting with stakeholders to develop an understanding of the system. This process is defined as conceptual modeling (CM) (Everman, 2005; Wand and Weber, 2002). It involves eliciting requirements, representing them, and having stakeholders interpret and validate these requirements. The second process formalizes this conceptual understanding into a set of functional requirements. This second process is defined as requirements engineering (RE). CM and RE are related processes that facilitate the common objective to reason and communicate about a domain. Because they are related, the same techniques are often touted for use in both

CM and RE, though the audience for the processes may be different. Use cases have often been suggested as useful tools for interacting with stakeholders, but use cases can also inform developers about process issues.

3. THEORETICAL FOUNDATIONS

Conceptual modeling involves the capture of domain information to develop understanding and support communication. Developing understanding of a system and its components is, therefore, a process of learning (Gemino and Wand, 2003). This is true for the person developing the model as well as the person viewing it. The design of conceptual modeling techniques may be informed, therefore, by theories of how humans develop understanding from the graphics and words they are presented with. Mayer (2001) suggests two contrasting views of learning –information acquisition and knowledge construction. These views are discussed briefly below.

Information Acquisition

Learning as information acquisition implies that learning is a process of adding to long-term memory. The model viewer receives information and stores it in memory. The responsibility for learning rests on the model creator to deliver appropriate information. The goal is to deliver required information efficiently. In this view, the conceptual model is a standard vehicle for efficient information delivery to the model viewer.

Knowledge Construction

An alternative view is knowledge construction. This view suggests knowledge is personally constructed. Two model viewers presented with the same conceptual model may come away with different learned outcomes. This occurs because the model viewers attempt to make sense of the information presented and integrate this information into a coherent mental representation. Knowledge construction suggests the model viewer is an active sense maker rather than a passive receiver of information.

A Model of Conceptual Modeling as Knowledge Construction

As a framework for reasoning about conceptual modeling, we use the model of knowledge construction (Gemino and Wand, 2003; 2005). In this model, the model viewer is constructing knowledge by actively organizing and integrating information with previous experiences. Three antecedents of the process are suggested: (1) content, (2) presentation method, and (3) model viewer characteristics. The content represents the domain information to be communicated. The presentation method is the way in which content is presented to the viewer. Viewer characteristics are attributes prior to viewing the content. These characteristics include knowledge and experience with the domain and with the modeling methods used to present information.

The construction process is where the sense making activity is hypothesized to occur. The results of knowledge construction are encoded into the long-term memory. The learning outcome modifies the model viewer's characteristics. Learning outcomes can then be observed, only indirectly, through learning performance tasks.

Cognitive Theory of Multimedia Learning

Messages that combine graphics and words are defined by Mayer (2001) as "multimedia messages". The Cognitive Theory of Multimedia Learning (CTML) provides a theoretical perspective on the level of understanding developed by a person viewing explanative material, such as an analysis diagram in requirements validation. The theory is based on work by Baddeley (1992) and Paivio (1986) and has been developed through a decade of empirical work (Mayer, 1989; Mayer, 2001).

The theory is focused on the interaction between a person and the information presented to him or her. The CTML suggests there are two pathways in cognition, verbal and visual. While independent, these channels communicate in working memory. When a person views presented material, relevant information from the verbal and visual channels is selected. This information is organized to create separate visual and verbal models. These two models then interact and are subsequently integrated with prior knowledge in long-term memory to develop new knowledge. An overview is provided in Figure 1.

In the CTML, an understanding of verbal and visual information is developed through three stages of memory. In the first stage, *sensory memory*, information is selected into one of the two dual coding pathways. The selected information is then developed into visual and verbal models in *working memory*. In the final stage, the verbal and visual models from working memory are integrated with *long-term memory* to create understanding. This describes the process of knowledge construction.

Learning Outcomes and Performance

The CTML has enabled Mayer to develop principles relating to the effective design of multimedia messages. He suggests the most effective communication occurs when verbal and visual pathways are utilized simultaneously. Mayer suggests three outcomes when presenting explanative material to people: 1) no learning, 2) rote learning and 3) meaningful learning. These outcomes are based on measures of two variables: retention and problem solving. Retention is the comprehension of material being presented. Problem solving is the ability to use knowledge gained to answer related problems not directly answerable from presented material. For example, if presented with an explanation of how a car's brake system works, a retention question might be "*List the components of a braking system*," but a problem solving question would be "*What could be done to make brakes more reliable?*" These problem solving task have been used by Bodart et. al (2001); Burton-Jones and Meso (2006) and Gemino (1999; 2004).

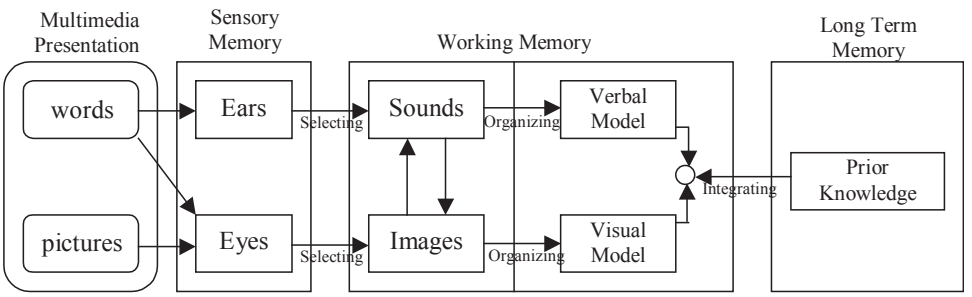
No learning occurs were retention and problem solving are low. Rote learning occurs where retention is high; however, problem solving measures are low. This indicates that although the material has been received, material has not been well integrated with prior knowledge. Meaningful learning occurs where retention and problem solving are high.

4. EXPERIMENTAL DESIGN AND HYPOTHESIS

Overview of Experimental Design

Three dependent variables (comprehension, retention and problem solving) will be measured. Other variables measured include prior knowledge of the domain,

Figure 1. The cognitive theory of multimedia learning (adapted from Mayer, 2001, p. 59)



knowledge of the modeling method, and participant demographics. Two treatment groups were compared using a single case. The first treatment was provided with a set of use cases describing a system. The second treatment was provided the same set of use cases along with a one-page use case diagram. The single page diagram shows the interaction between use cases and actors in the system as well as any interaction between use cases in the system. The following statement provides the underlying logic for conducting this experiment: If a participant is presented with a) a set of use cases and b) a set of use cases and a diagram relating these use cases, then the participant will gather a significantly higher level of understanding of the domain being presented with b) than with a).

Hypothesis

Mayer's (2001) multimedia principle suggests a potential for higher levels of understanding from use cases associated with diagram than use cases alone. The multimedia principle therefore enables us to suggest the following hypothesis:

H1: *According to the multimedia principle from the CTML, participants viewing a set of use cases with an associated use case diagram will develop a higher level of understanding of the domain than participants viewing use cases alone.*

5. METHOD

An empirical procedure was developed to test the hypothesis above. The procedure was based on Mayer (1989, 2001), and used for system analysis by Bodart et. al (2001), Burton-Jones and Meso (2006), Gemino (1999, 2004), Gemino and Wand (2005).

Participants

Forty-nine upper level business students took part in the study. All students had taken a system analysis course and had basic familiarity with use case models. Females accounted for 20 of the 49 participants (41%) of participants. Participation was voluntary. An incentive of $15 was provided for the top four performers. The average time to complete the study was 45 minutes. All participants were at an introductory level in business process design, and had no particular experience with object oriented analysis. A pre-test was given to measure experience with system analysis and the business domain used in the analysis as well as other demographic variables.

Materials

One case including five use cases and one use case diagram was used in the experiment[1]. The use cases and use case diagram were created using an approach described in Dennis and Wixom (2000). The text description was provided by the Voyager Bus company case in Bodart et. al. (2001).

Procedure

Participants were randomly assigned into two treatment groups. An envelope was given to each participant containing a pre-test, five use cases (plus diagrams if necessary), experimental tasks (comprehension, retention and problem solving) and a posttest. Participants worked independently and first completed the pre-test followed by the three experimental tasks and finally the post-test.

The first task was a twelve question multiple choice comprehension task (True, False, Uncertain). After the comprehension task, participants were instructed to put away the use cases and diagram (if provided). Participants were than given 6 minutes to complete a retention task, which asked participants to write down everything they knew about the processes in the use cases. This task was followed by four problem solving questions used by Bodart et. al. (2001). Participants were given 2 minutes to write as many answers as possible to each problem solving question.

Measures

Learning performance was measured using three variables: comprehension, retention and problem solving. Comprehension was the number of correct answers out of a possible of 12 questions. Retention and problem solving scores were coded by two individuals. The retention score was created by giving one mark for each complete and correct idea statement expressed by the participant. There was a maximum of 20 idea statements identified in the use cases. The problem solving score was created by giving participants one point for each acceptable response to the problem solving questions. The Pearson correlation between coders for retention was 0.88 and for problem solving questions 0.90. Differences between independent ratings were then discussed, and a final score for retention and problem solving was established.

6. RESULTS

Preliminary Tests

Since the sample size was relatively small, it is important to establish the homogeneity of variances before ANOVA analysis. Levene statistics for each of the dependent measures indicate that the hypothesis of equal variances is not rejected across any of the variables at the 0.05 level.

Domain and modeling experience were collected in the pre-test and used as covariates in an ANCOVA analyses. Both domain and modeling method experience were found to have insignificant influences on the dependent variables. This result may be due to the uniformly low levels of experience held by participants. While it seems likely prior domain experience and modeling method experience are related to the dependent measures, the factors, as measured in this study, had no significant effect in this study and were excluded in further analysis.

Results

The means and standard deviations of the dependent measures (comprehension, retention and problem solving) across the two treatment groups are provided in

Table 1. Means and Std. Dev. across treatments for dependent measures

Dependent Measure	Case: Voyager Bus			
	Treatment Groups			
	Without Diagram n=25 Means (SD)	With Diagram n=24 Means (SD)	Difference between means (With-Without)	Sig.
Comprehension	7.627 (.321)	8.139 (.328)	.0512	0.271
Retention	7.877 (.541)	9.670 (.552)	1.793	0.025*
Problem solving	12.174 (.824)	14.568 (.841)	2.394	0.045*

** significant at the 0.05 level*

Table 1 below. The results show little difference across treatment groups for comprehension measures. Note that participants had full access to use cases during the comprehension test. Since the information was available in either treatment, the diagram had little effect in basic comprehension.

Retention and problem solving measures showed differences in the anticipated direction. The size of the effects was approximately 20%. This is measured by dividing the difference between the "with" and "without" diagram scores and then dividing the result by the score for the without diagram group.

An ANOVA was applied to test the significance of these differences. Results, provided in the final column of Table 1, suggests significant differences for both problem solving and retention measures at $\alpha = 0.05$ level. This result provides evidence to support hypothesis H_1. These results suggest that although the content across treatments was the same, the organization provided by the use case diagram enabled participants with access to the diagram to build a more sophisticated mental model. Note that although the sample size is relatively small, the effect size is relatively large.

These results suggest that diagrams, even simple diagrams such as the use case diagram provided in this experiment, have measurable effects on viewer understanding.

7. CONCLUSIONS

Mayer's Cognitive Theory of Multimedia Learning has been used to demonstrate that humans process both text and pictorial images together to develop a deeper understanding than either media alone. Text descriptions often accompany drawings, but little formal research has been done to clarify the potential effect of exhibits. This paper describes an experiment which evaluates the level of domain understanding for subjects when drawings are used to support use cases compared to the use cases alone. The results support the hypothesis that a use case diagram has a significant positive effect of the level of understanding developed by a person viewing use cases.

Future research can be directed more closely on what diagram elements are most effective in supporting use cases. In addition, more empirical evidence is required to understand the effectiveness of use case modeling. While the text based approach has some excellent features and has appealed to practitioners, it is clear that diagrams are an important component for communication. More needs to be understood about this relationship if we are to make use case modeling an even more effective communication tool for stakeholders and developers.

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REFERENCES

Agarwal, R., P. De, and A.P. Sinha, "Object Oriented Modeling with UML: A Study of Developer Perceptions", Communications of the ACM, Vol. 46, No. 9ve, September 203, p. 248-256.

Baddeley, A. D., "Working Memory", Science, 1992, vol. 255, pp. 556-559.

Bodart, F., A. Patel, M. Sim, and R. Weber, "Should Optional Properties Be Used in Conceptual Modelling? A Theory and Three Empirical Tests," Information Systems Research, Vol. 12, No. 4, (December 2001) 384-405.

Burton-Jones, Andrew and Meso, Peter, "Conceptualizing Systems for Understanding: An Empirical Test of Decomposition Principles in Object-Oriented Analysis," Information Systems Research, Mar 2006, Vol. 17 Issue 1, pp. 38-60.

Dennis, A., and Wixom, B., System Analysis and Design: An Applied Approach, John Wiley and Sons, New York, 2000.

Dobing, B. and Parsons, J. " How UML is Used", Communications of the ACM, Vol. 49, No. 2, May 2006, p. 109-113.

Dori, D. "Why Significant UML Change is Unlikely", Communications of the ACM, Vol. 45. No. 11, November, 2002, p. 82-85.

Douglass, B. P. "UML for Systems Engineering" Computer Design's: Electronic Systems Technology & Design, (37:11), 1998. p. 44-49.

Evermann, J. Thinking Ontologically - Conceptual versus Design Models in UML. In: Rosemann, M. and Green, P. (eds.) Ontologies and Business Analysis. Idea Group Publishing, 2005, 82-104.

Evermann, J. and Wand, Y, "Ontology-Based Object-Oriented Business Modelling: Fundamental Concepts, Requirements Engineering Journal, Vol 10, No 2, 2005, 146-160.

Fedorowicz, J. and Villeneuve, A. 0, "Surveying Object Technology Usage and Benefits: A Test of Conventional Wisdom", Information & Management, (35:6), 1999. p. 331-345.

Gemino, A., Empirical Comparison of System Analysis Techniques, Ph.D. Thesis, University of British Columbia, Vancouver, British Columbia, June 1999.

Gemino, A. Empirical Comparisons of Animation and Narration in Requirements Validation, Requirements Engineering Journal 9 (3) (2004) 153-168.

Gemino, A. and Y. Wand, Evaluating Modeling Techniques Based on Models of Learning, Communications of the ACM 46 (10) (2003) 79-84.

Gemino, A. and Y. Wand, "Dimensions in Experimental Evaluation of Conceptual Modeling Techniques", Requirements Engineering Journal, vol. 9, 4, 2004, 248-260.

Gemino, A. and Wand, Y., "Simplicity versus Clarity: An Empirical Comparison of Mandatory and Optional Properties in Conceptual Modeling", Data and Knowledge Engineering, 55, 2005, p. 301-326.

Halpin, T. and A. Bloesch, "Data modeling in UML and ORM: A Comparison", Journal of Database Management, (10:4), 1999, pp. 4-13.

Jacobson, I., Ericsson, M., & Jacobson, A, The Object Advantage: Business Process Reengineering with Object Technology. Reading, MA: Addison-Wesley, 1994.

Jacobson, I., Booch, G. and Rumbaugh, J., The Unified Software Development Process, Reading, MA, Addison Wesley, 1999.

Johnson, R. A., "Object-Oriented System Development: A Review of Empirical Research", Communications of the Association for Information Systems, Volume 8, 2002, p. 65-81.

Kobryn, C, "A Standardization Odyssey", Communications of the ACM, (42:10), 1999 p. 29-38.

Mayer, Richard E., "Models for Understanding", Review of Educational Research, Spring 1989, Vol. 59, No. 1, pp 43-64.

Mayer, Richard E. and J.K. Gallini, "When is an Illustration Worth Ten Thousand Words?" Journal of Educational Psychology, 1990, Vol. 82, no.4, p. 715-726.

Mayer, Richard E., Multimedia Learning, Cambridge University Press, New York, 2001.

Mellor, Stephen J, "Make models be assets" Association for Computing Machinery. Comm. of the ACM; Vol. 45, No. 11, Nov 2002, p. 76-78.

Paivio, A. Mental representations: A Dual Coding Approach, Oxford, England: Oxford University Press, 1986.

Siau, K. and Q. Cao, "Unified Modeling Language (UML) - a complexity analysis", Journal of Database Management; Vol. 12, No. 1, Jan-Mar 2001, p. 26-34.

Siau, K. and Loo, PP, "Identifying Difficulties in Learning UML", Information and Management, (23,3), Summer 2006, p. 43-51.

Wand Y., and R. Weber, "On the Ontological Expressiveness of Information Systems Analysis and Design Grammars", Journal of Information Systems, vol. 3, 1993, pp. 217-237.

Wand, Y. and R. Weber, "Information Systems and Conceptual Modeling a Research Agenda," Information Systems Research, December, 2002, pp. 203-223.

ENDNOTE

[1] The exhibits used can be accessed online at http://parker.bus.sfu.ca/irma.pdf

Facilitating Enterprise Information System Engineering Through a UML 2.0 Profile: A Case Study

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ABSTRACT

Modern enterprise information systems are distributed systems usually built on multi-tiered client server architectures and can be defined using well-established frameworks such as the Zachman framework or the Open Distributed Processing Reference Model (RM-ODP). Both frameworks identify views regarding the system designer's viewpoint, but they do not suggest a methodology for view creation. A consistent framework for enterprise information system engineering, compatible with both the Zachman framework and RM-ODP is proposed by the authors. It consists of a metamodel describing alternative system views, a corresponding methodology comprising discrete stages performed either by the system designer or software tools and a UML 2.0 profile for view representation. In this paper, a case study where the proposed framework was applied is discussed, focusing on the features provided to the system designer using the UML 2.0 profile. The profile is implemented by extending the Rational Software Modeler functionality.

1. INTRODUCTION

When building an enterprise information system (EIS), the desired properties of the system should be defined, such as its structure and behavior, while the role of the system in the environment should also be considered. Many different stakeholders may be involved in this process, as defined in the Zachman framework (Zachman, 1999). Each of these stakeholders focuses on certain concerns and considers these concerns at a certain level of detail. A *viewpoint* defines the way the system is conceived by a stakeholder according to his concerns (Boer, 2004). The conception of the system according to a certain viewpoint is described as a system *view*, thus one or more views correspond to a certain viewpoint. Each view may be formally defined by a *model*, while it is communicated to the stakeholder by a *representation model*, which is a concrete representation of the system view on some medium (e.g. paper or computer program). A consistent representation of the systems implies that each view is not examined in isolation but interrelations between views are formally defined. We argue that the way system views are related must be fully and typically defined in the corresponding models. In order to formally define a viewpoint, one should define a metamodel describing the supported views independently of the modeling language used for system representation and then define the representation model. In this way, a view may be represented using different languages (e.g. UML), in a common manner, facilitating the transformation between representation modeling languages.

Having adopted this viewpoint-oriented description of information systems, we defined for the system enginnering viewpoint three complementary views, namely *Functional, Logical* and *Physical.* Some of them may be further decomposed into subviews emphasizing specific entities into a greater level of detail. These views are part of a framework introduced in (Nikolaidou et al., 2006) which offers a consistent framework for information system engineering. More specifically our framework comprises:

- A metamodel describing different views and the relations between them (EIS metamodel). These relations are strictly defined using constraints.
- A methodology for EIS engineering based on the proposed views. The methodology consists of discrete stages performed by system designer, software tools or a combination of both. Taking advantage of the formal definition of relations identified between views, system engineering stages may be invoked automatically, as a result of the metamodel constraint validation.
- A UML representation for all defined views. A UML 2.0 profile is defined for this purpose (EIS engineering profile).

The overall framework is briefly presented in section 2, emphasizing the supported views and the corresponding UML 2.0 profile. In section 3, a case study where the proposed framework was applied is discussed, focusing on the features provided to the system designer using the UML 2.0 profile. A Rational Software Modeler plug-in has been implemented to support the additional functionality of the profile.

2. EIS ENGINEERING FRAMEWORK

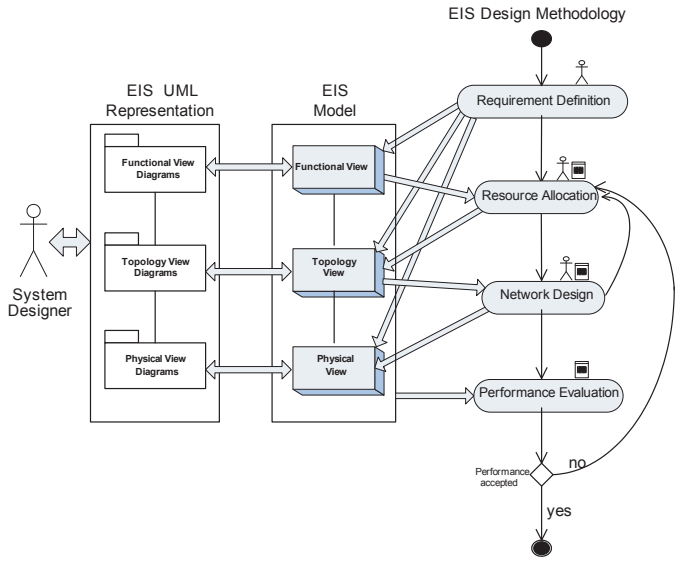
The framework is based on three complementary views:

Functional View is used to describe functional specifications such as system architecture, user behavior and application requirements. System architecture refers to the architectural model adopted. In case of our framework, multi-tiered client-server models are described. Services provided by each application tier (called module) are also defined. User behavior is modeled through user profiles describing the behavior of different user groups and their performance requirements. Application requirements are described in terms of quality of service (QoS) requirements imposed to the network infrastructure, e.g. amount of data processed, transferred or stored. Each service is described in a greater level of detail through the *service description* subview.

Topology View facilitates the definition of system access points and the resource allocation and replication. To characterize any location (i.e. a building, an office, etc.), the term *site* is used. As such, a site is a composite entity which can be further analyzed into subsites, forming thus a hierarchical structure. Functional and Topology views are interrelated. Resources (e.g. processes and files) correspond to services and data described through Functional view and are located into sites.

Physical View refers to the aggregate network. Network *nodes* are either *workstations* allocated to users or *server* stations running server processes. Topology and Physical views are interrelated. Both are decomposed to the same hierarchical levels of detail. At the lowest level, network nodes are related to processes/data replicas.

Figure 1. EIS engineering framework



2.1 EIS Engineering Methodology and Metamodel

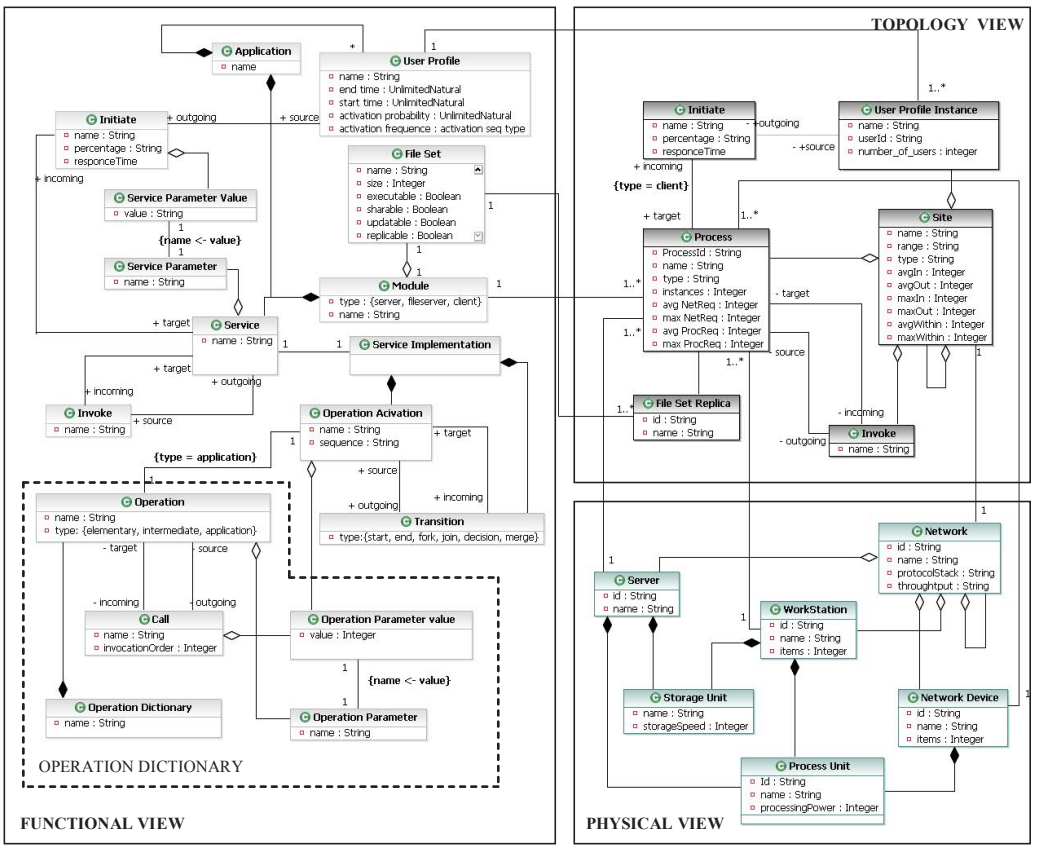
The proposed methodology includes the following discrete stages of the system engineering process:

1. System requirements definition.
2. Resource (process/data) allocation and replication policy definition.
3. Network architecture design.
4. Performance evaluation of the proposed solution (prior to implementation). Although it is not a necessity, it is certainly useful.

As resource allocation and network design problems cannot be independently solved, stages (2) and (3) are repeatedly invoked for different abstraction levels until an acceptable solution is reached. Both resource allocation and network architecture problems are usually supported by automated or semi-automated tools using mathematics, heuristics or a combination of both. These tools may be repeatedly invoked for different abstraction levels (Graupner et. al, 2001) and (Nezlek et. al, 1999). The system designer may perform or partially perform these tasks on his own, thus both options must be supported. To evaluate system performance, a simulation tool as the one described in (Nikolaidou et al., 2003) can be used. The simulator uses as input the overall system model and produces performance results. Since each of these tools supports its own representation metamodel (for example queuing networks, Petri-nets, objects), there is a need to properly create and instantiate the "internal" system model prior to invoking the tool.

The proposed methodology stages along with the EIS model consisting of the predefined views are presented in figure 1. Discrete stages receive/modify information from/to specific system views, as depicted by the arrows between them. The relation between views and between stages is also depicted in the figure. Requirements definition is the initial stage and corresponds to the definition of system architecture and application requirements (Functional View), the system access points (Topology View) and, if any, the existing network architecture (Physical View). Each view is represented by one or more UML diagrams properly extended. All the required extensions are grouped into a UML 2.0 profile which also describes the relations between views.

Figure 2. EIS engineering metamodel



As already mentioned the models created follow a formal metamodel which itself contains relationships and restrictions inflicted between system entities belonging to the same or different views, which may lead to a specific stage invocation (e.g. if the network hierarchy in Physical View is modified, this modification must be depicted in Topology View as well). Embedding restrictions within the metamodel facilitates the management of the EIS engineering, as the overall system model is taken into account and not a specific system view corresponding to a discrete stage. Thus, the overall process becomes more effective, since discrete stage (and corresponding tool) dependencies are depicted within the model as view dependencies and consequently they are easily identified. Furthermore, it becomes more efficient to integrate autonomous software tools at different levels of detail, as each of them is independently invoked without knowing the existence of others.

All the entities of the metamodel along with their interdependencies are presented in figure 2. As shown in figure 2, despite the fact that views concentrate on different aspects and thus include different model elements, there are however correspondences between them indicated in the diagram by the lines that cross view boundaries.

2.2 EIS Engineering UML 2.0 Profile

The defined UML 2.0 (OMG 2004a; OMG 2004b) profile comprises a number of stereotypes. Essentially, the concepts of the metamodel are reflected onto the stereotype attributes and constraints. Attributes convey the information required to describe the EIS metamodel entities (e.g. *throughput, activationFrequency, processingPower* etc.). Constraints, which are extensively used within the profile, represent relationships and restrictions between metamodel entities maintaining model consistency. Constraints mainly facilitate:

1. automatic computation of specific attribute values.
2. limiting attribute value range.
3. relating attribute values of specific elements to attribute values of other entities belonging to the same or other UML diagrams (implementing thus the linkage between different models).
4. model validation in view and overall model level.

Attributes and constraints for each stereotype are analytically introduced in (Alexopoulou et al, 2006). Following, the UML diagrams selected for each view are briefly presented. Stereotypes are listed in Figure 2 along with the EIS metamodel entity they correspond to. The relative icons are also included, so that the reader can understand the figures presented in the case study of section 4. Functional view is represented through UML component diagram, since component diagrams are eligible for depicting system functionality at a logical level. Concerning service description subview, it is represented through activity diagram, as it involves flow of operations. UML communication diagrams, which depict interaction between entities, are suitable for the representation of Operation Dictionary, since the latter involves interactions between operations showing in particular invocation order and parameter passing between them. Physical View, which comprises the network infrastructure, is illustrated through UML deployment diagrams, which are commonly used to represent network architectures (Kaehkipuro, 2001). Lastly, the representation of Topology View is based on UML component diagrams.

3. CASE STUDY

The proposed framework has been applied for the engineering of a typical banking system. In this case, resource allocation and network design stages were performed by IDIS software tool (Nikolaidou, 1999), that supports the representation and exploration of resource allocation and network topology design through algorithms combining mathematics and rules of thumb. To evaluate distributed system performance, the discrete event simulation tool described in (Nikolaidou, 2003) was used. Requirements definition was performed by the system designer using the EIS engineering UML 2.0 profile, implemented in Rational Modeler (IBM Co, 2005).

An appropriate UML modeling tool for EIS engineering UML 2.0 profile implementation must fulfill the following requirements: a) it must be UML 2.0 compatible, b) it must facilitate mechanisms to extend the provided functionality (e.g. by importing profiles) and c) it must export models in XML based on existing UML classes and profile-specific stereotypes. After serious considerations regarding various UML 2.0 tools, we decided to implement the profile in the Rational

Figure 3. Stereotypes of the EIS engineering profile

FUNCTIONAL VIEW		
Stereotype	**EIS Metamodel Entity**	**Notation**
ServerModuleComponent	Server Module	
FileServerModuleComponent	Server Module	
ClientModuleComponent	Client Module	
ServiceComponent	Service	
Invoke	Invoke relationship between Services	
UserProfileComponent	User Profile	
Initiate	Initiate relationship between User Profiles and Services of Client Modules	
Operation Dictionary		
OperationAction	Service operation	
ElementaryOperationLifeline	Elementary Operation	
IntermediateOperationLifeline	Intermediate Operation	
ApplicationOperationLifeline	Application Operation	
ArgumentsMessage	Message sent between operations conveying parameter values	

PHYSICAL VIEW		
Stereotype	**EIS Metamodel Entity**	**Notation**
NetworkPackage	Network	
ServerDevice	Server	
WorkstationDevice	Workstation	
ProcessUnitDevice	Process Unit	
StorageUnitDevice	Storage Unit	

TOPOLOGY VIEW		
Stereotype	**EIS Metamodel Entity**	**Notation**
SitePackage	Site	
ServerProcessComponent	Server Process Instance	
ClientProcessComponent	Client Process Instance	
UserProfileComponent	User Profile Instance	
DataComponent	Data Entity	
Initiate	Initiate relationship between User Profile Instances and Client Process Instances.	
Invoke	Invoke relationship between Server Process Instances	

Software Modeler environment (IBM Co, 2005). The extensibility features of the Rational Software Modeler are based on the open-source Eclipse platform. Eclipse provides useful APIs, frameworks (e.g. Workbench, Workspace, Help, etc.) and plug-ins that facilitate the development of new tools. EIS models are stored in an XML format in accordance with XMI (OMG 2005) to ensure interoperability. Before using a specific tool, the partial transformation of EIS model into the tool-specific internal model is realized. Using this transformation, the invocation and initialization of any tool can be automatically performed. The case study focuses on requirements definition and aims at demonstrating the use and implementation of EIS engineering profile through Rational Modeler. However, hits on the overall framework functionality are provided.

The Bank supports 38 discrete teller transactions. The amount of transactions/day varies according to branch size, while the average amount of teller transactions in large branches is over 10.000 per day. The required response time is 15-18 sec for most transactions. The system architecture relies on server-based computing. A central database is installed in headquarters, while transaction logs are maintained in local databases of each branch. Transactions are coordinated by a transaction monitoring system – TMS (Tuxido), also installed in headquarters. Transactions are composed by 24 discrete atomic transactions initiated by TMS. Each transaction consists of 3 to 7 atomic ones. All atomic transactions are implemented by stored procedures running in the central database. To enhance security and ensure a single authentication point, all user programs run on a dedicated execution server (CITRIX), while in user terminals only the corresponding client (CITRIX client) is installed.

FUNCTIONAL VIEW

Functional view facilitates the system designer to a) define the EIS architecture (client and server modules) and b) define the functionality provided by its modules and the requirements imposed by them and the interaction between them to the network infrastructure.

EIS modules identified were the following: *File Server*, *CentralDB, LocalDB*, *TMS* and *Citrix*. Since *LocalDB* represents logging, only a simple *insert* service was implemented for recording the log. *CentralDB* supports 33 stored procedures, represented as a different service. *TMS* Module includes 24 services corresponding to discrete atomic transactions. *Citrix* Module includes 38 services corresponding to discrete teller transactions. They involve the invocation and processing of forms, the activation of atomic transactions through *TMS* and log recording. Tellers are modeled as User Profiles initiating *CITRIX Client* modules corresponding to each teller transaction. In the following, we focus on teller transaction to demonstrate real-world system representation capabilities of the proposed framework.

Figure 4. Fraction of functional view: Transactions trx31600 and trx2000

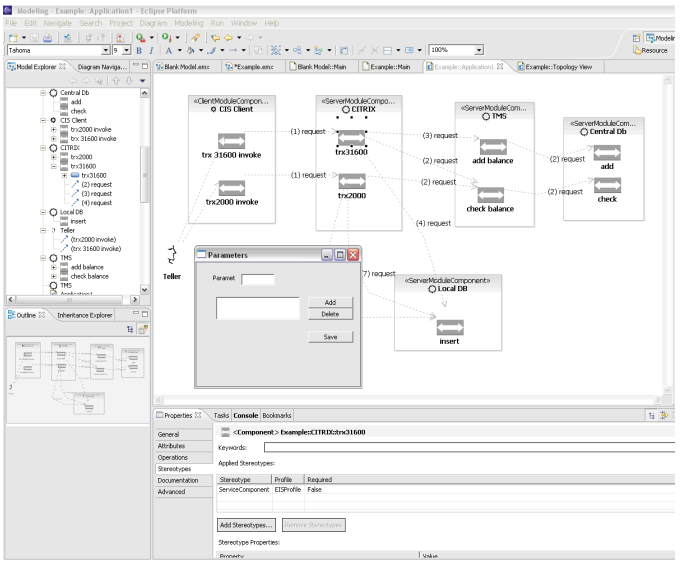


Figure 4 represents a fraction of Functional view, implemented as a Component diagram in Rational Modeler, emphasizing services needed for the representation of transactions trx31600 (i.e. cash deposit) and trx2000 (i.e. request business loan). As depicted in the figure, services are represented as component stereotypes and modules as package stereotypes. The *trx31600* service of the *Citrix* Service Module is selected in the figure. Additional stereotype attributes are stored in the corresponding fields supported within Rational Modeler platform (bottom right part of figure 4). Input parameters of each service are added by system designer through a custom menu created using Rational Modeler Eclipse API. In this case (*trx31600*), only the *module* attribute is filled, since the service has no input parameters (*inputParameterList* attribute is empty). On the left part of Rational Modeler's screen in figure 4, it is shown that *trx31600* service component is further decomposed into other entities.

Trx31600 service is described by the corresponding activity diagram, implemented as a subdiagram of the Functional view component diagram. It is represented in figure 5. As shown in the figure, trx31600 includes the activation of the appropriate forms (operation action 1), the activation of the central database through the TMS (operation action 2 and 3) and local database update (operation action 4). Each discrete step is represented by an action instantiating a predefined operation included in the Operation Dictionary. Operations represent requirements imposed to system resources (network, processing nodes, etc). When defining an action, all input parameter values of the corresponding operation must be filled. They must be either constant or already defined as trx31600 service input parameters. As shown in figure 5, all operation input parameters must be constant, since trx31600 service has no *inputParameterList*. The corresponding validation constraint is implemented as a custom script initiated by Rational Modeler's *Run Validate* default menu appearing when right-clicking on any UML diagram entity. Some of the actions, as *request* (selected in figure 5), result in the invocation of other services.

A constraint automatically adds the corresponding invoke entity between the relative service components of Functional View (figure 4). The invoke entity has the same name as the action.

OPERATION DICTIONARY

Figure 6 represents a fragment of the operation dictionary. All operations are decomposed into elementary ones (processing, storing, transferring), representing processing, storing and network requirements. The system designer may add new operations in the dictionary, to enhance operation expression.

In figure 6, the addition of *form_access* operation is presented. Three steps should be accomplished: parameter definition, definition of dependencies to existing operations and validation performance. A related constraint checks if all the parameters defined for an operation are passed as values to called operations used for its execution. Parameter and dependency definition is performed through pop-up forms. *Form_access* operation parameters are *FileServer, form_name* and *processing. Form_access* operation "uses" two other operations in order to be executed: *processing* and *write*. First, calls *processing* (which is elementary operation) and

Figure 5. Trx31600 activity diagram

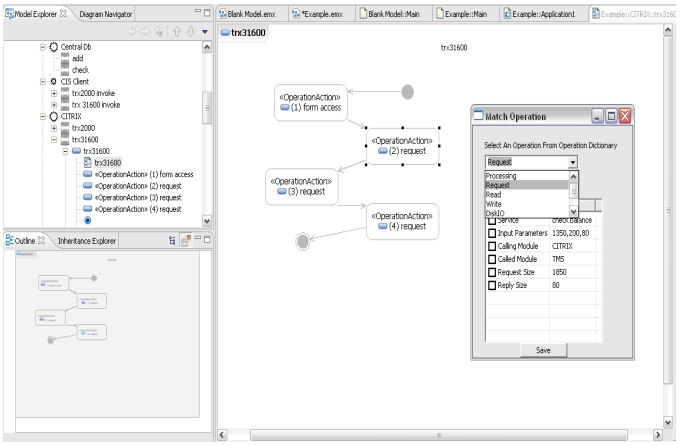
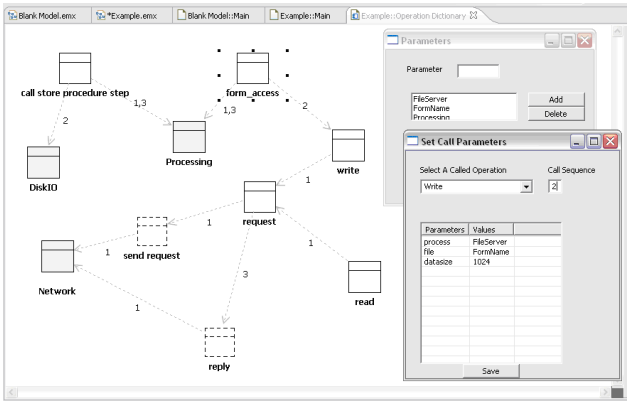


Figure 6. Operation dictionary fragment



then *write* and then again *processing*. Parameter values of the called operation must be defined. The pop-up window entitled *Set Call Parameters* depicts *write* operation parameter definition.

TOPOLOGY AND PHYSICAL VIEWS

The Topology View facilitates process and user profile allocation to sites. Allocation is performed by the designer through Rational Modeler interface. Alternative, the designer may invoke *IDIS* to perform the allocation of processes or data. Three different types of branches are supported: large, medium and small. Large branches have more than 30 tellers stationed at two different floors. The upper floor is dedicated to business transactions (10 tellers), while all others are served in the main hall. The corresponding fraction of Topology View is depicted in figure 7. Each hall is represented as a subsite of a branch site (both represented as *Site Packages*). Headquarters is also presented as a site.

Figure 7. Fraction of topology view

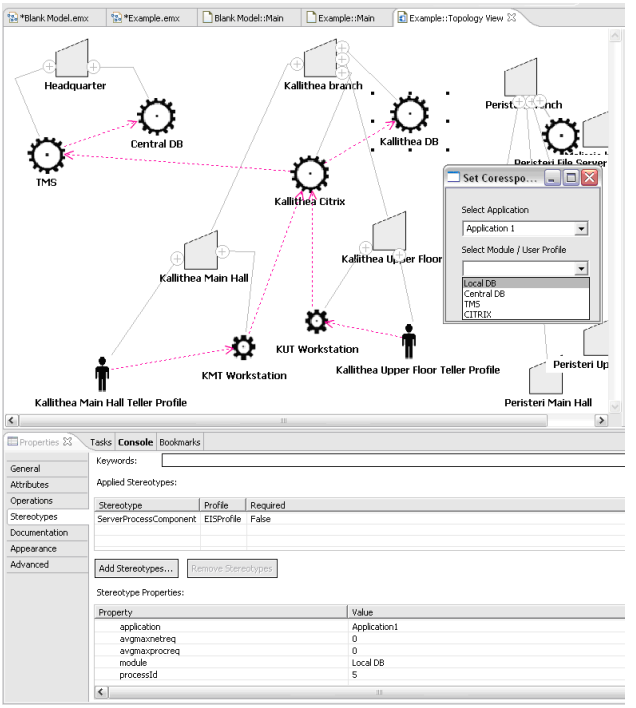
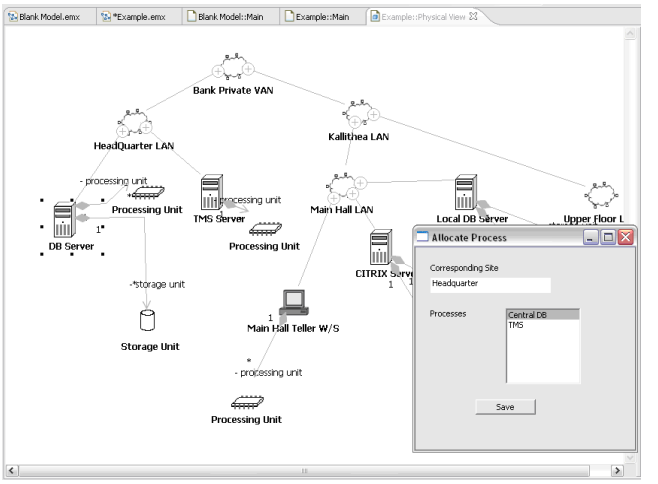


Figure 8. Fraction of physical view



Tellers, modeled as *users*, are placed in *Main Hall* and *Upper Floor* sites, along with corresponding *Citrix client* processes. Since the system relies on server-based computing, most server processes are placed only in headquarters, while no replication is employed simplifying the overall architecture. Furthermore, since there was a request to maintain log data in local branch databases, a local database server replica is placed in each branch. The only issue to be explored was the placement of *CITRIX Server*. Although the system designer placed a *CITRIX Server* process in each branch, the logical configuration tool removed the processes from medium and small branches and placed one in Headquarters to minimize communication cost. This is codified in the EIS model stored in XML. When this model is loaded again in the UML tool, Topology View appears automatically updated.

Processes and users appearing in Topology View must correspond to EIS modules and user profiles represented in Functional View. As shown in figure 7, when defining process replicas, a shortcut menu containing two drop-down lists appears. The first one corresponds to the application (described by a discrete Functional View) and the other one to the module (defined within the Functional View). Furthermore, the corresponding relationships between processes and modules must be defined in both diagrams. The properties of server process stereotype are shown at the bottom part of Rational Modeler Screen. In figure 7, the property values of *Kallithea DB* server component are shown. A related constraint is activated by the *Run Validation* menu option.

Physical View is rather trivial. It facilitates network design and is performed by the designer through Rational Modeler interface. Alternative, the designer may invoke *IDIS* to perform this task. A fraction of it is presented in figure 8. The overall network is TCP/IP based. Branches are connected to headquarters using leased lines, forming a private WAN. The connection speed is indicated as the name of membership relation between node devices and site packages. As indicated in the figure, branches are internally supported by switched 100BaseT Ethernet. The structure of Physical View in the banking system (network architecture) was predefined. As shown in the figure, the system designer may define the processes running on a node through a pop-up window. The candidate processes for a server node must belong to the corresponding site and be server processes. Network hierarchy must correspond to site hierarchy and vice versa. Thus, when validating the model presenting in figure 8, an additional site (corresponding to the Bank Private WAN) should be automatically added in Topology View of figure 7.

4. CONCLUSIONS

A consistent framework for EIS engineering was introduced. It consists of a metamodel describing alternative system views and the relations between them, a corresponding methodology comprising discrete stages performed by the system designer or software tools and a UML 2.0 profile for view representation. The main advantage of the proposed framework is the formal definition of views and their consistent UML 2.0 representation. This is accomplished using constraints

in both the metamodel and the UML profile. As proven by the presented case study, constraints play an important role in the consistent representation of the system under study, since they impose the necessary restrictions and relationships between entities participating in different views. The proposed framework is currently tested in terms of completeness and expressiveness, using large-scale EIS architectures as test cases.

5. ACKNOWLEDGMENT

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6. REFERENCES

Alexopoulou N., Nikolaidou M, et al, 2006. "Introducing a UML Profile for Distributed System configuration", in proceedings of *ICEIS 2006*.

Boer F.S., Bonsangue m.M., Jacob J., Stam A., Torre L., 2004. "A Logical Viewpoint in Architectures", in proceedings of *IEEE EDOC 2004*.

Graupner S., Kotov V., Trinks H., 2001. "A Framework for Analyzing and Organizing Complex Systems", in *Proceedings of the 7th International Conference on Engineering Complex Computer Systems*, IEEE Computer Press.

IBM Co, 2005. Introducing Rational Software Modeler, http://www-128.ibm.com/devworks/rational//05/329_kunal/

Kaehkipuro P., 2001. "UML-Based Performance Modelling Framework for Component-Based Distributed Systems", Lecture Notes in Computer Science 2047, *Performance Engineering*, Springer-Verlag.

Nikolaidou M., Lelis D., Mouzakis D., Georgiadis P., 1999. "A Discipline Approach towards the Design of Distributed Systems", *Distributed System Engineering Journal*, Vol. 2, No 2, IOP.

Nikolaidou M. Anagnostopoulos D., 2003. "A Distributed System Simulation Modeling Approach", *Simulation Practice and Theory Journal*, Vol. 11, No 4, Elsevier Press.

Nikolaidou M., N. Alexopoulou, A. Tsadimas, A. Dais, D. Anagnostopoulos, 2006. "A Consistent Framework for Enterprise Information System Engineering", in proceedings of *IEEE EDOC 2006*.

OMG Inc, 2004a. UML Superstructure Specification, Version 2.0, 8/10/2004.

OMG Inc, 2004b. UML 2.0 Infrastructure Specification, 30/4/2004.

OMG Inc, 2005. MOF 2.0/XMI Mapping Specification, v2.1

Zachman A. J. ,1999. "A Framework for Information Systems Architecture" *IBM Systems Journal*, Vol. 31, No. 3, pp.445 –470.

A Framework for Performance Evaluation of Intelligent Search Agents

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ABSTRACT

Because of the intelligent search agents (ISAs) can automate the process of searching through and evaluating reams of information on the Web, these agents are becoming increasingly popular in applications such as e-commerce and online businesses worldwide. While efforts have been made recently to develop various ISAs and multi-agents systems, very little is understood and known about the performance evaluation of such agents. A robust framework is required to assist efficient performance evaluation of ISAs. In this paper, we propose a framework for performance evaluation and comparison of ISAs. The proposed framework allows experimentation in which search agents can be evaluated based on a performance metric. This paper provides an in-depth performance evaluation of five selected ISAs to verify the robustness of the framework. The proposed framework is simple and can easily be adapted to applications requiring performance evaluation of similar intelligent agents.

Keywords: Intelligent search agents, performance evaluation, World Wide Web

INTRODUCTION

The competitive business environment and the growing complexity of work and personal lives create demands for performing many (often simultaneous) tasks more efficiently and promptly. To support these imperatives, new sophisticated and powerful intelligent software tools are developed. One such emerging software tool is the notion of an ISA (Boudriga & Obaidat, 2004).

ISAs are becoming increasingly popular in applications such as e-commerce and online businesses worldwide. This popularity results from the availability of various sophisticated and powerful intelligent agents that can automate the process of searching through and evaluating reams of information on the Web. For example, an ISA can be used to search on the Web to find a car matching a list of criteria, as tracking down the best price for purchasing grey Toyota Camry 2006.

A detailed discussion of intelligent agents, in general, can be found in (Boudriga & Obaidat, 2004; Dragan, 1998). Although many sophisticated and powerful intelligent agents and multi-agents systems have been developed in recently years, the performance evaluation of such agents is still an unexplored area in the field of agent technology (Saracevic, 1995; Srinivasan, Menczer, & Pantt, 2003).

This paper emphasizes that a good framework is required to assist efficient performance evaluation and comparison of ISAs. In summary, the main contributions of this paper are:

- We present a framework for performance evaluation and comparison of ISAs.
- We introduce a new performance metric called "search speed" for a better performance evaluation of ISAs.
- We provide an in-depth performance evaluation of five selected ISAs to verify the robustness of the proposed framework.

This research is exploratory in the sense that there was very limited prior research in the area of performance evaluation of ISAs to guide this research endeavour. Therefore, we adopted an empirical investigation methodology for the performance evaluation of ISAs (Dora, 2004; Serenko, 2006). The following research question was proposed:

How to select an ISA from a pool of search agents for a particular application?

The remainder of this paper is organized as follows. We first review past research on intelligent agents. We then introduce a framework for performance evaluation and comparison of ISAs. The experiment details and the performance evaluation of five selected ISAs are described. Experimental results are presented, and a brief conclusion ends the paper.

LITERATURE REVIEW

A number of recent studies demonstrate the usefulness and viability of using agent-based technologies in various applications; for example, in manufacturing automation (Heragu, Graves, Byung-In, & St Onge, 2002; Weiming, 2002), managing relational database (Rudowsky, Kulyba, Kunin, Ogarodnikov, & Raphan, 2005), network payment security (Hui-Zhang & Ji-di, 2004), e-business (Zi-Ming, Bo, & Yuan-Yuan, 2005), knowledge management (Houari & Far, 2004), fault diagnose system (Bo, Changhong, & Xiue, 2006), education (Pan & Hawrysiewycz, 2006), and web content filtering (Salter & Antonopoulos, 2006). In this section, we summarize previous work on performance evaluation of intelligent agents.

Mawlood-Yunis et al. (2004) experimented using two mobile agents and analyzed their platform's performance behaviour in distributed search. An interesting finding from their research is that in small networks multi agents systems do not provide any advantages and the associated overhead is high.

Camacho et al. (2002) evaluated various agent platforms (e.g., JADE, ZEUS, and SKELETON AGENT) based on the following metrics: number of agents used; number of requested documents; request time; and number of articles retrieved. Qi and Sun (2004) identified the operators that may increase the performance of a multi-agent system.

Lau and Zhang (2004) investigated how agents in a multi-agent system cooperate with each other. Results show that partial cooperation between agents is better than the fully cooperation of agents. Mao et al. (2004) point out that the coordination amongst the agents in a multi-agent system effects the performance of the system.

Samaras et al. (1999) stress the importance of performance benchmarking in the case of multi-agent distributed systems. O'Malley et al. (2000) examined the performance of static agents versus mobile multi-agent systems. The experiment involved searching for documents using static and multi-agent systems on a number of machines and then calculated the transmission control protocol/internet protocol (TCP/IP) traffic generated by the agents.

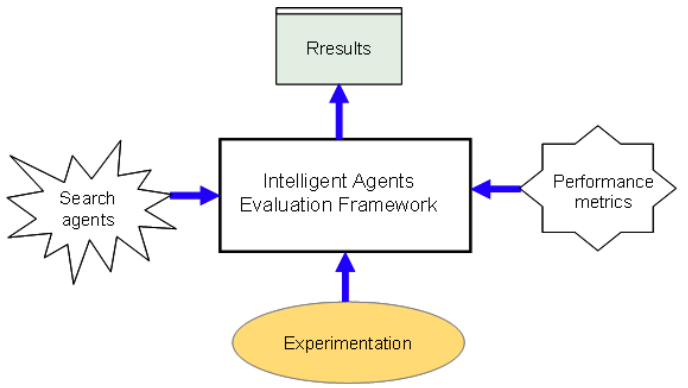
In summary, the proposed framework is almost alone in its goals and capabilities. The framework is described next.

THE PROPOSED FRAMEWORK

Figure 1 shows a simple framework for the performance evaluation of ISAs.

As seen in Fig. 1, the proposed framework allows experimentation in which search agents can be evaluated based on a performance metric. It is important to use an appropriate metric for the performance evaluation of ISAs. Once a performance metric is identified, the experiments can be conducted and results can be obtained using the proposed framework (Fig. 1).

Figure 1. The proposed framework



While various metrics for the performance evaluation of intelligent agents are reported in the software engineering literature, we briefly describe the following commonly used performance metrics:

Accuracy: In information retrieval, accuracy is measured in terms of recall and precision, where recall is relevance of the results obtained and precision is the cleanliness of the results (Kaki, 2004). This metric is not considered in our study since we did not have any human participants in the study who could rank the results obtained for accuracy measurement.

Throughput: This metric is commonly used for the performance measurement of communication networks. Throughput can be measured in bytes per second or packets per second or bits per second (bps). We ran all the experiments for the evaluation of ISAs under a control environment and measured the network throughput for every iteration performed, ensuring that the network throughput was not affecting the performance measures.

Round trip time: The round trip time (RTT) is the time required by a process to complete a task. For example, RTT is measured from the moment a query is placed on the source machine until the last packet arrives. The RTT can be affected by the size of a query.

Memory consumed: To measure the amount of computer memory consumed by a search agent, the MS Windows® default task manager utility can be used. This utility measures the memory usage dynamically when an application or process runs on the system.

Results returned: This parameter gives us the total number of results returned by an ISA per search.

Both "RTT" and "Results returned" can be used independently for performance comparison of ISAs. However, for simplicity and better performance comparison, it is useful to be able to compare the ISAs based on a single metric. Therefore, we define a new metric called "search speed" by combining both Results returned and RTT. The search speed (S_{speed}) is defined as

$$S_{speed} = \frac{N_{srr}}{T_{rtt}} \quad (1)$$

Where, N_{srr} is the total number of results returned in one search; and T_{rtt} is the round trip time (in seconds).

The search speed tells us about the capacity of an ISA (i.e., how many results returned by an ISA per second per query). An agent is said to be more powerful compared to another agent if it has a higher search speed.

EXPERIMENT DETAILS

The experimental setup consists of a desktop PC (Intel Pentium 4, 2.8 GHz; 512 MB RAM; 60 GB Hard disk; MS Windows XP Professional) and an ADSL modem (upload and download at 128 Kbps and 2 Mbps, respectively) linked to the Internet as shown in Fig. 2.

To measure the RTT and throughput, an open source software tool called Ethereal (www.ethereal.com) was used to captured packets from the live network and save them in a log for analysis.

Figure 2. Experimental setup

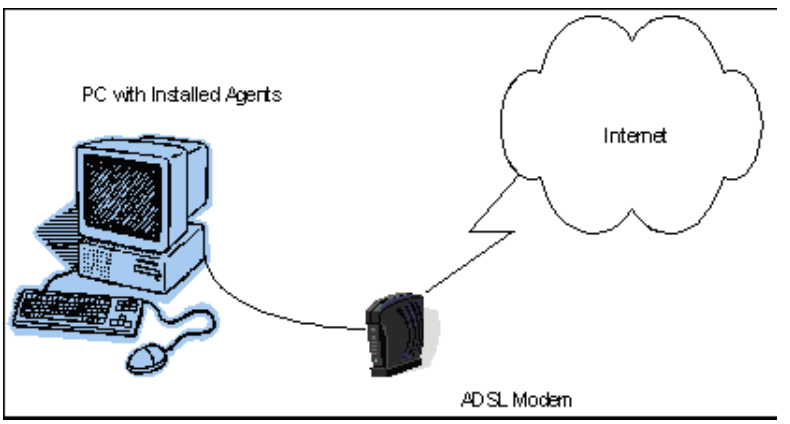


Table 1. Queries used in the experiments

Number of terms	Query
4	nicotine level smokeless tobacco
3	attention deficit disorder
2	dog crate

The selection of queries was very crucial in our experimentation. According to Jansen (2000) most of the web queries are only of two terms. A term can be a word, number, symbols, or even a URL. A query also contains one or more search terms and logical operators. In the experiments, we have used queries with 2, 3, and 4 terms as shown in Table 1 (Jansen, 2000).

Selection of ISAs

The selection of ISAs was a multifaceted and complex task since there were very limited number of ISAs available at free of costs for download and experiment in a control environment. The following five ISAs were selected for experimentation to test the robustness of the proposed framework:

FirstStop WebSearch™: This search agent provides a comprehensive search results and run under MS Windows. It can search on multiple search engines and websites concurrently.

WebSeeker™ 5.0: This agent has an indexer built into the program that keeps track of the browsed pages and monitors for new information. It has the ability to check whether the results can be reachable or not.

WebFoil 2.1: This agent provides multiple search sources at a time and search results provided through a detailed report.

Copernic Agent: This search agent can search multiple resources, combine the results, and stores the search history for later use.

WebFerret 5.0: This agent searches multiple sources, and sorts the results.

To facilitate an accurate data collection, it was vital to eliminate all the extraneous differences among the ISAs. Therefore, the advanced options provided by the ISAs were not selected in our experiments and only the default settings were used. To obtain an accurate and unbiased result, each query was submitted 10 times to each of the five ISAs in turn and all the measurements were recorded. This process was repeated at three different times of the day (at 0900, 1600, and 2100 hrs) for each of the five ISAs. In summary, we took the mean value for 30 observations per query. The experimental results are presented next.

RESULTS AND DISCUSSION

The experimental results for the performance comparison of five selected ISAs are summarized in Table 2. The ISAs are shown in the first column. The mean results returned by each ISA, and the corresponding mean RTT (in seconds) are shown in column 2 and 3, respectively. In column 4, we present mean throughput (bytes/second) which was measured for all iteration performed during experimentation. The mean search speed and the standard deviation are shown in the column 5 and 6, respectively. The 95% confidence interval (C.I) of the mean search speed is shown in the brackets.

As seen in Table 2, Copernic performs better (in terms of search speed) than the other four agents. The standard deviation of search speed varies significantly from its mean. We observe that the mean throughput performance of the ISAs differs slightly (from one another), but this variation is not very significant and does not affect the search speed.

We also found that as the complexity of the queries increases, ISAs tend to lose their search speed. For example, in the case when we used a quotation in the first query "nicotine level smokeless tobacco" to match the exact phrase, almost all five ISAs performed very low (results are not shown here due to the space limitation).

The mean search speeds of the ISAs are compared to see whether they differ significantly. The one-way ANOVA (also called F test) was carried out for the analysis of variance for the five ISAs under study. The F value after the ANOVA test was found to be 20.99, which is the ratio of the two variances: (1) the mean square between agents; and (2) the mean square within the agents. The degree of freedom was 4, which is the variation between the agents.

Figure 3 shows the difference (in magnitude) among the search speeds of the five ISAs (A = Copernic Agent, B = FirstStop, C = WebFerret, D = WebFoil, and E = WebSeeker). As seen in Fig. 3, Copernic has the highest search speed while the WebFoil has lowest.

LIMITATIONS OF THE STUDY

Firstly, a very limited number of ISAs was available (free of costs) for download and install on a local machine for experimentation. Due to the budget constraint we could not get hold of commercial agents to be included in our study. Another limitation was the time constraint as we had to complete the project within the given time frame.

CONCLUSION AND FUTURE WORK

In this paper, we proposed a framework for performance evaluation and comparison of intelligent search agents (ISAs). The framework allows experimentation in which search agents can be evaluated based on a performance metric. For a

Figure 3. Variation of search speed (magnitude) among the five ISAs

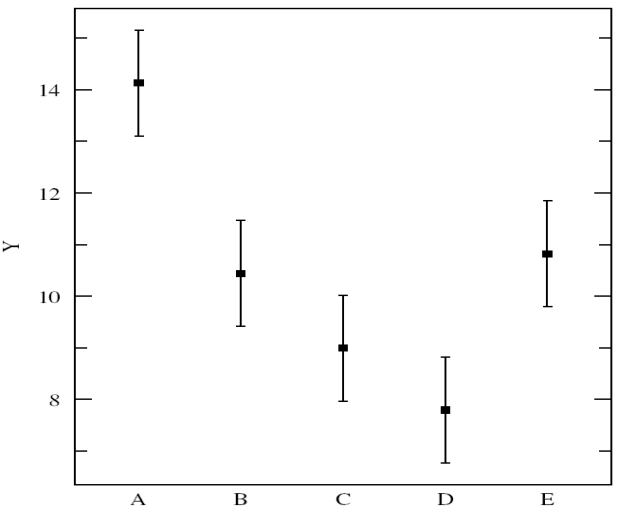


Table 2. Performance comparison of ISAs

Search agents	Mean results returned	Mean RTT (second)	Mean Throughput (bytes/second)	Search speed (results returned/second/query)	
				Mean (95% C.I)	Standard deviation
FirstStop	229.05	19.11	136190.83	10.40(9.41,11.46)	4.95
WebSeeker	218.62	19.40	125482.32	10.80(9.80,11.85)	6.11
WebFoil	166.22	21.07	128475.43	7.79(6.77,8.82)	4.35
Copernic	237.05	16.50	129326.87	14.10(13.10,15.15)	7.74
WebFerret	172.97	18.55	121421.73	8.99(7.97,10.02)	4.75

better performance comparison of ISAs, we introduced a new metric "search speed" by combing the number of results returned and the RTT. Through various experiments and measurements under a control environment, we gained an insight into the performance comparison of the ISAs by using search speed as one of the performance metrics.

We found that not all the five ISAs can perform equally well in terms of their search speed. For example, among the five ISAs evaluated, Copernic is up to 36.2% ($\frac{4.1-8.9}{4.1}\times 100\%$ faster than the WebFoil.

The proposed framework is simple, easy to implement and can be used for performance evaluation of similar intelligent agents from other domains, such as online shopping. We have tested the framework and found to be robust.

This study can be further extended by using a case study in evaluating the performance of similar ISAs. Further research on the impact of query length and complexity (e.g., more terms using Boolean operators) on the performance of ISAs is suggested. The performance of search agents under different data types, such as text, images, and multimedia data is also planned as an extension of the present study.

REFERENCES

Bo, C., Changhong, W., & Xiue, G. (2006, January 19-21). *Research on the intelligent agent of distributed fault diagnose system.* Paper presented at the First International Symposium on Systems and Control in Aerospace and Astronautics. pp. 1-4.

Boudriga, N., & Obaidat, M. S. (2004). Intelligent agents on the Web: a review. *Computing in Science & Engineering [see also IEEE Computational Science and Engineering], 6*(4), 35-42.

Camacho, D., Aler, R., Castro, C., & Molina, J. M. (2002). *Performance evaluation of ZEUS, Jade, and SkeletonAgent frameworks*, IEEE International Conference on Systems, Man and Cybernetics. pp. 1-6.

Dora, J. (2004). *Evaluating reactive scheduling systems.* Paper presented at the IEEE/WIC/ACM International Conference on Intelligent Agent Technology (IAT 2004). pp. 458-461.

Dragan, R. (1998, June 9). Software Agents. *PC Magazine*, 166.

Heragu, S. S., Graves, R. J., Byung-In, K., & St Onge, A. (2002). Intelligent agent based framework for manufacturing systems control. *IEEE Transactions on Systems, Man and Cybernetics, Part A, 32*(5), 560-573.

Houari, N., & Far, B. H. (2004, August 16-17). *Application of intelligent agent technology for knowledge management integration.* Paper presented at the Third IEEE International Conference on Cognitive Informatics. pp. 240-249.

Hui-Zhang, S., & Ji-di, Z. (2004, November 16-18). *Application of intelligent agent in network payment security.* Paper presented at the 29th Annual IEEE International conference on Local Computer Networks. pp. 437-440.

Jansen, B. J. (2000). The effects of query complexity on Web searching results. *Information Research, 6*(1), 30-54.

Kaki, M. (2004). *Proportional search interface usability measures.* Paper presented at the Proportional search interface usability measures, Tampere, Finland. pp. 365-372.

Lau, H. C., & Zhang, L. (2004). *A two-level framework for coalition formation via optimization and agent negotiation.* Paper presented at the IEEE/WIC/ACM International Conference on Intelligent Agent Technology (IAT 2004). pp. 441-445.

Mao, X., Wang, J., & Yu, E. (2004). *A framework to specify and evaluate coordination in MAS with logic.* Paper presented at the IEEE/WIC/ACM International Conference on Intelligent Agent Technology (IAT 2004). pp. 325-328.

Mawlood-Yunis, A., Nayak, A., Nussbaum, D., & Santoro, N. (2004). *Comparing performance of two mobile agent platforms in distributed search.* Paper presented at the IEEE/WIC/ACM International Conference on Intelligent Agent Technology (IAT 2004). pp. 425-428.

O'Malley, S. A., Self, A. L., & Deloach, S. A. (2000). *Comparing performance of static versus mobile multiagent systems.* Paper presented at the IEEE National Aerospace and Electronics Conference (NAECON 2000). pp. 282-289.

Pan, W., & Hawrysiewycz, I. (2006). Assisting learners to dynamically adjust learning process through software agents. *International Journal of Intelligent Information Technologies, 2*(2), 1-15.

Qi, D., & Sun, R. (2004). *A comparison of team evolution operators.* Paper presented at the IEEE/WIC/ACM International Conference on Intelligent Agent Technology (IAT 2004). pp. 369-372.

Rudowsky, I., Kulyba, O., Kunin, M., Ogarodnikov, D., & Raphan, T. (2005, April 4-6). *Managing a relational database with intelligent agents.* Paper presented at the International Conference on Information Technology: Coding and Computing. pp. 238-242.

Salter, J., & Antonopoulos, N. (2006). CinemaScreen recommender agent: combining collaborative and content-based filtering. *IEEE Intelligent Systems [see also IEEE Intelligent Systems and Their Applications], 21*(1), 35-41.

Samaras, G., Dikaiakos, M. D., Spyrou, C., & Liverdos, A. (1999). *Mobile agent platforms for Web databases: a qualitative and quantitative assessment.* . Paper presented at the First International Symposium on Agent Systems and Applications, and Third International Symposium on Mobile Agents. pp. 50-64.

Saracevic, T. (1995). *Evaluation of Evaluation in Information Retrieval.* Paper presented at the ACM SIGIR, Seattle, USA. pp. 138-146.

Serenko, A. (2006). Importance of interface agent characteristics from end-user perspective. *International Journal of Intelligent Information Technologies, 2*(2), 49-60.

Srinivasan, P., Menczer, F., & Pantt, G. (2003). *Defining evaluation methodologies for topical crawlers.* Paper presented at the ACM SIGIR, Toronto, Canada. pp.

Weiming, S. (2002). Distributed manufacturing scheduling using intelligent agents. *IEEE Intelligent Systems [see also IEEE Intelligent Systems and Their Applications], 17*(1), 88-94.

Zi-Ming, Z., Bo, M., & Yuan-Yuan, Z. (2005, August 18-21). *An Intelligent Agent-Based System in Internet Commerce.* Paper presented at the International Conference on Machine Learning and Cybernetics. pp. 299-303.

How Work System Formalization and Integration Impact IS Funcation Performance in Manufacturing Firms

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ABSTRACT

The development of successful IS practices relies on the existence of well documented, formal work system practices and the existence of cross-functionally integrated of work teams. In manufacturing firms, formal work system practices serve as a public repository of organizational knowledge, including key manufacturing policies, procedures, and definitions. Cross-functional work teams provide the vehicle by which new work system practices may be quickly created and implemented throughout the firm. Study results indicate that firms with high levels of manufacturing work system formalization and integration have higher levels of IS strategic planning effectiveness, IS responsiveness to organizational computing demands, and IS end-user training effectiveness. Perceptions of IS performance were also higher for firms with greater work system formalization. Data were collected from 265 senior manufacturing managers who were selected because their perspective of IS performance was desired and because manufacturing units are an important user of the services. ANOVA was used to test our hypotheses.

Keywords: Information System Development, Work System Formalization, Work System Integration, IS Strategic Planning Effectiveness, IS Responsiveness, End-User Training, IS Performance

1.0. INTRODUCTION

Today's global manufacturing environment has significantly impacted the basis of competition for U.S. firms (Nam et al., 2004). Many U.S. manufacturers have sought to improve the effectiveness of production processes and capabilities through the implementation of IT-reliant work systems. A work system is defined as "a system in which human participants and/or machines perform work using information, technology, and other resources to produce products and/or services for internal and external customers" (Alter, 2003). Thus, an IT-reliant work system must capture key organizational knowledge for its information-based technologies and systems to improve the speed and quality of decision processes.

In the case of manufacturing firms, the purpose of information-based technologies and systems is therefore to support the activities of the production work system. While the boundary between a firm's work systems and its information systems may overlap and blur with time, the development of successful IS practices remains a critical outcome the IS function must achieve in support of this requirement. An important prerequisite for the development of successful IS practices is the existence of well-documented, formal work system practices (Alter, 2003).

Formal work system practices provide a vital reference, serving as a public repository of organizational knowledge (i.e., key manufacturing policies, procedures, definitions, etc.), which are necessary to develop supportive IS practices (Lee & Choi, 2003). Cross-functional work teams provide the integration mechanism by which new work system practices may be more quickly created, disseminated, and then implemented throughout the firm (Bailey, et al. 2001). The integration of the work system provides a basis for employees to resolve differences related to the common meaning and definition of manufacturing work system practices, thus accelerating this process (Rondeau et al., 2000).

The central tenet of this study is therefore that firms demonstrating both high work system formalization and integration will provide a consistent and stable basis upon which to build effective IS practices. Such firms should be perceived to have higher levels of IS strategic planning effectiveness, IS responsiveness to organizational computing demands, and IS end-user training effectiveness. Perceptions of IS performance are also expected to be higher. For this study, data were collected from 265 senior manufacturing managers who were selected because their broad perspective of their firm's work system and IS practices of interest was desired. Ultimately, their perceptions matter most because they may choose to pay for IS services or to outsource, downsize, or replace their IS function's services. The ANOVA procedure is used to test our research hypotheses.

2.0. RESEARCH MODEL, LITERATURE REVIEW, AND HYPOTHESES DEVELOPMENT

This research proposes IS practices will be higher for firms demonstrating more formal work system practices and greater work system integration. The matrix given in Figure 1 shows that firms may be classified into one of four cells by level of work system formalization (i.e., low or high) and level of work system integration (i.e., low or high). Manufacturing firms classified within ***Cell 1*** (i.e., low IS function success) possess low levels of both work system formalization and integration. They may have less need for information processing and therefore have a lower IS requirement. In contrast, firms classified within ***Cell 4*** (i.e., high IS function success) possess high levels of both work system formalization and integration characteristic of a post-industrial environment. These firms should have an information-rich, internal environment that is capable of flexible resource deployment.

Firms in ***Cells 2*** and ***3*** should demonstrate moderate levels of IS function success. These firms will possess either a high level of work system formalization and low

Figure 1. Research model

Work System Formalization (FO) \ Work System Integration (IN)	Low	High
High	**Moderate IS Performance (Cell 2)**	**High IS Performance (Cell 4)**
Low	**Low IS Performance (Cell 1)**	**Moderate IS Performance (Cell 3)**

work system integration (i.e., Cell 2) or a low level of work system formalization and high work system integration (i.e., Cell 3). Those demonstrating high formalization and low integration may require standard information products and services requiring little or no customization. Those demonstrating low formalization and high integration may require non-standard information products and services requiring extensive customization. These firms are therefore expected to exhibit moderate levels of perceived IS effectiveness.

2.1. Work System Formalization

Formalization may take the shape of written operating procedures, quality improvement methods, employee handbooks, and other documents that direct employee action towards customer requirements (Price & Mueller, 1986). Without documentation, standard operating procedures and work methods are subject to misinterpretation. Over time, organizations may forget their purpose, including the reasons why they were developed. When formalized, the full meaning and benefits of the written documentation can be shared freely between departments, across plants, and throughout the firm (Argotte & Epple, 1990; Levitt & March, 1988).

2.2. Work System Integration

Integration is the process of blending elements of the organization into a united whole. When organizations face a complex and uncertain environment, they are more likely to use integrative devices such as task forces, committees, or liaisons to increase their chances for success (Germain et al., 1994; Miller and Droge, 1986). As management struggles to gather and process more information and make increasingly complex decisions, they delegate decision-making to lower-level work groups. The increased interdependence of workers that results gradually diminishes existing job and work group boundaries, increases individual task meaningfulness, and expands information exchange (Romme, 1997; Susman & Dean, 1992).

2.3. IS Strategic Planning Effectiveness

Senior management assessments of IS strategic planning effectiveness should accommodate: 1) senior managers' preference to discuss IS strategy in ways that more generally relate IS strategy to business strategy (Hirschheim & Sabherwal, 2001) and 2) their need to relate IS strategy to its impact on customers and the marketplace in general (Henderson & Venkatraman, 1999). The final IS plan must therefore project a clear vision of the IS organization's role, IS goals and objectives, and the ways the firm's information technologies and systems should operate to be effective in a manner understood by senior management (Rockart & Hofman, 1992; Teng et al., 1994).

High work system formalization is critical for more effective IS strategic planning because potential misinterpretation of work system support requirements (and risk) is decreased due to specific, well-defined, and widely distributed work system documentation (Palmer & Dunford, 2002; Segars & Grover, 1999). High work-system integration is also critical in that it helps firms understand the relationship between existing and emerging work practices (Suchman, 2002). Effective IS planning requires the existence of formal knowledge to insure IS plans incorporate critical work practices in proposed solutions. It also allows the politics and personalities of the enterprise to be considered in these solutions (Hodge, 1989). Thus, we hypothesize:

H1: *Firms scoring high in both Work System Formalization and Integration (i.e., Cell 4) will score higher in IS Strategic Planning Effectiveness than firms scoring low in both Work System Formalization and Integration (i.e., Cell 1).*

2.4. IS Responsiveness to Organizational Computing Demands

A lack of responsiveness to user issues, questions, and concerns by the IS function is commonly cited as one of the primary reasons behind IS downsizing and outsourcing initiatives. Many users experience frustration when their IS function fails to properly prioritize requirements and deliver useful results on time and within budget. As such, these IS functions are often the focus of intense user dissatisfaction and the target of poor user performance evaluations (Doll & Doll, 1992; Due, 1992; Powell, 1993; Rowley & Smiley, 1993).

An IS function within firms with high work system formalization and integration should be perceived to be more responsive to users. High work system formalization establishes a well-documented, stable work environment. This better supports the development of more efficient, standardized computing support services. High work system integration enables the rapid prioritization of work system goals and objectives, clarifying the importance of related IS support requests. This better supports the development of a more appropriate IS response, based on the relative importance of organizational computing needs, to be generated. Thus, we hypothesize:

H2: *Firms scoring high in both Work System Formalization and Integration (i.e., Cell 4) will score higher in IS Responsiveness to Organizational Computing Demands than firms scoring low in both Work System Formalization and Integration (i.e., Cell 1).*

2.5. IS Effectiveness in End-User Training

Effective end-user education and training involves teaching general problem solving approaches, including abstract reasoning and specific technical skills (Nelson, 1991). Attaining this is critical in an IS environment where cognitive skills, that are necessary for continued learning, vary greatly among participants and may, on-the-average, be less than desired (Harrison & Rainer, 1992). Effective end-user education and training can enable the rapid acceptance of new technologies and software, empower users to experiment more freely, and motivate them to deploy new technologies more quickly (Kappleman & Guynes, 1995).

High work system formalization enables the definition of specific worker skills and abilities required to perform business processes. This specificity better supports the identification of key information technologies, including the IT user training solutions required for workers to use these technologies effectively. High work system integration allows for common agreement on the content of business processes and type of IT user training that may be needed. This better supports the definition of both formal coursework and on-the-job learning experiences. Thus, we hypothesize:

H3: *Firms scoring high in both Work System Formalization and Integration (i.e., Cell 4) will score higher in End-User Training Effectiveness than firms scoring low in both Work System Formalization and Integration (i.e., Cell 1).*

2.6. IS Performance

Management's satisfaction with IS performance depends on the ability of IS to facilitate better decision-making (Raghunathan & Raghunathan, 1996). End-users recognize the benefits of the services provided by IS, especially how these services lead to faster and better decisions in highly competitive situations (Rondeau et al., 2003). The challenge faced by the IS function is to develop clear, objective measures of IS performance (Costea, 1990). High work system formalization can create a more predictable user environment, enabling IS managers to be more effective in anticipating users' IS product and service needs. High work system integration allows users to work out their differences related to business requirements before attempting to translate them to IS requirements. Thus, we hypothesize:

H4: *Firms scoring high in both Work System Formalization and Integration (i.e., Cell 4) will score higher in IS Performance than firms scoring low in both Work System Formalization and Integration (i.e., Cell 1).*

3.0. INSTRUMENT DEVELOPMENT AND DATA COLLECTION

Work system formalization (FO) and integration (IN) items were developed based upon a review of the manufacturing literature. Items designed to measure IS strategic planning effectiveness (SP), IS responsiveness to organizational computing demands (RD), and end-user training effectiveness (UT) were developed from a review of the appropriate IS literature. Items designed to measure IS performance (IP) were adapted from an instrument by Ragunathan & Ragunathan (1996). All items are measured on a five point Likert scale. Structured interviews were conducted, a pre-pilot test done, a pilot study done, and a large-scale study that targeted executive-level manufacturing managers. These steps were taken to

Table 1. Factor analysis for the scales

Item #	Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy = 0.92. Only factor loadings above 0.40 are shown.					
	Manufacturing Work System Integration (IN)	**IS Performance (IP)**	**Manufacturing Work System Formalization (FO)**	**IS Responsiveness to Organizational Computing Demands (RD)**	**IS Strategic Planning Effectiveness (SP)**	**IS End-User Training Effectiveness (UT)**
IN1	0.89					
IN2	0.88					
IN3	0.84					
IN4	0.80					
IN5	0.75					
IN6	0.74					
IN7	0.69					
IP1		0.80				
IP2		0.79				
IP3		0.76				
IP4		0.75				
IP5		0.68				
FO1			0.82			
FO2			0.80			
FO3			0.78			
FO4			0.76			
FO5			0.57			
FO6			0.56			
RD1				0.81		
RD2				0.80		
RD3				0.80		
RD4				0.65		
RD5				0.63		
SP1					0.76	
SP2					0.76	
SP3					0.73	
SP4					0.72	
SP5					0.72	
UT1						0.82
UT2						0.75
EV[1]	4.90	3.76	3.71	3.68	3.54	1.65
%[2]	16.32	12.54	12.36	12.26	11.81	5.50
CP[3]	16.32	28.86	41.22	53.48	65.29	70.79

ensure the content validity, reliability, and brevity of the instruments as well as internal and external validity.

Data were obtained as part of a mail survey designed to capture both IS and manufacturing data. All firms selected had at least 250 employees within US SIC codes 25 and 34 to 38 (see Table 1). The mailing yielded 265 responses: an effective response rate of 4.3%. While less than desired, the makeup of the respondent pool was considered adequate. 44.9% of the respondents reported a job title of president, CEO, vice president, or general manager. 30.6% said that they were plant managers, directors, or senior managers. 20.4% were managers and 4.1% did not provide job title information. Tests of non-response bias indicated no statistically significant difference between the firms on the mailing list and the responding firms for either SIC code or firm size (number of employees).

4.0. STUDY RESULTS

4.1. Results of the Measurement Model

The items for all work system and IS dimensions were submitted to exploratory factor analysis. Principal component was selected for the extraction procedure with varimax factor rotation. Results are given in Table 2. Most factor loadings were 0.60 or 0.70 or better with two manufacturing work system formalization items being 0.50 or better. While formalization items F03 and F06 factor loadings were less than desired, they were considered important to this research and were thus retained. Factor loads below 0.40 are not shown with no significant cross loads, implying convergent and discriminant validity. All of the factors were composed of a single dimension. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.92.

Table 2. Statistical attributes of the factors

	Scale	# of Items	Mean	Standard Deviation	Reliability
FO	Work System Formalization	6	3.93	0.86	0.92
IN	Work System Integration	7	3.96	0.79	0.85
SP	IS Strategic Planning Effectiveness	5	3.14	0.99	0.92
RD	IS Responsiveness to Organizational Computing Demands	5	3.34	0.91	0.90
UT	End-User Training Effectiveness	2	3.05	1.03	0.77
IP	IS Performance	5	3.16	0.99	0.90

Table 4. Analysis of variance results

Work System Formalization (FO)	Work System Integration (IN)		Source of Variation	F-Value	Significance of F
	Low	High			
IS Strategic Planning Effectiveness (SP)					
			Main Effect	18.551	0.000
High	3.23	3.56	FO	37.235	0.000
			IN	5.529	0.019
Low	2.56	2.79	Two-Way Interaction	0.179	0.672
I. S. Responsiveness to Organizational Computing Demands (RD)					
			Main Effect	9.219	0.000
High	3.28	3.65	FO	13.582	0.000
			IN	4.756	0.030
Low	2.99	3.11	Two-Way Interaction	1.119	0.291
End-User Training Effectiveness (UT)					
			Main Effect	23.741	0.000
High	3.11	3.54	FO	47.027	0.000
			IN	5.278	0.022
Low	2.43	2.56	Two-Way Interaction	1.478	0.225
Information Systems Performance (IP)					
			Main Effect	3.735	0.012
High	3.24	3.34	FO	8.595	0.004
			IN	0.549	0.460
Low	2.87	2.96	Two-Way Interaction	0.004	0.951

Note: IS construct means for firms classified within each FO and IN, low or high cell combination are provided in the left side of this table. Overall IS construct means are shown in Table 2.

Table 3 gives the means, standard deviations, and reliability estimates (Cronbach, 1951) for the IS dimensions. All factor reliabilities are above 0.80 or 0.90 except for end-user training effectiveness, which is 0.77. The final instruments are short and easy to use. Each scale has seven or fewer items, and the total number of items across all scales is only thirty. Due to manuscript space limitations, the instruments have not been included but are available from the authors. The instruments meet generally accepted validity and reliability standards for exploratory research.

Figure 2. Respondents classified by cell

Note: A total of 265 respondents were split into High or Low cells by FO and IN factor means.

Work System Formalization (FO) \ Work System Integration (IN)	Low	High
High	45 (17%) (Cell 2)	114 (43%) (Cell 4)
Low	55 (21%) (Cell 1)	51 (19%) (Cell 3)

4.2. Approach to Hypothesis Testing

The division of the sample into the cells shown in Figure 1 depends on the calculation of overall construct means for FO and IN, which are given in Table 3. Individual responses were then classified into the four cells shown in Figure 1 by comparing them to these overall means. If a respondent's FO and IN score was above the construct mean, it would be considered to be above average in terms of its formalization or integration. If a respondent's FO and IN score was below the construct mean, it would be considered to be below average in terms of its formalization or integration. SPSS was then used to conduct analysis of variance (ANOVA) tests to determine whether the dimensions of the IS environment varied significantly among the four cells. Figure 2 shows the final classification of respondents into four cells.

4.3. Results of Hypothesis Testing

The results shown in Table 3 support hypotheses 1, 2, and 3 as discussed earlier as well as the corollaries to these hypotheses. Firms that are high in both FO and IN have higher levels of the SP, RD, and UT than firms that are low in both FO and IN. The *F* values for the main effects for SP, RD, and UT indicates statistically significant differences in the group means at the $p<0.01$ level. Hypothesis 4 was only partially supported with firms having high FO also having higher levels of IP than firms that are low in FO. The *F* value for FO effects for IP indicates statistically significant differences at the $p<0.01$ level while the *F* value for IN effects for IP indicates no statistically significant differences. Therefore, hypothesis 4 was not supported relative to IN effects on high or low levels of IP.

There were no significant interaction effects found in the analyses. This result indicates general support for the argument that manufacturing firms with highly formalized and integrated work systems tend to have high levels of these information systems variables, including IS performance. These results are statistically significant at $p<0.01$ or $p<0.05$ in all cases except IS Performance. In this case, FO generates a significant difference at the $p<0.05$, but IN does not.

One explanation for this may be that manufacturing IS users may view information technologies as tools to assist them in performing standardized work. What may be most important is how closely the IS function replicates and supports formalized work system practices. Senior manufacturing managers may simply view the IS function as a tool builder/provider and not a participant in work system integration efforts intended to improve these practices. Thus, their perceptions of IS performance may be more closely associated the IS functions ability to replicate formalized work system practices than with its involvement in work system integration efforts.

A second explanation is that a relationship does exist between manufacturing work system integration and IS performance, but it may be indirect in nature. Work system integration may directly impact other manufacturing or IS related variables which may in turn directly impact IS performance. For example, IS strategic planning effectiveness, IS responsiveness to organizational computing demands, and end-user training effectiveness have all been hypothesized to impact IS performance in the IS downsizing, IS outsourcing, IS satisfaction, and end-user training literatures.

5.0 CONCLUSION, LIMITATIONS, AND FUTURE RESEARCH

This study explores the contingent nature of a firm's IS environmental variables in the context of work system formalization and integration. Study results indicate that more formal work system knowledge is needed to develop more effective IS practices. Greater work system integration complements and supports the development of formal work system knowledge. Firms exhibiting both greater work system formalization and integration aide their IS functions in maximizing their effectiveness.

One important implication of these findings is that manufacturing user departments should create formal policies, procedures, instruction manuals, and other forms of documentation to reduce the ambiguity of their IS support requirements. A second implication is that manufacturing user departments should seek to become more cross-functionally integrated to insure that IS support requirements reflect common organizational needs and definitions. Doing both should increase the speed at which IS support requirements may be defined and implemented in support of manufacturing work system requirements. Study results lend support for the assertion that IS departments located in firms with low work system formalization and low work system integration may be predisposed to poor perceptions of IS performance.

These IS departments may find help in the form of modern knowledge management technologies (KMT). KMTs allow work system practices to be captured, cataloged, organized, saved, and retrieved much more easily. They also allow users to share work system knowledge and contribute to its ongoing development on a real-time basis. Thus, IS functions located within manufacturing firms characterized by low work system formalization and/or integration may find benefit through the introduction of such technologies.

5.1. Limitations

The results of any research study and its generalizability have to consider limitations. Though precautions have been taken to avoid obvious limitations, it is impossible to avoid all such concerns. Both the dependent and independent variables in this study have been measured through a single respondent, which may introduce response bias. The assumption is that senior manufacturing managers have knowledge of their firms FO, IN, and IS practices.

The amount of data captured in this study and the need to collect data from top managers have created a low response rate. To ensure that response/non-response bias is not an issue, tests were done to compare attributes of these groups. The IS variables measured in this research are not exhaustive. In addition, they focus mainly on the internal aspects of the organization and not on the external links with suppliers and customers. Finally, one factor, end-user training effectiveness has only two items, which casts doubt on the reliability of this measure.

5.2 Future Research

Clearly, future research can attempt to address each of the procedural problems identified in the limitations section. Furthermore, the inclusion of additional work system or IS variables that focus on the relationship between an organization and its IS function could be important. For example, such studies could examine the impact of work system variables on other IS-related practices not addressed here such as IS development approaches or end-user computing practices. Other studies could further address the impact knowledge management software could have on improving work system formalization and its subsequent impact on IS development practices.

6.0 REFERENCES

Alter, S. (2003). The IS core – XI: Sorting out issues about the core, scope, and identity of the IS field. Communications of the AIS 2003(12), 607-628.

Argotte, L., and Epple, D. (1990). Learning curves in manufacturing. *Science* 247, 920-924.

Bailey, T., Berg, P., and Sandy, C. (2001). The effect of high-performance work practices on employee earnings in the steel, apparel, and medical electronics and imaging industries. *Industrial and Labor Relations Review* 54 (2A), 525-543.

Costea, I. (1990) The struggle for integration. *Information Strategy: The Executive's Journal* Summer, 38-42.

Cronbach, L. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika* 16, 297-334.

Doll, W., and Doll, M. (1992). Downsizing at CBS/FOX video. *Information & Management* 23, 123-139.

Due, R. (1992). The dangers of downsizing: Many hidden costs do exist. *Information Systems Management*, Summer, 65-67.

Germain, R., Droge, C., Daugherty, P. (1994). The effect of just-in-time selling on organizational structure: An empirical investigation. *Journal of Marketing Research* 31, 471-483.

Harrison, A., and Rainer, R. (1992). The influence of individual differences on skill in end-user computing. *Journal of Management Information Systems*, 9(1), 93-111.

Henderson, J., and Venkatraman, N. (1999). Strategic alignment: Leveraging information technology for transforming organizations. *IBM Systems Journal*, 38(2&3), 472-484.

Hirshheim, R., and Sabherwal, R. (2001). Detours in the path toward strategic information systems alignment. *California Management Review* 44(1), 87-108.

Hodge, R. D. (1989). Integrating systems. *Journal of Systems Management*, 40(8), 18-20.

Kappelman, L., and Guynes, C. (1995) End-user training and empowerment: lessons from a client-server environment. *Journal of Systems Management* 46(5), 37-41.

Lee, H., and Choi, B. (2003). Knowledge management enablers, processes, and organizational, performance: An integrative view and empirical examination. Journal of Management Information Systems 20(1), 179-228.

Levitt, B., and March, J. (1988). Organizational learning. Annual Review of Sociology 14, 319-340.

Miller, D., and Drodge, C. (1986). Psychological and traditional determinants of structure. *Administrative Science Quarterly* 31, 539-560.

Nam, A., Vonderembese, M., and Koufteros, X. (2004). The impact of organizational culture on time-based manufacturing performance. *Decision Sciences* 35(4), 579-607.

Nelson, R. (1991). Educational needs as perceived by IS and end-user personnel: A survey of knowledge and skill requirements. *MIS Quarterly*, 15(4), 503-525.

Palmer, I., and Dunford, R. (2002). Out with the old and in with the new? The relationship between traditional and new organizational practices. The International Journal of Organizational Analysis 10(3), 209-225.

Powell, J. (1993). Rightsizing the IS department. *Information Systems Management* 10(2), 81-83.

Price, J., and Mueller, C. (1986). *Handbook of Organizational Learning*, Pitman Publishing, Inc., Marshfield, MA.

Raghunathan, B., and Raghunathan , T. (1996). *Strategic Orientation of Information Systems* The construct and its measurement. White Paper, The University of Toledo, College of Business, IMES Department.

Rockart, J., and Hofman, J. (1992) Systems delivery: evolving new strategies. *Sloan Management Review* 33(4), 21-31.

Romme, A. (1997). Organizational learning, circularity and double-linking. *Management Learning* 28(2), 146-160.

Rondeau, P., Ragu-Nathan, T., & Vonderembse, M. (2003). Exploring work system practices for time-based manufacturers: their impact on competitive capabilities. Journal of Operations Mangement 18(5), 509-529.

Rondeau, P., Ragu-Nathan, T., & Vonderembse, M. (2003). The information systems environment of time-based competitors. Omega: The international journal of management science, 31(4), 253-268.

Rowley, T., and Smiley, J. (1993). Rightsizing for an effective IS department. *Information Strategy: The Executive's Journal* 9(3), 3-9.

Segars. A., and Grover, V. (1999). Profiles of strategic information systems planning. Information Systems Research 10(3), 199-232.

Suchman, L. (2002). Practice-based design of information systems: Notes from the hyperdeveloped world. The Information Society 18, 129-144.

Susman, G. and Dean, J. "Development of A Model for Predicting Design for Manufacturing Effectiveness," In: *Integrating Design for Manufacturing for Competitive Advantage*, Susman, G. (Ed.), New York: Oxford University Press, 1992, pp. 207-227.

Teng, J., Grover, V., and Fiedler, K. (1994). Re-designing business processes using information technology. *Long Range Planning* 27(1), 95-106.

Terror Spam and Phishing

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ABSTRACT
We claim that mail Spam and Phishing can become an operational tool in the hands of terrorists, to perform more than just simple recruiting and fund raising activities. We show that by using spam methods terrorists can reach the heart of society, and succeed in getting some of its fringes to act on their behalf. This "outsourcing" of terrorist activity to own members of the attacked society may adversely affect law enforcement ability to use profiling in the war against terror. We describe a system that combines standard spamming techniques with standard and adapted security mechanisms, and which provides the functionality needed to target, recruit, and operate terrorist cells and opportunistic accomplices.

1. INTRODUCTION
If you are like most Internet users, your mailbox has been routinely flooded with "spam". Spam are email messages that try to tempt the recipient into buying something, and spammers typically send millions of identical unsolicited messages in order to get only a few buyers – altogether it estimated that spammers send 12 billion messages daily, or more than half of all email messages[Spam Filter Review, 2004].

Whereas today, spam is used primarily by commercial companies who want to increase their sales, we are already seeing cyber criminals who start using spam-based "phishing".

Phishing is a form of criminal activity using social engineering mainly to access private and secret information. Phishing today is mainly being used to extract secret codes and other information for fraudulent financial transactions [Phishing report 2004]. According to a recent survey, 43% of US adults have been targeted by phishing attempts [First Data *Phishing Survey, 2005]*.

This Article reveals a new possible method that terrorists can easly take advantage of when carrying out there terror activities, and exposes the absence of current technology from tackling such terrorists activity

The article will show how terrorists can use spam and phishing methods not only to recruit members and raise funds, but also to influence other people to carry out attacks on their behalf. We will also show that through the use of spam terror, terrorists can create fear and terrorize the public, even without taking any action.

Clearly, however, the most dangerous prospect is that terror spam can be used to draft agnostic individuals and units, from within the inner parts of the attacked society, who will commit terror attacks on behalf of, and under the guidance of terrorists. When the enemy could be almost anyone and anywhere, law enforcement will find it very difficult to use profiling techniques in its war against terror.

2. CURRENT USE OF CYBER MEDIA BY TERRORIST GROUPS
The Internet today contains endless information, tools and opportunities. Terrorist use the Internet today to satisfy their own needs. Much has been said about terrorists seeking to enlarge their power and capabilities taking advantage this important tool. Listed down are some of the main ways in which terrorists are using the Internet today.

- Mass-Communication Tool.
- Planning and coordination of terror attacks.
- Intelligence gathering.
- Fund raising.
- Recruitment.
- Psychological Warfare.
- Cyber Attacks.
- Providing Instructions to Potential Attackers.

Is Spam the Next Ultimate Tool in the Hands of Terrorists?
In this article, we claim that spam may become the important tool in the war against terrorism. Clearly spam can serve as a useful tool to spread terrorist's messages and knowledge, and to raise funds for terrorist's organizations. More interestingly, we claim that Spam can also serve as a tool for terrorists to influence individuals to act on their behalf or at least serving their purpose.

3. SPAM AND SPAMMING METHODS
The Spam Phenomenon
Spam refers to one or more **unsolicited** messages, sent or posted as part of a larger collection of messages, all having **substantially identical content**. It usually manifests itself as an email campaign that targets millions of email accounts around the world, in an unsolicited fashion *[Monkeys]*. Experts estimate as many as 12 billion spam messages daily, making for over 75% of all email traffic *[Spam Filter Review, 2004*

Spam proved itself as an easy way to reach a large audience, and an effective sales tool that works well despite the low apriority success rate of each individual email message.

Phishing
Whereas most spam is commercially motivated, "phishing" is a relatively new form of spam that is probably closest to the terror spam that we introduce next. Phishing is spam, used by fraudsters to get access to the passwords and other private or financial information of unsuspecting users. *[Drake, Jonathan & Eugene 2004]*

4. TERROR SPAM
We believe that spam can become attractive to terrorist groups, not merely as a tool to spread their messages, but also to raise funds and recruiting members. More importantly, we speculate that spam can be used by terrorists to influence non-members to carry out attacks that coincide with the terrorist's goals and plans, and to coordinate activities of a dispersed heterogeneously motivated network of activists. Whereas today, it is commonly assumed that some Islamic terrorist organizations will only recruit staunch believers to carry out attacks (especially suicide attacks), we believe that in the future they may use "outsourcing" techniques, and will find the right justification to doing so. The trigger may be lack of resources, or the clear logistical and operationally benefits of "outsourced" activity, but in any event this may result in higher quality attacks.

The main features that make terror spam and phishing attractive to terrorists are:

1. Anonymity and difficulty of tracing;
2. Low cost to reach a large audience and hence the ability to engage a large number of (low probability) initiatives;
3. Leverage in reaching new and otherwise inaccessible audiences
4. Ability to recruit operatives from within the attacked society
5. Ability to spread fear, even without any action being taken

Usage
Terrorists can clearly use spam as a means to achieve there goals. Especially by focusing on direct needs to carry out attacks such as:

- Communications.
- Funding.
- Recruitment.
- Influencing individuals on taking extreme actions.

5. HOW TERROR SPAM MAY WORK

In this section, we describe how terror spam may work. We start by reviewing potential target audiences for terror spam, and the chances of response/success. We then discuss various technical modifications to traditional spam, which may be required to facilitate terror spam.

Target Audiences

In this section, we present terror as a "product" to be spammed. Like any other product, the terror spammer needs to consider the target audience(s), so that the campaign reaches the intended recipients, and so that the campaign is structured to appeal to the respective audiences. While it is true that the direct cost of spamming is very low, terror spammers may still want to avoid indiscriminant campaigns. First, spamming indiscriminately requires more resources, and will also reduce the time-to-block time frame, i.e., the time it would take law authorities to stop the spam and to block the next step of making contact with a collaborating receiver. Second, and more importantly, it may be important for terror spammers to craft different messages that will appeal to specific audiences.

We consider the following groups as primary targets for terror spammers:

- **Affinity religious, ethnic, and national groups**.
- **Sympathizers.**
- **Disadvantaged and disgruntled groups**.
- **Teens**.

Terrorists group can benefit from almost any outcome such a spam campaign will bring.

By throwing spam campaign terrorists will be able to achieve physical damage in some cases and advertisement that can lead to public panic in other cases, in both cases terror organization will benefit.

A spam campaign can be used to coordinate an attack among a number of people

This type of coordination can be achieved due to the high level of control that the technology environment provides i.e. giving guide to many people that are located in distance places. Exact orders can be given to all executers telling them precisely what to do in a specific time period or place, additional guidelines can be given via SMS. More over a special secured forum or chat room can be opened and enable the attackers to exchange information between themselves.

If at the same day a number of American symbols such as restaurants, entertainment chains etc…will be attacked the media effect will be very large.

The spam campaign can simply empower "Traditional" cyber terror actions

By encouraging users to DDOS web sites email addresses and other web based services of governments and private companies such as banks, e-com web site etc…and by that disrupt public services.

In some cases the potential users will prefer not to take an active role in terror actions but will be willing to volunteer critical information. Security leaks of critical infrastructure, governmental offices and public places can give a meaningful added value to the terror organizations. Terrorists can tempt users to "help" by offering money to any sensitive information that will be delivered to them.

In Some cases the spread of fear and instability is far more damaging then the physical act of terror itself.

If up until now we thought that a terrorist must come from a certain part of the world or alternative believe in certain things at this point we will have a problem of defining a terrorists due to the fact that it can be the next door neighbor that doesn't believe in anything suspicious and revenge is the only thing that guides him.

6. TECHNICAL IMPLEMENTATION OF TERROR SPAM CAMPAIGN

We propose an implementation blueprint for a Terror Spam System (TSS) that uses available spam technology, and simple modifications thereof that provide the additional security services that terrorists may need.

System Overview

The TSS is designed to enable terrorists to initially contact a wide target audience, and to then continue to communicate with respondents safely until and after the terror act is actually committed.

In the initial phase, the TSS enables the terrorist groups to reach as many potential agents (prospects) as possible. Some prospects may share the terrorist's motivations, whereas others may simply want to leverage the terrorist's capabilities and resources in order to achieve their own goals (which may partially coincide with the sponsoring terrorists). In this phase, the TSS provides some mechanisms that would reduce the risk of detection, and others that would help segregate communication channels.

Once the first responses are received, The TSS provides additional security mechanisms, and various controls on the communication with different prospects, including mechanisms designed to segregate communication channels, and to reduce the risks posed by informants and ingenuine respondents, as well as the risk of exposure of genuine respondents.

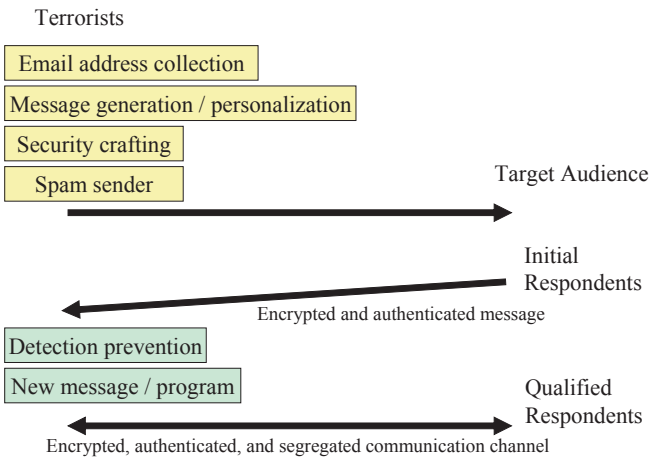
Figure 1 shows an overview of the TSS system and the flow of information and processing.

Just like in a marketing spam campaign, the goal of the first phase is to mass mail to prospective "agents". The first step in this phase is to acquire lists of email addresses of potential prospects, based on a specified set of target audience criteria. This is done by the "**Email address collection**" component.

Next, the TSS "**Message generation and personalization**" component shall construct/design a message (or select one from a number of pre-designed alternatives) to match each of the targeted prospects. The goal here is to personalize a message that is likely to draw the attention and response of targets. Thus, different messages can be mapped to different target audiences.

Subsequently, each message shall be enhanced with security mechanisms using the "**Security crafting**" component. For example, we propose that messages contain a script, and recipients are requested to reply through this script rather than by clicking "Reply" and using the regular SMTP reply. This script may, for example, encrypt the reply using a public-key scheme. The security mechanisms shall make it more difficult for the ISP to record and track the response, and shall make it difficult for an eavedropper to interpret the actual message. The script may also collect some information about the recipient's machine, using spyware-like technologies. This information, together with the message unique ID, and a time

Figure 1. Overview of TSS system



stamp indicating when the message was sent, may later be used to authenticate the respondent and to detect possible "mischief". Finally, different batches of outgoing messages shall be designed to respond to different email addresses (collection points), for segregation reasons.

The next step is of course to send the messages, using the "**Spam Sender**" component. This component will use standard spamming techniques to distribute the email messages to the target addresses. As an example, to avoid detection, the Spam Sender may distribute the messages into several batches which will be sent through several mail servers and at different times.

This completes the first phase of mass mailing.

The expectation is that a small fraction of recipients will respond to the initial email campaign. The secured script that is embedded in the message will use the identifier, time stamp, and the unique public-key that is provided for this message to encrypt this communication. The reply will be sent to one of several receiving email addresses, per the above mentioned segregation policies. The receiving program will then use the "**Detection prevention**" component to review the responses for authenticity and for various tell-tales of possible risks. Replies in which there is a mismatch between the unique identifier and the address to which the original message was sent, and the address from which the response was received will be ignored. It is also possible to ignore responses that are not received within a certain time window from their time stamp, as ones that may have been tampered with, e.g., the received may have contacted law enforcement authorities. (of course this may result in some loss of genuine respondents). Filtered messages will be sent to human operators, who will then use a separate communication channel with each respondent.

In the beginning of this "second level communication", the prospect would be provided with software components that would enable the implementation of additional security mechanisms, e.g.

- confidentiality – through encryption using public and/or symmetric key schemes for the communications, as well as for communication traces and data stored locally on the prospect computer
- authentication – using cryptographic means, and also physical and OS identification of the prospect computer
- segregation – using a unique channel and communication address for each prospect
- detection avoidance – by frequent changing email addresses and other "meeting locations"
- detection of mischief – through a spyware component that would monitor the activities of the prospect, and his/her other communications

Description of Specific System Components

In this section, we provide a more granular description and discussion of each of the TSS components.

1. Email addresses collection
   The role of this component (which will likely be implemented as a set of specific systems and procedures) is to acquire email lists according to the characterization of the target audience. Spammers are implementing similar systems, which use a variety of automatic and manual methods, e.g.,
   - extracting email addresses from mailing lists, directories, chat rooms, and discussion forums
   - automated harvesting of email addresses from web pages, who-is contact lists, etc.;
   - guessing email addresses for a specific domain, e.g., as a combination of first and last name;
   - using social engineering methods to obtain email addresses and other personal information;
   - legitimate purchase, and/or bribing for, and/or breaking into consumer databases
2. **Message generation/personalization**
   Mail messages should attract prospects to open and read, and if possible entice prospects to respond/act. In general, messages should be short and to the point. As indicated, the message shall also collect necessary information and initiate second-level contact.
   A possible implementation may start with a number of pre-composed message templates in several languages that will support localization, and then select and fill out the template that best fits each targeted recipient. A matching function shall be constructed to maximize the match between the features of the message and those of the prospective recipient. Dynamically adapting matching functions may be programmed to learn from past response rates.
3. Security crafting
   This component adds a security response script to each message. The script shall support automated encryption of the response, and targeting of the response directly to one of the collection centers. The script shall also verify that response does not exceed the valid time window. In addition, the script shall collect and send back some identifiers from the user's machine like the user and machine names, MAC, and IP address. The script may also collect more subtle information such as email correspondence, browsing information, bookmarks, etc, and may even install a spyware component (or even a trojan) that will continue monitoring the activity on the machine.
4. Spam Sender
   The spam sender is fed with a list of email addresses and the message templates that were selected for each. Before sending, the spam sender attaches a time stamp to each message, to start its validity window. The main challenge of the spam sender is to avoid its detection and the blocking of its messages. Spammers have specialized in this, and use methods such as:
   - use many and frequently changing IP addresses, as well as use of spoofed addresses;
   - use third-party outgoing mail relays that were left open
   - sending smaller batches from each outgoing mail server;
   - adapt the templates messages to a form that would be less detectable by filtering programs (this shall probably be done in the messages database itself, rather than in the sender, but we bring it here because it is one of the ways to avoid detection)
   - use HTML messages with Java script-encrypted frame tags that launch the body text only at the email client
   - use web beacons, and deceptive opt-out links to verify which addresses are active (again, this shall probably be fed back into the email addresses database)
   - use Trojans on some of the recipients to send more messages from *their* machines
5. Detection prevention
   The role of the receiver is to detect responses from law enforcement and other impersonators. Responses that are not well encrypted with the originally provided keys (in the script) will be rejected. Several rules in the detection prevention component shall seek suspicious information in the machine-specific data returned from script. This data shall also be stored and compared to future communication with same prospect. In case of serious suspicion, the receiver may abandon the entire communication associated with this email collection center, assuming it was compromised.

7. SOME RECOMMENDATIONS

In order to prevent and/or minimize terrorist's success in achieving their goals by using spam we'll suggest a few actions that could be taken.

1. Create a "Terror Spam Tracing Center" that will monitor all terror transportation.
   This center will gather data from all ISP's and publish domains, ISP', IP's etc…of mails that are suspected to be from terror organizations and publish them to all ISP's. The ISP's will be obliged to block all mails from the terrorists list.
2. Send a follow up email to every address that receives a "spam-terror" email saying that you just received an email from a terror organization, please delete it, Indicating that cooperating with terror organizations is a felony, letting the recipient understand that is actions are being watched and he's will be better off if he stops the contact with terrorist organization.
3. Create a unit that will detect and follow the traces of terror spam, in order to reach the perpetrators. Detectives in this unit shall respond to terror spam, and shall create contact where possible (under cover of course) with the relevant cells, with the goal of gathering intelligence and making arrests
4. Shut down servers that were used to send terror spam using either legal or semi-legal means depending on the location of those servers.
5. Some thought should be taken in order to protect the mobile phone industry from SMS terror Spam.

8. CONCLUSION

There is evidence today that religions terror organizations are linking with other terror organization in order to join forces against common enemies. For example Al Qaeda and far right groups such as neo-nazis and skinheads in Europe, these links are suspected to be both on the financial and action carrying levels. If terror organization will decide to further extend there links to individuals whom not necessarily believe in their organization ideology but are willing to take actions that might serve it than Spam email might serve as a perfect tool to achieve those links. By using this simple tool we showed how terror organizations can easily cause more violent incidents and increase the terror level world wide. Spam can reach civilians inside a target population that want to harm their own population provides a perfect communication tool. The spam will allow individuals to contribute both silently and actively to terror organizations dependent on each individual's preference. We showed that spam is hard to stop and detect, although the industry is taking more meaningful and aggressive approaches verse spam still spam is difficult to detect and many spam emails reach the users mailbox at the end of the day. By using spam terror organization will spread the knowledge of creating dangerous weapons, as technology is getting better and better the task of creating explosives is getting to be unbelievably simple in a way that teenagers can easily build explosives and activate them, Moreover spam can help coordinate between people who do not interact directly and by that increase the level of the terror actions and the public insecurity and fear. Finally we showed a few actions that can be taken in order to fight the phenomena of spam terror.

REFERENCES

1) [France2002] France, Mike "Commentary: Needed Now: Laws to can spam Business Week September 26, 2002 http://www.businessweek.com/magazine/content/02_40/b3802104.htm
2) [Weimann 2004] Weimann, Gabriel "How Modern Terrorists use uses the internet" 2004
3) [Wanger 2004] Thomas, Wanger: "Internet Emerges As Potent Terrorist Tool" September 24, 2004 http://federalnewsradio.com/index.php?nid=84&sid=138527
4) [SearchSecurity 2004] SearchSecurity.com Definitions - distributed denial-of-service attack http://searchsecurity.techtarget.com/sDefinition/0,,sid14_gci557336,00.html
5)[Prichard & MacDonald, 2004] Prichard, Janet and MacDonald, Laurie: "Cyber Terrorism: A Study of the Extent of Coverage in Computer Security Textbooks" 2004
6) [Wikipedia] Wikipedia: "Spam Definition" http://en.wikipedia.org/wiki/Spam_(e-mail)
7) [Leung 2003] Leung, Andrew: "Spam The Current State" August 8, 2003
8) [Monkeys] Monkeys, Spam Defined " http://www.monkeys.com/spam-defined/definition.shtml"
9) [Spam Filter Review 2004] Spam Filter Review : Spam Statistics http://spam-filter-review.toptenreviews.com/spam-statistics.html
10) [Vatis 2004] Vatis, Michael : "Cyber Attacks: Protecting America's Security Against Digital Threats" June 2004
11) [Lewis 2002] Lewis, James: "Accessing the risk of cyber-terrorism cyber war and other cyber threats" December 2002
12) [Denning, 2000] Denning, Dorothy: "Testimony before the Special Oversight Panel on Terrorism Committee on Armed Services U.S. House of representatives http://www.cs.georgetown.edu/~denning/infosec/cyberterror.html May 23, 2000
13) [Erica, 2004] Erica, Bozzi "Expectations of social behavior and cognitive dissonance among college freshman as influenced by mass media"http://www.anselm.edu/internet/psych/sr2003/bozzi/webpage.htm 2004
14) [Phishing report, 2004] Anti fishing working group "Phishing attack trend report 2004"
15) [Prashanth, 2003] Prashanth , Srikanthan "An overview of spam handling techniques" 2003
16) [Drake, Jonathan & Eugene 1004] "Christine E. Drake, Jonathan J. Oliver, and Eugene J. Koontz Anatomy of fishing email"
17) [ASTA, 2004] "Anti-Spam Technical Alliance Publishes Industry Recommendations to Help Stop Spam"
18) [AOL Spam Lawsuit] "AOL signs on to anti-spam lawsuit" 2004 http://www.bizjournals.com/washington/stories/2004/03/08/daily21.html
19) [Microsoft Spam Lawsuit] Microsoft spam lawsuits http://informationweek.com/story/showArticle.jhtml?articleID=54201964
20) [EL Qaeda 2004] "How El Qaeda uses the internet" 2004
21) [Garfinkel, 2003] Simson L. Garfinkel "Enabling Email Confidentiality through the use of Opportunistic Encryption" 2003
22) [Adabi, Glew, Horne & Pinkas, 2002] Matrin Adabi, Neal Glew, Bill Horne & Benny Pinkas"Certified Email with a Light Onlinerusted Third Party:Design and Implementation" 2002
23) [First Data Phishing Survey, 2005]. Survey: 43 Percent of Adults Get 'Phished'. http://news.yahoo.com/s/ap/20050512/ap_on_hi_te/phishing_survey
24) [Hinnen] Todd M. Hinnen "The cyber-front in the war on terrorism: curbing terrorist use of the internet"
25) [Timothy L] Timothy L. "Al Qaeda and the Internet:The Danger of "Cyber-planning"

The Use of Information Technology by Government in Combatting Disasters: Lessons from Katrina

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ABSTRACT

In August, 2005, Hurricane Katrina caused a massive loss of life and destruction of property on the Gulf Coast of the United States. This paper examines the role Information Technology can play in predicting disasters, and in mitigating the impacts of those that do occur. The analysis indicates that available IT resources were not used to their fullest potential in the case of Hurricane Katrina.

Keywords: Crisis Management, Information Technology, Post 9/11.

INTRODUCTION: USING TECHNOLOGY TO COMBAT DISASTERS

The Post 9/11 environment has been characterized by an increased emphasis on disaster planning on the part of national and local governments. Government funding for new technologies aimed at combating terrorist attacks has resulted in a wide range of new initiatives. Additionally, there has been an increased public awareness of the potential for disasters, not only from terrorist attacks, but from accidental failures such as blackouts, and natural disasters such as hurricanes. This paper will argue that many of the evolving technologies for countering terrorism can also be used to help inform and protect citizens from large scale accidents and natural disasters as well. Information technology can provide governments with a means of: 1) educating their citizens about the likelihood of the occurrence of a potential disaster, 2) disseminating up to the minute information about any disasters that are immediately threatening, 3) mitigating the impact of disasters through evacuation planning, health care availability, and emergency food and water supplies and 4) recovering from and rebuilding after the disaster has happened.

In August 2005, Hurricane Katrina hit the Gulf Coast of the United States, causing over 1500 lives to be lost and irreparable damage to many homes, businesses, and unique historical landmarks. This paper will provide an analysis of this devastating event and analyze how information technology could have been used to mitigate the impact of this disaster, and to prevent future hurricanes from having as severe an impact. A disturbing revelation in the aftermath of Katrina was that many of the IT based strategies that were available were not used, or were used and the results not acted upon. Local, state and federal government did not respond as citizens of a highly technologically advanced society would have expected them to.

The results of the analysis will indicate IT based strategies for predicting future natural disasters, informing the public about their likelihood and the most appropriate response, mitigating their impact, and helping urban environments recover and rebuild.

LEARNING FROM HURRICANE PAM

Unlike terrorist attacks, which rely on surprise, hurricanes and most natural disasters can be predicted before they occur and tracked with enough lead time to allow evacuation. In the case of terrorist plots, information gathering on suspects must be balanced against civil rights violations. Natural disasters do not need their privacy protected. Therefore, IT based information gathering can be used to the fullest extent possible. IT based radar systems can illuminate developing storms, and IT based simulation models can give managers and government leaders experience with "virtual disasters" that can help them prepare for real ones. Evacuation routines can be designed to ensure that everyone has the time and means to reach safety. Supply chain management systems can be tailored to help relief agencies provide emergency assistance. Supply chain alliances with private sector organizations and individuals to provide emergency relief can be established before emergencies occur.

In the case of New Orleans, simulation models had already predicted that the levees protecting the city would not withstand a Class 3 hurricane and weather experts had predicted that a hurricane of such force was well within the realm of possibility. National Geographic magazine in October, 2004 published an article called, "Gone with the Water," which included the following warning (Bourne, 2004, p. 100):

...The doomsday scenario is not far-fetched. The Federal Emergency Management Agency lists a hurricane strike on New Orleans as one of the most dire threats to the nation, up there with a large earthquake in California or a terrorist attack in New York City. Even the Red Cross no longer opens hurricane shelters in the city, claiming the risk to its workers is too great.

Also in 2004, a computer simulation of a hurricane, called Hurricane Pam, was developed as an exercise for dealing with a major hurricane in New Orleans. The result was widespread devastation (Brinkley, 2005, p. 18):

270 officials from all levels of government did participate in a FEMA-funded week long simulation of a Category 3 Hurricane striking New Orleans, a fake but very realistic storm called Hurricane Pam based on extensive models developed at Louisiana State University. The primary assumption of the Hurricane Pam exercise was that "Greater New Orleans is inundated with ten feet of water within the levee systems as a result of a Category 3 or greater hurricane." The attendees learned that it would not be just water, in fact, but a "HAZMAT gumbo." They heard that the total number of people left stranded in the toxic water "may approach 500,000" if residents didn't evacuate. And they were further informed that a monstrous storm such as Pam would leave 30 million cubic yards of debris—not counting human remains—spread out over 13 parishes in Southern Louisiana.

Local government leaders and relief agencies were told to prepare accordingly, but the recommendations resulting from the model were not implemented. "Having lived through Pam for a week, the 270 officials just went home (Brinkley, 2005, p. 19).

For three days prior to Katrina reaching New Orleans, radar models showed the storm approaching and measured its strength. "Surge warriors," such as Ivor van Heerden, had developed sophisticated ADCIRC (advanced circulation) computer models to predict the impact of hurricanes in the gulf. Thirty hours before landfall, experts predicted that there was a strong likelihood of a major disaster, yet a mandatory evacuation was not called for. When major flooding was indicated, van Heerden "forwarded the results to every official at every level of government I could think of " saying a worst case scenario had developed and that mandatory evacuation was necessary (van Heerden, 2006, 41). Only a voluntary evacuation was called for. By the time the evacuation was mandated a day later, there was not enough time to have it implemented.

PREPARE RELIEF EFFORTS BEFORE THE DISASTER OCCURS

On the positive side, private sector organizations, such as Wal-Mart, predicted the seriousness of the storm and began planning the delivery of emergency supplies to areas they feared would suffer the greatest damage. After the initial hit of Katrina, Wal-Mart provided the greatest share of water, food and equipment to stricken areas (Brinkley, 2006, p. 251).

Wal-Mart, the world's largest retailer and America's biggest private employer, stepped up to the plate by offering vast warehouses full of essential supplies to those stricken by the Great Deluge. Under the lighting quick leadership of CEO Lee Scott, Wal-Mart used its muscle to meet the needs of the victims in the three ravaged Gulf States, donating emergency supplies ranging from Strawberry Pop Tarts to Hanes underwear…"Wal-Mart was our FEMA," said Warren Riley of the New Orleans Police department.

Partnerships between local governments and private sector organizations that specialize in supplying customers with the necessities, should be forged before emergencies occur. Supply chain management software, widely used by these large chains, could be modified to help streamline relief efforts should an emergency occur. Volunteering to assist in local emergencies should win large chain stores a great deal of good public relations in their surrounding communities.

Likewise, a number of heroic individuals emerged from Katrina. Individuals within New Orleans with private boats rescued their neighbors. "Far flung American communities galloped to do all they could (Brinkley, 2006, p. 250)", but FEMA denied permission to enter until a chain of command could be established. A database of certified volunteer first responders should be developed so that these individuals can be contacted, transported to disaster areas, and deployed effectively. Good Samaritan legislation needs to be developed to protect volunteers from lawsuits, should their best attempts have negative consequences.

Additionally, private sector initiatives from Amtrak, Marriott, Continental Airlines, and a number of faith based groups were also refused or delayed. Offers of medical support from Cuba, airdropped military rations from Germany, and cash and oil supplies from Kuwait were also refused. Even FEMA subcontractors were put on hold (Brinkley, 2006, p. 250).

Cool Express, an ice company in Blue River, Wisconsin had a standing contract for ice deliveries in disaster situations. Yet the company didn't receive permission to send trucks to the region until 4 p.m. on Monday. By that time, the ice wouldn't even reach the staging area in Dallas until late Tuesday. After that, it would be another eight-hour drive to southern Louisiana.

Disaster recovery alliances with the private sector other countries need to be developed and designed before hand. Simulation modeling of future disasters should include members of these alternative sources of relief.

BECOME FAMILIAR WITH THE LOCAL ENVIRONMENT AND LOCAL CUSTOMS

Rescue efforts in New Orleans were also hindered because rescuers were not familiar with local street names or the location of key relief centers (Brinkley, 2006, p. 258).

The problem the U.S. Coastguard had with FEMA was that FEMA didn't know the local geography or place names or wards of New Orleans. They couldn't pronounce Tchoupitoulas (choppa-too-liss) Street, let alone spell it. They couldn't cross over the Crescent City Connection bridge because they thought it was a shuttle service to Houston.

GPS systems should be developed and used before a disaster to help relief workers navigate an area and reach important destinations effectively. Alternative routes can also be developed if part of an area is under water, or otherwise inaccessible. Simulation models need to be tailored to the social and cultural environment of the disaster.

An enhanced knowledge of local customs and language would also aid rescue workers. An economically and culturally diverse urban area, such as New Orleans or New York consists of a number of different subcultures. Differences in language and attitudes toward authority figures such as police and government officials made rescue efforts in New Orleans more difficult. Government officials need to be aware of the various languages spoken in an urban area so that warnings can be issued in appropriate languages. Internet access must be available to all citizens so that emerging threats can be delivered on a timely basis. Rescuers need to be aware of social customs regarding approaching strangers in a non-threatening manner. Language translation software and simulation modeling of social interactions developed for soldiers in Iraq, needs to be tailored for first responders confronting diverse social groups in their own country.

DIRECTIONS FOR FUTURE RESEARCH

This analysis will be extended and enhanced by including a wider range of sources about the disaster, and more concrete descriptions of IT based tools that can be used to predict, prevent and prevail over future disasters. Post Katrina initiatives will also be examined and evaluated.

REFERENCES

References upon request.

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Degrees of Delight: A Model of Consumer Value Generated by E-Commerce

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ABSTRACT

This study proposes a model of Web applications to guide designers of the next generation of Web based businesses. This study will draw upon the Theory of Consumer Involvement, exploring the implications of consumer involvement in designing appropriate applications. The theory will be extended to create a four part Consumer Value Model—based on four different kinds of value a site can deliver. Implications for Web site development and design, Critical Success Factors for sites delivering each form of consumer value, and the appropriate business model for making each type of site profitable will result.

Keywords: Consumer Involvement theory, Critical Success Factors, Consumer Value Model, E-Commerce, High Engagement, High Product Involvement, High Purchase Involvement, Low Engagement, Web site design.

THE NECESSITY OF PROVIDING CONSUMER VALUE

After an exciting and tumultuous first decade, E-Commerce has experienced a wide range of successes and failures. Designers of next generation Web based businesses need to know which applications will provide value to customers and profits to the businesses that create them.

This paper proposes a new perspective, the Consumer Value Model **(CVM),** that distinguishes the *types of value to the consumer* provided by an E-Commerce application, and argues that it is only by providing one of these types of value to customers that an E-Commerce site can *generate business value* to the creators of the Web based business.

This study will draw upon the Theory of Consumer Involvement from the field of Consumer Behavior in Marketing and develop a Consumer Value Model **(CVM)** based upon the type of underlying involvement with the product or service offered by the Web site. This approach is in contrast to earlier studies that focused on the consumers' involvement with Web use in and of itself. The result of the analysis will be a four-part model of consumer value that will have implications for the Critical Success Factors of Web site development and design, and the appropriate business model for making the site profitable.

This paper will argue that a *consumer value* oriented approach to technological development will provide valuable insights. Allen (2003) argues that the search for applications that provide value to users can be more important than technological innovations.

Furthermore, a given user may interact with a computer in a number of different roles and contexts, giving web designers alternative means of providing value to the same consumer. Users may learn the details of a player trade on their favorite sports team, seek important information for buying a home, conduct routine transactions like bill paying, or pass time playing a game, through the same computer. Roussos, Peterson, and Patel (2003) argue that each user assumes a number of identities when interacting with a computer and that each identity must be managed.

THEORETICAL PERSPECTIVE: INVOLVEMENT THEORY

This study will draw on *Involvement Theory* from Consumer Behavior research to inform the analysis. A consumer's involvement with a product can be defined in terms of, 'the degree of personal relevance that the product holds for the consumer. Under this definition, high involvement purchases are those that are very important to the consumer and thus provoke extensive information processing' (Schiffman & Kanuk, 1999, p. 186). Consumer behavior further distinguishes between *product involvement,* which occurs when the consumer finds the product inherently meaningful and enjoyable, and *purchase involvement*, which occurs when a consumer takes an interest in the details of a product because he or she is making an expensive or risky purchase. *Low involvement* products tend to be commodities which consumers find neither fascinating nor risky. Although a number of studies (Venkatesh, 1999, Agarwal & Karahanna, 2000, Novak & Hoffman, 2000) addressed user's involvement with computer use and Internet surfing per se, Lally (2003, 2004) first addressed the idea of studying users' involvement with the underlying product or service as a determinant of Web site success. Lally (2003,2004) argued that the typical Internet user doesn't surf the Internet because they find computers or the Internet inherently fascinating but because the Internet: 1) allows them to interact with something they do find fascinating, 2) helps them gather information for important purchases or other major decisions, or 3) allows them to conduct routine transactions in a convenient and efficient manner. Her results indicated that users seeking serious information versus entertainment require fewer of the immersive features provided by multimedia, but require more timely, accurate content.

HIGH PRODUCT INVOLVEMENT: PROVIDE HEDONIC VALUE

Goods for which consumers develop high degrees of product involvement include high end stereo equipment, automobiles, music, art, and movies. Celebrities and sports teams can also generate high levels of involvement among their fans. Customers become educated about the product and enjoy discussing it with others. They find visiting retail outlets for these products inherently enjoyable, even if they are not planning an immediate purchase. This intrinsic pleasure in shopping is called *hedonic value.* Customers willingly devote time and attention to learning about the details of the product and develop sophisticated levels of knowledge. When they do make purchases, customers are willing to pay a premium for products whose characteristics suit their personalities and satisfy their tastes.

High product involvement goods are typically sold in retail outlets where they are displayed in an attractive and involving manner to increase hedonic value. Sales representatives need to be well informed about product features. Educating potential customers and interacting with already knowledgeable customers is part of their job. Because these products tend to have a strong visceral component, customers are often given the opportunity to interact physically with the product before making a purchase.

In E-Commerce, Web sites targeting consumers with high product involvement must confront the limitations of the on-line shopping experience. Consumers cannot physically experience the products as completely as when they are in a retail outlet. As bandwidth limitations become less of a constraining factor, however, Web designers can use multimedia to compensate for the lack of physical presence. Lui, Arnett, and Litechy (2000) suggest that Web designers should aim to create hedonic value for users by making sites playful and engaging. High quality graphics, sound, and animations can provide virtual experiences that consumers find inherently enjoyable. On-line experts can provide advice about products. User groups can provide the enjoyable experience of discussing the products with others. High end auction houses have found, for example, that customers will purchase very expensive works of art over the Web if they can view details of the artwork through high quality graphics, and interact with art experts to become more informed about their potential purchase.

Because High Product Involvement addresses an enduring personal interest on the part of consumers, a *subscription revenue model* is most likely to be successful.

Users are likely to return to sites over and over again, just as they look forward to new issues of magazines on their favorite subjects. Therefore, content must be continually refreshed to provide new experiences with the desired product.

HIGH PURCHASE INVOLVEMENT: INFORM RATHER THAN ENTERTAIN

Unlike consumers with high product involvement, consumers with high purchase involvement do not find their product inherently enjoyable. Instead they invest time and attention because the product is important, expensive and/or risky. High purchase involvement goods include information about buying a home, medical information when they or a loved one need medical help, and financial investments.

When shopping for high purchase involvement goods, consumers want access to essential facts to help them make important or risky decisions. They willingly engage in extensive information processing to help them make the right decision. For managers of Web sites for these products, involvement theory suggests that the emphasis be put on informing, rather than entertaining the consumer.

For consumers making one time important purchases such as buying a home, a fee for content business model would most likely be the most successful. Unlike the case with High Product Involvement, High Purchase Involvement does not represent an enduring interest in a product, so users would be less likely to want to subscribe on a long term basis.

LOW INVOLVEMENT PRODUCTS: MAKE IT QUICK AND SIMPLE

Low involvement products, in contrast, do not personally engage the user. Cash from automatic teller machines, soda from vending machines, and office supplies are examples of products that customers seek out of necessity, not because they find the shopping experience inherently enjoyable. Customers prefer 'limited information processing when the purchase is of low personal relevance' (Schiffman & Kanuk, 1999, p. 186). Involvement theory suggests that an efficient purchasing process is the quality most valued for these products. Kaufmann and Lally (1994) found, for example, that for automatic teller machines, easy access dominated design features in attracting customers.

A fee for transaction business model would be most appropriate. Users with heavy demands on their time and attention are frequently willing to pay a premium to minimize the time and effort required of them to conduct routine tasks. Usability testing upfront is critical, but once the site is well designed frequent changes and updates are likely to confuse, rather than provide value, to the customer.

Table 1 summarizes the design consequences and business models suggested by the theory of consumer involvement for E-Commerce applications.

The three categories can be characterized as:

- High Product Involvement: High Intrinsic Interest, High Importance.
- High Purchase Involvement: Low Intrinsic Interest, High Importance.
- Low Involvement: Low Intrinsic Interest, Low Importance.

PASSIONS VERSUS PASTIMES: EXTENDING THE MODEL

An examination of the growing proliferation of casual entertainment E-Commerce applications, such as computer gaming and downloading TV shows for iPods, indicates that there exists a fourth category of applications. *These applications provide high intrinsic interest to the consumer, but are not of enduring personal importance*. Consumer based applications aimed at killing time in a pleasant and engaging matter attract a significant number of consumers. This analysis proposes to extend the theory of consumer involvement to include applications that provide this form of value and substitute the terms High Engagement and Low Engagement for the Low Involvement category suggested by involvement theory:

- High Engagement: High Personal Interest, Low Importance.
- Low Engagement: Low Personal Interest, Low Importance.

These sites should charge for the service they provide consumers with a pleasant means of passing the time, either though connect time or usage. As new, more exciting forms of High Engagement applications become available, customers are likely to switch to them, hence the need for constant innovation. Because the degree of personal relevancy of a particular product is low, customer loyalty is likely to be fleeting.

Table 2 extends the categories suggested by the theory of consumer involvement to include High Engagement sites.

Table 1.

	Critical Success Factors	Business Model
High Product Involvement	Media rich immersive interfaces	Subscription
High Purchase Involvement	Timely, accurate information	One time fee for individuals. Subscriptions for business.
Low Involvement	Quick efficient transactions	Fee for Transaction

Table 2.

	Critical Success Factors	Business Model
High Product Involvement	Media rich immersive interfaces—high quality information conveyed through a range of media—fascinate user continually over long periods of time.	Subscription
High Purchase Involvement	Timely, accurate information, facts conveyed clearly—inform users for important decisions.	One time fee for individuals. Subsciptions for business.
High Engagement	Media rich interfaces to hold users attention over immediate time period.	Fee for Connect Time
Low Engagement	Quick Efficient transactions simple interfaces—minimize users transaction costs.	Fee for Time Used.

CONCLUSION

This paper has presented a model of consumer value, for understanding the motivations behind consumer adoption of E-Commerce applications, what features are most appropriate and what business models apply. Empirical studies will follow to address the applications of the model to next generation Web Applications.

REFERENCES

References upon request.

Pervasive Computing: The Cause for Including Mobile Application Development in Undergraduate IS Curriculum

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INTRODUCTION

Computing for the end user has changed dramatically with the shrinkage of the personal computer and the availability of wireless connections. Not only is the Web ubiquitous and the Internet universally available, but the saturation and the size of the hardware used for personal computing has changed as well. What is commonly referred to as mobile computing has changed application development. Users have moved from cabinet-sized desktop computers to laptops and notebook computers, to personal digital devices, Palm Pilots, Blackberries, Pocket PCs, and finally to smart phones. Cell phones with Internet access and various software applications in addition to established telephony software are now common. The situation of ever-present computing power in all aspects of our lives has become known as *pervasive computing* (Bergeron, 2001.)

The importance of teaching our IS majors with modern GUI software programming tools that use new Java and .NET programming languages is well-recognized in most American computer information systems departments granting undergraduate degrees. However, teaching IS majors programming that can be ported to smart devices and interfaces with Web services that are accessed wirelessly is relatively new. The importance of new IS graduates knowing how to develop appropriate mobile computing applications should not be ignored. IS curriculum for the undergraduate should include programming for mobile devices. This gives our new graduates more competitive employment opportunities: entry level IT positions remain competitive, despite slight improvements in the job market (Bureau of Labor Statistics, 2006.)

The required programming course(s) in most undergraduate IS programs has always concentrated on the basic logic and programming techniques needed for entry level positions in industry. And that is still true: there is no substitute for basic problem solving methodology, design tools, logic of basic constructs, and rudimentary coding skills. Yet when employers advertise available positions, they almost universally request specific skills. Academics know that keeping current in IT curricula is a constant struggle, but one with definite paybacks. Keeping programming language curricula current has never been easier, or more rewarding. It *is* possible to teach mobile computing applications in our programming courses, and thus give our students experience in programming for a pervasive computing environment.

When GUI tools and IDE's (integrated development environments) became common, the old command-line instruction and heavy emphasis on syntax gave way to teaching modern fourth and fifth generation programming languages that were object oriented. *Cobol* was replaced by *C*, then *JAVA* and/or *Visual Basic*, and *C++* . Building console applications with a *C* compiler within *UNIX* often was replaced with building *Windows* applications within microcomputer operating platforms. Attention to user interface and connecting to data sources for database file processing and more robust transaction processing systems became a reality within undergraduate programming courses. The RAD (rapid application development) tools available provided an environment where students could do more in-depth programs within a semester time-frame. Next, development of Web-based transaction processing systems as well as *Windows* applications was possible when programming suites were introduced. The same opportunity now exists for students to develop Web services and applications for Smart Mobile Devices such as Pocket PCs and cell phones, using the emulators built into programming suites. Students in an existing programming class at Metropolitan State College of Denver used Pocket PCs with wireless access to develop smart device mobile applications while learning to program in *C#.NET*. The response was positive, the programs were relevant and immediately useful, and the experience obtained with WI-FI (wireless fidelity) and mobile devices were true resume builders.

DISTINCTIONS WITH MOBILE COMPUTING APPLICATIONS

The interface of modern programs is vastly different from the command-line interface of the mainframe and early microcomputer days. Text-based systems are scarce today, and are foreign to most computer users –even those in the IT industry. The early GUI appearance of application programs has evolved into a Web-like interface. Ample RAM, high resolution devices, and faster processors have given us the luxury of highly sophisticated multimedia interfaces. The smart device programs that students learn to program must take into consideration the audience using them; they are culturally, occupationally, and geographically dispersed. Blom, Chipchase and Lehikoinen conducted extensive research on contextual and cultural challenges for Nokia, Inc. (2005.) They studied the length of typical smart device use, the cultural idiosyncrasies, the personal nature of the use, the privacy and security concerns of users, the use of smart devices while commuting, walking, sitting in meetings, on public transportation—even use while driving or cycling. In 1997 Page developed a model of requirements for *Windows* mobile-based products (2005). There is a profile for the typical smart device user.

Nokia was a pioneer of smart mobile device applications. The designers of their third party application software deemed the most important aspect of the design was to provide the user with feedback. The use of cell phones and smart mobile devices by a younger population drove the user requirement for a very visual application. The proliferation of ring tones, IM (instant messaging), text messaging, and the exchange of digital photos and video by cell phone users confirm Kangas and Kinnumen's multimedia recommendations (2005.)

Sprint, Inc. holds that previously there were two basic consumer screens: the TV and the PC. In 1999 they set out to develop a third—the mobile phone screen (Balaji, 2005.) Done correctly, it would evolve into the most used personal screen, since users would use the same device—a variety of the smart phone—to communicate, to access the Web, to view TV and movies, and to compute. One device would be used individually for all computing and communicating uses; it would be small and mobile. The PCN (personal communications network) that was advocated in the late 1980s would be common by 2010 (Marold, 1996.)

THEORETICAL UNDERPINNINGS OF TEACHING MOBILE APPLICATIONS

As Roger Schank points out, scholars from Aristotle, to Galileo, to Dewey, to Einstein have concurred that real learning is by doing (2001a). We learn when we need to use the concept, and we understand when we physically perform the steps toward mastery (Schank, 2001b). Learning by doing with mobile devices is nearly impossible to implement in a traditional college computer lab setting.

However, when a disconnected practice environment is provided, when each student is responsible for his/her own server and Pocket PC, when the student has enough exposure for a comfort level, application development for mobile devices can be successful. Mobile devices and wireless connectivity are integral to the learning process. Bergeron notes that the majority of mobile technologies simply fit into the process of everyday business and personal life. If they do not fail unexpectedly, they fade out of conscious existence (2001).

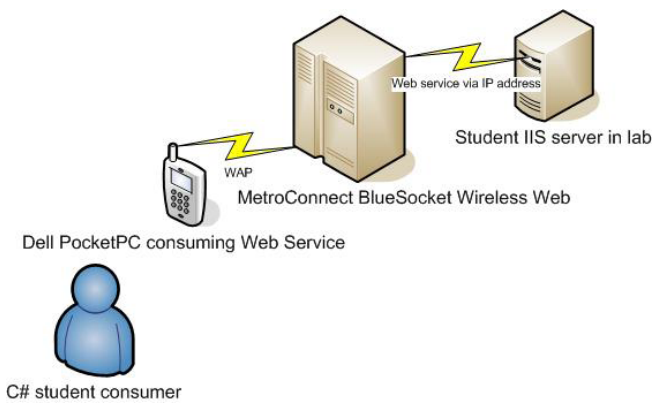
Adapting for programming instruction in mobile smart device applications requires some adjustments and some capital outlay for the institution. A special needs lab for information systems majors at Metropolitan State College of Denver was completed five years ago (Fustos, 2004). Once the lab was in operation, the potential for teaching mobile applications and Web services was evident. The programming software, the IIS (Internet Information Services) server software, and development stations were already there. All types of hand-held devices, from Palms and PDAs, to Blackberries, to cell phones have become less expensive (Tam, 2005). The prototype applications students build can give IS majors a "feel" for what modern programs they will be designing for the industry.

DETAILS OF PROGRAMMING FOR MOBILE DEVICES

Using computer labs to teach programming classes is recognized as an optimal setting—provided that the environment can be controlled. Metro's special needs lab has twenty stations in the lab, giving students plenty of room to work. There is an instructor station with display equipment and "smart classroom" touch pads that are easy to use. The instructor station controls all student client stations with *SynchronEyes* software. This allows the instructor to lock stations, broadcast the instructor monitor to all stations, and display any student client machine at any time—either to the whole class, or individually and privately. Students can work along with the instructor in interactive sessions, or easily follow an instructor demonstration or *PowerPoint* presentation on their monitors.

The added expense for this class was the purchase of twenty Dell Pocket PCs with WI-FI capability, so that the Pocket PC could serve as a client and wirelessly access the student desktop computer station as its server. Development for all applications, whether Web applications or not, was on the desktop station using the *Visual Studio.NET 2003 Professional* software. The installation of *ActiveSync* software allowed students to move their applications to the Pocket PCs from their server computers using a USB (universal serial bus) connection—a simple drag and drop operation. The special needs lab computers have an additional removable hard drive where students have all privileges and may develop Web applications using IIS (Internet Information Services). The students programmed their Web applications to use the IP (Internet Protocol) address of their own servers for the Web reference, allowing them to wirelessly consume a Web service. (Although there is a Pocket PC Emulator built into the *Visual Studio.NET Professional*, the value of being able to port programs to individual mobile devices and use WI-FI 802.11.B technology to access servers cannot be underestimated.) The class could experiment with wireless technology—WI-FI, infrared beaming, and Bluetooth short distance FTP, all of which were included on the Dell Pocket PCs. The exposure to pervasive computing included projects that were developed within the semester-long class: there were independent smart applications, mobile Web pages, and creating and consuming Web services. Figure 1 shows how this was done.

Figure 1. Using WI-FI to consume Web services with pocket PCs



DISCUSSION

The existence of the campus wireless BlueSocket Web site simplified the process of using the Pocket PCs to connect to the student lab servers. In 2004 Metro installed Wireless Access Points(WAPs) on campus. BlueSocket is heavily used by students with laptops. Therefore, students in the C# class could simply login to the BlueSocket site with their Pocket PCs, and then connect to their individual lab servers via the IP address. The simplicity of the hardware connections allowed them to concentrate on the software—the programming content of the course. Aside from the security of their assigned lab servers and their vulnerability to modifications or removal of their programs (backups were constantly stressed), student implementation was optimal. Students were responsible for programming their own applications and maintaining their own Pocket PCs. They were kept in a locked cabinet in the lab, and checked out as needed. After the instructor corrected student programs and assigned grades for them, the Pocket PCs were returned and reset for reuse. The servers are on removable drives in the lab. They are re-imaged every semester, so there is a fresh start with the desktop computers as well. The use of WI-FI and Pocket PCs for the course allowed students to learn programming using the C# programming language in a three-tier architecture. It also exposed them to three popular wireless methodologies.

CONCLUSION

Incorporating mobile computing into the information systems curriculum at Metropolitan State College of Denver has received accolades from instructors, students, administration, and potential employers. Pervasive computing that has become the *modus operandi* of our society dictates an adjustment in how we educate our future information technology workers. Experience with wireless application development with smart mobile devices is another step toward keeping information systems curriculum current.

REFERENCES

Balaji, T.S, B. Landers, J. Kates, and B. Moritz. (2005). A Carrier's Perspective on Creating a Mobile Multimedia Service. Communications of the ACM. 48:7. 49-53.

Bergeron, B. (2001). The Wireless Web. McGraw-Hill. New York.

Blom, J, J. Chipchase, and J. Lehikoinen. (2005). Contextual and Cultural Challenges for User Mobility Research. Communications of the ACM. 48:7. 37-41.

Bureau of Labor Statistics. (2006) http://data.bls.gov/oes/sector.do. Accessed 1/2/07.

Fustos, J. and K. Marold. (2004). Using a Unique Campus Instructional Computer Lab for Information Systems Curriculum Delivery. Proceedings of the 46th Annual Mountain Plains Management Association Conference. Document 67.

Kangas, E. and T. Kinnunen. (2005). Applying User-Centered Design to Mobile Application Development. Communications of the ACM. 48:7. 55-59.

Marold, K. and G. Larsen.(1996). Beyond the Internet: Using Personal Computers to Communicate. CTI of Thomson Publishing. New York. Chapter 10.

Page, C. (2005). Mobile Research Strategies for a Global Market. Communications of the ACM. 48:7, 42-48.

Schank, R. (2001a). The Computer Isn't the Medium, It's the Message. Communications of the ACM. 44:3, 142-144.

Schank, R. (2001b). Revolutionizing the Traditional Classroom Course. Communications of the ACM. 44:12, 21-24.

Tam, Pui-Wang. (2005). The Hand-Helds Strike Back. Wall Street Journal. May 18, 2005. D1-6.

Round-Tripping Biblical Hebrew Linguisitic Data

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1. INTRODUCTION

In processing language electronically, one can either concentrate on the digital simulation of human understanding and language production, or on the most appropriate way of storing and using existing knowledge. Both are valid and important. This paper falls in the second category, by assuming that it is useful to capture the results of linguistic analyses in well-designed, exploitable, electronic databanks. The paper focuses on the conversion of linguistic data of Genesis 1 between an XML data cube and a multidimensional array structure in Visual Basic 6 in order to facilitate data access and manipulation.

2. RELATIONAL DATABASE TECHNOLOGY VS. XML TECHNOLOGY

If the linguistic data of Genesis 1 were to be captured in a typical relational database, organised according to clauses as records in rows, and according to linguistic categories as logical attributes in columns, the word order of the elements in the clauses would be lost. One could, of course, store the positions of the words or phrases in a separate table and use a system of primary keys, foreign keys and joins to reassemble the original text, but this would cause much overhead (cf. Bourret, 2003).

Since the tables in traditional two-dimensional relational databases consist of rows and columns implying a maximum depth of two levels (Jeong & Yoon, 2001), one could only capture information of one linguistic module in a row without losing coherence. However, even if only the analysis of one linguistic module were captured in a table, it would be sparsely populated. One would therefore need multidimensional data storage facilities in order to find a better solution.

This paper, therefore, investigates XML technology to mark up free text, because it allows the hierarchical and multidimensional organisation of data. This data can be transformed into a three-dimensional array, processed by a computer program and saved back to XML for storage or transfer. Furthermore, XML was chosen because it is itself text-based and intuitively provides a suitable means to capture linguistic, textual data. It is very simple to use and does not require a high level of programming skills. An XML file is also platform independent and can be used by various programming languages and other software packages.

3. THE STRUCTURE OF THE DATABANK

3.1 The Structure of the Databank in XML

An XML document comprising of the text and markup of Genesis 1 may be regarded as a native XML database while a VB6 program that manipulates the data may be regarded as a content management system (cf. Bourret, 2003). The structure of the databank in XML for this project is built on the hierarchy as shown in Figure 1.

A complete discussion of the use of XML to build the Genesis 1 linguistic data cube may be found in Kroeze (2006a).

3.2 The Structure of the Databank in VB6

Although a lot of processing, such as indexing and searching, can be done directly on XML documents, one often needs a program to do more ambitious analyses (cf. Burnard, 2004). Visual Basic 6 (VB6) was chosen to perform this role with a view to this project, because XML is essentially a hierarchical system which fits the three-dimensional array data structure facilitated by VB6 perfectly.

Figure 1. Hierarchy underlying the XML databank containing linguistic data of Genesis 1

Hebrew Bible	- not used in this study
Bible Book	- not used in this study
Chapter	- root element in this study: <Genesis1>
Clause	- each clause represented by one table: <clause>
Clause Number	- each clause's ID: <clauseno>
Table Headers	- headings for each column: <headers><header>
Language Levels 1-5	- the various modules of analysis: <level1> ...
Level Description	- description of module per row: <leveldesc>
Phrases 1-5	- the word groups in a clause: <phrase1> ...

When converted into VB6, the databank module consists of a multidimensional array data structure. Multi-array data storage is one of the two main ways of implementing data warehouses (Wang & Dong, 2001). Typical data warehousing processing that may be performed on the clause cube using arrays and loops has been discussed in Kroeze (2004b). A multidimensional array structure is very suitable for a limited data set, such as the data in this project, due to its built-in indexing. Multidimensional online analytical products (MOLAP) "typically run faster than other approaches, primarily because it's possible to index directly into the data cube's structure to collect subsets of data" (Kay, 2004). The VB6 program discussed in this paper may be regarded as a simple MOLAP tool.

The three-dimensional array in VB6 contains records of 108 clauses. Each clause has five or less phrases. Each phrase potentially has five levels of analysis. One

Figure 2. The first unit in the three-dimensional array populated with linguistic data from the first clause in Genesis 1

```
Option Explicit
Public Clause(1 To 108, 1 To 5, 1 To 6) As String
Sub Main()
Clause(1, 1, 1) = "Gen01v01a"
Clause(1, 1, 2) = "bre$it"
Clause(1, 1, 3) = "in the beginning"
Clause(1, 1, 4) = "PP"
Clause(1, 1, 5) = "Adjunct"
Clause(1, 1, 6) = "Time"
Clause(1, 2, 1) = "-"
Clause(1, 2, 2) = "bara"
Clause(1, 2, 3) = "he created"
Clause(1, 2, 4) = "VP"
Clause(1, 2, 5) = "Main verb"
Clause(1, 2, 6) = "Action"
Clause(1, 3, 1) = "-"
Clause(1, 3, 2) = "elohim"
Clause(1, 3, 3) = "God"
Clause(1, 3, 4) = "NP"
Clause(1, 3, 5) = "Subject"
Clause(1, 3, 6) = "Agent"
Clause(1, 4, 1) = "-"
Clause(1, 4, 2) = "et ha$amayim ve'et ha'arets"
Clause(1, 4, 3) = "the heaven and the earth"
Clause(1, 4, 4) = "NP"
Clause(1, 4, 5) = "Object"
Clause(1, 4, 6) = "Patient"
End Sub
```

level of analysis is added to record the verse number as primary key for reference and searching purposes. An array of 108 x 5 x 6 is used to implement this data structure. If manually populated with data, the first clause could be coded as shown in Figure 2.

A complete discussion of this structure may be found in Kroeze (2004a). The same structure is used in this project to convert the data captured in the XML document into the VB6 array.

4. CONVERSION BETWEEN VB6 AND XML (ROUND-TRIPPING)

One of the advantages of an XML databank is the separation of the data and the manipulation thereof. The same data can be used for various purposes. An XML document in itself is not very reader-friendly. Therefore, one needs other software to efficiently process the data in such a repository (Kumar et al., 2005). Conversion is often necessary to make the data accessible for algorithms that implement efficient retrieval and human-friendly interfaces (cf. Ramsay, n.d.; cf. Witt, 2005).

If data is represented in a different format, it should first be parsed by an application. In our experiment, the data should be represented in an interlinear format which is easier to read. This necessitates that the VB6 program reads the data into an array in order to be printed as a series of linear tables on the screen. Removal of the XML tags restores the original text so that the layers of analysis become more comprehensible.

The conversion to and from XML format is called round-tripping. Round-tripping is the circular process of storing document data in a (XML) database and recreating the document from the database, a process which could result in a different version of the original document (Bourret, 2003). In this experiment round-tripping refers to the process of converting the Genesis 1 XML document to the three-dimensional array structure in VB6 and saving it again in XML format. If no changes are made while the data resides in the array, the resulting XML document should be an exact copy of the original (*ideal* round-tripping - Smiljanić, Blanken, Van Keulen, & Jonker, 2002). However, the array phase should facilitate updates to be made, which should also be reflected in the resulting XML document. Due to the limited scope and length of this paper, no program code is presented here.

4.1 From XML to VB6

All data in an XML document is text. The markup itself is also text only (Huitfeldt, 2004). For a linguistic database this creates no problem, since it also contains text data only. Therefore, in VB6 all the variables of the three-dimensional array are also of type *string* only. The limitation of arrays that all the elements should be of the same type (string, integer, boolean, etc.) therefore poses no problem. To strip the XML code from its tags, much string processing is performed (cf. Petroustos, 1999).

The easiest way to convert the Genesis 1 data would be to ensure that empty elements (e.g. where a clause has less than five noun phrases) are represented by a dash (-).The loop that reads the data cube elements into the three-dimensional array can then simply assume that the next line in the XML document will be the next element in the data structure. Not all phrases have syntactic or semantic functions and these missing elements may also be rendered by a dash. This simple implementation is used in this experiment, because it also ensures that the XML document is an exact copy of the original document after ideal round-tripping.

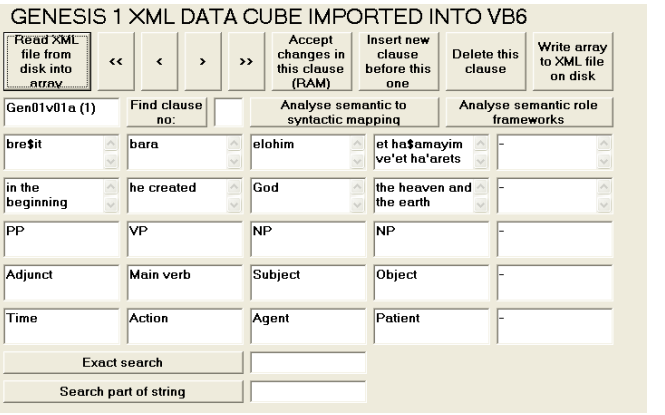
Although validation is usually done by means of a schema, it could also be performed here during the conversion process. In a subroutine the tags are first stripped and the remaining data tested against a standardised list of valid entries (e.g. syntactic and semantic functions) before it is transferred to the array. To show the contents of the array, the elements of each clause are displayed in a series of textboxes. When the program is run, the interface looks as shown in Figure 3.

Advanced data mining may now be performed on linguistic data stored in the three-dimensional array. Compare, for example, Kroeze (2006b) for a study of the semantic role frameworks extracted from Genesis 1.

4.2 From VB6 to XML

The conversion of the content of the three-dimensional array in VB6 to XML is more or less the reversal of the above process. While it is not necessary to perform validation again, string processing is used to convert the variables to lines of text

Figure 3. Interface used to render, process and round-trip linguistic data stored in a three-dimensional array and XML data cube



wrapped in applicable XML tags. The structure of the XML schema must be strictly adhered to in order to create a file that can again be read into VB6. In order to keep the test data intact, the current date and time could be added to the name of the output file so that a different XML file is created each time the button "Write array to XML file on disk" is pressed. If one wants the output file to have the same name as the input file (as in ideal round-tripping) that part of the code should be changed by replacing the name of the output file with the name of the input file.

5. CONCLUSION

This project proposed a database solution for the capturing and use of linguistic data. The paper focused on the conversion of linguistic data between an XML document and an array structure in VB6. After referring to the data structures in both XML and VB6, a method was discussed to round-trip the linguistic data between these software formats. One may conclude that these technologies are suitable for the efficient storage, transfer and processing of linguistic data.

REFERENCES

Bourret, R. (2003). *XML and databases.* Retrieved October 20, 2003, from http://www.rpbourret.com/xml/XMLAndDatabases.htm

Burnard, C. (2004). A gentle introduction to XML. *Essays in Humanities Computing.* Retrieved November 23, 2005, from http://www.digitalhumanities.org/Essays/

Huitfeldt, C. (2004). Scholarly text processing and future mark-up systems. *Essays in Humanities Computing.* Retrieved November 23, 2005 from http://www.digitalhumanities.org/Essays/

Jeong, H. W., & Yoon, A. (2001). Linguistic database handling using XML in web environment. In *ISIE 2001: 2001 IEEE International Symposium on Industrial Electronics Proceedings, 12-16 June 2001: Vol. 2* (pp. 833-838). Piscataway, NJ: IEEE.

Kay, R. (2004, March 29). Data cubes. *Computer World, 3*(13), 32. Retrieved December 8, 2006, from http://www.computerworld.com/action/article.do?command=viewArticleBasic&articleId=91640

Kroeze, J. H. (2004a). Towards a multidimensional linguistic database of Biblical Hebrew clauses. *Journal of Northwest Semitic Languages, 30*(2), 99-120.

Kroeze, J. H. (2004b). Slicing and dicing cyber cubes of Biblical Hebrew clauses. Paper read at the *SASNES Conference, Rand Afrikaans University, Johannesburg, August 2004.*

Kroeze, J. H. (2006a). Building and displaying a Biblical Hebrew linguistics data cube using XML. Paper read at the Israeli Seminar on Computational Linguistics (ISCOL), Haifa, Israel, June 29, 2006. Retrieved December 8, 2006, from http://mila.cs.technion.ac.il/english/events/ISCOL2006/ISCOL20060629_KroezeJH_XML_Paper.pdf

Kroeze, J.H. (2006b). Semantic role frameworks extracted from a multidimensional database of Gen. 1. Paper read at the SASNES Conference, University of South Africa, Pretoria, September 11-12, 2006.

Kumar, A., Schreibman, S., Arneil, S., Holmes, M., Bia, A., & Walsh, J. (2005). *<teiPublisher>:* a repository management system for TEI documents [Electronic version]. *Literary and Linguistic Computing, 20*(1), 117-132.

Petroustos, E. (1999). The complete Visual Basic 6 language reference. In J. Crawford (Ed.), *Visual Basic 6 complete* (pp. 744-904). San Francisco, CA: Sybex.

Ramsay, S. (n.d.). Databases. *Essays in Humanities Computing.* Retrieved November 23, 2005, from http://www.digitalhumanities.org/Essays/ (Reprinted from *A companion to digital humanities.*)

Smiljanić, M., Blanken, H., Van Keulen, M., & Jonker, W. (2002, October). *Distributed XML database systems.* Retrieved July 27, 2005 from http://www.purl.org/utwente/38064

Wang, X., & Dong, Y. (2001, October 29 - November 1). XML-based data cube. In *Proceedings of the Fifth International Conference on Info-tech and Info-net, Beijing, China, Vol. 5* (pp. 48-53). [Electronic version]. IEEE.

Witt, A. (2005). Multiple hierarchies: new aspects of an old solution. In S. Dipper, M. Götze, & M. Stede (Eds.), *Heterogeneity in focus: creating and using linguistic databases* (pp. 55-85). Universitätsverlag Potsdam, Germany. (Interdisciplinary Studies on Information Structure (ISIS), 2, Working Papers of the SFB 632.)

Towards a Meta-Model for Socio-Instrumental Pragmatism

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ABSTRACT

We claim that a general conceptual framework for the IS field should provide some kind of common upper-level ontology to describe and explain artifact-mediated social interaction. Such an ontology, Socio-Instrumental Pragmatism (SIP), has been suggested. Our aim is to refine and formalize this ontology by providing a meta-model in the form of a UML class diagram. We discuss the implications of such a model as well as its relation to other ontologies.

1. INTRODUCTION

The rise in the use of information systems (IS) is undeniable, and every day IS become a more important part of organizations. But far from being perfect, the design and implementation of IS in organizations is still a very problematic task that is often fraught with failure (Ågerfalk et al., 2006). There is a need for a better understanding of IS, organizations, and their relation to come up with a framework capable of integrating these two concepts. For the past two decades, theories of communication have been imported into the IS field, and the Language Action Perspective (LAP) has been proposed as a way to understand IS and organizations based on communication (Winograd and Flores, 1986; Goldkuhl and Lyytinen, 1982). Later on an ontology to capture the social world was proposed and described in Goldkuhl (2001), Goldkuhl, Röstlinger and Braf (2001), Goldkuhl (2005), and Goldkuhl and Ågerfalk (2002). This ontology was named "Socio-Instrumental Pragmatism" since it aims toward human actions which are supported by the use of instruments and performed within the social world (Goldkuhl, 2002). Socio-Instrumental Pragmatism (SIP) presents a generic framework which allows for the analysis of the social world. Within this world there are six ontological categories:

1. Humans
2. Human inner worlds
3. Human Actions
4. Signs
5. Artifacts
6. Natural objects

Since SIP was intended as a generic framework which can serve as a base to analyze the social world it is not aimed exclusively at the IS field. We think that a meta-model based on the SIP ontology but with a focus on the IS field is needed. This meta-model has its foundations in both LAP and SIP, and presents a model that will allow us to view organizations and IS together with a focus on actions.

The model consists of the basic categories: actors, objects and actions. In addition to this we also consider other important aspects of organizations that are related to their functioning.

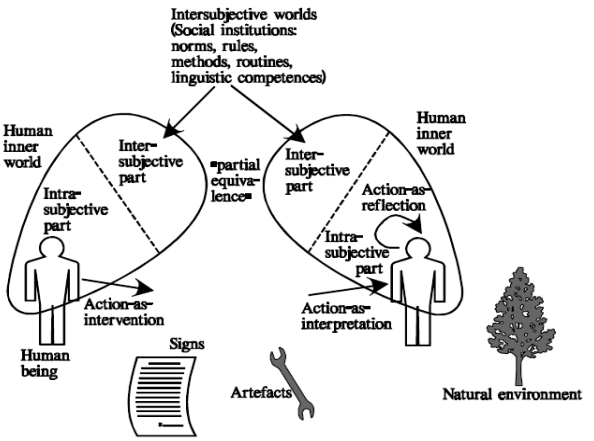
2. TOWARDS A NEW META-MODEL

2.1. Socio-Instrumental Pragmatism

As mentioned before, there is a need for a framework that allows us to describe social systems in a clearer and more thorough way. Our work is based on the SIP ontology. Within the SIP ontology there are six ontological categories (Goldkuhl, 2002):

- **Humans** are the most important participants in the social world described by the SIP ontology; they act in the world based on meanings and perceptions.

Figure 1.



- **Human inner world** represents the knowledge that a human being has acquired over time about themselves and the external world; this inner world is intended to be seen as part of the human being.
- **Human actions** also form a part of the human being; they can be overt, which means that the actions are intended to intervene in the external world, and they can be covert, when they are aimed to change some human being's inner world; covert actions try to change knowledge that is present in the human inner world.
- **Signs** are the result of communicative actions; for instance, when someone writes a note saying, "I will be at the store", the writing of the note is by itself a communicative action but the note created is a sign which will mean something to the person that will read it.
- **Artifacts** are things which are not symbolic and not natural but which are material and artificially created. Examples of artifacts are cars, clothes, a knife, etc. The difference between signs and artifacts is that while signs are intended to mean something to someone (symbolic), artifacts perform material actions. For instance, a human might use a knife (artifact) to cut some carrots, i.e. artifacts are needed to perform material actions.

Natural environment are the objects present in the environment that are not artificially created by humans (e.g. trees).

Figure 1 shows the different realms of the world according to the SIP ontology.

2.2. Meta-Model

Our model is divided into three main categories:

- Actors
- Objects
- Actions

Although we do not see Agent as a category; we do acknowledge the importance of agency and describe it as a special element in the model.

2.2.1. Actors

Actors are the main entities in our model, and they can perform either as locutor or addressee within a communicative context. When actors perform actions directed towards another actor we speak of social actions. They can be performed either in a human-human relation or in a human-artifact-human relation. When performing as locutor the actor is trying to change some aspect of the world by means of his/her actions. For instance, when a person pays the phone bill he/she is trying to avoid the interruption of his/her phone service. When performing as addressee the actor receives and interprets an action directed to him and can act as a consequence of that action. Taking our example the addressee will be the phone company, which at the moment of receiving the payment will not make any attempt to interrupt the customer's phone service.

Besides locutor and addressee we can distinguish between organizational actors and human actors. The former is an actor that performs as an agent on behalf of the organization; the latter performs an action on behalf of his/herself.

2.2.2. Objects

An object may be physical or conceptual and it may be formed by other objects or related to them, but every object is unique (Embley, Kurts and Woodfield, 1994). Under the object category we have artificial and natural objects. Artificial are those created by human beings, while natural objects are those created by nature and found in the environment. Among artificial objects we have artifacts (material objects) and signs (material or immaterial). Artifacts are created to extend actors' capabilities and are seen as tools. Signs on the other hand are not tools but messages in a static phase waiting to be interpreted by actors or artifacts. A message can take either a physical form (a written text) or a non-physical form (an utterance) (Goldkuhl, 2002).

We can distinguish between 4 different types of artifacts: static, dynamic, automated and multi-level. Static artifacts are those that cannot perform any operation by themselves, e.g. a stone or an axe. Dynamic objects are those capable of performing some operations by themselves but they need constant control by a human being to function properly, for example a car or a driller. Automated artifacts are those that can operate entirely by themselves and only need to be started by an actor. Here we can mention a washing machine as an example. (Goldkuhl and Ågerfalk, 2005).

Multi-level artifacts are those that have a mix of capabilities and can perform either as static, dynamic or automated artifacts depending on the circumstances. They have an important property which is the capability of creating and interpreting signs, they lack consciousness and are ruled by a pre-defined set of instructions that serve as a guide to perform the pre-defined actions they do. IT systems are an example of multi-level artifacts. Signs can be created either by human beings or artifacts, and every sign can be interpreted by human beings only, by artifacts only, or by both (Goldkuhl, 2005). A written note is a sign, an utterance performed by an actor is another example of a sign as well as a ticket printed by a system in an electronic store.

2.2.3. Actions

The objective of human actions is to change something in the world. Actions can be communicative or material. The main difference between these two types of actions lies in the fact that communicative actions are intended to change knowledge. Knowledge is implicitly meaningful to someone; and knowledge handling is an exclusive characteristic of actors within an IS. On the other hand, material actions are aimed at material conditions and aspects of the world which are meaningful to someone. They are intended to change something physical among the external world. Winograd and Flores (1986) stated that language is prior to consciousness, and we might add that consciousness is prior to actions performed by actors. As a human characteristic, knowledge can be learned through actions, either communicative actions (e.g. a conversation) or material actions (e.g. when studying an object). Knowledge is the result of the actor's interpretation of both communicative and material actions, and it can be acquired in a social context from other actors transferring knowledge (e.g. in a classroom) or in a non-social context (a person reading a book on his/her own) (Goldkuhl, 2001).

We can divide actions into i-actions (intervening actions) and r-actions (receiving actions). I-actions are those intended to make a change in the external world. For instance, the action of opening a window is intended to change a particular aspect of the external world (the window will move from close to open). R-actions are those executed covertly, for example when two people are going out and person A tells B "It's cold outside" (communicative i-action). Person B listens and interprets the message (r-action) and maybe after that person B will take a jacket on the way out (material i-action) (Goldkuhl, 2001). Among i-actions and r-actions we have indefinite and predefined actions. Indefinite actions are those performed by humans and we call them indefinite since it is not certain how they will be performed by the actor. The same action can vary from actor to actor. When two employees are ordered to clean a shelf, they will both do it but not in the same way, one can do it better or faster than the other one. Indefinite actions can be either r-actions or i-actions. A person that executes indefinite actions has the capability of performing both, i-actions and r-actions. For example, cleaning the shelf is clearly an i-action, the person is modifying something external, something physical. However, we can also find indefinite actions that execute covertly, for example, the person interpreted the order (covertly) and then started to clean the shelf.

We also have pre-defined actions which are performed by artifacts. These actions will always be performed in the same way following previously programmed instructions (Goldkuhl, 2005). Pre-defined actions are i-actions, since they are intended to change an aspect of the external world. Among indefinite actions we can find both, communicative and material actions, and among pre-defined actions we will always have material actions, sometimes with communicative intentions. Table 1 shows how pre-defined and indefinite actions can be either material or communicative. Let us take the example of printing a sales ticket. This action is performed by an IT system, it is a pre-defined i-action with communicative intentions. The objective of printing the sales ticket is to give information to the customer, who will interpret the ticket (r-action) in a communicative manner.

Organizational actions can be either internal or external, and material or communicative. Although human beings perform the actions within organizations, we can say that an organization can act. An organizational action has human origins and purposes and is done through humans, by humans or by artifacts that act on behalf of the organization (Goldkuhl, Röstlinger and Braf, 2001). We will consider

Table 1. Pre-defined and indefinite actions

Example	*Performer*	*Type of action*	*Nature of action*	*Intention*
Printing of a sales ticket	IT-system	Pre-defined	Material with Communicative intentions	i-action
Reading of a sales ticket	Customer	Indefinite	Communicative	r-action
Cleaning a shelf	Employee	Indefinite	Material	i-action
Change of the inventory when performing a sale	IT-system	Pre-defined	Material	i-action
E-procurement of goods transaction	IT-systems	Pre-defined	Material	i-action from the buyer, r-action from the seller

that organizational actions constitute an interaction of two or more elements from the organization (actors or artifacts) within an organizational context. A worker at a clothes factory using a sewing machine to manufacture clothes is performing an organizational action. He is acting to perform an organizational objective (to produce clothes). But a man on a farm that goes to the forest to chop wood using an axe, although using an artifact to perform the action, is not performing an organizational action since there is no organizational purpose if he merely burns the wood to warm up his house.

When performing actions by means or with the help of IT systems we can distinguish between three different types of actions: interactive, automatic and consequential actions. Interactive actions are supported by and performed through IS and they consist of one or more elementary interactions. Elementary interactions (e-actions) consist of three phases: a user action, an IT system action and a user interpretation (Goldkuhl, 2001). Let us take the example of an online bank transfer done by a user online. The user will initially introduce his username and password to access the bank system (Phase 1), after this the IT system will check in the database if the information is correct and if it is it will grant access to the user and display a welcome screen (Phase 2). The welcome screen is interpreted, and the user now knows that he can start his transaction. This is the end of the elementary interaction. Later on the user inputs the data to make the bank transfer, such as account number, amount to be transferred, etc. (Phase 1 of a second e-interaction), and so on.

Automatic actions are performed by IT systems that produce messages for the actors or other systems. They are done entirely without human intervention. Taking the bank system again: After logging on a message pops up telling the customer that the due date for the credit card payment is very close. The system will execute this operation by itself and present it to the user.

Consequential actions are those performed as a consequence of a message. In the bank example , when the customer sees that his payment is due he might proceed to execute the payment, or he might decide not to do it and wait for the final day.

Based on these types of IS actions, IS are seen as Information Action Systems. This perspective is called actability. Actability is supposed to reinforce the concept of usability within the IS framework and focuses on action and communication. IS actability is the information system's ability to perform actions, and to permit, promote and facilitate the performance of actions by users, either by means of the system or based on information provided by it in a business context (Sjöström and Goldkuhl, 2002).

The components of the IS are the IT system, the actor and the e-action. IT systems are social systems that are technically implemented and have an action memory which stores the past and future actions. Actors can play the role of communicator, performer or interpreter in the IS.

2.2.4. Agents

Agents are a special type of object; we can position agents between objects and actors. They are created by actors, and perform actions to help them complete their tasks. They can be seen as servants of actors, but they have a level of communicative capabilities that allow them to act as communicative mediators. They are also capable of creating signs for the actors or other agents to interpret. Agents have a transformative capability, a property that human beings have as well. The difference between agents and human beings lies in the fact that human beings can perform both socially aware (such as a conversation) and non-socially aware actions (such as a blink) while agents can only execute the latter (Rose and Jones, 2004).

IT systems can perform as agents. They can be seen as static artifacts, automated artifacts or dynamic artifacts (Goldkuhl and Ågerfalk, 2005). In all three cases the common denominator is communication. Communication is seen as a kind of action that IT systems can perform and by doing so they become communication mediators. IT systems as well as actors have the capability to create signs and to process them. Actors can also interpret them (Goldkuhl, 2001). The relation between the signs and their interpreters is called pragmatics. Within IS pragmatics, actions are divided into those that occur within the sign transfer and consequential actions that are performed in response to the transferred sign (Goldkuhl and Ågerfalk, 2002).

2.2.5. Organizational Actions

Roughly we can say that within an organization every actor acts to fulfill organizational objectives, hence they are agents helping to accomplish organizational actions. In Example 1, we provide an example of how our meta-model can be applied. Let us take the case of an electronics store.

Example 1.

A customer (C) comes into the store and the following dialog with the salesperson (S) develops.

(S): "May I help you?"
(C): "Yes, I would like to buy some batteries."
(S): "Which type of batteries do you want?"
(C): "Rechargeable AA batteries please."
(S): "We have X and Y brands."
(C): "I would like X."
(S) passes the batteries over the bar code reader and says: "10 dollars, please."
(C) pays.
(S) completes the sale in the system and hands the receipt to the customer.

Table 2. Sales process for an electronic store

Actor	*Action*	*Type of action*	*Details*
S	Utterance: May I help you?	Communicative i-action	
C	Utterance: Yes, I would like to buy some batteries.	R-action → communicative i-action	C interprets utterance by S and responds
S	Utterance: Which type of batteries?	R-action → communicative i-action	Dto. (switched roles)
C	Utterance: Rechargeable AA batteries, please.	R-action → communicative i-action	Dto. (switched roles)
S	Takes the batteries and passes them trough the bar code reader.	R-action → interactive i-action	S interprets utterance by C and performs interactive action
IS (Agent)	Reads bar code and gets product information from the database.	Automatic action	IT system performs automatic action and displays product details on screen
S	Reads product information and informs C.	R-action → consequential i-action	S interprets message on screen and passes info to C
C	Pays for the batteries.	R-action → material action	C interprets utterance of S and pays
S	Receives payment and hands C the receipt.	R-action → interactive i-action → automatic action → material action	S receives payment, S closes sale in IT system, IT system modifies inventory and prints receipt, S hands receipt to C

When we analyze this business interaction according to our meta-model we arrive at the results shown in Table 2. We will see organizational actions as those actions performed to fulfill an organizational objective. In Table 2, the objective is to sell batteries. We can also notice that many of the actions are multi-functional, i.e. one "surface" action corresponds to a number of implied, "hidden" actions. When the salesperson asks for the type of batteries, he performs an implicit r-action by correctly interpreting the request "I would like to buy some batteries." At the same time he also responds appropriately by performing the i-action of asking for the type of batteries.

3. OTHER ONTOLOGIES

In the literature we can find a number of competing ontologies that are also potential candidates for a general conceptual framework for the IS field. Social roles, for example, were introduced by Masolo et al. (2004). They characterize social entities only partially and do not cover the issue of actions which is central in the social realm. Intentional collectives (Bottazzi et al., 2006) introduce actions but mainly in the form of plans and tasks. In this model action objects are not seen as an important issue. Nevertheless, this theory has a very detailed description of social concepts based on social roles.

The Actor Network Theory (ANT) (Tatnall and Gilding, 1999) argues for the symmetry of the elements in the social world (i.e., the network of social actors). This means that both actors and action objects are viewed as so-called actants. This implies that we cannot distinguish between the different roles that these elements have in social action (McLean and Hassard, 2004). For the ANT theorists, the elements of the network relay and prolong collective actions, and no element is considered as the source of the actions. Therefore, instead of being actions, they are seen as events. Events are described in the same way as being collective actions that have no source but are performed by the actants of the network (McLean, and Hassard, 2004).

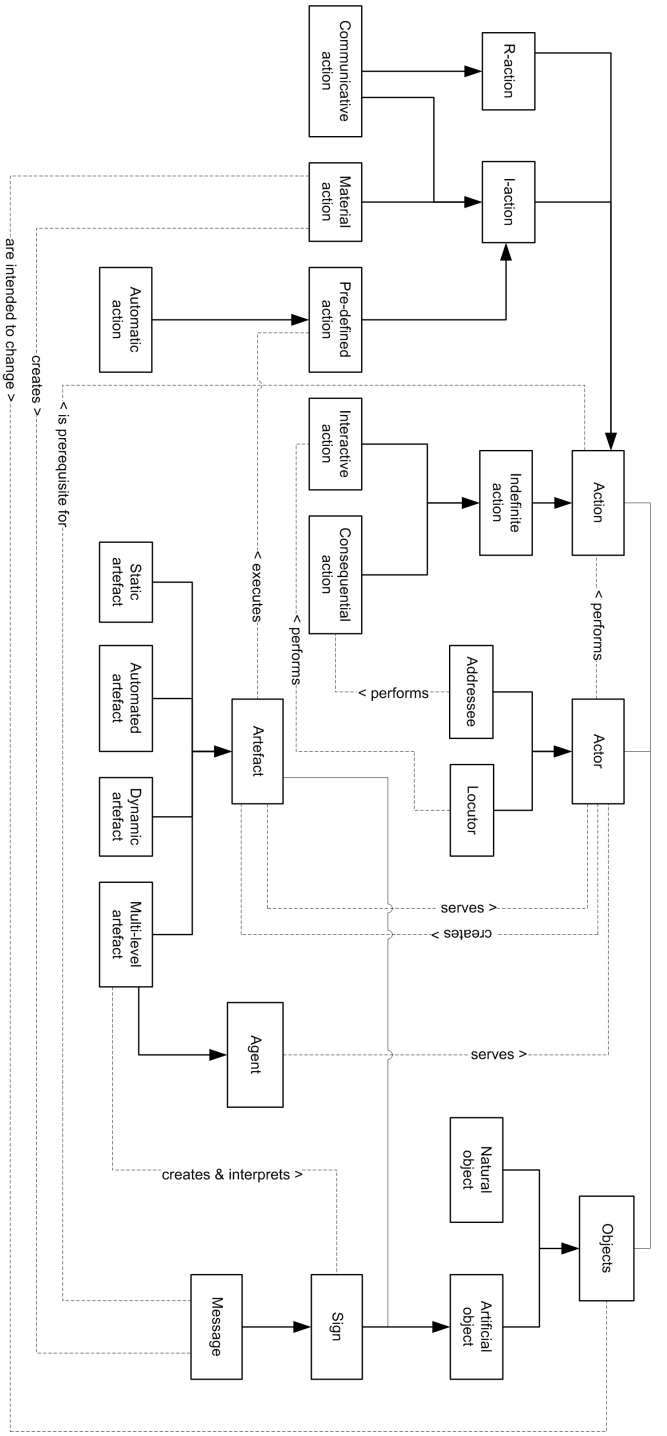
As a result of the contemplations in the previous sections we have developed a meta-model (see Figure 2) that covers the most important aspects of Socio-Instrumental Pragmatism as discussed in the relevant literature. Technically the meta-model takes the form of a UML class diagram with generalization / specialization and association.

4. CONCLUSIONS

We started our paper with the assumption that Socio-Instrumental Pragmatism might contribute towards the development of a general conceptual framework for the IS field. We then set out to capture both the breadth and depth of the SIP literature with a suitable meta-model. This process consisted of uncovering the central concepts and their (often implicit) relations and making them explicit in a clear and concise way. We did this with the help of a UML class diagram, a modeling language which is well established and documented and can therefore be expected to support the communication of and about the meta-model among a large group of IS researchers.

We are well aware of the fact that such a meta-model is not, and cannot be, the ultimate solution to a general conceptual framework for the IS field. However, we think that our model can stimulate a fruitful discussion about the vital components of such a framework. We do not know of any other meta-models that cover the breadth of IT-mediated social action with similar stringency.

Figure 2. Meta-model of SIP



REFERENCES

Bottazzi, E., Catenacci, C., Gangemi, A., and Lehmann, J. (2006). "From collective intentionality to intentional collectives: An ontological perspective". *Journal of Cognitive Systems Research, Special Issue on Collective Intentionality (in press)*.

Embley, D., Kurtz, B. and Woodfield, S. (1994). *Object Oriented System Analysis: A model-driven approach*. New Jersey: Prentice Hall.

Goldkuhl G. (2001) "Communicative vs material actions: Instrumentality, sociality and comprehensibility", *In Proceedings of the The Language-Action perspective on communication modelling 2001*.

Goldkuhl G. (2002) "Anchoring Scientific Abstractions: Ontological and Linguistic Determination Following Socio-Instrumental Pragmatism", *In Proceedings of the European Conference on Research Methods in Business and Management Studies (ECRM 2002)*, Reading, UK: MCIL.

Goldkuhl G. (2005) "Socio-Instrumental Pragmatism: A Theoretical Synthesis for Pragmatic Conceptualisation in Information Systems", *In Proceedings of the Action in Language, Organisations and Information Systems (ALOIS 2005),* Limerick, Ireland.

Goldkuhl, G., Lyytinen, K. (1982). "A language action view of information systems". *Proceedings of the 3rd international conference on information systems*, TIMS/SMIS/ACM.

Goldkuhl G., Röstlinger, A. and Braf, E. (2001) "Organisations as Practice Systems – Integrating Knowledge, Signs and Artefacts and Action", *In Proceedings of the IFIP 8,1 Working Conference Organisational Semiotics: evolving a sience of information systems,* July 2001, Montreal.

Goldkuhl, G. and Ågerfalk, P. (2002). "Actability: A way to understand information systems pragmatics". Sweden.

Goldkuhl, G. and Ågerfalk, P. (2005). "IT Artefacts as Socio-Pragmatic Instruments: Reconciling the Pragmatic, Semiotic, and Technical", *International Journal of Technology and Human Interaction*, pp. 29-43, July-September 2005.

Masolo, C., Vieu, L., Bottazzi, E., Catenacci, C., Ferrario, R., Gangemi, A., and Guarino, N. (2004). "Social roles and their descriptions". *In Ninth International Conference on the Principles of Knowledge Representation and Reasoning*, Whistler Canada.

McLean, C. and Hassard, J. (2004) "Symmetrical Absence/Symmetrical Absurdity: Critical Notes on the Production of Actor-Network Accounts". *Journal of Management Studies.* Vol. 41, No. 3, pp. 493-519.

Rose, J., and Jones, M. (2004). "The double dance of agency: a socio-theoretic account of how machines and human interact". Denmark.

Sjöström, J., Goldkuhl G. (2002). "Information systems as instruments for communication – Refining the actability concept", *In Proceedings of the 5th International Workshop on Organisational Semiotics,* June 2002, Delft.

Tatnall, A. and Gilding, A. (1999). "Actor-Network Theory and Information Systems Research". *In Proceedings of the 10th Australian Conference on Information Systems*.

Winograd, T. and Flores, F. (1986). "Understanding computers and cognition: A new foundation for design", Ablex, Norwood.

Ågerfalk, P., Goldkuhl, G., Fitzgerald, B., Bannon, L. (2006). "Reflecting on action in language, organizations and information systems". *European Journal of Information Systems*, Vol 15 (1), pp. 4-8.

Forecasting Trading Rule Performance Using Simulation

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ABSTRACT

We create a generic trading rule and simulate its performance characteristics. By understanding that a specific trading rule which belongs to this generic rule shares the same performance characteristics in the long run, we can decide if the trading rule will achieve our trading goals and therefore, if it should be included in our trading system.

1. INTRODUCTION

A company devoted to trading financial markets for profit, such as a hedge fund, should have explicit trading goals. A hedge fund's trading system should be constructed so that it achieves these goals.

To optimize its value, a hedge fund must: survive for as long as possible; produce the best performance possible; and, grow assets under management.

So, an important trading goal is to grow assets under management. Historically we may find that to achieve optimal asset growth maximum draw-downs must be less than 30%, and the annual return must be greater than 10%. This means that the hedge fund must be confident that its trading system should meet these conditions; else, the company will not achieve its goals.

How do we know if a specific trading rule can achieve certain trading goals without testing it thoroughly on every market? Using the methodology described in this work we can predict what performance characteristics a trading rule will have in the long run, irrespective of the market on which it is traded.

The key is that we use a combination of a generic trading rule and simulated data for trade generation. For a generic trading rule, simulation can provide accurate estimates for any performance characteristics of interest irrespective of the market traded.

This insight is very powerful: it means that once we classify a trading rule as belonging to the generic class, we know what performance characteristics it must have. This power is obtained through the use of simulated data. Since our data is not market specific, nor are our estimated performance characteristics.

The performance characteristic of a real trading rule tested on the real market data will converge to the simulated performance characteristics in the long run. Thus we can decide if the trading rule will achieve our trading goals and if it should be included in our trading system.

There is virtually no literature in this area.

2. TRADING RULE MODEL

We begin with a discussion of the generic trading rule. The assumptions for our model are that:

1. The components of position management, transaction costs, risk management, and position sizing completely specify a trading rule and its performance.
2. Given a sequence of trades, the result of the next trade is unknown. It is random.
3. Each trade result is independent from previous trades and no serial correlation exists in any sequence of trade results.
4. A trading rule can have only one entry. It has at least one exit.

The first assumption is straightforward; if we knew of other components that were a part of the trading rule, they would be included.

Assumptions 2 and 3 are justified by a simple argument. If either assumption were untrue, we would have additional information that would improve the success of the trading rule. Any rational trader would use this additional information to improve their returns. Therefore, these assumptions hold.

Assumption 4 may appear to be an oversimplification. The assumption allows us to understand a simple trading rule. We can then build on that knowledge to understand increasingly complex systems.

The equations that describe our simulation are:

$$e_i = e_{i-1} + \Delta_i$$

$$\Delta_i = r_i \cdot p_i - c_i$$

$$c_i = k * p_i$$

$$p_i = R_i / R$$

$$R_i = y * e_{i-1}$$

$$e_0 = \text{initial capital}$$

$$r_i \sim D$$

where i,=1…N is the trade number; r_i, trade return for time i; p_i, position size of trade i; e_i, equity after trade i is complete; e_0, initial equity; y, percentage of equity at risk; R_i, total equity at risk; R, stop loss at a percentage of entry price.

D, is the distribution of trade returns. Historically, this has been performed utilising trade returns from tests of a particular trading rule implementation against market data. Instead we use the structure of the trading rule (its entry and exits) to define shape of D.

2.1 Deriving the Distribution of Trade Returns

In this section we create D, the distribution of trade returns, using the structure of the trading rule.

We know that D is a conditional distribution function; it is conditional on the entry signal. Once a trade is open, we have to exit.

We start by looking at D for a simple trading rule that has only two possible exits, a stop gain and a stop loss. We will call this class of trading rules, 'dual stop trading rules'.

A dual stop trading rule has a distribution function that two step functions at the stop gain/loss points. If we set the value of a stop loss to be –R (a percentage of entry) and the stop gain to be at mR where m=1,2 or 3.

-R is the stop loss, which is the maximum acceptable loss, it is clear that R is related to the risk management calculation. In fact, R is the loss on a single security, whereas R_i is the total acceptable loss on a trade. Therefore, $R = R_i / n$, where n is the number of securities (e.g. shares) taken in the trade. We get n from the position size divided by the cost of a security.

Rather than involve market prices we will set R in this work during the simulation.

What then is m? It is the size of a winning trade compared to the size of a loss. We call m the winning trade size from herein.

There is an implicit assumption in the model, that the distribution is static over time.

Table 1. Values used in simulation

	Variable	Values Tested
R	Stop loss	1%, 5%, 9%
y	Risk Management	1%, 1.5%, 2%
k	Transaction Costs	1%, 1.5%, 2%
m	Multiple	1-3 steps 1
	Probability of win	20% - 90% steps 10%

2.2 Simulation Details

We test dual step trading rules in our simulation. For each trade, only two values are possible in the trade return distribution: stop win or stop loss. Also required are the probabilities for each value.

For this m will be set to range from 1 to 3 and the probability of a winning trade will be range from 20% to 90%. Only combinations that have positive expectancy are simulated.

As we iterate through each value of m, we will calculate the position size using the current equity for each trade and the percentage risk model of money management.

The initial equity, e_0, is set to 1000. Each simulation run will consist of 50 trades. This approximates one trade per week (about one year) or once per month (about 5 years). For each trading rule combination, 50 simulation runs are performed. With multiple simulation run, we have a distribution of results for each performance metric.

Each unique combination of parameters is a defined to be a trading rule. That is, a generic trading rule can be defined by specifying various simulation values: a stop loss of 5%; a fixed risk management of 2%; transaction costs of 2%; a multiple of 3; and a probability of winning of 50%. In reality, there may be many (or none) actual trading rules that correspond to this generic system.

3. PERFORMANCE METRICS

In our analysis of simulated trading rule performance, we consider three performance metrics: maximum drawdown, time below the high water mark, and expected net profit per trade.

During the course of a series of trades, a trader's equity goes up and down depending on the result of each trade. Each high (peak) in equity has a low point (valley) that follows it before the next peak. The difference between a peak and its subsequent valley is the peak-to-valley drawdown (**Figure** 1, left hand figure**)**. The maximum of all peak-to-valley drawdowns in any sequence of trades is the maximum drawdown. It gives a measure of the largest loss that a trading rule underwent due to a sequence of trades. Maximum drawdown is a percentage of the peak equity. The lower the maximum drawdown the better; it represents a smaller loss.

The high water mark is the highest equity value that a trading rule has produced to date in a sequence of trades. It never decreases. Measured as a percentage of overall trading time, time spent below the high water mark is a loss, even when the trading rule is profitable overall, as it is a lost opportunity to earn a return elsewhere (Figure 1, right hand figure).

The expected net profit per trade is the average profit per trade, measured using the profit net of transaction costs.

4. SIMULATION ANALYSIS

In this section we consider each performance measure in turn.

4.1 Average Profit per Trade

The median average profit per trade for all systems tested was $548 and the mean $1,486 and it ranged from a minimum of -$1,852 to a maximum of $29,470.

From Figure 2, the median average profit per trade grows exponentially with an increase in the stop loss. The inter-quartile range grows at the same rate and both the first and third quartiles increase.

Median average profit per trade shows a linear decline as transactions cost increase. Since costs reduce profits, this is expected. The inter-quartile range does not change, but the first and third quartiles decrease at the same linear rate as the median.

From Figure 2, we can see that the median average profit per trade increases linearly as risk increases and the change is statistically significant. The inter-quartile range increases but the third quartiles increase at a larger growth rate than the decline in the first quartile. Thus, as we increase risk, we increase the probability of a low average profit per trade, but at slower rate than we increase the probability of a higher average profit per trade. Interestingly, even with risk at its lowest value (1%), the first quartile is below zero, which gives a 25% chance of having a negative average profit per trade.

As the probability of winning increases, the median average profit per trade increases exponentially. There is an anomalous result at a winning probability of 50%. Addition of trading rules with a winning trade size of at least two is the cause of this anomaly. At a winning probability of 30%, inter-quartile range is totally below zero; which means there is a 75% chance of losing within the overall systems tested.

Increasing the winning trade size also has an exponential growth affect on the median average profit per trade. The inter-quartile range increases with the increase in winning trade size, the third quartile is increasing exponentially, the first quartile linearly.

For a trader wanting to improve their average profit per trade, it means improving their probability of a winning trade or increasing the size of a winning trade. If neither of those is feasible, they can increase their risk, but the rate of improvement is only linear compared with the exponential benefit of increasing the winning probability or the size of a winning trade.

Figure 1. A pictorial representation of draw-downs (on the LHS) and time under water (on the RHS)

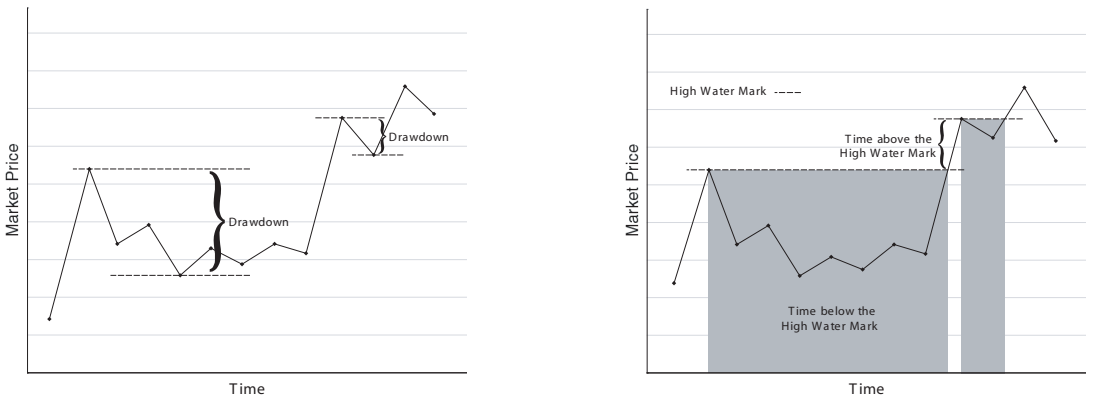
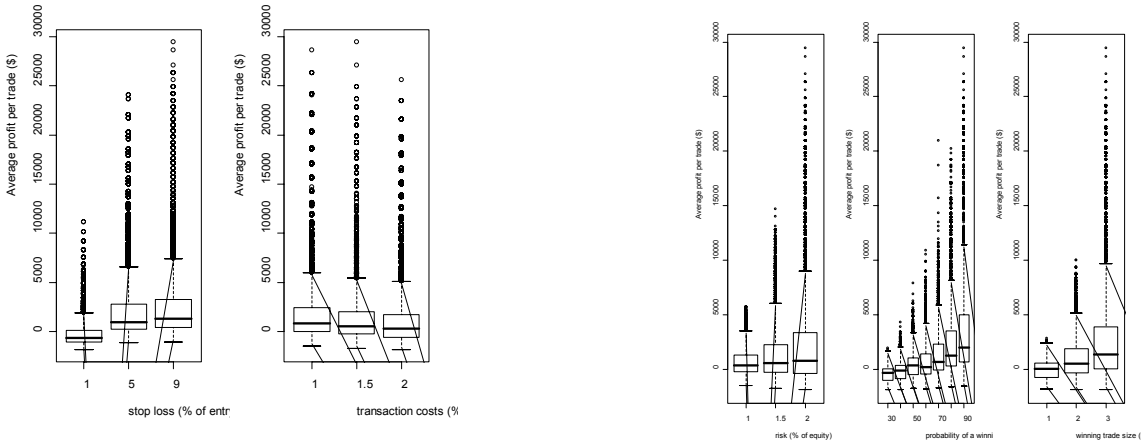


Figure 2. Box plots of transaction costs and stop loss against average profit per trade Box plots of risk, probability of a winning trade and winning trade size against the average profit per trade



The stop-loss can be increased but it has a diminishing affect on average profit per trade after 5%.

4.2 Maximum Drawdown

Maximum drawdown, across all systems simulated, ranged from a minimum of 0% to a maximum of 92.6%, with a mean of 17.33% and a median of 8.597%.

In Figure 3, increases in the stop loss show an exponential decline in the median maximum drawdown. Inter-quartile range decreases at the same rate as the stop loss increases. Increasing stop loss to reduce maximum drawdown is an exercise in diminishing returns.

There is linear growth in the median maximum drawdown and the first quartile as transaction costs are increased. The change in median is significant. The inter-quartile range and the third quartile increase exponentially. For a trader, this means increasing transaction costs, exponentially increase the uncertainty in the maximum drawdown, but the increase in the median is less dramatic.

Since traders avoid drawdowns where possible, transaction cost management is valuable in reducing both the probable maximum drawdown and the uncertainty around the maximum drawdown.

Looking at Figure 3, median maximum drawdown increases as risk increases. It decreases exponentially as winning probability increases. Both relationships are statistically significant. For both risk and winning probability, the inter-quartile range changes at the same rate.

Winning trade size has no significant impact on median maximum drawdown.

As risk increases, the impact of a loss increases and hence the median maximum drawdown increases. The inter-quartile range increases as risk increases and moves upwards. This means that as risk is increased the levels of maximum drawdown at the first and third quartiles increase; our chances for worse drawdowns increases.

Conversely, as the probability of winning increases, fewer losses are likely and the median maximum drawdown decreases. The inter-quartile range decreases, lowering the spread of the maximum drawdown. Both the first and third quartiles decrease and our chance of lower maximum drawdowns increases.

Increasing the winning trade size has no significant impact on the median, nor does the first quartile move but the third quartile diminishes exponentially. This means the probability of a low drawdown (below the median value) does not change but the probability of high drawdowns (above the median) decreases. As winning trade size increases, expectancy increases. This has the positive effect of reducing the maximum drawdown as the system is profitable and spends less time in a drawdown. This is visible in Figure 3.

4.3 Time Below the High Water Mark

Time below the high water mark, for all systems tested, has a mean of 62.01% and a median of 66.0% and ranged from 0% to 100%.

Figure 3. Box plots of stop loss and transaction costs against maximum drawdown and Box plots of risk, winning trade size and probability of a winning trade against maximum drawdown

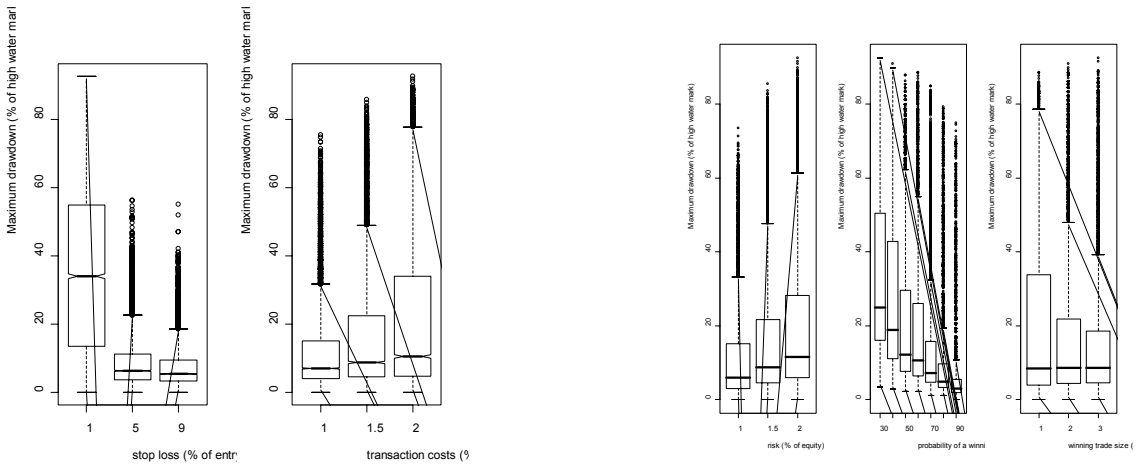
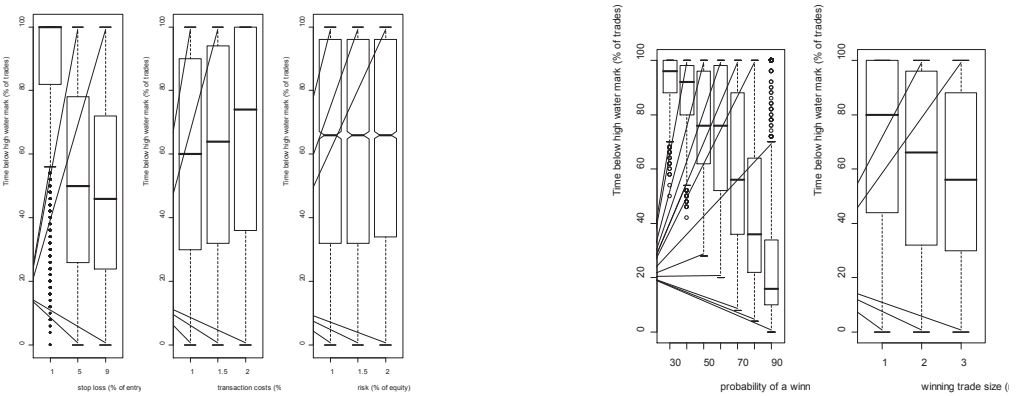


Figure 4. Box-plots of stop-loss, transaction costs, risk, probability of winning trade and time below high water mark



Change	Effect
Increase probability of a win	• Increases median return on assets • Decreases median maximum drawdown • Increases median average profit per trade • Decreases median time below the high water mark • Decreases median length of the longest losing streak
Increase risk	• Increases median return on assets • Increases median maximum drawdown • Increases median average profit per trade
Increase the size of a winning trade	• Increases median return on assets • Increases median average profit per trade • Decreases median time below the high water mark
Increase transaction costs	• Decreases median return on assets • Increases median maximum drawdown • Decreases median average profit per trade • Increases median time below the high water mark
Increase stop loss	• Increases median return on assets • Decreases median maximum drawdown • Increases median average profit per trade • Decreases median time below the high water mark

From, **Figure 4** there is an exponentially decreasing relationship between time below the high water mark and stop loss. As the stop loss increases, trading rules spend less time below the high water mark. This is due to the interaction between the stop loss and winning trade size.

Increasing transaction costs has an exponential affect on the median time below the high water mark, another good reason for traders to control costs. The inter-quartile range is constant for increasing transaction costs.

From **Figure 4, c**hanging the risk had no significant affect on the median time below the high water mark. Nor did it have an impact on the inter-quartile range. It may seem counter-intuitive that increasing risk has no impact. Recall, however, that under the percentage risk model, increasing risk will decrease the size of the position.

Let us look next at the probability of a winning trade and the winning trade size against time below the high water mark (see **Figure 4**). Most apparent is the decline in the median time below the high water mark as the probability of a winning trade increases; yet the range of values for time below high water mark increases at first and then decrease once probability of winning exceeds 60. As the time below the high water mark metric is bounded by minimum and maximum values of zero and 100% respectively, this is to be expected.

What is unexpected, is the increase in the median at a probability of winning of 60% and the inter-quartile range increase at the same point. Interaction with another component might be the cause this effect. For a winning trade size of one and a stop loss of 1%, all winning probabilities returned a 100% time below the high water mark value. Interesting, but why does this happen? When the stop-loss is 1% and the winning trade size is one, transaction costs equal or exceed the size of a win. The separation of transaction costs clearly identifies that, in this instance, transaction costs are making a profitable system, unprofitable. For this type of system, transaction costs must be less than the size of the stop loss.

There is an exponential decline in the median time below the high water mark (see **Figure 4)** and the winning trade size; inter-quartile range does not change with an increase in winning trade size.

As indicated earlier, we only recorded results for trading rules with a positive expectancy. When the winning trade size is equal to one (winning and losing trades are the same percentage size), it takes until the probability of winning exceeds 50% before there is a positive expectancy. In this case, it is likely that a large portion of time is spent below the high water mark, due to the losses incurred. As this multiple increases, the impact of a single loss is smaller than the impact of a win and so the time below the high water mark decreases.

5. CONCLUSION

The aim of this paper was to forecast the performance characteristics of a trading rule. To do this we built a model for trading rule simulation, modelled the class of dual step trading rules, and analysed the data from simulating the model. The analysis identified clear guidelines for traders to improve performance.

REFERENCE

GUPTA, P. (2004) Project report. Monash University.

Process Asset Library in Software Process Support Technology: A Review of the Literature

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ABSTRACT

Process assets library (PAL) is a repository of software process-related documents, necessary to implement technologically infrastructures in support of organizational process. This paper offers a review of the literature related to PAL and exposes some questions for solving in Software Process Engineering.

Keywords: Software Process Improvement, CMMI, Process Support Technology, Software Process Assets.

1. INTRODUCTION

The objective of this paper is to present the current situation on software process asset libraries, which are repositories that store information about software process of an organization, allowing that accumulated experience could be used in future software projects.

PAL concept is included nowadays in the CMMI model as a way to achieve the software process definition. This repository is composed generally by a great quantity of no structured information that makes difficult search and reuse of software process assets.

Planning, design and building of a PAL is a task that still is in an initial research phase; therefore, this paper presents a summary of the main studies, advances and questions found in the research of this kind of libraries.

The paper is organized as followed. Second section presents a body of knowledge of the main areas that delimit the concept of PAL. Third section reviews works related to PAL. Fourth section shows a summary of dissertations related. Fifth section discusses issues for solving. Concluding remarks are given in the last section.

2. BODY OF KNOWLEDGE

2.1. Main Areas of Knowledge

Due to the great quantity of meanings that exist in software process engineering domain, a conceptual definition is necessary to avoid serious confusions on having use the PAL term in the area of Software Engineering. This conceptual definition is showed in Figure 1.

- *Software Engineering*: The application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software; that is, the application of engineering to software.
- *Software Process*: A set of partially ordered process steps, with sets of related artifacts, human and computerized resources, organizational structures and constraints, intended to produce and maintain the requested software deliverables.
- *Software Process Management:* This area is concerned with the management of the technical aspects of the software development process. It includes knowledge about software process elements: activities, methods, and practice that people use to develop software.
- *Software Process Engineering:* It deals with methodologies, tools, and techniques for the design and implementation of software processes. It includes knowledge about representing the important characteristics of a process as a coherent, integrated set of well-defined software engineering and management processes for organizations, teams, and individuals.
- *Software Process Improvement (SPI):* It is a systematic procedure to improve the performance of an existing process system by changing the current processes or adding new processes for correction or avoidance of the problems identified in the old system by process assessment.

2.2. SPI Models

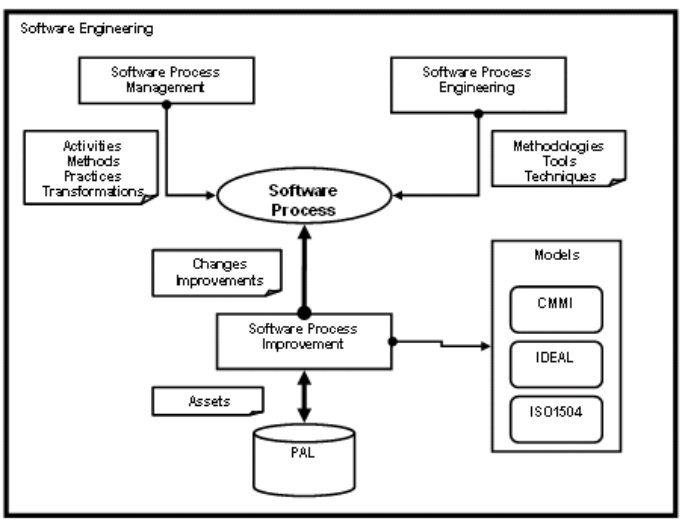
To achieve a successful SPI, the industry has developed models that assess the reached maturity and to identify improvement strategies.

One of the most known proposals is Capability Maturity Model Integration (CMMI) developed for Software Engineering Institute (SEI). CMMI consists of best practices that address the development and maintenance of products and services covering the product life cycle from conception through delivery.

Other models related to SPI are:

- IDEAL: Describes a model defining the main phases and stages to introduce SPI in an organization and to establish supporting infrastructure.

Figure 1. Areas of knowledge



- ISO 15504: It is an international standard, which specifies a reference model with two dimensions: a process dimension and a capability dimension.

2.3. Process Asset Library: PAL

The documentation of software processes to obtain a CMMI certification contains information related to organization's process assets (knowledge about how the organization realizes its processes). The documentation must be available by a repository named PAL. The use of a PAL is a required practice for achieving CMMI Level 3 and achieving a defined process.

PAL belongs to software process support technologies allowing the integration of production and management technologies and supporting for storage and retrieval of organization's process information.

PAL is an organized, well-indexed, searchable repository of process assets that is easily accessible by anyone who needs process guidance information like examples, data, templates, or other process support materials [12]. Some main purposes of a PAL are:

- Provide a central knowledge base for acquiring, defining, and disseminating guidance about processes related to the organization's tasks.
- Provide mechanisms for sharing knowledge about the organization's process assets and how they are used.

Another useful applications of PAL are to assemble sub-processes in constructive fashion y/o derive modified processes by replacing and/or modifying constituent sub-processes.

3. RELATED WORKS

PAL concept is related to many efforts found in the literature about software process improvement: Software Process Reuse, Process Libraries, PSEE, Experience Library, STARS Program, Zahran's Proposal and other proposals (Figure 2). These works incorporate some technical infrastructures and solutions in organizational process.

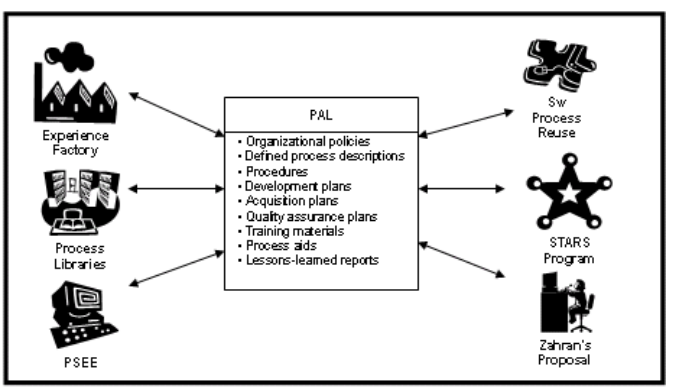
3.1. Software Process Reuse

CMMI indicates that the organization is expected to have one or more approved software life cycles. Individual projects are expected to follow established guidelines and criteria for: selecting the most appropriate of the approved life cycles, tailoring and elaborating the selected life cycle and the organization's standard software process, to fit the needs and particulars of that project [19].

Some studies about software process reuse are:

- Gertrude [29] is a model to re-use software processes, based on object-oriented methods.
- In [25] the characteristics of process components are indicated, allowing projects the freedom to define their own life cycles.
- GPM [17] is a web-based software process management and monitoring tool, providing a mechanism for a software process model to be defined, modified, tracked and measured by a GUI.

Figure 2. Related works



- Case-based reasoning approach has been used on: APSEE [27] a system to identify the similarity between the problem with previous situations stored in the case base and CABS [11] a system that uses a formal notation allowing the user to sketch new processes or adapt template processes, in a matching process which identifies and suggest the reuse of similar processes and process components stored in a library.
- Reuse Architectures: Process Reuse Architecture [10] that uses facets, reuse guidelines and process patterns taxonomy, and Open Architecture for Software Process Asset Reuse [5] through the identification of architectural elements and the specification of element interfaces.
- In [16] a set of process notations and methods for defining processes and tailoring reusable processes is described.
- GUIDE [14] is a rule-based system, for which specific projects are tailored through decision trees used at an arbitrary level of project detail.

3.2. Process Libraries

Process libraries supports reuse capabilities for processes, including the creation, update, deletion, measurement, and management of process assets [33].

A set of works related to building of process libraries is outlined:

- SPLib [24] organizes a process collection constituting a multilevel knowledge base.
- Process Evolution Dynamics Framework [26] is based on an experience-based categorization of process evolution-related activities.
- QUEST [1] is a collection of tools when it highlights a repository, which is a knowledge-based software process model.
- PROGEN [20] is a knowledge-based system for process model tailoring and reuse.

3.3. PSEE

Process-centered Software Engineering Environments (PSEE) can be considered a new generation of software development environments with possibility of adapting to every specific software project, providing a better automated support.

A PSEE interacts with a process model developed by Process Modeling Language and a Process Engine can then enact the process model. The process engine has three components [8]:

- An interpreter that executes the process model.
- A user interaction environment (UIE).
- A repository that stores the artifacts produced during the process. This repository can offer some attributes and purposes of a PAL

3.4. Experience Library

Other proposals to capture critical knowledge from software projects are experience-based approaches and organizational learning, named Experience Library or Repository of Experience [4].

These approaches consist in apply past knowledge to current projects while software practitioners engaging in knowledge creation processes. BORE [15] is a tool that supports this experience-based approach, which collects and disseminates project experiences as "cases" representing emerging knowledge of development practices in an organization.

3.5. STARS Program

The mission of DARPA's Software Technology for Adaptable, Reliable Systems (STARS) program is stimulate the productivity from process reuse technologies. Key constituents of the model are: a PAL, process definition, process enactment, process measurement, and process evolution [13]. PAL provides reusable process assets from public repositories over broad-area networks.

3.6. Zahran's Proposal

Zahran [30] provides a framework for establishing an environment for SPI. The framework has two infrastructures:

- Organizational and management: with roles and responsibilities to manage SPI activities.
- Technology and tools: with facilities and tools for automating process activities and supporting the various process improvement roles and responsibilities.

3.7. Others Proposals

Other ideas related to development of software process information repositories are:

- DAGAR [21] is a repeatable and documented process with accompanying language and is based on a domain architecture process.
- Collaborative Parallel Enactment (COPE) Process Architecture [28] has basic capabilities for specifying process elements, their characteristics and interconnections.

4. RELATED DISSERTATIONS

There are several dissertations related to repositories for Software Process Engineering. Some of them are outlined as followed.

- A Software Process Asset Management and Deployment System is developed in [18] that captures the existing processes, as well as the improvements and changes to these processes into a set of assets that can be reused in future process instances.
- A Workflow Reuse Management System is developed in [22] to unify efforts in PSEEs and Workflow.
- In [7] a study is realized on Process Support Systems that generally are slightly flexible when unexpected situations arise during process execution, producing deviations and inconsistencies. A framework to formalize the concepts of deviation and inconsistency is proposed.

Some studies have been developed in Alabama University about Software Process Engineering to support projects related to *NASA's Flight Software Group at the Marshall Space Flight Center*. One project is Standards Advisor Project, a software system designed to improve the quality and productivity of space systems development by making it easier to find and use standards and other information that guide system development. Some works developed are:

- A Web portal is developed in [23] for delivery information related to process and capturing experience.
- The use of metadata is proposed in [2] to storage standards.

5. ISSUES FOR SOLVING

In spite of the quantity of published results, a lot of questions for solving related to SPI and PAL still continue.

Issues as questions with regard to process model languages, which must be tolerant and allow for informal and partial specification that facilitates their adoption for the practitioners.

Also there are similar questions in PSEEs, since many systems have been developed without a wide acceptance and use, because mainly to their lack of flexibility.

Issues relating to software processes expect to be clarified [9]: requirements for process modeling notations and formalisms, representing global process constraints, granularity, integrating product models, process capture, process-centered environment, enforcement and process automation. There is little information about: what kinds of processes to capture, what processes to ignore, and the need to consider different representations of these processes and other materials for the different roles to be played and the different purposes for which it will be used [6].

Some aspects to consider in future researches are [27]: separation of details in process modeling, level of detail, abstraction mechanisms, search criteria for process elements, mechanisms to ensure the correct reuse of retrieved elements.

Atkinson [3] exposes characteristics that a software library must include: nature of the asset, scope of the library, query representation, asset representation, storage structure, navigation schema, and relevant criterion. Also he defines issues of technical design for software libraries that must be considered: assets definition, assets modeling, definition of relationship between assets, and definition of insertion, removal, update and access policies.

All these issues presented about PAL wait to be faced and solved in future works.

6. CONCLUSIONS

To create a PAL that achieves to standardize and reuse a software process, it is necessary: to describe the process; to store it in a suitable format; to identify the desired process in a database and to retrieve it; and to adapt it to organizational needs [29].

The bibliographical review has discovered that the researchers have carried out many efforts in the first aspect (process description) leaving aside other aspects that even have not been solved.

Models for software process improvement as CMMI indicate the need to build and manage this kind of repositories. Nevertheless CMMI does not specify what technical characteristics are needed to implement a PAL successfully. For which, it is an obligatory requirement that already has begun to obtain results, with the emergence of research proposals that try to address the problem of defining infrastructures for supporting software process assets (standardized and integrated in the future) to create, to organize, to access and to reuse information concerning software process improving.

ACKNOWLEDGMENT

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REFERENCES

[1] Ahn, Y et al. **Design of knowledge-based integrated software process improvement tools.** IEEE. 1998.
[2] Arla, B. An XML-based Metadata Repository for NASA Standards Advisor. University of Alabama. 2003.
[3] Atkinson, S. A Formal Model for Integrated Retrieval from Software Libraries. In Technology of Object-Oriented Languages and Systems. 1996.
[4] Basili, V. et al. Experience Factory. In Encyclopedia of Software Engineering: Wiley & Sons, 1994.
[5] Boehm, B. et al. An open architecture for software process asset reuse. Proceedings of the 10th International Software Process Workshop. 1996.
[6] Carter, L. Managing the Invisible Aspects of High-Performance Teams. In Crosstalk Journal of Defense Software Engineering. 2001.
[7] Cugola, G. Inconsistencies and Deviations in Process Support Systems. Politecnico di Milano. 1998.
[8] Cugola, G. et al. Software Processes: a Retrospective and a Path to the Future. In Software Process. 1998.
[9] Dowson, M.: Software Process Themes and Issues, International Software Process Symposium. 1990.
[10] Fiorini, J. et al. Process Reuse Architecture. In Computer Science. Proceedings of the 13th International Conference on Advanced Information Systems Engineering. 2001.
[11] Funk, P. et al. Reuse, Validation and Verification of System Development Processes. First International Workshop on the Requirements Engineering Process. 1999.
[12] Garcia, S. Improving Process Improvement with Process Asset Libraries. 2004.
[13] Hart, H. et al. Panel: The STARS Process Approach and Ada Projects. Proceedings of the conference on TRI-Ada. ACM Press. 1992.
[14] Henninger, S. An Environment for Reusing Software Processes. Fifth International Conference on Software Reuse. 1998.
[15] Henninger, S. Tool Support for Experience-Based Methodologies. In Advances in Learning Software Organizations. 2003.
[16] Hollenbach, C. et al. Software Process Reuse in an Industrial Setting. Fourth International Conference on Software Reuse. 1996.
[17] Hutchens, K. et al. Web-based software engineering process management. In Proceedings of the Thirtieth Annual Hawaii International Conference. 1997.
[18] Kaltio, T. Software Process Asset Management and Deployment in a Multi-Site Organization. 2001.
[19] Kellner, M. Connecting reusable software process elements and components. Process Support of Software Product Lines. 1996.
[20] Kerschebrg, L. et al. PROGEN: A Knowledge-based System for Process Model Generation, Tailoring and Reuse. 1996.
[21] Klingler, C. et al. DAGAR: a process for domain architecture definition and asset implementation. Proceedings of the conference on TRI-Ada. 1996.
[22] Kruke, V. Reuse in Workflow Modeling. Norwegian University of Science and Technology. 1996.

[23]Ma, H. Standards Advisor: Activity Modeling and Model-Driven Web Portal for a Software Engineering Process. University of Alabama. 2003.
[24]Mi, P. et al. A Knowledge-Based Software Process Library for Process-Driven Development. In Proc 7th Knowledge-Based Software Engineering Conference. 1992.
[25]Mogilensky, J. et al. Applying Reusability to Software Process Definition. Proceedings of Tri-Ada. 1989.
[26]Nejmeh, B et al. A Framework for Coping with Process Evolution. In the Proceedings of the Software Process Workshop. 2005.
[27]Reis, R. et al. APSEE-Reuse: A Case-Based Reasoning Model for Reuse and Classification of Software Process Assets. Brazil. 2001.
[28]Riddle, W. Coping with Process Specification. Integrated Design and Process Technology. 2003.
[29]Succi, G. et al. Standardizing the reuse of software processes. StandardView. 1997.
[30]Zahran, S. Software Process Improvement. Addison-Wesley. 1998.

Smooth ERP Migration by Using Next Generation Distributed ERP Systems*

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ABSTRACT

In a distributed ERP (Enterprise Resource Planning) system, the different local ERP systems are integrated in such a way that each local system can use the resources/stocks managed by the other local ERP systems. Businesses with branch offices may benefit greatly from such systems. In this paper, we will describe how a distributed ERP system can be used to convert/migrate to a new ERP system in a smooth way. The smooth migration property is a consequence of the distributed ERP systems ability to allow different ERP systems to operate on the same stock table. That is, the distributed ERP system can use the stock file from the old ERP system while customers over time are converted to the new distributed ERP system. As this type of converting does not need to take place overnight, it may reduce the risk and peak load for manpower in the converting period.

Keywords: ERP migration, converting risks, converting time, distributed ERP systems.

1. INTRODUCTION

Converting to a new ERP system is normally done overnight for the following reasons:

- Most major companies can only live a short time without an ERP system or the old legacy systems.
- It is not possible to run the new and the old ERP system in parallel as product stocks normally cannot be updated from both systems in a smooth way.

Converting overnight may be risky as the new system cannot be tested in a full scale production environment because the employees rarely have time to use both systems in the test period. A distributed ERP system may reduce the converting risk as such a system will make it possible to update the stock table from both the new and the old ERP systems. This makes it possible to do the converting over time.

A distributed ERP system used for converting must be able to update heterogeneous databases, which will present a problem with the ACID properties. The extended transaction model used in this paper implement the global atomicity property by using compensatable, pivot and retriable subtransactions in that order as described in e.g. Frank and Zahle [2].

The global consistency property is not implemented but it is the responsibility of the application designers to use countermeasures against the isolation anomalies in such a way that the database always will converge towards a consistent state.

The paper is organized as follows: First, we will describe the replication designs we recommend for distributed ERP systems that make it possible for different ERP systems to operate in parallel. Next, we will describe the architecture of a distributed ERP system as such a system is used in the new converting method. Finally, we will describe the method for smoothly converting to a new ERP system.

Related Research: The different replication designs used in this paper are described and evaluated in [4]. The extended transaction model used in this paper is *The Countermeasure Transaction Model* [2]. This transaction model owes many of its properties to e.g. [4], [5], [6] and [7].

2. THE MOST IMPORTANT REPLICATION DESIGNS

In general, replication methods involve n copies of some data where n must be greater than 1. The basic replication designs storing n different copies of some data are defined to be n-safe, 2-safe, 1-safe or 0-safe, respectively, when n, 2, 1 or 0 of the n copies are consistent and up-to-date at normal operation. In autonomous databases, it is normally only possible to use the 1-safe or 0-safe replication designs and, therefore, only these designs are used in this paper.

In general, it is not possible to select one of the replication designs as the best because all the designs have very different properties. However, if one knows the requirements of application, it is possible to select the most inexpensive design fulfilling those needs. This is illustrated by Frank [3].

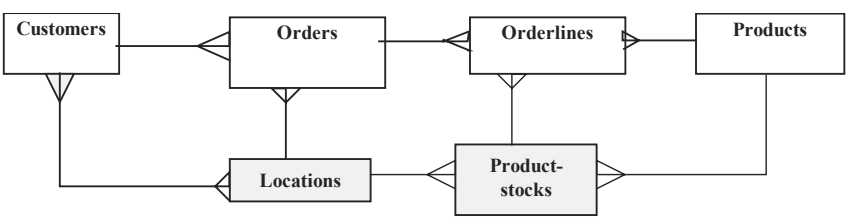
3. ARCHITECTURE OF A DISTRIBUTED ERP SYSTEM

In the following, we will describe in broad outline the table design of some of the most important tables in a distributed ERP system. In a distributed ERP system each local ERP system must have local autonomy to operate in disconnected mode. In the following design, we have also tried to optimize performance, availability and possibility of recovery.

The Product table is vital in all locations. We recommend that the Product table is replicated by using the basic 1-safe design with a central primary copy and secondary copies in all the other locations. We do not think it is necessary to use the n-safe, 0-safe, or expensive versions of the 1-safe designs, because normally the file is only updated from the central location when product prices are changed or new products are introduced. Therefore, updates can be executed in advance with an operation date. This means that in case of failure, it is possible to defer all updates of the Product table until the failure has been repaired, i.e. no lost transactions will occur. In other words, no risks are taken by using the inexpensive basic 1-safe design.

We will recommend that the Customer records for customers who deal with more than one branch office are fragmented and 0-safe with primary copy commit in the central location. The secondary copies will be stored in all the locations where a

Figure 1. Entity-relationship diagram for a distributed ERP system



customer has placed orders previously. The balance of a customer must be updated each time an Order is invoiced, and, therefore, the balance is first updated in the local Customer record. Later, the updating should be committed globally at the central primary copy. The other involved remote branch offices will (sooner or later) receive the updates committed globally by the update of the central primary copy. We will recommend that the Customer records for local customers are fragmented and 1-safe with commutative updates. The primary copies are stored in the locations that deal with the local customers and the secondary copies are stored in the central location.

We will recommend that the Order table is fragmented with the basic 1-safe design as an Order record is normally used only in the location where the corresponding sale took place. However, for backup and data warehousing a secondary copy can be stored in the central location.

Suppose the Product-stock table has a record that includes the quantity of each product in stock at each store location. We recommend that the Product-stock table has the no-replication design, as it may be too expensive to replicate the data on-line. The table is also fragmented in such a way that each store location has its own Product-stock records. (A snapshot copy of the local Product-stock tables should be stored for backup in the central location).

We recommend that the Orderline table is fragmented and 0-safe with primary copy commit in the store location and a secondary copy stored in the location that created the order. In other words, first the Orderline should be created in the database of the order location and later it should be confirmed in a store location where a primary copy of the Orderline is created if the quantity ordered is in stock.

4. CONVERTING TO THE NEW ERP SYSTEM

An overnight conversion may be risky as the new system cannot be tested in a full scale production environment because the employees rarely have time to use both systems in the test period. A distributed ERP system may reduce the conversion risk as such a system will make it possible to update the stock table from both the new and the old ERP systems. This makes it possible to do the conversion over time.

The idea is to run the distributed ERP system in the same location as the ERP system that is going to be converted. All the replicated tables described in example of the previous section are created in the new distributed ERP system except the stock table. By using a special interface, it should be possible to access the stock table in the old ERP system through the new distributed ERP system.

It is possible to create a test department with customers in the distributed ERP system and test how to sell and restore the stocks in a production environment. At the same time, it is possible to use the old ERP system as usual. After a test period, it is possible to convert the sales departments one by one. When all sales departments have been converted to the distributed ERP system, the Stock file may be converted too. Now, the sale module of the old system can be deleted. Other ERP modules may be converted in the same way, but it is important not to delete old tables before all modules that use the old tables have been converted. If the company does not need a distributed version of the ERP system when the conversion has been completed, a non distributed version of the new ERP system can use the converted ERP database of the distributed ERP system. The conversion method described above is not simple. Therefore, the method is only recommended if the overnight conversion is too risky or costly compared to the new method. Another problem with the new conversion method is that special software is needed if the old and new ERP systems are heterogeneous. The special software is necessary to access the old stock file from the distributed ERP system. Special software is also needed for the different replication methods as the replication methods of the distributed ERP system only can be used between homogeneous ERP systems. On the other hand, a great deal of the replication programming has to be done anyway as the tables from the old ERP system must be converted to the new ERP system.

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REFERENCES

[1] Y. Breibart, H. Garcia-Molina and A. Silberschatz, "Overview of Multidatabase Transaction Management", *VLDB Journal*, 2, pp 181-239.

[2] L. Frank, and Torben Zahle (1998), Semantic ACID Properties in Multidatabases Using Remote Procedure Calls and Update Propagations, *Software - Practice & Experience*, Vol.28, 1998, pp77-98.

[3] L. Frank, 'Architecture for Integration of Distributed ERP Systems and E-commerce Systems', *Industrial Management and Data Systems (IMDS)*, Vol. 104(5), 2004, pp 418-429.

[4] H. Garcia-Molina and K. Salem, "Sagas", *ACM SIGMOD Conf*, 1987, pp 249-259.

[5] S. Mehrotra, R. Rastogi, H. Korth, and A. Silberschatz, "A transaction model for multi-database systems"*, Proc International Conference on Distributed Computing Systems*, 1992, pp 56-63.

[6] G. Weikum and H. J. Schek, 'Concepts and Applications of Multilevel Transactions and Open Nested Transactions', *A. Elmagarmid (ed.): Database Transaction Models for Advanced Applications*, Morgan Kaufmann, 1992, pp 515-553.

[7] A. Zhang, M. Nodine, B. Bhargava and O. Bukhres, 'Ensuring Relaxed Atomicity for Flexible Transactions in Multidatabase Systems', *Proc ACM SIGMOD Conf,* 1994, pp 67-78.

[8] J. Gray and A. Reuter, Transaction Processing, *Morgan Kaufman*, 1993.

Does Economic Freedom Enhance the Impact of Technology on Global Productivity?

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ABSTRACT

This paper assesses the joint effects of economic freedom and technology on productivity. Using regression analysis we examined a sample of more than 100 countries from 1990 to 2000. The results indicate that countries with greater economic freedom have an increased association between technology and productivity.

INTRODUCTION

Productivity is considered a key indicator of national success. Consequently, much effort has been expended in the economics literature to determine factors influencing it. Our concern is with a subset of this literature pertaining to the effect of technological investments on productivity. This literature generally finds that technology is associated with productivity and economic growth.

But technology cannot be considered in isolation. Other factors may affect or modify the relationship between technology and productivity. In this study, we consider one such factor, economic freedom. The objective of this paper is to assess the joint effects of economic freedom and technology on productivity. The existing literature tends to treat these two factors as separate and our contribution is to consider the joint effects. We argue that technology has a greater effect on productivity when coupled with economic freedom. We test this hypothesis using a sample of more than 100 countries and find supportive evidence.

BACKGROUND AND LITERATURE REVIEW

Technology and Economic Performance

Many studies have investigated the relationship between Information Technology (IT) investment, productivity, and economic growth. Dedrick, Gurbaxani and Kraemer (2003) categorize these studies based on the aggregation level of data: firm-level, industry-level, and country-level. The initial debate in the literature centered on whether IT produced economic growth or productivity. Early tests did not indicate a relationship, but tests using data from the 1990s indicate that IT influences productivity.

While most of the studies were conducted using firm-level data, many studies also used country-level data. These studies are of recent vintage (mid-1990s onward) and use univariate tests associating IT investments with economic growth and productivity. The greatest impact of IT is found in developed countries (Yoo 2003). The link between IT and economic performance is not robust in developing countries (Dewan and Kraemer 2000).

The lack of an IT impact in developing nations is further explored by Indjikian and Siegel (2005). These authors review existing evidence and conclude that IT investments by themselves cannot solve the travails of developing nations. This raises the possibility of moderating factors affecting the link between IT and productivity.

Economic Freedom and Productivity

Economic freedom, as distinguished from civil and political freedoms, refers to the degree in which a market economy exists and provides an environment favoring voluntary exchange, free competition, property rights, and a limited degree of interventionism in the form of government ownership, regulations, and taxes (Gwartney and Lawson 2002). Most but not all studies indicate that economic freedom is positively and significantly correlated to productivity. Focusing specifically on developing countries, there has consistently been empirical evidence that economic freedom is one of the most important factors that affect economic performance. Countries that better protect economic rights tend to grow faster (Goldsmith 1997). According to Wu and Davis (1999), the establishment of free a market is essential to a developing country's economic growth. Other studies have demonstrated that economic freedom combined with other factors such as political freedom, civil freedom, and democracy has a positive effect on the economic performance of developing countries (Nelson and Singh 1998; Vega-Gordillo and Alvarez-Arce 2003).

Contribution of this Study

The notion that IT investments and diffusion need to be supported by complementary investments and environmental conditions (Green, Melnyk and Powers 2002; Lee, Gholami and Tong 2005) is an important one and lies at the heart of our study. At the firm-level such complementary investments may include items such as workforce training. At the national level too, there are many environmental variables affecting the impact of IT. In this paper, we consider economic freedom to be a complementary variable.

Our study is perhaps most closely related to Meso, Datta, and Marika (2005). These authors examined the modifying effects of governance variables on the relationship between economic growth and IT. They found an interaction effect for certain variables. For instance, they found that Voice, Accountability, and Rule of Law interact with IT to further economic growth. However, they also find IT to be negatively related to economic growth contrary to much of the literature. Our study uses different dependent and independent variables and measures in different time periods. More importantly, our focus is on economic freedom and not governance.

DATA AND METHODOLOGY

Productivity

The dependent variable in our study is Gross Domestic Product (GDP) per worker adjusted for purchasing power parity and expressed in US currency. We collected values for this variable for the years 1990 and 2000 from the Global Market Information Database issued by Euromonitor International. The database covers 205 nations from 1977 to 2006.

Technological Capability

Our independent variables are technology and economic freedom. We measure technology through the Indicator of Technological Capabilities for Developed and Developing Countries. The indicator was complied by Archibugi and Coco (2004). We use this index because it is one of the most widely used and detailed indexes.

Economic Freedom

Our economic freedom variable is the Economic Freedom of the World (EFW) indicator by **Gwartney** and **Lawson** (2002). It is measured on a ten point scale with 10 denoting the highest level of economic freedom. EFW contains the following five areas: 1) size of government, 2) legal structure and property rights, 3) sound money, 4) openness of markets, and 5) regulation of credit, labor and business.

The EFW measure is also one of the most widely recognized and detailed indexes of economic freedom. We focus on economic freedom rather than political freedom because we are more interested in the policies that directly effect economic productivity. The index has been stable over time and has been used in several published papers (e.g., Vega-Gordillo and Alvarez-Arce 2003). The index has been compiled since 1970 and is publicly available at www.freetheworld.com.

Regression Models

Throughout the tables as well as in the text, we use the variable names mentioned above. We estimate the following models:

- Model A: $Prod2000 = \beta_0 + \beta_1 Tech2000$
- Model B: $Prod2000 = \beta_0 + \beta_1 Free2000$
- Model C: $Prod2000 = \beta_0 + \beta_1 Tech2000 + \beta_2 Free2000$
- Model D: $Prod2000 = \beta_0 + \beta_1 Tech2000 + \beta_2 Free2000 + \beta_3 Tech2000*Free$

Where:

- Prod2000 = GDP per worker in 2000
- Tech2000 = Indicator of Technology Capabilities for Developed and Developing Countries in 2000
- Free2000 = Economic Freedom of the World indicator in 2000
- Free = dummy variable equaling 1 when Free2000 is median or higher

RESULTS

Descriptive Statistics

Table 1 reports descriptive statistics on the three key variables: technology, freedom, and productivity. Tech2000 ranges from 0.028 to 0.867 and has a mean and median of 0.329 and 0.313 respectively. Free2000 ranges from 3.5 to 8.7 and has a mean and median of 6.399 and 6.5 respectively. Prod2000 ranges in value from 183 to 105,064 and has a mean and median of 13,273 and 3,978 respectively.

We also calculate correlations. Consistent with the literature on the effects of technology and freedom on productivity, we note significant correlations between technology and productivity as well as between freedom and productivity.

Regression Analysis and Models of Productivity

Model A is a regression of Prod2000 on Tech2000. Consistent with results reported in the literature, we find high R-squares (0.6416) as well as a significant coefficient for Tech2000. We also find strong results with Model B that uses Free2000 as the independent variable. Comparing the R-squares for models A and B, we note a stronger explanatory role for Tech2000. This is confirmed by model C which uses both Tech2000 and Free2000 as explanatory variables. While both variables have significant coefficients we note that the R-square for model C is only slightly higher than R-square for model A.

A key contribution of our study is an understanding of how freedom modifies the effect of technology. Model D adds the interaction variable indicating how freedom modifies the effect of technology on productivity. This variable has a significantly positive coefficient of 26,254 with a t-statistic of 2.71. This indicates that countries with higher levels of freedom have a greater link between technology and productivity. This is consistent with McNair (1998) who argues that there is synergy between IT and economic freedom.

Table 1. Descriptive statistics

	N	Min	Max	Median	Mean	Sigma
Tech2000	162	.028	.867	.313	.329	.190
Free2000	123	3.500	8.700	6.500	6.399	1.066
Prod2000	166	183	105,064	3,978	13,273	19,377

Table 2. Regression analysis using data from 2000

Model		(A)	(B)	(C)	(D)
Intercept	coef.	-15898	-74165	-43146	-21675
	t-stat.	-6.37	-8.48	-5.50	-1.97
	p-val.	<.0001	<.0001	<.0001	0.0512
Tech2000	coef.	87530		67147	48624
	t-stat.	14.45		8.36	4.69
	p-val.	<.0001		<.0001	<.0001
Free2000	coef.		14030	5397	2113
	t-stat.		10.44	3.64	1.12
	p-val.		<.0001	.0004	0.2642
Tech*Free	coef.				26254
	t-stat.				2.71
	p-val.				0.0077
N		117	117	117	117
Adj. R^2		.6416	.4821	.6762	.6933

SUMMARY

Using a sample of more than 100 countries, we assess the joint impact of technology and economic freedom on productivity. We use two samples, one containing 1990 data and the other containing 2000 data. We find consistent results indicating that both technology and economic freedom are influential variables. We also find indications that technology is the more important variable and the impact of economic freedom is primarily through its modifying effect on technology. Thus, countries with greater economic freedom have a greater link between technology and productivity.

We caution readers about the suggestive nature of these results. Because we rely on cross-sectional associations, we cannot make strong statements about causality. Further, we may be detecting spurious correlations by not properly specifying all relevant variables. In particular, our research design could be subject to the problem of correlated omitted variables. Nevertheless, our results are reasonable and consistent with expectations. Thus our study is a valuable complement to the large literature on IT effectiveness.

REFERENCES

Archibugi, D. and Coco, A. "A New Indicator of Technological Capabilities for Developed and Developing Countries (ArCo)," *World Development* (32:4), 2004, pp. 629-654.

Dedrick, J., Gurbaxani, V., and Kraemer, K.L. "Information Technology and Economic Performance: A Critical Review of the Empirical Evidence," *ACM Computing Surveys* (35:1), March 2003, pp. 1-28.

Dewan, S. and Kraemer, K.L. "Information Technology and Productivity: Preliminary Evidence from Country-Level Data, *Management Science* (46:4), April 2000, pp. 548-562.

Goldsmith, A.A. "Economic Rights and Government in Developing Countries: Cross-National Evidence on Growth and Development," *Studies in Contemporary International Development* (32:2), Summer 1997, pp. 29-44.

Green, S., Melnyk, A., and Powers, D. "Is Economic Freedom Necessary for Technology Diffusion," *Applied Economics Letters* (9), 2002, pp. 907-910.

Gwartney, J.D. *Economic Freedom of the World,* www.freetheworld.com.

Indjikian, R. and Siegel, D.S. "The Impact of Investment in IT on Economic Performance: Implications for Developing Countries," *World Development* (33:5), 2005, pp. 681-700.

Lee, S.T., Gholami, R., and Tong, T.Y. "Time Series Analysis in the Assessment of ICT Impact at the Aggregate Level – Lessons and Implications for the New Economy," *Information and Management* (42), 2005, pp. 1009-1022.

Meso, P., Datta, P., and Marika, V. "Moderating ICTs' Influences on Socio-Economic Development with Good Governance: A Study of the Developing Countries," *Journal of the American Society for Information Science and Technology*, 2004.

Nelson, M.A., and Singh, R.D. "Democracy, Economic Freedom, Fiscal Policy, and Growth in LLDs: A Fresh Look," *Economic Development and Cultural Change*, 1998, pp. 677-696.

Vega-Gordillo, M. and Alvarez-Arce, J.L. "Economic Growth and Freedom: A Causality Study," *Cato Journal* (23:2), Fall 2003, pp. 199-215.

Wu, W. and Davis, O.A. "The Two Freedoms, Economic Growth and Development: An Empirical Study," *Public Choice*, (100:1-2), July 1999, pp. 39-64.

Yoo, SH "Does Information Technology Contribute to Economic Growth in Developing Countries? A Cross-Country Analysis," *Applied Economics Letters* (10), 2003, pp. 679-682.

Deployment of Electronic Commerce Tools in the Business-to-Business Services Context

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ABSTRACT

The aim of this paper is to show how electronic commerce (EC) tools are deployed to manage business-to-business services. The case study reports on usage of various EC tools including the internet, the email, and ERP system to speed up and eliminate some manual administrative work in business-to-business service processes. For managers this paper shows how processes between companies and interfacing processes in a business-to-business service context can be done in a more cost-effective manner. For academics this study provides some ideas for further and consistent empirical research on the impact of EC tools on business services.

INTRODUCTION

It has been suggested in the literature (Vargo and Lusch, 2004) that markets must move away from economics based dominant logic of marketing into a revised logic focused on intangible resources, the co-creation of value, and relationships. In here, we focus on services and the co-creation of value between the service suppliers and the clients and relationships between the suppliers and clients.

The emergence of EC in forms of interconnected computers, the internet and mobile phones has enabled radically new and innovative services to be offered to customers via digital channels. Digital channels have appeared and been adopted very rapidly (see Poon and Joseph 2000; Cho and Park, 2003).

EC have changed the place and characteristics of service setting. In business-to-business setting companies are using novel EC tools such as the extranet to interact within and between organizations digitally (Vlosky et al., 2000). Businesses can use EC tools to re-engineered business processes (Aldin et al., 2004) and those also enable many novel channel and communication solutions (Agnihotri et al., 2002). The basic aim of the paper is to understand, explain and describe how EC based tools can be deployed in the business-to-business service industry. A detailed review of different types of EC tools that can be deployed also in service industry setting is provided by Salo (2006).

First, we present a review of the services literature. Second, we present the methodology section of the paper. A case study elaborates on the use of EC in a business-to-business service organization. Finally, we conclude with a discussion of future research areas for business-to-business services conducted with EC.

BUSINESS-TO-BUSINESS SERVICES

After the invention of the internet companies started to utilize it for various marketing purposes including providing a variety of services ranging from buying airline tickets to monitoring thermal power plants. As practitioners continued to add different kinds of services and products to the information highway academics only pondered the possible consequences of this new phenomenon. Until recently Zeithaml, Parasuraman and Malhotra (2002) and Parasuraman and Zinkhan (2002) among others have provided insights into the changes occurring in the service industry sector. Digital delivery of services has altered some features of service quality as well as made service consumption more convenient to customers (see Ruyter et al., 2001). It should be noted that the internet and mobile phones are just channel additions that need to be managed accordingly.

METHODOLOGY

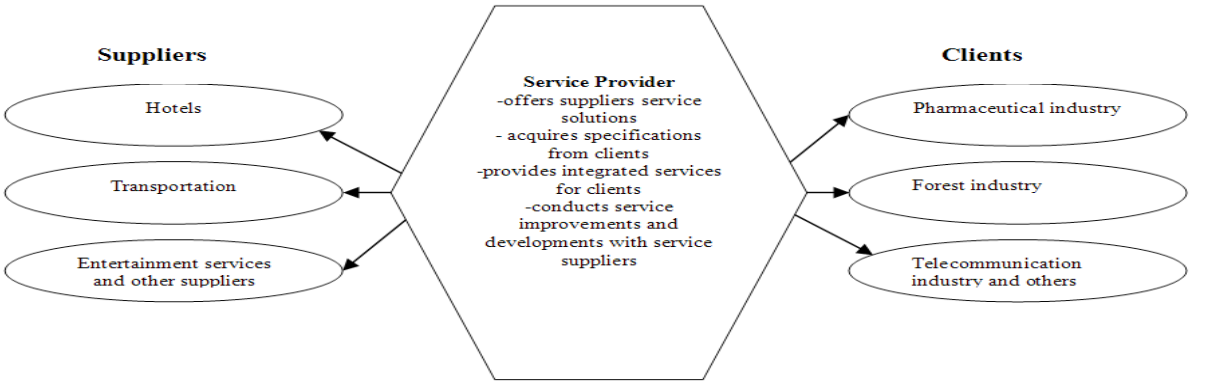
Due to the novel nature of this phenomenon in which the researcher has only little or no control at all over events occurring in a real-life context, a case study is the most appropriate method (Yin, 1994). The case company was selected based on the idea that it should represent the problem of the study. Besides the interview the empirical part of this study consists of various kinds of data. The objective of data collection was to get rich primary data from the studied phenomenon. The semi-structured interview formed the main data source from which the issues were identified and the framework was completed.

USAGE OF EC TOOLS IN B2B CONTEXT

The company studied is a relatively large Finnish service industry company providing mainly B2B customers with a wide range of entertainment and catering services, including transportation and accommodation. The Service Provider has faced rapid growth since its establishment in 2000. The Service Provider has been successful in offering various services to its clients. Clients are usually large pharmaceutical companies developing different types of medicines, forest industry companies providing paper and wood based solutions to end-customers and telecommunication industry clients such as mobile phone manufacturers and developers. The Service Provider has over 100 established business relationships with its clients. Service suppliers are hotels, transportation services providers, and entertainment service providers. Currently, the Service Provider has close relationships with a large number of service suppliers and even more loosely structured connections with other service suppliers. These suppliers provide the means for the Service Provider to solve their client's problems. For example, many large pharmaceutical companies need an excellent location and entertainment services to present new solutions to medical doctors; businesses in the forest industry need ways to reward excellent work conducted by their employees, for example by having an unofficial get together or party. The growth in demand partly stems from the fact that the CEO has personally created and maintained many of the relationships with clients and suppliers. The company has a special role in the value-chain as it facilitates transactions with help of its competence in collecting a wide array of services into one commodity offering as presented in Figure 1.

Figure 1 shows in detail the central role of the Service Provider between its large clients and relatively small service suppliers. Locally, suppliers are large but on a global scale, and when compared to the Service Provider's clients, the suppliers are relatively small. The Service Provider combines multiple business organizations that offer different kinds of services ranging from hotel services to fly fishing activities into an integrated service which is targeted to their clients. Since the Service Provider offers routine services and some tailored services to its clients it is heavily dependent on the collaborative supplier network. This co-operation is possible because before the establishment of the Service Provider company the CEO operated a catering firm and collaborative networks of organizations emerged in early 1996. She was conducting business with many organizations and simultaneously created a wide personal contact base. The collaborative network at that time consisted of the Service Providers' future clients but also future collaborative network suppliers. The relationships and partnerships developed during that time were important for the rise of the Service Provider company.

Figure 1. Central role of the service provider



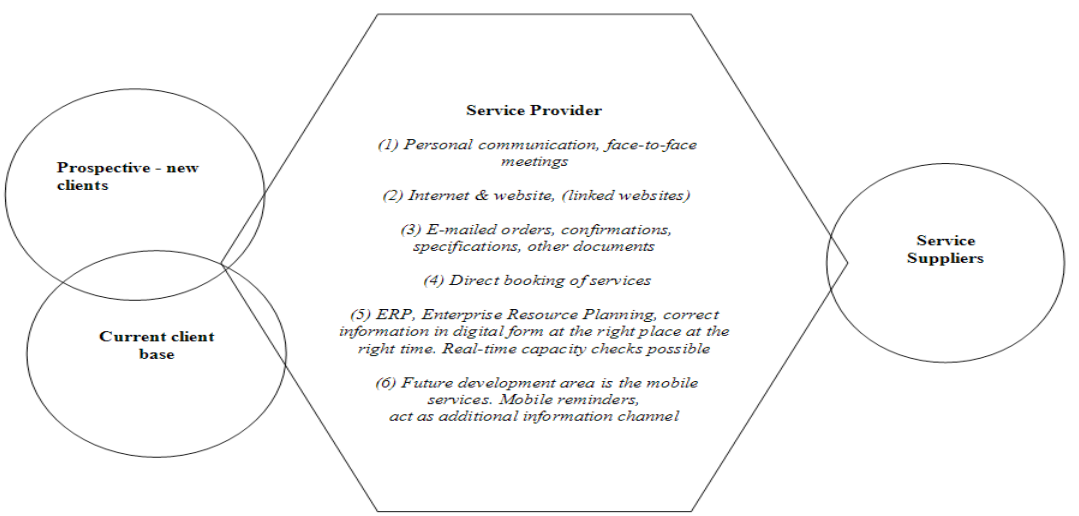
Besides offering routine services to clients the Service Provider also develops new services in interaction with its suppliers. Basically the Service Provider develops services based on each client's specifications. In practice, the new service development is conducted together with several service suppliers in joint meetings. After a new service concept is developed it is offered to many customers. For example, a small theatrical play performed in a restaurant or pub context is one of the newly developed service concepts. The co-creation of services would not be possible if the Service Provider was not acting as a middle man between the service suppliers and clients.

In addition to developing new service concepts, the Service Provider and service suppliers have established several means to communicate digitally. According to the CEO, 90 percent of sales come from B2B clients and 70 percent of sales are initiated with the help of EC tools such as e-mail or the internet. The CEO explained that older customers contact the Service Provider directly by e-mail while the internet is a very attractive channel for new customer acquisition. Moreover, digital interaction is used in routine communications and to handle administrative issues. Clients of the Service Provider can also interact digitally with the company. Companies can order hotel rooms and book tables in restaurants in advance digitally. This frees the time of salespeople and their assistants for other more productive work. The room and table reservation system was developed by a local software house. The newest digital addition is a real time ERP system that enables both the clients and suppliers to interact digitally with each other. It helps with communication and streamlines the decision making process as well as driving down extra costs related to booking services. The Service Provider is also creating loyal client electronic mailing lists to develop even more trustful service relationships. The CEO is also very interested in developing mobile services especially for B2C customers and adds that without the internet it would be almost impossible to operate so effectively. The future challenge is to develop a coherent computer based service system that serves B2B and B2C customers equally. Figure 2 depicts the eminent role of EC tools in the service network created by the Service Provider.

CONCLUSION

We have illustrated how a service industry company serving business clients and providing service development to its service suppliers used different types of EC tools to improve the value gained by both clients and suppliers. Based on the case study it can be proposed that the digital infrastructure development is an antecedent for successfully digital service delivery. In addition, the selection of proper EC tools to be used in service development and delivery are the second step while pilot testing serves as third phase of the EC tool adoption in service setting. After successful adoption of an EC tool further service re-engineering and automation as well as digitization possibilities are analyzed and planned. For managers this paper has provided several interesting insights into the EC tool adoption in business-to-business service setting. The paper discussed sequential adoption of EC

Figure 2. Role of the EC tools in the interaction between the actors



tools and also highlighted the pertinent role of social communication especially in a new service development setting. These future contributions could be done with the help of longitudinal case studies or surveys. It should be noted by the managers that the amount of EC tools used to deliver service is dependent on customer acceptance (see Ruyter et al., 2001). Thus, under what conditions and in what service settings deployment of EC tools is useful might be an interesting future study area (see Cho and Park, 2003).

REFERENCES

Agnihotri, S., Sivasubramaniam, and Simons, D. (2002) "Leveraging technology to improve field service", International Journal of Service Industry Management, Vol 13 No 1, pp. 47-68.

Aldin, N., Brehmer, P-O. and Johansson, A. (2004) "Business development with electronic commerce: refinement and repositioning", Business Process Management Journal, Vol 10 No 1, pp. 44-62.

Cho, S-E. and Park, K. (2003) "Characteristics of product/service process and customer needs of geographical accessibility in electronic commerce", International Journal of Service Industry Management, Vol 14 No 5, pp. 520-538.

Parasuraman A. and Zinkhan G.M. (2002) "Marketing to and Serving Customers Through the Internet: An Overview and Research Agenda", Journal of the Academy of Marketing Science, Vol 30 No 4, pp. 286-295.

Poon, S. and Joseph, M. (2000), "Product characteristics and Internet commerce benefit among small businesses", Journal of Product & Brand Management, Vol 9 No 1, pp. 21-34.

Ruyter, K., Wetzels, M. and Kleijnen, M. (2001) "Customer adoption of e-service: an experimental study", International Journal of Service Industry Management, Vol 12 No 2, pp. 182-207.

Salo, J. (2006). "Business relationships redesign with electronic commerce tools: An empirical investigation", Business Process Management Journal, (In press).

Vargo, S.L. and Lusch, R.F. (2004) "Evolving to a New Dominant Logic for Marketing", Journal of Marketing, Vol 68 No 1, pp. 1-17.

Vlosky, R.P., Fontenot, R. and Blalock, L. (2000) "Extranets: impacts on business practices and relationships", Journal of Business & Industrial Marketing, Vol 15 No 6, pp. 438-457.

Yin, R. (1994), Case Study Research. Designs and methods, Sage Publications, Thousands Oaks California.

Zeithaml, V., Parasuraman A. and Malhotra, A. (2002) "Service Quality Delivery Though Web Sites: A Critical Review of Extant Knowledge", Journal of the Academy of Marketing Science, Vol 30 No 4, pp. 362-375.

A Multi-Criteria Decision Support System for Selecting Cell Phone Services

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INTRODUCTION

Cell phones have achieved high levels of market penetration in a relatively short time. According to the Canadian Wireless Telecommunications Association (CWTA, 2006), more than half of all Canadians are cell phone customers and 47% of all phone connections in Canada are wireless. For many organizations, equipping their employees with cell phones is an accepted operational cost. The industry-analyst firm Yankee Group estimates that businesses now spend a quarter of their telecommunications budgets on cell phone expenses (Allianceone, 2006). In Massachusetts, over 10% of cell phone bills are paid by employers (Cummings & Smith, 2005).

Most areas have multiple cell phone service providers, and each typically provides a wide variety of plans with different cost structures. One Canadian company claims that most companies are actually spending 20-50% more than they need to (Allianceone, 2006). There are several reasons for this. First, finding the most cost-effective plan from among so many choices is complex and time-consuming. Second, each employee can have a different calling pattern in terms of total minutes, where the calls are originating from or going to, and when the calls are placed. Often there is no single plan that is best for everyone. Third, cost is not the only factor to consider; service quality varies as well. Moreover, plan costs, calling patterns and service quality are constantly changing. While larger organizations can use specialized consulting companies and have the volume to get special discounts, smaller businesses are often very much on their own to determine which plan(s) is best for them.

The goal of this research is to develop a Multi-Criteria Decision Support System (MCDSS) to help organizations, particularly small businesses, determine the best cell phone plans for their employees. Finding the lowest cost plan is relatively straightforward using a computer-based system; each calling pattern can be compared over all plan cost structures. To incorporate non-cost factors, a survey was conducted among small businesses to determine which they considered to be most important. These factors were then integrated into the MCDSS using the Analytic Hierarchy Process (AHP). The system allows decision makers to have different preferences for the importance of non-cost factors, different rankings for how each service provider performs on these factors, and different weightings between cost and non-cost factors overall.

CELL PHONE INDUSTRY

This research was conducted in a small city (population under 100,000) in Canada in 2006. At that time, there were four major cell phone providers, two owned by the same company, offering a total of ninety business plans with different rates. The rates have a similar structure across different plans. The main elements are a fixed monthly cost, per minute rates and additional options. The fixed monthly cost covers service fees (including system access and 911 emergency services) and often includes an allotment of "free" minutes. Once these have been exhausted, per minute rates come into effect.

Per minute rates are based on when the call is placed and its origin and destination. Canadian cell phone service providers usually divide location into three categories: local, long distance within Canada and from Canada to the U.S., and long distance from the U.S. to Canada. Within each category, the minutes can be classified by time as weekday, evening, and weekend. Each plan can provide different free minute allotments and different per minute rates for each of the nine combinations of location and time. However, each provider currently has identical weekend and evening rates so there are actually only seven call types to consider.

Some plans offer additional options that customers can select according to their needs and usage patterns (e.g., caller ID). Some affect costs, such as special rates when calling other cell phones from the same provider and business pooling plans that allow a group to share unused free minutes.

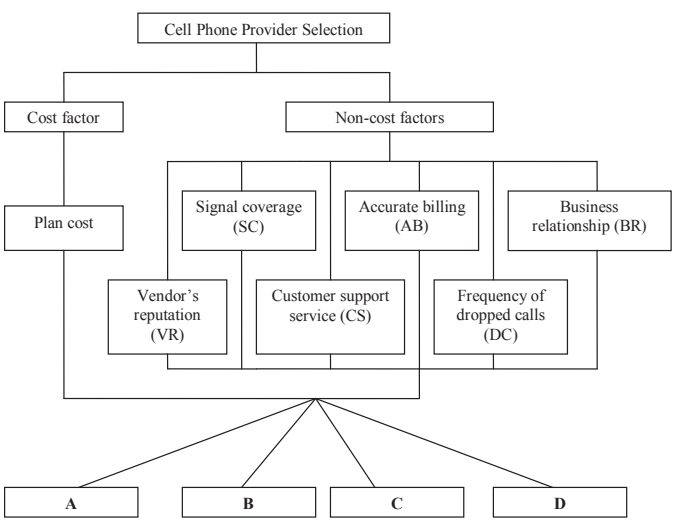
CUSTOMER SURVEY

Finding the best provider of a product or service is a common task that typically involves multiple criteria. The lowest cost plan is not necessarily the best plan. Non-cost factors can significantly affect a user's experience with any supplier, and cell phone service customers are starting to focus more on factors such as billing accuracy, provider reputation, and service quality (Cummings & Smith, 2005; Mao, Srite, Thatcher, & Yaprak, 2005; Navarro, 2005; Totten, Lipscomb, Cook, & Lesch, 2005; Woo & Fock, 1999). We selected 13 of these criteria (Table 1) for consideration.

A survey was constructed using a five-point Likert scale to measure the importance of each criterion. In addition, some demographic data were collected to help understand the characteristics of local business cell phone use. After constructing the questions, 10 academic researchers with backgrounds in the cell phone industry examined the clarity of the questions, the accuracy of the language, and the structure of the questionnaire. The questionnaire was refined and finalized after incorporating their feedback.

The survey was mailed to a random sample of 140 businesses, identified using the local Yellow Pages telephone directory. Most of them were in construction,

Figure 1. A four-level AHP hierarchy for selecting cell phone service vendors



transportation, and automotive retailing. Two response methods (regular mail or Web-based) were provided. A 29.2% response rate was obtained within four weeks. The six most important non-cost criteria (with 5.0 being the highest possible rating) were signal coverage (4.53), customer support service (4.53), accurate billing (4.47), frequency of dropped calls (4.45), provider's attitude and willingness to maintain the business relationship (4.37), and vendor's reputation 4.26. The two most important cost factors, ranked fifth and seventh, were the fixed cost of the plan(s) (4.37) and the per minute rate (4.21). Respondents were given the opportunity to include additional factors not included in the survey. Contract handling and warranty coverage were among them, but none of the entries occurred frequently enough to be included in the system.

Most respondents reported that their cell phone bills are less than $2,000, and none were responsible for cell phone bills for over 50 employees. The average monthly cost for each user is estimated at $64.71.

SYSTEM DESIGN

The goal of this research was to build a Decision Support System (DSS) to help small businesses find the right cell phone plan for their needs. The system was designed using a standard framework (Sprague, 1980), where the key component parts are a database, model base, and dialogue generator (or user interface).

Database

The database typically requires external and internal data. In this case, the external data are the cost structures for each plan. These were retrieved from provider web sites on February 2, 2006. The internal data is based on 500 different simulated employee calling patterns, which are generally consistent with local calling patterns. The database was stored using Microsoft Access.

Model Base

The model base has three main parts, which analyze cost and non-cost factors and then integrate them to provide a final decision (Figure 1). The Analytic Hierarchy Process (Saaty, 1980), a multi-criteria decision making technique which permits the inclusion of subjective factors in arriving at a recommendation, was used to assess the criteria because it can handle both quantitative and qualitative criteria. For that reason, a large number of DSS covering many types of products and services have been developed using the AHP (Vaidya & Kumar, 2006; Vargas, 1990).

The AHP facilitates decision making among a number of alternatives and criteria by formulating priorities. The process requires that the decision maker provide judgments about the relative importance of each criterion (e.g., signal coverage, customer service support, etc.) and then specify preferences for each decision alternative (cell phone provider) on each criterion. The output of AHP is a prioritized ranking, indicating the overall preference for each of the decision alternatives (Saaty, 1980, 1990). Expert Choice™ a commonly used software package to perform AHP computations, is used in this system.

Non-Cost Factors

Non-cost criteria are attributes of the four cell phone service providers, not the 90 individual plans. In order to determine the weight of each of the top six non-cost criteria (Figure 1), 15 entries are required for the pairwise comparison matrix. Table 1 provides an arbitrary set of example ratio judgments. These would normally vary among decision makers. Similarly, the ratio preferences of alternatives (providers) with respect to each criterion were entered into pairwise comparison matrices. Based on an example set of ratio preferences, the relative priorities of the providers with respect to the set of criteria are computed by Expert Choice™ (Table 2). The missing entries, excluding the main diagonal of the matrix, can be determined using the reciprocal. For example, if Signal Coverage (SC) has a priority of 2 over Customer Support (CS), then CS has a priority of 0.5 over SC.

Finally, the aggregate relative priorities (combining the criteria weights in Table 1 with the relative priorities of the providers in Table 2) were generated using Expert Choice. These priorities (p_i^{NC}) range from 0.323 (A), the best choice when cost is not a consideration, to 0.269 (B), 0.215 (C), and 0.193 (D).

Cost Factors

The lowest cost cell phone plan for an employee can be found by simply computing the cost of every plan for that employee's calling pattern (i.e., number of minutes for each of the seven calling types) and selecting the minimum. For this system, a Search Decision Rule (SDR) approach was used based on Taubert (1968) who proposed this method for the aggregate scheduling problem.

The search algorithm for this system seeks the minimum cost with respect to different calling patterns. In the search loop phase, the minimum cost for the seven different call types (based on call time and locations) for a calling pattern are obtained within the inner search loops, and the total minimum cost is determined through an outer search loop. In both loops, comparisons are made between the

Table 1. Pairwise comparisons of criteria

Criteria	SC	CS	DC	AB	BR	VR	Weights
SC			3.0			2.0	0.136
CS	2.0		4.0	1.0	2.0	2.0	0.258
DC							0.065
AB	3.0		3.0		2.0	2.0	0.270
BR	2.0		2.0			2.0	0.168
VR			2.0				0.105

Note. SC: Signal coverage; CS: Customer support service; DC: Frequency of dropped calls; AB: Accurate billing; BR: Provider's attitude and willingness for business relationship; VR: Vendor's reputation

Table 2. Relative priorities of providers with respect to each criterion

	Criteria					
Providers	SC	CS	DC	AB	BR	VR
A	0.232	0.200	0.205	0.167	0.167	0.232
B	0.140	0.200	0.169	0.333	0.333	0.395
C	0.232	0.400	0.288	0.333	0.333	0.232
D	0.395	0.200	0.338	0.167	0.167	0.140

currently achieved cost and its previous optimal cost. If the current cost is less than previous optimal one, minimum cost becomes the current cost. Otherwise, the existing minimum cost is retained.

This can be expressed more clearly as follows. Let U_{ik} be the projected usage time for calling type k (below) for the i^{th} employee. Based on plans offered by local cell phone providers, seven different calling types are included:

- Local daytime usage (k = 1)
- Local weekend usage (k = 2)
- Local evening time usage (k = 3)
- Long distance daytime usage within Canada or from Canada to the U.S. (k = 4)
- Long distance weekend/evening usage within Canada or from Canada to the U.S. (k = 5)
- Long distance daytime usage within the U.S. or from the U.S. to Canada (k = 6)
- Long distance weekend/evening usage within the U.S. or from the U.S. to Canada (k = 7)

A particular cell phone service provider P may have N_p plans available. Every provider has different costs for each calling type for each service plan. Each plan has a basic service charge and allots a maximum amount of free time (which could be 0) for each calling type. When an employee's usage exceeds these amounts, the organization is charged for additional use at various rates. Even for the same provider, these rates vary from plan to plan and this cost is denoted by $C_{ik}^{\ j}$ and will be calculated whenever applicable by the function $f^j(U_{ik})$ for a particular vendor as follows:

$$C_{ik}^{\ j} = f^j(U_{ik}) \quad (j = 1, .., N_p)$$

where $C_{ik}^{\ j}$ is cost of the k^{th} calling type under the j^{th} service plan for the i^{th} employee. Note that $f^j(U_{ik})$ calculates the cost for additional time beyond the free allotment and therefore $C_{ik}^{\ j}$ is equal to zero if the time used is at or below that free allotment.

The total cost for the i^{th} employee under a given plan j is given by

$$C_i^j = B_i^j + \sum_{k=1}^{T} C_k^j \quad (j = 1, .., N_p)$$

where:

C_i^j = the total cost for the i^{th} employee under the j^{th} plan

B_i^j = the basic service (fixed) cost for the i^{th} employee under the j^{th} plan

T = number of calling types (T=7)

$C_i^{j_i^*}$ is the minimum of all plan costs for the i^{th} employee for the plan j_i^* among all N_p plans, where:

$$C_i^{j_i^*} = \min\left\{C_i^j, j \in N_P\right\}$$

For a group of N employees, the total minimum cost is:

$$C^* = \sum_{i=1}^{N} C_i^{j_i^*}$$

Using the simulated user calling patterns, the minimum cost when using a single provider is the sum of these minimum costs, which are $29,058.69 (D), $36,869.57 (B), $47,377.18 (A) and $52,466.97 (C).

To determine the relative priorities of the providers with respect to cost, a pairwise comparison matrix was generated. The lower the cost, the more preferred it is. For example, selecting B is 1.423 (52,466.97/36,869.57) times preferred compared to C. As for non-cost factors, the preference of C compared to B can be determined using reciprocity (i.e., $a_{ji} = 1/a_{ij}$ for i^{th} and j^{th} providers). The relative priorities of each provider with respect to cost (p_i^C), generated using Expert Choice™, are 0.208 (A), 0.267 (B), 0.187 (C), and 0.338 (D).

Integrating Cost and Non-Cost Priorities

Finally, both cost and non-cost priorities for the providers need to be integrated to produce the overall final ranking (Sarker & Zahir, 2006). Let p_i^C and p_i^{NC} be the relative priorities of i_{th} provider for cost and non-cost factors, and w_1 and w_2 be weights of the factors, respectively (subject to $w_1 + w_2 = 1$). The overall aggregate relative priority A_i for the i_{th} provider is:

$$A_i = w_1 \times p_i^C + w_2 \times p_i^{NC}.$$

The decision maker can choose different weights in accordance with the goal of the organization, and finally determine which provider, and associated minimum cost plans, is optimal for an organization.

As shown in Table 3, A outperforms the rest of the providers when the cost weight is less than 46% while D is the best choice for higher cost weightings.

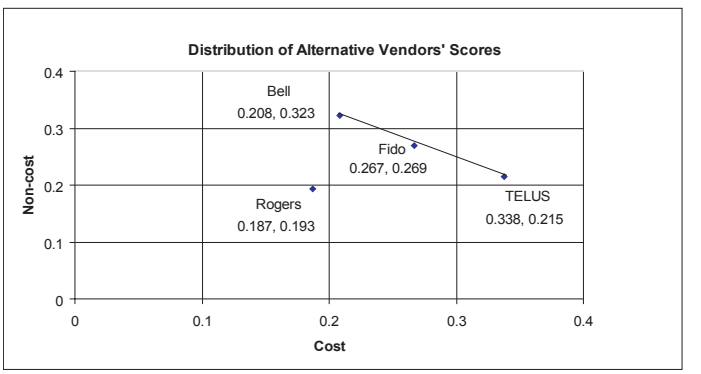
Figure 2 provides a graphical view showing that only A or D can be the optimal solution.

Table 3. Aggregate relative priorities of providers for different cost and non-cost weights

Cost Weight (w_1)	A	B	C	D
0%	**0.323**	0.269	0.193	0.215
10%	**0.312**	0.269	0.192	0.227
20%	**0.300**	0.269	0.192	0.240
30%	**0.289**	0.268	0.191	0.252
40%	**0.277**	0.268	0.191	0.264
46%	**0.270**	0.268	0.190	**0.272**
50%	0.266	0.268	0.190	**0.277**
60%	0.254	0.268	0.189	**0.289**
70%	0.243	0.268	0.189	**0.301**
80%	0.231	0.267	0.188	**0.313**
90%	0.220	0.267	0.188	**0.326**
100%	0.208	0.267	0.187	**0.338**

Note. $w_1 + w_2 = 1$ (w_2 is non-cost weight)

Figure 2. Providers' relative priorities with respect to cost and non-cost factors



CONCLUSIONS

Selection of cell phone service providers can be solved as multi-criteria problem involving both quantitative and qualitative factors. An integrated DSS was constructed to help organizations select the best cell phone provider(s). The method is a significant improvement compared with existing methods that are cost-oriented only. Both the literature review and the results of the survey indicate that several non-cost criteria play important roles in determining the optimal cell phone service provider. Signal coverage was considered most critical, and this may be particularly important to organizations that not only serve the city they are in but also a large surrounding rural area.

The AHP-based analysis of potential providers makes it possible to include multiple non-cost criteria. The factors relevant to the cell phone provider selection can be manipulated in accordance with the user's preferences. Moreover, not only are non-cost factors included but the results of the analysis can be used to demonstrate how and why these factors are influencing a decision.

REFERENCES

Allianceone. (2006). Raising the Bar. Retrieved January 1st, 2006, from http://www.allianceone.ca/media/pdf/AO_whtpaper7.pdf

Cummings, D., & Smith, K. (2005). Can you hear us now? A report on how the cell phone industry has failed consumers. Retrieved January 1st, 2006, from http://masspirg.org/reports/cellphonereport.pdf

CWTA. (2006). Wireless Facts & Figures. Retrieved May 1st, 2006, from http://www.cwta.ca/CWTASite/english/industryfacts.html

Mao, E., Srite, M., Thatcher, J. B., & Yaprak, O. (2005). A research model for mobile phone service behaviors: Empirical validation in the U.S. and Turkey. *Journal of Global Information Technology Management, 8*(4), 7-29.

Navarro, P. (2005). Cell phone roulette and "consumer interactive" quality. *Journal of Policy Analysis and Management, 24*(2), 435-441.

Saaty, T. L. (1980). *The Analytic Hierarchy Process.* New York: McGraw-Hill.

Saaty, T. L. (1990). How to make a decision: The analytic hierarchy process. *European Journal of Operational Research, 48*(1), 9-26.

Sarker, R., & Zahir, S. (2006). A supply chain expansion plan: Prioritizing the optimal scenarios. *Proceedings of the ASAC Annual Conference.* Banff, Alberta, Canada.

Sprague, R. H., Jr. (1980). A framework for the development of decision support systems. *MIS Quarterly, 4*(4), 1-26.

Taubert, W. H. (1968). A search decision rule for the aggregate scheduling problem. *Management Science, 14*(6), B343-359.

Totten, J. W., Lipscomb, T. J., Cook, R. A., & Lesch, W. (2005). General patterns of cell phone usage among college students: A four-state study. *Services Marketing Quarterly, 26*(3), 13-28.

Vaidya, O. S., & Kumar, S. (2006). Analytic hierarchy process: An overview of applications. *European Journal of Operational Research, 169*(1), 1-29.

Vargas, L. G. (1990). An overview of the analytic hierarchy process and its applications. *European Journal of Operational Research, 48*(1), 2-8.

Woo, K., & Fock, H. K. Y. (1999). Customer satisfaction in the Hong Kong mobile phone industry. *Service Industries Journal, 19*(3), 162-174.

Utility Computing and Its Applications

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ABSTRACT

Utility Computing (UC) is an on demand delivery of enterprise applications and business process in a shared, secured and scalable standards based environment over the Internet. Though many service oriented architectures have failed before to deliver on their promises of remote delivery of IT services, the ubiquitous nature of computing which is now present is the motivating factor for computing to be seen in a "Utility model". This paper also elaborates on how we could accommodate such a system using a mobile interface.

1. INTRODUCTION

As service oriented model is becoming more popular Utility Computing (UC) is becoming more acceptable. Many businesses are not aware about the productivity it could increase by using this model. However some business has already adopted this model partly, by using services provided by an external vendor to augment their existing Information Technology (IT) infrastructure.

The problem currently the industry is facing is that there is no established framework about how to adopt these changes strategically for the organization to effectively utilize its IT services. Many organizations are moving away from the current licensing model to use software IT services, provided by an external vendor to suit their specific business needs, and focus on their core business. The chief benefit from moving away from the licensing model gives the company more flexibility in the way it can use the software upon its need not because they have to buy everything what a software vendor pushes the user to buy. Most people would not imagine having a cow in their back yard for a cup of milk. It is easier to go to the super market to buy a specific quantity for consumption. The electricity is another example of how we pay for what we use, and not buy in bulk. Computing has become ubiquitous in nature by which if there was a remote device that could deliver services through a network to any device which could access it could become very popular.

Utility Computing is going to impact on the IT-Infrastructure of any organization and how IT services will be delivered in the future. In most business services are provided by specific components for example to support a Unix application, a UNIX based server has to be installed. These components by themselves may not be compatible with each other leading to data inconsistencies or IT resource duplication. The creation of many independent data centers, all of them running on same hardware and for the most part running similar software has imposed several penalties on many firms[1], which could lead to problems in integration, and compatibility of the software with the hardware are some issues organizations face today. Regular updates are to be made at regular intervals to support the applications organizations use. The update software is not tested for every individual application on board, which may lead to unreliable systems. Such a fragmented system may not provide good use of the existing infrastructure. Though the present systems are profitable in a vendor's perspectives such that the vendor can push the new hardware technology on to the consumers. This leads to Organizations over investing in their IT resources; this trend may not provide sustainable growth in the IT industry.

The advances in the network technology are enabling it to extend and reach out to other business across the supply chain and in many instances, directly to the consumer [2]. According to the recent Gartner study, the Application Service Model (ASP) goes beyond savings on technology, and includes savings associated with hiring, and rapid implementation of projects, and the ability to scale up the system and benefits related to business process enhancement [5]. Thus the concept of providing IT resources from a remote location is becoming more acceptable. Early forms of UC are already happening as some companies have outsourced their backup and recovery process to corporations like IBM and HP. These remote data centers could be maintained remotely by expert organizations that have the skills and resources to be able to look after stored corporate data. This is now becoming very acceptable; this demonstrates that very complicated network intensive applications like backup of data could be implemented using the Utility model.

2. ADOPTION OF UTILITY COMPUTING BY ORGANISATIONS

Organizations are actively investigating cost of effective alternatives such as IT outsourcing and the use of application services delivered over the Internet by external providers. Utility computing is software on demand service and is likely to have a major impact by providing IT solutions to the end user organizations.

It could be debated about how such a model could be established using an existing IT infrastructure and study the impact of Utility computing architecture in many small to medium organizations. I have chosen a mobile architecture, because it can easily demonstrate the ubiquitous nature of today's computing environment.

It could support my argument for adopting UC in a grand scale by enhancing specific hardware and software technologies. Most mobile devices like mobile phones are able to access the Internet remotely and use many day-to-day applications remotely through the device, usually a mobile phone.

IT vendors are eager to establish partnerships with the organizations to deliver service-oriented model such as the UC model to deliver IT services. Delivery of such services is possible because of the advancement of Internet technologies like broadband i.e. 3g network from Telstra and dedicated VPN. The granularity of the service depends on which model is being adopted. Application Service Model " ASM " provides applications to organizations remotely. The "Business Process outsourcing model" is responsible for providing parts of the IT services remotely.

The impact on productivity is limited by the amount of expert resources required to configure, install and operate enterprise applications and the fast rate of technology change, which require periodic maintenance. [4] From the service consumers point of view it is a challenge how to integrate different services provided by multiple organizations, another issue is what architecture model to follow to allow such an integrated scalable of IT services customized to different users in the same organization. One could only imagine the complications in customizing applications remotely to serve one particular person in an organization. It is also debatable on what architecture to be followed in order for business to use Utility Computing model.

As most current available software has proprietary architectures it makes it difficult to integrate with other applications. In order to provide interoperability among applications, it is vital to allow different applications to share date and business process. The question then is how to adopt an architecture which addresses the needs from a end user perspective and how to make them compatible with the clients view of effectively managing IT resources which needs to be addressed.

An attempt is made by me to integrate a mobile architecture to suit the Utility model.

3. UNIQUE MOBILE ARCHITECTURE TO SUPPORT UTILITY COMPUTING

Mobile computing is becoming popular because it provides data and voice access remotely. A mobile device needs to interact with several heterogeneous components in order to fulfill its task. XML standards exist to make data non-platform specific. For example the World Wide Web can serve as a best resource in locating the best price for any product. It is very difficult to catalog and send contents in the public domain, in order to provide a semantic access to the data. However agents

independent of the browser application do the task of locating the best price for a product. The problem quickly becomes multifaceted when a combination of contents and catalogs has to be transmitted and received from various sources from the web in order to provide dynamic access to the data.

Here we can clearly see that the UC based applications are only feasible if many different heterogeneous entities cooperate with each other as a federated system.

The Utility approach could bring about a scalable implementation maximizing its use of hardware and software resources. The current ongoing development of SOAP (Simple Object Access Protocol), WSDL (Web Service Description language) and others promises to provide substantial advantages to problems in software integration [6].

However in order to support multiple data sources which can deliver customized information to many end users using a utility model requires a semantic integration of data sources. However Semantic Web has much broader implications upon data access. The semantic solution is to provide descriptions of information on the Web to allow, "Machine understanding" of information. This could allow intelligent agents to automate many information-processing tasks [7]. This also enables dynamic service discovery and composition for a Utility Based Model (UBM). Therefore the service provider is transparent to the end user.

An optimal infrastructure to best suite the Utility Computing paradigm is a server which has integrated components such as a Web Server, a business logic layer and a database to support Ansi Sql query standards. This database could be used to facilitate storage and retrieval of large files with media content. (Unstructured data) In addition to the existing layers an added layer which could support semantic data integration which can communicate with the mobile device is ideal to generate personalized content remotely from an integrated server approach to support Utility Computing model.

CONCLUSION

Utility Computing is a new paradigm shift in the way computing could be done in the future. As computing is becoming ubiquitous in nature, soon people would see that there is no rational in adding more hardware to increase productivity. The advancement in network infrastructure and the power of the internet are the impetus for developing a model, which treats computing power as a form of utility, such that an organization can pay only for what it uses, and not what the vendor wants to sell. Organizations like IBM would become powerhouses which would enable smooth and efficient use hardware technology and provide scalable IT-Services to its end users.

REFERENCES

1) N.G Carr, "Does IT matter? Information Technology and the corrosion of competitive advantage " (Boston: Harvard Business School Press, 2004)
2) "The Utility Business Model and the Future of Computing Services," IBM Systems Journal 43, no.1(2004):32-42
3) N.G Carr, " The end of Corporate Computing", MITSloan Management Review Vol 46 NO3 SPRING 2005.
4) Feuerlicht G. and Vorisek J Impact of the service model of delivering enterprise applications over the Internet, International Journal of Information Technology and Management, Volume 3, No 2/3/4, 2004 pages 292-302 ISSN 1461-4111.
5) Smy Mizoras (2002) The financial returns of Software as a Service: Oracle E-business Suite Outsourcing, IDC White paper, March 2002. (http://www.oracle.com.outsourcing/collateral/.)
6) J.Hendler and D.NcGuiness," The DARPA Agent Markup Language" IEEE Intelliegnt systems, vol 15 no 6 Nov/Dec 2000 pp 72-73
7) J. Hendler, " Agents and Semantic Web". Intelligent systems vol16 no2.

Multimedia and Virtual Reality Technologies in Architecture Education

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ABSTRACT

The evolution of multimedia and Virtual Reality (VR) technologies can open new educational opportunities in architecture education. This paper describes an example in this educational field.

Keywords: Hypertext, Multimedia, Hypermedia, Virtual Reality, Education, Architecture.

1. INTRODUCTION

Multimedia is the use of several different media (e.g. text, graphics, animation, audio, video, and interactivity) to convey information. With increases in performance and decreases in price of the hardware, multimedia is now commonplace. Therefore, this technology could offer new opportunities in educational environment, for example integrating different media in the teaching path.

Virtual Reality (VR) is another technology which could have great potential in the school of the next future. It is an environment that is simulated by a computer. The origin of the term "virtual reality" is uncertain though. It has been credited to *The Judas Mandala*, a 1982 novel by Damien Broderick where the context of use is somewhat different from that defined now. As a medium, VR has three defining characteristics [1]. It is interactive (users can interactive with models), spatial (models are represented in three spatial dimensions), and real-time (feedback from actions is given without noticeable pause). VR can be classified according to its methods of display; we have immersive VR (which involves a high degree of interactivity and high cost peripheral devices, for example the head mounted displays), and non-immersive VR in the form of a windows into a virtual world displayed on a computer's monitor [2]. A virtual reality system has the following three primary requirements [3]: immersion (which permits to the user the physical involvement, capturing exclusive visual attention and responding to three-dimensional input. For example, through a head-tracker, 3D mouse, data glove, or fully instrumented body suit); interaction (through the three-dimensional control device to "navigate" in the virtual environment); and visual realism (which is a representation of the virtual world using computer graphics techniques). This paper describes an application of multimedia and virtual reality in a faculty of architecture, where these technologies are used in the teaching paths in different courses.

2. MULTIMEDIA AND VIRTUAL REALITY IN ARCHITECTURE EDUCATION

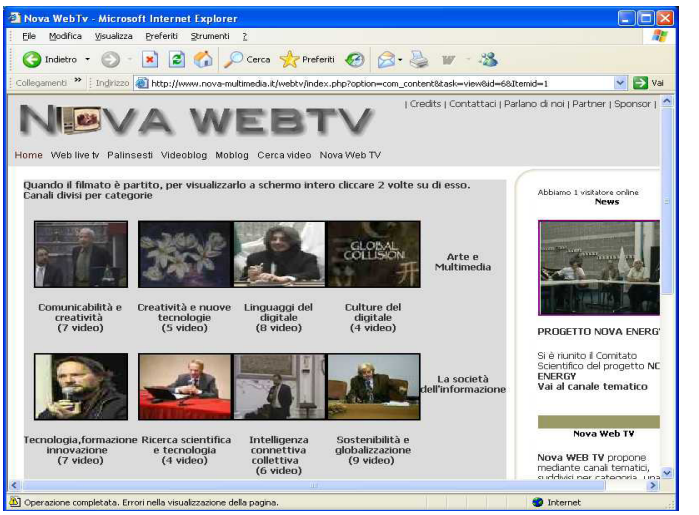
Multimedia are modifying the ways in which we share information. In particular, it is affecting methods of teaching and learning [4, 5]. We analysed the teaching impact of multimedia technologies in a faculty of architecture, in particular in two courses: one of mathematics and the other dedicated to the computer science. The investigations followed the question: "How to organize some academic courses using multimedia solutions and virtual objects integrated in the teaching path?" To answer it, two courses, specifically conceived for the Faculty of Architecture at University of Lugano (Mendrisio, Switzerland), have been organized starting from 2000 [6]. In these courses, the traditional lectures were integrated by the use multimedia as a teaching strategy. First course, named "Mathematical thought", was inserted in the first year of the studies until 2004 (5 credits ECTS, European Credit Transfer and Accumulation System). It introduced basic facets of mathematical thought connected to the arts and to the architecture (e.g., the symmetry, the proportions, the golden ratio, the curves and the surfaces, the fractal geometry and the complexity in the study of the urban grown). The second course, named "New media for the architecture" (third year, 5 credits ECTS), is actually in the curriculum of the faculty. This course proposes how new media and the graphics solutions can create new architectural shapes, for example hypersurfaces, and a new kind of architecture (for example, cyberarchitecture transarchitecture, and hyperarchitecture).

The traditional lectures were integrated by the use multimedia, because 60% of students today are visual learners [7, 8]. This category of learners may benefit most from multimedia presentations, which combine words with pictures and audio can help to redefine the teaching methods [4, 7, 9].

The lectures were organized using hypertexts and multimedia presentations, didactic CD-ROM, animations in Java language, scientific documentaries, data streaming, dedicated to the information and communication technologies. Figure 1 shows the home page of Nova Web TV (http://www.nova-multimedia.it/webtv/) that is a section of the portal Nova Multimedia (http//www.nova-multimedia.it), which collects interviews, "media book", and scientific data streaming dedicated to the connections between arts, new media and computer science. "Media Book", available on line in pdf format, collects the theoretic contributes of famous contemporary scientists coming from the international academic and scientific panorama. We used some interesting "media book" and the interviews, present in the section Nova Web TV, integrating their in the teaching path. The lecture hall was provided with the technological structures which was allowing to use different media in the lessons. Their contents were integrated in the teaching path.

Other technological tool integrated in the teaching path was the Virtual Reality (VR). In recent years, VR has emerged as a revolutionary human/computer interface, challenging everything to which individuals are accustomed. Research institutes around the world have demonstrated the potential of VR systems as a visualization tool and, as technology continues to improve, it is proposed that VR systems will become increasingly pervasive as tools for education [10, 11]. Thus, inside our educational environment, the virtual reality have been used in two ways. One is to insert this technology in the process of teaching. For example, to

Figure 1. Home page of Nova Web TV (http://www.nova-multimedia.it/webtv/)



explain the 3D surfaces some 3D virtual objects have been created, using VRML (Virtual Reality Modelling Language). The virtual objects can be observed in the theoretical lessons and it is possible interact with their during the laboratory activities [6]. The students manipulated the polyhedrons, observing them from different points of view. They also analysed the connection between virtual polyhedrons, the nature and the architecture (for instance, looking for an analogy between the polyhedron forms, the forms of Radiolaria, a kind of protozoa, and the geodesic domes). They studied the crystals' shapes and their symmetry, with virtual crystal created using VRML, and they came in virtual buildings to observe their geometrical components and their analogy with natural shapes.

Second way is to integrate virtual reality in the design process, for example to realize virtual models of buildings. It has been developed in the laboratory activities of the course of "New media for the architecture", where the students use the virtual reality technology, and they present their architectural projects using hypermedia presentations and "virtual tours" inside them. This educational approach is begun in 2001 and it continues everything today. During these five years, the students evaluated the teaching process through multiple choices tests. During the exams, we evaluated the quality of the teaching method analysing the students' school profit. Important deductive considerations are shown.

In brief:

1. multimedia assists the teaching process (in fact, different communication codes in a lecture make more incisive the explanation);
2. the lectures are now more interactive (for example, in the laboratory activities the students can create virtual objects and they can navigate in didactic hypermedia); and
3. the students got good grades in the exams.

Some of the possible benefits of VR on the design process and practice of architecture could be:

- the ability to test ideas in "real time" in a "three-dimensional" space during the design process;
- communication of ideas, and the power to illustrate the projects;
- the elimination of much of the guesswork in design;
- braver and better designs; and
- the integration of the design process.

These deductive considerations are in agreement with recent studies which have recognized that virtual reality offers benefits, and it can support the education and the design project [1, 10, 11, 12, 13, 14, 15]. In particular, in the faculties of architecture where the design is affected by the medium used [1, 16]. Henderson (1999) notes that: "Young designers trained on graphics software are developing a new visual culture tied to computer-graphics practise, that will influence the way they see and will be different from the visual culture of the paper world" [17, p. 57]. Architects who have grown up with digital media and virtual reality will be expert users of interactive, spatial, real-time environments [1, 18]. These designers will solve problems using representations that do not emulate paper-based media.

3. CONCLUSIONS AND FUTURE TRENDS

Educators and researchers look for more efficient ways of teaching and learning. Furthermore, it is proposed that different media assists in the teaching processes. Kozma (1991) argues that media which promotes cognitively relevant characteristics such as symbol systems and processing capabilities, enables students to process information more effectively and understand it more fully [4]. Bagui (1998) has observed that, because multimedia allows guided discovery, students involvement in learning is increased, understanding is greater, and the intrinsic features of the computer (e.g., immediate feedback, animation, and individualization) are more likely to motivate students to learn [19].

We are proposing that multimedia and virtual reality can assist the teaching process, in agreement with other researchers [4, 12, 13, 14, 15, 19, 20, 21, 22]. Therefore, all subjects of our courses have been organized implementing multimedia solutions [6, 23]. In fact, the use of multimedia technologies in the traditional lectures have promoted the following pedagogies including:

- an in depth study of the platonic solids
- application of the perspective
- to observe the fractal forms
- to manipulate some virtual object in 3D (e.g, virtual geodesic domes, or virtual crystals).

We observed that the hypertexts facilitate human learning. Recent researches show that a more tree-like or hierarchical text structure limits navigational difficulties as compared to a purely heterarchical structure [21, 22]. During the laboratory activities we noted that in the students' navigation in hypertext some students can only interact with pages passively, by reading and clinking the links. For this reason, it is important that in the laboratory activities the presence of the professorial assistants, it is important because their facilitation can illustrate the correct and active navigation inside the document organized as hypertext [23].

In order to effectively apply VR as an educational tool in architecture, and in other technical areas, a number of simulation difficulties have to be identified and solved. For example, to maintain high frame rates on personal computers and the low resolution of inexpensive viewing devices. One of the main aims of VR is to create virtual worlds and virtual environments in which humans can interact together. The problem of the interaction with other users and with virtual objects will raise in the next future. The realism presumably will play a major role in the programs' success and likely will prove positive in the future. How to create the virtual worlds? Some virtual worlds will be oriented certainly to the educational field and other for training, works or fun. Architects will potentially help to make the virtual world a pleasant and stimulating place to work and live in, with a good quality of life. This will require people who understand the psychological effects of the spaces, generated by the computer, on people inside them, and the architects have to prepare themselves to this new work opportunity. Architects as designers of Virtual Worlds will be required to make these environments interesting, rich, and engaging places. Therefore, it is important to prepare a correct training on the use of VR in the faculties of architecture [1, 16, 24]. Some architectural theorists are looking at VR as such an inhabitable alternative reality. Whyte (2002) affirms: "they describe objects in interactive, spatial, real-time media as though they existed in a new form of space, rather than in spatial representations and look at Novak (1996) terms the vitality of architecture after territory" [1, p. 46]. VR is also connected to the cyberspace. Novak argues that: "Cyberspace as a whole, and networked virtual environments in particular, allow us to not only theorize about potential architectures informed by the best of current thought, but to actually construct such spaces for human inhabitation in a completely new kind of public realm" [25]. For the architectural education, virtual reality will become the place to go to do things that you could not normally do in architect-designed buildings.

The educational approach presented is only a small step towards locating a correct fit, or the integration between new media, and traditional media in the teaching process [26]. It also uses Virtual Reality. As such it can promote more interesting and interactive the lessons, instead of the traditional educational methods [26]. It is also proposed that this approach will accommodate different learning styles, favouring the visual learners. This paper is a set of suggestions emerging from our teaching activities. With them we hope to give an aid to the teachers that want to use multimedia and virtual reality technology in their work.

4. REFERENCES

1. Whyte, J., *Virtual Reality and the Built Environment*, Architectural Press, Oxford, 2002.
2. Earnshaw, E., Chilton, N. and Palmer, I., Visualization and virtual reality on the Internet, W.R. Earnshaw, and J. Vince (eds), *The Internet in 3D Information, images and interaction,* Academic Press, San Diego, 1997, pp. 203-222.
3. Rosemblum, L.J., and Cross, R.A., The Challenge of Virtual Reality, Earnshaw, W.R., Vince, J., and Jones H. (eds.) *Visualization & Modeling*, Academic Press, San Diego, 1997, pp. 325-399.
4. Kozma, R.B., Learning With Media, *Review of Educational Research*, Summer 1991, vol. 61, 2, pp. 179 - 211.
5. Sala, N., Multimedia Technologies In Educational Processes: Some Examples, A. Karmouch (Ed.), *Multimedia Modeling MMM 99*, World Scientific, Singapore, 1999, pp. 489 - 506.
6. Sala, N., The role of new technologies to support the teaching and the learning of mathematics, *Int. J. Continuing Engineering Education and Lifelong Learnin*g, Vol. 13, Nos. 3/4, 2003, pp. 303-317.
7. McCormick, S., The case for visual media in learning. *Syllabus*, 1999, pp. 4-6.

8. McKay, E., and Garner, B., The complexities of visual learning: Measuring cognitive skills performance, *ICCE'99 (7th International Conference on Computer in Education) Advanced Research in Computers and Communications in Education: New Human Abilities for the Networked Society*, vol. 1, Chiba, Japan, G. Cumming, T. Okamoto & L. Gomez (Eds.), 4-7 November 1999, pp. 208-215.
9. Luebke, S.M., Mason, H. A., and Rebelsky, S.A., Annotating the World Wide Web. *Proceedings World Conference on World Conference on Educational Multimedia, Hypermedia & Educational Telecommunications ED-MEDIA 99,* Seattle, Washington, USA, 1999, pp.409 - 414.
10. Brown, J. Visualization and Scientific Applications. In Earnshaw R., Vince J., Jones H., *Visualization and Modeling*, Academic Press, London, 1997, pp. 1 – 11.
11. Youngblut, C., *Educational Uses of Virtual Reality Technology.* Institute for Defence Analyses, IDA Document D-2128, 1998, http://www.hitl.washington.edu/scivw/youngblut-edvr/D2128.pdf
12. Ainge, D, Introducing Primary Students to VR with Do 3D, *VR in the Schools* [Online], 4(3), 2000. Retrieved 6 June, 2001 from http://www.coe.ecu.edu/vr/vrits/4-3Ainge.htm
13. Mantovani, F., VR learning: potential and challenges for the use of 3D environments in education and training, G. Riva (eds.), *Towards CyberPsycology: mind, cognition and society in the Internet age* (vol. 2), Amsterdam: IOS Press, 2001, pp. 207-225.
14. Gerval, J.P., Popovici, M., Ramdani, M., El Kalai, O., Boskoff, V., and Tisseau, J., Virtual Environments for Children, *Proceedings International Conference on Computers and Advanced Technology Education (CATE),* Cancun, Mexico, 2002, pp. 416-420.
15. Shin, Y.S., Virtual Experiment Environment's Design for Science Education, *International Journal of Distance Education Technologies*, Vol. 2, N. 2, 2004, pp. 62-76.
16. Sala, N., and Sala, M., Virtual Reality in Education, Carbonara D. (eds.), *Technology Literacy Applications in Learning Environments*, Idea Group Inc., Hershey, PA, 2005, pp. 358-367.
17. Henderson, K., *On Line and On Paper: visual representations, visual culture and computer graphics in design engineering*, MIT Press, 1999.
18. Prestinenza Puglisi, L., *HyperArchitecture Spaces in the Electronic Age*, Birkhäuser, Basel, 1999.
19. Bagui, S., Reason for increased learning using multimedia. *Journal of Educational Multimedia and Hypermedia,* 7(1), 1998, pp. 3 – 18.
20. Maye, R.E., Multimedia learning: Are we asking the right questions? *Educational Psychologist,* 32, 1997, pp. 1 – 19.
21. Girill, T.R., and Luk, C. H., Hierarchical search support for hypertext on-line documentation. *International Journal of Man-Machine Studies,* 36, 1992, pp. 571 – 585.
22. Linn, C. , and Davidson-Shivers, G., Effects of linking structure and cognitive style on students' performance and attitude in a computer-based hypertext environment. *Journal of Educational Computer Research,* 15, 1996, pp. 317 – 329.
23. Sala, N., Teaching Mathematics Using New Media. *Proceedings CIEAEM53: Mathematical Literacy in the Digital Era,* Ghisetti e Corvi Editori, Verbania, Italy, 2001, pp. 56 – 63.
24. Sala, N., Multimedia and Virtual Reality in Architecture and Engineering Education, *Proceedings of the 2nd WSEAS/IASME International Conference on Educational Technologies,* Bucharest, Romania, October 16-17, 2006, pp. 18-23
25. Novak, M., *Transmitting architecture: the transphysical city*, 1996, Retrieved 27 January 2006 from http://www.ctheory.net/text_file.asp?pick=76
26. Sala, N. "Le nuove tecnologie nella didattica e nella formazione/aggiornamento dei docenti di matematica", *Matematica e scuola: facciamo il punto*, Ghisetti e Corvi Editori, Milano, Italy, 200, pp. 55- 60, (Italian version).

Structuring the Market for E-Collaboration Systems: A Study Based on Cluster Analysis

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ABSTRACT

Software systems for supporting communication, coordination and cooperation processes in groups have become the backbone infrastructure to support knowledge work in a globalized economy where virtual work has become the prevalent modus operandi. Fuelled by recent technology trends numerous new E-Collaboration systems have appeared in the marketplace. In this paper a study that aims to shed light on the market for E-Collaboration systems is presented. A sample of 66 E-Collaboration systems was characterized in terms of their feature sets using a classification approach. Cluster analysis was used to uncover patterns in the resulting data. Four systems classes and a range of sub classes were identified each of which is briefly described. The results, being a reflection of the existing market complexity, should be equally helpful for researchers who deal with E-Collaboration systems as their objects of interest, as well as for business executives, who need to gather information to support buying decisions.

INTRODUCTION

E-Collaboration systems are an increasingly important class of information systems. For many people work arrangements with colleagues from different companies in spatially distributed teams have become the new reality in contemporary organizations (Bélanger *et al.*, 2003). Increasingly, virtual teams are used to organize knowledge-intensive work in projects where the best experts are distributed across the globe (Lavin Colky *et al.*, 2002). Consequently, E-Collaboration systems have become a key technology and indispensable infrastructure for many enterprises. Fueled by recent trends such as the emergence of new communication media numerous new E-Collaboration systems have appeared in the marketplace. Hence today, an almost incomprehensible number of systems exists that often support a wide range of features.

In this paper a study is presented that aims to shed light on this market by structuring the range of available systems in meaningful classes. Such a classification is equally desirable from a management point-of-view having to deal with the selection of systems, as well as for researchers who focus on E-Collaboration systems as their objects of interest. Researching the application and the impact of E-Collaboration systems on individuals and organizations is only possible, if one has a good understanding for the typical features of these systems and available alternatives.

SYSTEMS CLASSIFICATION AND CLUSTER ANALYSIS

Previous attempts to the classification of E-Collaboration systems were mainly conceptual and based on single features; systems were divided in classes such as E-Mail, Conferencing, Calendars and the like (e.g. Munkvold, 2003). Today, most E-Collaboration systems would fall in two or more of these categories. With the diversification and the expansion of the available range of features such a classification seems no longer suitable. Rather, this study follows an empirical approach that explores systems classes in the marketplace by means of cluster analysis. Only those systems were included in the study that support direct inter-personal interactions in terms of group communication, coordination, and collaboration. According to this definition no systems were considered that only support human-computer or computer-to-computer interactions like electronic data interchange (EDI) applications.

An initial Internet search resulted in a list of 212 software systems that comply with this definition. Based on a catalogue of classification criteria a sample of 66 systems was classified[1]; the sample was made up of all systems about which enough information was available on the Internet to carry out the classification. The resulting sample turned out to be quite diverse so that it provides a good representation of the entire market.

Classification Criteria

Since the aim of our study was to distinguish systems from a user perspective and in regards to the support of E-Collaboration processes and not their technical background, characteristics like systems architecture were not considered.

Table 1. Catalogue of classification criteria

Group process	Communication			Coordination			Collaboration		
Types of communication	Text			Audio			Video		
	synch.	asynch.		synch.	asynch.		synch.	asynch.	
Shared resources and features	Discussion forum	Black board		Document spaces	Surveys		Online presentation	Application sharing	
	Address book	Group calender		Task list	Project plan		Resource management	Project controlling	
	Document distribution list		Workflow			Protocol			Whiteboard
System use	Continuous					Situational			
Role for group	Primary					Secondary			
Awareness	Informal Awareness		Group structural Awareness			Social Awareness			Workspace Awareness

The following list gives a brief introduction of the classification criteria; table 1 provides a detailed summary[2]:

- *Group processes supported by the system*: Group processes can be distinguished according to their level of interdependency: Communication describes the process of inter-personal information exchange by means of various types of media. Coordination refers to aligning group activities in regards to joint activities, and collaboration describes the joint work on shared objects where people are jointly responsible for the outcome.
- *Types of communication*: Communication can take different forms and be distinguished by media type and temporal distribution. Depending on temporal distribution the three media types *text*, *audio,* and *video* can be differentiated in synchronous and asynchronous communication.
- *Shared resources and features*: Besides access to communication media most E-Collaboration systems provide a range of shared resources or features that support group processes such as electronic forums, blackboards, document spaces, application sharing facilities, group calendars, project plans etc.
- *Typical use of system*: E-Collaboration systems can further be distinguished by their typical use within the group, whether they are typically used continuously in a day-to-day fashion to support ongoing activities or whether the system is used only situational to support a specific activity.
- *Role for the group*: Systems that provide functions for the support of basic group processes are regarded as primary systems; they support the group members with all essential functions like for example e-mail communication or calendar functionality. Secondary systems provide additional functions that complement primary systems.
- *Awareness features supporting shared perceptions*: Compared with traditional workplaces distributed collaboration has several deficits in relation to the perception of shared activities (Jang *et al.*, 2000). To this end, E-Collaboration systems offer functionality to create what is called *group awareness* in order to bridge these deficits: „Awareness is an understanding of the activities of others, which provides a context for your own activities" (Dourish and Bellotti, 1992, 117). Four types of awareness can be distinguished (acc. to Greenberg *et al.*, 1996): 1) *Informal awareness* refers to the knowledge of the location and availability of group members. 2) *Group structural awareness* indicates the structural properties of the group. 3) *Social awareness* refers to the perception of others in a shared work environment. 4) *Workspace awareness* describes the knowledge of actions of others in relation to shared documents.

Cluster Analysis

Based on the criteria catalogue a sample of 66 E-Collaboration systems was classified. The resulting data was used to perform a cluster analysis using the statistical software package SPSS in order to uncover patterns of similarity between systems in the data set. A cluster analysis is an explorative analysis that typically involves an iterative process of applying different algorithms and interpreting the results in order to come to a result that is found meaningful with regards to the criteria. In doing so, the *Ward* method was used as the main algorithm with other procedures to corroborate the results. According to Everitt the *Ward* algorithm is a versatile method that in most cases promises interpretable results (1993). The method tends to the formation of clusters that are relatively homogeneous and in most cases signals the correct number of clusters (Everitt, 1993). Euclidean Squared Distance was used as the proximity measure, since it is suitable for binary data and also recommend in combination with the *Ward* algorithm.

A cluster analysis is deemed successful if the researcher, who is familiar with the data, can sensibly interpret the resulting clusters (Everitt, 1993). A good set of clusters shows homogeneous and clearly separable clusters. To identify the clusters dendrograms were used in combination with rearranging the classification matrix according to the set of clusters found in each of the analysis runs.[3] The first turn of applying Ward already delivered a well interpretable and almost satisfactory result. However, the resulting clusters contained some allocations that did not quite fit. It quickly became clear that all wrongly allocated systems where smaller tools that only provided a limited set of features. Hence, a total of 17 systems were separated from the rest of the sample to become the class of "specialized tools". Processing the remaining 49 systems using *Ward* then delivered a clear and unequivocal result. The dendrogram (see appendix A) shows three clearly separated clusters.[4]

RESULTING E-COLLABORATION SYSTEMS CLASSES

According to the cluster results the market for E-Collaboration systems can be divided into four systems classes. Since these classes are still quite large and contain a range of systems further sub classes were identified.[5] In the following, the classes are described using typical characteristics; for details and examples please refer to the resulting classification in appendix B.

Everyday Systems

Everyday systems are continuously used by the group as primary systems to support everyday activities. To this end, the systems provide basic features to support all three group processes - communication, coordination and collaboration. Everyday systems focus on asynchronous text-based communication; all systems offer e-mail as the primary type of communication; most systems also provide discussion forums. Other typical features are calendars, address books, task lists, and document spaces. The only supported form of awareness is workspace awareness in relation to documents in shared spaces. The class holds a total of 23 systems in five sub classes:

- *Client server groupware systems* have a long history in the market. Most systems descend from traditional e-mail systems offering typical functions such as calendars, address books, task lists. These systems are directed at middle sized to large enterprises because of considerable setup costs.
- *Web-based team rooms* follow a different philosophy. Access to the system is provided via an Internet browser. The core idea is to provide a shared online workspace. In addition to the typical features provided by Client server groupware they also provide discussion forums and black boards. The systems are suited for smaller enterprises; some providers offer ad hoc workspaces that can be rented by teams for the duration of a project.
- Although being similar to web-based team rooms in terms of features *Intranet systems* differ in their focus in that they are intended for enterprise-internal use. They supply typical Intranet features such as discussion forums and black boards. In addition, some systems support enterprise-internal processes by providing document distribution lists.
- *Document-oriented systems* have their origin in document management systems. Their main focus is on asynchronous collaboration on shared documents. To this end, the systems support document versioning as well as mechanisms for the structured storage and retrieval of knowledge objects.
- *Real-time systems* are a rather small sub class[6]. Beside the support of asynchronous group processes these systems also provide means of synchronous real time communication via Instant messenger as well as audio and video conferencing. A central feature is the presence information of the team members for the purposes of creating informal awareness.

Coordination Systems

This class comprises 13 systems that focus on group coordination processes. The systems are typically used continuously by the group members albeit as secondary system to complement everyday systems; typically they do not support the most basic group processes such as E-Mail communication. Typical features are document archives, group calendars, task lists, project and resources plans, project controlling, as well as document distribution lists and workflows. Most systems support group structural awareness that gives team members an overview of group structures, roles and competences in order to further support coordination. Three sub classes were identified:

- *Process coordination systems* focus on the planning, modeling, execution, and coordination of processes in teams and organizations. The systems are mainly specialized workflow tools but systems like Actionworks also offer a broader range of resources to support team coordination besides workflow support.
- *Project coordination systems* focus on the project as the main entity. In addition to project planning features, project coordination is further supported by project controlling features (i.e. to capture times and project expenses) and shared calendars, document spaces, and sometimes document distribution lists.
- *Task coordination systems* are used for day-to-day coordination mainly within enterprises, e.g. with the focus on field service coordination. The systems feature shared calendars to coordinate meetings, appointments, or client visits. The systems also offer a rudimentary project support by means of task lists or documents distribution lists.

Table 2. Characteristics of systems classes

Criteria	Everyday systems	Coordination systems	Meeting systems
Group processes	Communication Coordination Collaboration	Coordination Collaboration	Communication Collaboration
Type of communication	Text asynchronous and synchronous	Text asynchronous	Text, Audio, Video synchronous
Shared resources and features	Group calender Address book Task list Document spaces Discussion forum	Group calender, Task list Project plan Ressource management, Project controlling Workflow Dokument spaces	Whiteboard Application sharing Presentations Surveys Protocols Document spaces
Use of syste,	Continuous	Continuous	Situational
Role for the group	Primary	Secondary	Secondary
Awareness	Workspace	Group structural	Informal, social, workspace

Session and Meeting Systems

Meeting systems comprise 13 systems that support online sessions and video conferences; they are used situational and as secondary systems. Online meetings are typically used for decision making or simultaneous work on shared documents. The systems are based on extensive synchronous communication such as audio and video communication. Other typical features are application sharing and whiteboards. Surveys can be administered to support ad hoc decisions and online presentations can be held to conduct online seminars. Awareness is supported to a significant degree in the informal, social, and workspace dimensions. Three sub classes were identified:

- Two of the systems in this class can be described as *Ad hoc meeting systems*. These are smaller tools that allow for the quick and uncomplicated initiation of conferences.
- *Standard meeting systems* offer all functions described above and thus support shared meeting sessions. Sessions and meetings can be planned using a scheduler.
- In addition to the standard features of meeting systems *systems with seminar capabilities* offer services for the planning and realization of online seminars and entire e-learning curricula. These seminars can be given by tutors or be recorded and provided for asynchronous use.

Specialized Tools

This class summarizes the group of 17 systems that only implement limited features to support computer-aided group work. Since this group is quite heterogeneous no common characteristics can be identified that are shared by all systems. Nevertheless, the following sub classes can be described:

- *E-mail systems* provide server functionality that allows enterprises to setup their own e-mail infrastructure.
- *Forum servers* support the setup of discussion forums, text chat or voice conferences. Enterprises can use these systems to open up communication channels for teams in an intranet environment.
- *Social software* describes a novel type of Internet systems that provide new ways of text-based collaboration. Popular examples are Blogs or Wikis. These technologies can be used in teams to facilitate discussions or joint work on text documents.
- *Team calendars* are web-based tools that provide group calendars to coordinate and schedule team meetings and project work.
- *Instant Messaging and A/V chat systems* offer synchronous text, audio and sometimes video communication. These are small software tools that hold a list of contacts (the buddylist), provide presence information, and facilitate the ad hoc initiation of conference calls.
- *Group editors* support concurrent work on text documents. The spectrum reaches from simple text editors to server software that enables the synchronous use of modern office programs.

CONCLUSION AND OUTLOOK

The market study has produced four systems classes and a range of sub classes that provide an overview of the fast growing E-Collaboration market. The systems were characterized using typical features and characteristics. The study provides practitioners with an overview of available systems classes and their respective focus in order to support investment decisions. Researchers who are interested in the development, use, and adoption of E-Collaboration systems can use the typology as guidance to structure their domain and as support in selecting suitable systems as research objects.

While the study illustrates the status quo of the market, two interesting trends emerged from our inquiries that are likely to shape future market developments. First, drawing from recent media reports, it becomes clear that there is a tendency towards integrating richer sets of communication media. This trend is fueled both by the popularity of Instant Messaging as well as voice-over-IP telephony. Today, with *real-time systems* already showing up as a sub class in this study it can be assumed that the trend towards real-time communication (RTC) systems will gain momentum. RTC systems are based on instant synchronous communication and presence awareness information and aim at improving availability and coordination in distributed work processes (Riemer and Frößler, 2006). Second, there is a tendency towards systems integration and convergence. On the one hand, a convergence of different market segments can be observed. A good example is the fusion of the markets for document management systems with traditional groupware; the *document-oriented systems* are a result of this trend. On the other hand, software enterprises like IBM, Microsoft or Oracle pursue strategies of systems integration which creates comprehensive E-Collaboration Suites. IBM for example is at the moment integrating its Workplace suite with its Lotus Domino products in order to create an integrated collaboration infrastructure that features characteristics of more than one of the systems classes described in this study.

Hence, a replication of this study in a few years time is likely to paint a slightly different picture with more synchronous media support and a range of integrated systems likely to show up in the cluster analysis. The proliferation of new types of integrated systems will create new research opportunities for researchers in the E-Collaboration domain.

REFERENCES

Bélanger, F., Watson-Manheim, M.-B. and Jordan, D. H. (2003) Aligning IS Research and Practice: A Research Agenda for Virtual Work, in M. Khosrow-Pour, (ed.), *Advanced Topics in information resources management*, Hershey, PA: Idea Group, pp.1-31.

Dourish, P. and Bellotti, V. (1992) Awareness and Coordination in Shared Workspaces, in *Proceedings of Conference on Computer-Supported Cooperative Work (CSCW'92)*. Toronto, pp.107-114.

Everitt, B. S. (1993) Cluster Analysis (Third Edition), London Melbourne Auckland: Edward Arnold.

Greenberg, S., Gutwin, C. and Cockburn, A. (1996) Using Distortion-Oriented Displays to Support Workspace Awareness, in *Research Report Department of Computer Science/University of Calgary, Nr. 96/581/01*, Calgary.

Jang, C. Y., Steinfield, C. and Pfaff, B. (2000) Supporting Awareness among Virtual Teams in a Web-Based Collaborative System: The TeamSCOPE System, *ACM Siggroup Bulletin 21*(3): 28-34.

Lavin Colky, D., Colky, M. T. and Young III, W. H. (2002) Managing and Developing People in the Virtual Organization, Malabar (Florida): Krieger Publishing.

Munkvold, B. E. (2003) Implementing Collaboration Technologies in Industry, London et al.: Springer.

Riemer, K. and Frößler, F. (2006) Presence-based, Context-sensitive Real-Time Collaboration (RTC) - research directions for a new type of eCollaboration system. in 19th Bled eConference (Slovenia, 5-7 June).

ENDNOTES

[1] The systems classification was carried out by three experts independently. A few deviations arose during the process of classifying; these were discussed and led to a more precise specification of the criteria.

[2] For detailed information on the classification criteria, background information on the study and additional material such as classification tables and dendrograms please visit our web site online at http://collaborate.uni-muenster.de/market-study.

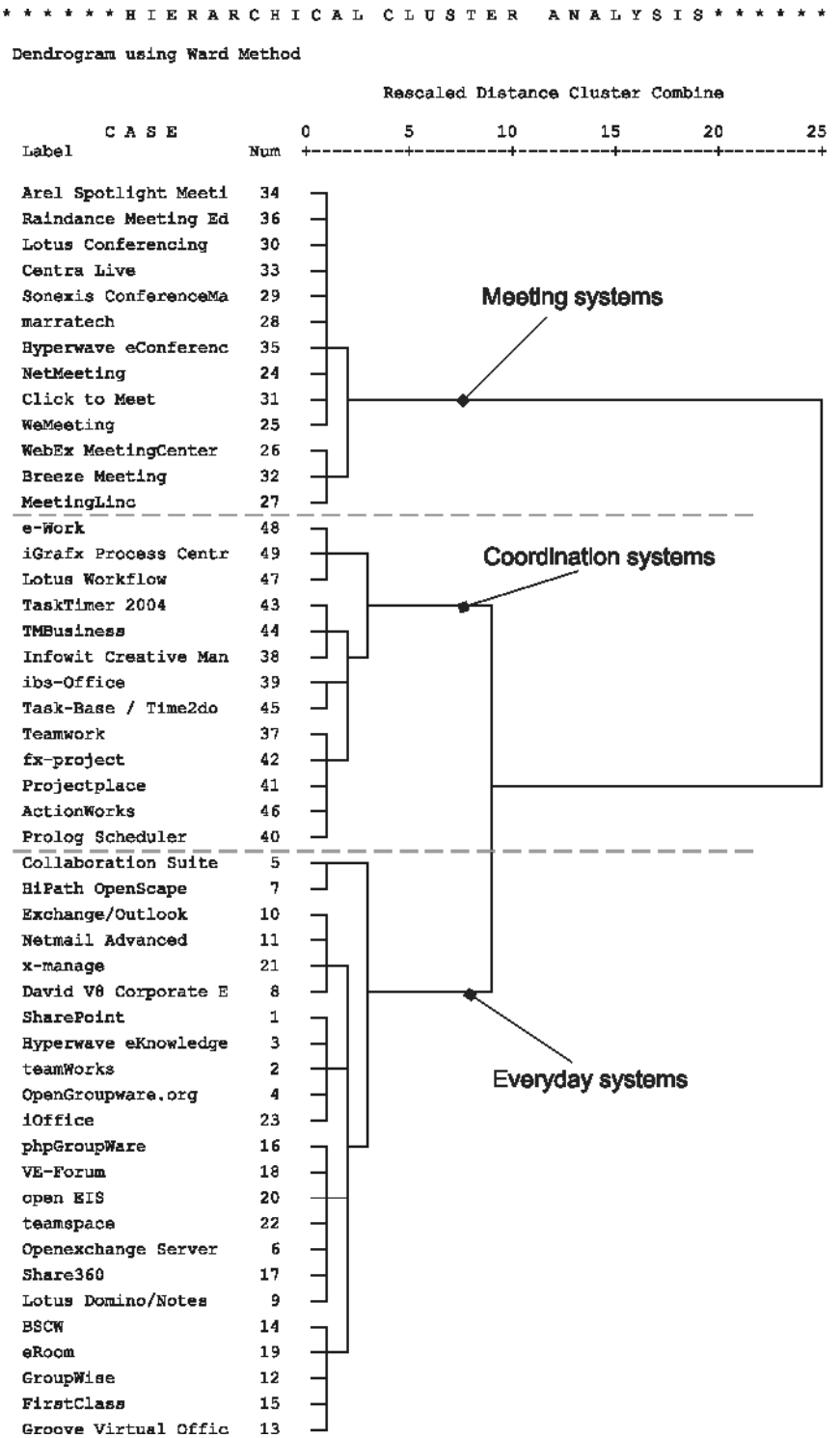
[3] See appendix A for the final dendrogram and appendix B for a rearranged matrix for the final result.

[4] Two more procedures (average linkage and complete linkage) successfully corroborated these results. The resulting dendrograms were omitted due to space restrictions.

[5] Please note that the sub classes are not based on the cluster analysis and do not correspond with the dendrogram shown in appendix A; internally, the three clusters are too homogenous for the algorithms to come up with sensible sub classes. Rather, they were identified by the researchers using the classification criteria as well as other information such as the history and market positioning of the systems.

[6] Oracle Collaboration Suite qualifies both as documents-oriented and a real-time system (see classification in appendix B).

APPENDIX A: DENDROGRAM OF WARD CLUSTERING



APPENDIX B: RESULTING CLASSIFICATION WITH SYSTEMS CLASSES

			Process			Use		Role		Type of comm.						Shared resources and features															Awareness			
			Communication	Coordination	Collaboration	continuous	situational	primary	secondary	Text/synchronuous	Text/asynchronuous	Audio/synchronuous	Audio/asynchronuous	Video/synchronuous	Video/asynchronuous	Discussion forum	Black board	Documnt spaces	Survey	Online presentation	Application sharing	Address book	Group calender	Task list	Project plan	Ressource management	Project controlling	Document distribution	Workflow	Protocol	Whiteboard	Informal Awareness	Group-Structural Aw.	Social Awareness	Workspace Awareness
Everyday systems	Client-Server groupware	Lotus Domino/Notes	x	x	x	x		x		x	x							x				x	x	x									x
		Exchange/Outlook	x	x	x	x		x			x							x				x	x	x									x
		Netmail Advanced	x	x	x	x		x			x							x				x	x	x									x
		Novell GroupWise	x	x	x	x		x		x	x							x				x	x	x							x			x
		Openexchange Server	x	x	x	x		x		x	x					x	x	x				x	x	x										x
		FirstClass	x	x	x	x		x		x	x		x			x		x				x	x	x							x			x
		David V8 Corporate Edition	x	x	x	x		x			x		x					x				x	x	x										
	Doc.-oriented	SharePoint	x	x	x	x		x			x					x		x				x	x	x										x
		Hyperwave eKnowledge Suite	x	x	x	x		x		x	x					x		x				x	x	x										x
		Collaboration Suite (Oracle)	x	x	x	x		x		x	x	x	x	x	x			x			x	x	x	x				x			x	x		x
	Real time	HiPath OpenScape	x	x	x	x		x		x	x	x	x	x	x			x			x	x	x								x	x		x	x
		Groove Virtual Office	x	x	x	x		x		x	x	x				x		x				x	x	x							x	x	x		x
	Web-based teamrooms	OpenGroupware.org	x	x	x	x		x			x						x	x				x	x	x									x		
		BSCW	x	x	x	x		x			x					x		x	x			x	x											x
		phpGroupWare	x	x	x	x		x		x	x					x	x	x	x			x	x	x											
		VE-Forum	x	x	x	x		x		x	x					x	x	x	x			x	x	x							x				
		eRoom	x	x	x	x		x		x	x					x		x	x			x	x	x	x					x					
		x-manage	x	x	x	x		x			x							x				x	x	x											
		teamspace	x	x	x	x		x		x	x					x	x	x	x			x	x	x	x										x
	Intranet systems	teamWorks	x	x	x	x		x			x					x	x	x				x	x	x				x							
		Share360	x	x	x	x		x			x					x	x	x				x	x	x											x
		open EIS	x	x	x	x		x		x	x					x	x	x				x	x	x											x
		iOffice	x	x	x	x		x			x					x	x	x				x	x	x			x	x							x
Meeting systems	Ad hoc	NetMeeting	x		x		x		x	x		x		x							x									x				x
		WeMeeting	x		x		x		x	x	x	x								x	x									x				x
	Standard meeting systems	Sonexis ConferenceManager	x		x		x		x	x		x						x	x	x	x								x	x				x
		WebEx MeetingCenter	x		x		x		x	x	x	x	x	x					x	x	x								x	x				x
		Raindance Meeting Edition	x		x		x		x	x		x		x				x	x	x	x								x	x				x
		Click to Meet	x		x		x		x	x		x		x				x		x	x								x	x				x
		Lotus Conferencing	x		x		x		x	x		x		x				x	x	x	x								x	x				x
		Hyperwave eConferencing Suite	x		x		x		x	x		x		x					x		x								x	x				x
	Systems w/ seminars	MeetingLinc	x		x		x		x	x	x	x	x	x	x				x	x	x									x				x
		marratech	x		x		x		x	x		x		x						x	x								x	x				x
		Breeze Meeting	x		x		x		x	x	x	x	x	x	x			x	x	x	x								x	x				x
		Centra Live	x		x		x		x	x		x		x				x	x	x	x								x	x				x
		Arel Spotlight Meeting	x		x		x		x	x		x		x				x	x	x	x								x	x				x
Coordination systems	Project coordination	Prolog Scheduler		x	x	x			x	x	x					x		x						x	x	x	x	x		x		x		
		Projectplace	x	x	x	x			x		x					x		x				x	x	x	x		x	x				x			
		fx-project		x	x	x			x									x	x			x	x	x	x	x	x					x			
		Teamwork		x	x	x			x		x							x					x	x	x	x	x					x			x
		Infowit Creative Manager		x		x			x		x					x							x	x	x	x	x					x			
	Task coordination	TaskTimer 2004		x		x			x		x											x	x	x		x	x					x			
		TMBusiness		x		x			x		x											x	x	x		x						x			
		Task-Base / Time2do		x		x			x		x							x						x		x		x		x		x			
		ibs-Office		x		x			x		x							x						x			x	x		x		x			
	Process coordination	ActionWorks		x	x	x			x		x					x		x						x	x			x	x			x			x
		Lotus Workflow		x	x	x			x									x										x	x			x			
		e-Work		x		x			x															x					x			x			x
		iGrafx Process Central		x	x	x			x		x							x						x					x			x			x
Dedicated, specialized tools	E-mail	IMail Server	x			x			x		x					x																			
		Sendmail	x			x			x		x																								
	Forum servers	phpBB	x			x			x		x					x			x																
		WebBoard	x			x			x	x	x					x	x	x												x					x
		SiteSticky	x				x		x	x		x																		x	x				
	Social Software	bBlog	x			x			x		x					x																			
		Blogger.com	x			x			x		x					x																			
		MediaWiki			x	x			x		x					x		x																	
	Cals	Wcal		x		x			x		x												x	x											
		Web Calendar		x		x			x		x											x	x	x											
	Instant Messaging & AV chat	Trillian	x			x			x	x	x																				x				
		Skype	x			x			x	x		x	x																	x		x	x		
		Teamspeask	x				x		x	x		x																			x				
		Eyeball Chat	x				x		x	x		x		x	x																x		x		
		Spontania4IM	x				x		x			x		x																	x		x		
	Joint edit	PabloDraw			x		x		x											x															x
		CoOffice			x		x		x											x															x

Quality Aspects in Ontology-Based Information Retrieval

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ABSTRACT

Ontologies are increasingly used in various applications (e.g., semantic interoperability, data integration). One of the reasons is that ontologies are seen as a means to improve qualitative characteristics of applications. In particular, there is an intensive on-going research on ontology-based information retrieval. Typically, ontology usage in information retrieval adds another level of complexity; therefore we propose a holistic method for evaluation of ontology-based information retrieval systems as well as define a set of essential features for ontology-based information retrieval tools.

INTRODUCTION

In this article we investigate the application of ontology to enhance Information Retrieval (IR). Since information quality is critical for organizations, ontologies have been used in a number of information retrieval systems (Aitken & Reid, 2000; Brasethvik, 2004; Ciorascu et al., 2003; Nagypal, 2005; Suomela & Kekalainen, 2005; Vallet et al., 2005) in order to improve their performance.

There are sparse evaluations of ontology-based information retrieval (ObIR) tools (e.g., Aitken & Reid, 2000; Brasethvik, 2004; Suomela & Kekalainen, 2005; Vallet et al., 2005), and they report improvement compared to a traditional IR systems. However, it is not clear whether this improvement is optimal, i.e. how could ontology properties enhance IR.

Furthermore, IR evaluation methods are mainly based on relevance of retrieved information. However, additional sophistication of ObIR tools adds complexity on user interaction to reach improved results. Therefore, standard IR metrics as recall and precision are not feasible to measure user satisfaction because of complexity and effort needed to use the ObIR systems. Furthermore, evaluation methods based on recall and precision do not indicate the causes for variation in different retrieval results (Alemayehu, 2003). There are other factors that influence the performance of ontology-based information retrieval, such as query quality, ontology quality, complexity of user interaction, etc.

We investigate quality aspects essential for improvement of information retrieval. This paper tries to answer two following questions. How can we enhance ObIR performance? How should an ObIR system be evaluated?

Related work comes from several areas. Consequently, in next section we first take a look at ontology-based IR systems and then we proceed with an overview of IR systems and ontology evaluation methods and metrics. Then we discuss essential features of ObIR systems relating these features to users' experience and present a holistic evaluation model for ObIR quality assessment. In last section we conclude the paper and outline future work.

RELATED WORK

First, we summarize ontology-based information retrieval (ObIR) approaches, classifying them according complexity of user interaction. Second, we survey the IR evaluation methods and metrics, pointing out their weakness in analyzing the cause of variation in results. Third, we take a look at ontology evaluation, as ontology plays one of the central roles in ObIR systems.

Ontology-based Information Retrieval

An increasing number of recent information retrieval systems make use of ontologies to help the users clarify their information needs and come up with semantic representations of documents. While general assumption of ObIR is as follows. If a person is interested in information about *B*, its likely that she will find information about *A* interesting, with a condition that *A* and *B* are closely related terms/concepts in the ontology. Then user provided query is expanded by hypernyms (superclasses) or hyponyms (subclasses) or other related concepts (sibling concepts or other neighborhood concepts).

Furthermore, approaches to ontology-based information retrieval can further be categorized according to the complexity of required user interaction: a) simple keywords based entry into text field; b) multi-optional specification of search parameters; c) advance interaction through a specific ontology query language. Approaches belonging to the first category allow user to enter keywords in a simple text field. The provided query is expanded using an ontology without any further interaction from the user (e.g., Ciorascu et al., 2003). The second category of ObIR systems spans more diverse range of approaches. The approaches here require more interaction by the user. Nagypal (2005) uses ontology to disambiguate queries. Simple text search is run on the concepts' labels and users are asked to choose the proper term interpretation. Tomassen and Strasunskas (2006) discuss four abstraction levels of query terms, where users are allowed to specify the granularity of information needed. Other approaches let users to browse the provided ontology and select relevant concepts (e.g., Suomela & Kekalainen, 2005). Approaches in the latter category typically adopt knowledge base approach to interact with the information using reasoning mechanism and ontological query languages (e.g., SPARQL, RDQL, OWL-QL) to retrieve instances. Documents are treated either as instances or are annotated using ontology instances (Ciorascu et al., 2003; Kiryakov et al., 2005; Rocha et al., 2004; Vallet et al., 2005). These approaches require advanced knowledge of ontology query languages and target professional users.

Information Retrieval Evaluation

When evaluating information retrieval systems retrieved information is typically assessed by its relevance or non-relevance to the users' information needs. Then IR systems are compared based on their ability to retrieve and rank relevant information. Evaluation methods in information retrieval are focused on precision and recall metrics (Baeza-Yates & Ribeiro-Neto, 1999). Furthermore, there are a number of other similar metrics derived from the precision and recall metrics such as *novelty*, *coverage*, *the E measure*, *Harmonic mean* (a.k.a. *F – measure*) (Baeza-Yates & Ribeiro-Neto, 1999). Korfhage (1993) discussed *satisfaction* and *frustration* metrics, where satisfaction metric takes into account only relevant documents, while frustration – non relevant documents.

Important information that indicates the causes for variation of different retrieval results remains hidden under the average recall and precision figures (Alemayehu, 2003). Gao et al. (2004) argue that there are other factors than IR system that needs to be considered in the evaluation. These factors are as follows (Gao et al., 2004): indexing and searching methods; difficulty of a searching topic with respect to retrieval; and quality of a query. The detail analysis on how these factors and their interactions affect a retrieval process can help to dramatically improve retrieval methods or processes. In fact, it is widely acknowledged that factors external to an IR system can affect retrieval result significantly and examination of these factors is essential to the improvement of IR systems (Alemayehu, 2003; Gao et al., 2004; Jansen & Pooch, 2001; Kim & Allen, 2002; Zins, 2000).

Ontology Evaluation

The ontology's ability to capture the content of the universe of discourse at the appropriate level of granularity and precision and offer the application understandable correct information are important features that are addressed in many

ontology/model quality frameworks (e.g., Burton-Jones et al., 2005; Gangemi et al., 2005; Lindland et al., 1994; Tartir et al., 2005). Most of them are generic quality evaluation frameworks, which do not take into account ontology applications (i.e. metrics are not defined for task specific usage of ontology). For instance, Ontometric (Lozano-Tello & Gomez-Perez, 2004) methodology defines Reference Ontology that consists of metrics to evaluate ontology, methodology, language and a tool used to develop ontology.

Brak et al. (2004) summarize main perspectives of ontology evaluation. Below we comment applicability of the evaluation perspectives for ontology evaluation in ObIR.

- *Lexical, vocabulary, or data layer*. Checks the vocabulary used to represent concepts. Ontology best fits to a particular domain when its vocabulary corresponds to the vocabulary used by a user and terminology in a document collection.
- *Hierarchical or taxonomical relations vs. other semantic relations*. Some methods evaluate the ratio of IsA relationships and other semantic relationships in ontologies, where the presence of various semantic relationships identifies the richness of an ontology. This perspective is important for ObIR systems, since higher richness (i.e. more diverse relationships) allows better matching of the provided query in a form of triples, which results in better performance.
- *Context and application level*. Here it is evaluated how the results of an application are affected by the use of an ontology. However, in the case of ObIR, adding an ontology into a system changes its architecture and the way of interacting with the system. As well it is difficult to create an experimental environment where no other factors but the ontology influence the performance of the application.
- *Syntactic level*. Since ontologies are created in particular languages, the ontology specification needs to match the required syntax of the language. This ontology quality is a precondition for any ontology usage, including ObIR.
- *Structure, architecture, design*. Ontologies need to meet certain predefined design principles. Parts of a domain may be badly specified therefore the ontology may need maintenance.

Figure 1. Essential features of ObIR systems depending on users' experience

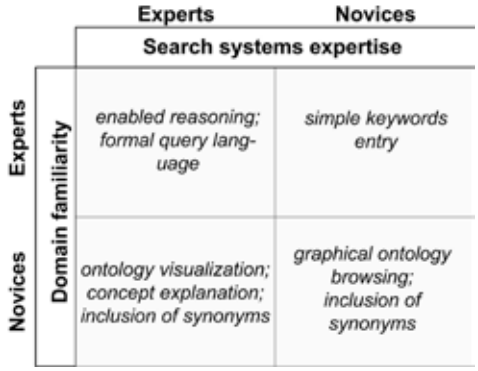
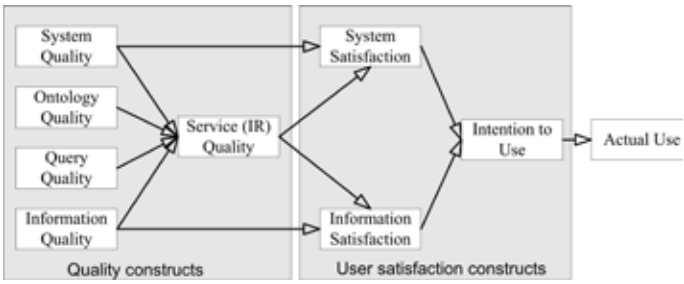


Figure 2. Holistic evaluation model for ontology-based information retrieval system



EVALUATION MODEL FOR ONTOLOGY-BASED INFORMATION RETRIEVAL

An important factor in search is the experience of the users. Expertise in this area is often considered along two dimensions, namely, domain expertise and search expertise (Jenkins et al., 2003). The former subjects are knowledgeable about a particular domain, while the latter have experience in using search engines and tools. Domain experts evaluate search results more closely as well as web search experts investigate results deeply, while search novices use breadth-first search strategy (Jenkins et al., 2003). Surprisingly enough, even the experienced users (computer specialists) are using 3 words on average in query to specify their information needs (Fox et al., 2005), and that seems to be valid for web search in general (Gulla et al., 2002). This important aspect demonstrates a certain need for query expansion by certain means.

Choice of search strategies depends on the level of experience as well as level of sophisticated interaction with ontology-based information retrieval systems (see Figure 1). Evaluation of some ObIR systems indicates that ontology based IR systems perform better for more generic queries (Brasethvik, 2004; Suomela & Kekalainen, 2005). Inexperienced users find ontologies helpful in comprehending domains by familiarizing themselves with the terminology and formulating queries (Brasethvik, 2004; Suomela & Kekalainen, 2005). Therefore, in these cases a graphical visualization of the ontology is a certain quality. In addition, it was found that linguistic enhancements (inclusion of synonyms) close the gap between ontology concepts and documents, and enable ObIR to perform better for queries that are required to find only a small number of documents (Aitken & Reid, 2000; Brasethvik, 2004). Furthermore, inclusion of synonyms facilitates mapping between user's query and ontology concepts (i.e. it eases query processing in ObIR). However, domain experts prefer to specify terms/concepts directly in a search field, instead of browsing an ontology (Suomela & Kekalainen, 2005).

However, the complete quality of the ontology-based information retrieval system needs to be seen as a composition of various qualities, where all these qualities contribute to final user satisfaction. We define a holistic evaluation model for the ontology-based information retrieval systems (see Figure 2). The model is inspired by Technology Acceptance Model (Davis, 1989) - a model for explaining and predicting user acceptance of information technology. The arrows in the figure depict dependency between the model constructs.

The constructs of the holistic ObIR evaluation model are defined as follows. *System Quality* concerns indexing, ranking and user interface implementation qualities. Some value-adding aspects of user interaction with an ObIR system are presented in Figure 1. *Ontology Quality* aspects have been discussed above; though need to be elaborated further and related to a particular ontology usage scenario in an ObIR tool. *Query Quality* really depends on the users' experience in the domain and information seeking per se. Figure 1 deploys ways to help to specify more precise information needs. *Information Quality* is external to an ObIR system, and can be partially compensated by good ranking algorithms. Furthermore, information quality is a research topic itself and for more details the reader is referred, for instance, to Eppler (2006). Quality of these four components directly impacts *Service Quality* that can be measured using traditional (i.e. recall and precision based) methods.

System Satisfaction denotes the degree to which a user perceives the use of a system being effortless. *Information Satisfaction* is the degree to which a user believes that retrieved information would be useful. System and information satisfactions are determined by quality of corresponding components of an ObIR system and a service quality. *Intention to Use* is the degree to which a user intends to use a system and that depends on both, system and information satisfaction. Intention to use determines *Actual Use* that can be observed in longer period of time.

CONCLUSIONS AND FUTURE WORK

In this paper we have focused on quality aspects of ontology-based information retrieval (ObIR). We have argued about added complexity to interaction with information retrieval systems by employing ontologies. Consequently, we have related a set of vital features of ObIR depending on users' experience.

Furthermore, we have argued inadequacy of traditional information retrieval evaluation methods to assess ObIR quality and potential adoption by the users. We have

presented a holistic evaluation model for ObIR tools. We will need to conduct a series of empirical evaluation of ObIR systems in order to test our holistic evaluation model and reconfirm dependencies between constructs defined there.

Ontology quality aspects have been overviewed; though need to be elaborated further, since the value of specific ontology properties depends on the actual use of the ontology in these systems. Therefore, major future work is to define specific application scenarios of ontology in IR and accordingly relate required ontology properties.

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REFERENCES

Aitken, S. & Reid, S. (2000). Evaluation of an Ontology-based Information Retrieval Tool. In A. Gomez-Perez, V.R. Benjamins, N. Guarino, & M. Uschold (Eds.), *Workshop on the Applications of Ontologies and Problem-Solving Methods, ECAI 2000*, Berlin.

Alemayehu, N. (2003). Analysis of Performance Variation Using Query Expansion. *Journal of the American Society for Information Science and Technology* 54(5), 379–391.

Baeza-Yates, R. & Ribeiro-Neto, B. (1999). *Modern Information Retrieval*. Addison Wesley, ACM Press, 1999.

Brak, J., Grobelnik, M. & Mladenic, D. (2005). A survey of ontology evaluation techniques. In *Conference on Data Mining and Data Warehouses (SiKDD 2005)*, Ljubljana, Slovenia.

Brasethvik, T. (2004). *Conceptual modelling for domain specific document description and retrieval- An approach to semantic document modelling*. PhD thesis, IDI, NTNU, Trondheim, Norway.

Burton-Jones, A., Storey, V.C., Sugumaran, V. & Ahluwalia, P. (2005). A Semiotic Metrics Suite for Assessing the Quality of Ontologies. *Data and Knowledge Engineering*, 55(1), 84-102.

Ciorascu, C., Ciorascu, I., & Stoffel, K. (2003). knOWLer - Ontological Support for Information Retrieval Systems. *Proceedings of SIGIR 2003 Conference, Workshop on Semantic Web*, Toronto, Canada.

Davis, F.D. (1989). Perceived usefulness, perceived ease of use and user acceptance of information technology. *MIS Quaterly* 13(3), 319-340.

Eppler, M.J. (2006). *Managing information quality: Increasing the value of information in knowledge-intensive products and processes* (2nd ed.). Springer.

Fox, S., Karnawat, K., Mydland, M., Dumais, S. & White, T. (2005). Evaluating implicit measures to improve web search. *ACM Transactions on Information Systems*, 23(2), 147-168.

Gangemi, A., Catenacci, C., Ciaramita, M., & Lehmann, J. (2005). Ontology evaluation and validation. An integrated formal model for the quality diagnostic task. Technical Report, ISTC-CNR, Trento, Italy, 2005. Retrieved January 3, 2007 from http://www.loa-cnr.it/Files/OntoEval4OntoDev_Final.pdf

Gao, X., Murugesan, S. & Lo, B. (2004). Multi-dimensional Evaluation of Information Retrieval Results. *Proceedings of the IEEE/WIC/ACM International Conference on Web Intelligence* (WI'04). IEEE Computer Society, 192- 198.

Gulla, J.A., Auran, P.G. & Risvik, K.M. (2002). Linguistic Techniques in Large-Scale Search Engines. Fast Search & Transfer.

Jansen, B.J. & Pooch, U. (2001). A Review of Web Searching Studies and a Framework for Future Research. *Journal of the American Society for Information Science and Technology* 52(3), 235–246.

Jenkins, C., Corritore, C. & Wiedenbeck, S. (2003). Patterns of information seeking on the web: A qualitative study of domain expertise and web expertise. *IT and Society*, 1(3), 64-89.

Kim, K. & Allen, B. (2002). Cognitive and Task Influences on Web Searching Behavior. *Journal of the American Society for Information Science and Technology* 53(2), 109–119.

Kiryakov, A., Popov, B, Terziev, I., Manov, D. & Ognyanoff, D. (2005). Semantic Annotation, Indexing, and Retrieval. *Journal of Web Semantics* 2(1), Elsevier, 49-79.

Korfhage, R. (1993). *Information storage and retrieval*. Morgan Kayfmann Publishers.

Lindland, O. I., Sindre, G. & Solvberg, A. (1994). Understanding Quality in Conceptual Modeling. *IEEE Software*, 11 (2), 42-49.

Lozano-Tello, A. & Gomez-Perez, A. (2004). Ontometric: A method to choose appropriate ontology. *Journal of Database Management*, 15(2), 1-18.

Nagypal, G. (2005). Improving Information Retrieval Effectiveness by Using Domain Knowledge Stored in Ontologies. *OTM Workshops 2005*, LNCS 3762, Springer-Verlag, 780-789.

Rocha, C., Schwabe, D. & de Aragao, M.P. (2004). A hybrid approach for searching in the semantic web. *Proceeding of WWW 2004*, ACM, 374-383.

Suomela, S. & Kekalainen, J. (2005). Ontology as a Search-Tool: A Study of Real User's Query Formulation With and Without Conceptual Support. *Proceedings of ECIR 2005*, LNCS 3408, Springer-Verlag, 315-329.

Tomassen, S.L. & Strasunskas, D. (2006). Query Terms Abstraction Layers. In R. Meersman, Z. Tari, P. Herrero, et al. (eds.), *OTM Workshops 2006*, Springer-Verlag, LNCS 4287, 1786-1795.

Tartir, S., Arpinar, I.B., Moore, M., Sheth, A.P. & Aleman-Meza, B. (2005). OntoQA: Metric-Based Ontology Quality Analysis. *Proceedings of IEEE Workshop on Knowledge Acquisition from Distributed, Autonomous, Semantically Heterogeneous Data and Knowledge Sources*, IEEE Computer Society, 45-53.

Vallet, D., Fernandez, M. & Castells, P. (2005). An Ontology-Based Information Retrieval Model. In A. Gomez-Perez, J. Euzenat, J. (Eds.), *Proceedings of ESWC 2005*, Springer-Verlag, LNCS 3532, 455-470.

Zins, C. (2000). Success, a Structured Search Strategy: Rationale, Principles, and Implications. *Journal of the American Society for Information Science* 51(13), 1232–1247.

Applying RFID to Patient Care: Challenges and Opportunities

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INTRODUCTION

The application of Radio Frequency Identification (RFID) to patient care in hospitals and healthcare facilities has become more widely accepted in recent years. RFID and other wireless technologies are the next evolutionary step in patient/object/asset identification and tracking. RFID can potentially deliver many benefits to the healthcare industry. The appropriate application of RFID technologies can reduce many manual operations performed in patient care. When RFID is applied to existing workflow models of patient care, the number of manual steps involved in checking and processing patients can be reduced. RFID can automate the admitting, screening and treating processes for patients, enhance communications between caregivers and support teams, and reduce medical errors (Wicks, Visich, and Li, 2006). In addition, to reduce the number of medical errors, some hospitals have started to use RFID chips on wristbands that can be embedded with data and scanned with a reader to identify patients and what surgical procedure is needed (Hancox, 2006).

However, despite the promised benefits, over 90% of the hospitals in the U.S. still have not adopted the technology (BearingPoint, 2006). As such, this paper examines the current information process used to process patients from admission to discharge, and then it considers where RFID can be applied in a hospital setting to improve patient care and hospital operations. Next the paper investigates the challenges associated with deploying RFID technology in a hospital environment. It is expected that the results of this study will be useful to hospital administrators contemplating RFID deployment in identifying challenges and opportunities.

OVERVIEW OF RFID

RFID is a communication mechanism utilizing radio energy to enable a remote device to communicate with the base station. RFID relies on storing and retrieving data using devices called RFID tags. A tag contains writable memory, which can store data for transfer to various RFID readers some distance away. An RFID system may consist of several components: tags, tag readers, edge servers, middleware, and application software. The purpose of an RFID system is to enable data to be transmitted by a tag which is read by an RFID reader and processed according to the needs of a particular application. The tag contains a transponder with a digital memory chip that has a unique electronic identifier. The interrogator (i.e., reader), which consists of an antenna packaged with a transceiver and decoder, emits a signal activating the tag so the interrogator can read from and/or write to it. Automatic tag reading allows vast amounts of data to be stored and transmitted at once, streamlines and speeds up operations while improving accuracy and productivity. Automatic tag reading also does not require direct contact or line of sight between RFID tags and readers.

Active RFID tags contain their own power source, usually an on-board battery. *Passive* tags obtain power from the signal of an external reader. *Semi-passive* tags are a variant of passive tags where a battery is included with the tag, but the tag must be excited by a reader in order to transmit data (RedPrairie, 2005). See Table 1.

Table 1. Comparison of different RFID systems (RedPrairie, 2005)

Characteristics	Active	Semi-Passive	Passive
Power Source	Battery	Inductive	Inductive
Memory	Up to 288 bytes	Variable	Up to 288 bytes
Read Range	<1500 ft.	<100 ft.	<15 to 30 ft.
Class	Read only Write once, read many Multi read/write	Write once, read many	Read only
Frequency	125KHz, 134KHz, 13.56MHz, 868-930MHz, 2.4GHz	915MHz, 2.4GHz	303MHz, 433MHz

RFID IN HOSPITALS

In the context of hospitals, hospitals offer a wide range of services and functions. This study proposes identifying where RFID can be applied from the perspective of the patient. Specifically, the different stages of the patient life cycle—from admission to discharge—are identified, and where RFID may be applied to improve operations is explored.

Patient Life Cycle: From Admission to Discharge

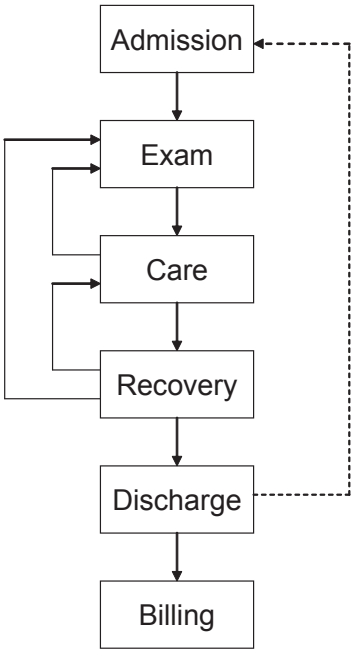
Many hospitals track their patients using manual systems. These systems are typically paper driven utilizing everything from whiteboards, cards, and charts to self-adhesive notes. One useful tool to examine where opportunities of improvement may lie is the patient life cycle. The cycle has six stages (see Figure 1):

Admission: Admission to a hospital usually involves paperwork being filled out by the patient and hospital staff. The information recorded includes: insurer/ability to pay, patient name/contact information, and reason for admittance. Once this information is obtained, the patient is assigned an identification (ID) number that is written on the chart and a wristband which is then attached to the patient.

Examination: After formal admission, the patient is delivered to the appropriate department for diagnostics and treatment. As the patient is treated by the medical staff, the wristband, orders, and charts are visually inspected to confirm procedures, medications, transportation, and later the ultimately discharge from the hospital. This process is performed to assure the correct patient is being treated.

When a patient is first treated, a visual inspection of the patient is performed. If a visual inspection does not provide the cause of the problem, additional tests are performed. Test results are reviewed to determine possible causes. If enough information is obtained, the treatment is started, otherwise, more tests are performed until enough information can be evaluated to provide care. At this point, the patient is either discharged or assigned to additional care.

Figure 1. Patient life cycle



Patient Care: When it is determined that a patient needs further care, he or she is assigned a bed and transported to his or her room by an orderly. On regular intervals the following procedures are carried out:

- Blood work is drawn and analyzed (by phlebotomist).
- Blood pressure, pulse, temperature, and O_2 saturation are recorded.
- IV fluid levels are recorded and replaced as needed.
- Other evaluations of the patient are recorded (e.g., pupils, motor skills, awareness, pain sensations).
- Other specimens are obtained and sent to labs.

As needed, the patient is removed from his or her room and transported to departments where procedures, treatments, tests and examinations are performed. To document the treatments, caregivers record actions taken and results on the patient's chart.

Recovery: As the patient improves, he or she is encouraged to walk around for exercise. The patient's movements are recorded of when they left and returned. Meals, medical supplies, and medications consumed by the patient are continuously recorded.

Discharge: Hopefully, the patient reaches a point where the physician determines that hospital care is complete. At this stage, the patient is issued post-hospital care instructions, and the patient is processed for discharge from hospital. When leaving the hospital, the patient is typically transported on a wheelchair to the curbside or transported back home using a non-emergency medical transport service.

Billing: Billing information is processed and statements sent to appropriate parties (e.g., insurer) for payment.

Benefits of Using RFID

Given that less than 10% of hospitals in the U.S. have adopted RFID (BearingPoint, 2006) and that hospitals still predominantly use paperwork, there should be many opportunities of using RFID to improve operational processes in hospitals. In many hospitals, records and charts are recorded in paper form with some information entered into computer terminals to be printed out and placed in the chart. Procedures, inventory control of assets and consumables, and billing information are all still recorded manually and later entered into a computer.

In an environment where RFID is integrated into the hospital information system, a patient can be tracked from the time they enter the hospital to the time they leave. This process starts when a patient is issued an RFID wristband (during *admission*). Once tagged, the patient can be monitored as they enter and exit rooms. As care is provided to the patient, handheld scanners and terminals with wireless capabilities may be used to input information about procedures performed and the condition of a patient. For example, an emergency room (ER) staff scans the patient as he or she is admitted and all materials used in the care of the patient (during *examination*). Medicines and materials would be associated with a patient and recorded automatically. The collected data enable other medical staff in the next shift to review what was administered to treat the patient. By automating these systems, harmful drug interactions can be identified automatically and notification sent to the physicians.

When properly integrated into an existing medical system as part of a systems solution, RFID can be used in conjunction with automation to check for errors and perform routine record keeping. When scanners are connected to the network using wireless networking and docked networking, a caregiver can update a patient's chart in real time to provide hospital staff with the most current information (during *care*). Vital signs, test results, and procedures can be viewed and checked instantly by medical staffs or by automated routines. If a patient were to be administered a drug, real time tracking could show what medication was dispensed and when it was delivered and taken by the patient. At any time during this physical process, software can check for errors and notify hospital staff if the wrong medicine was dispensed or administered to a patient (Wicks, Visich, and Li, 2006).

With all this information recorded centrally, it makes sense to utilize existing network technologies to allow closer monitoring of the patient by medical staff (during *care*). This would allow nurses to use workstations to record and look up patient information in real-time. Doctors and nurses could look up patient records using handheld devices, wireless notebook computers, or even cell phones. If a patient's condition worsens or improves, physicians can be notified automatically by event triggers written into the patient tracking software. No longer would the doctor need to see the patient or the printed chart to assist the patient. Doctors could quickly identify a patient, retrieve comprehensive medical records, review patient's recovery status, and check past medical logs which have been recorded by nurses via RFID terminals.

As the patient recovers, he or she is frequently encouraged to exercise and walk around the hospital (during *recovery*). As a patient moves about, his or her movements can be tracked by RFID readers scattered throughout the facility. Such information can be logged and can give the tending physician an idea of how much physical activity the patient has engaged in. In addition, when the patient becomes well enough to leave the hospital, the discharge process can be streamlined (during *discharge*) since most information related to his or her care has already been captured using RFID. Moreover, a record of the entire care process captured by RFID is also useful if the patient ever returns for additional care. If the patient returns, his or her medical history could be retrieved to view past diagnosis and treatment. If RFID were extended to a hospital-issued card (e.g., a tagged hospital card or subcutaneous implant) to be kept with the patient, such a card can expedite the subsequent admission process.

While the patient was being cared for at the hospital, equipment and consumables can be tracked and recorded as they are issued or used on a patient. Such tracking is necessary for inventory and billing needs (for *billing*). With fully recorded information, the hospital can automate billing generation for patients and insurance companies. The medical care industry is cost driven where cost recovery determines the profitability of a hospital. By more closely tracking the consumables using RFID, hospitals will be able to avoid excess inventory, reduce out-of-stock periods, and improve the efficiency of medical service supply chain. With a more complete care history, it will also be easier to identify billing fraud.

CHALLENGES OF ADOPTING RFID IN HOSPITALS

RF Interference with RFID Tags

As with any wireless technology, there is the possibility of interference from external sources. Solutions include (1) suppressing interference sources and (2) requiring closer proximity between the RFID tag and the scanner. In any case, there may be situations where it is not practical to scan RFID tags because of the environment. An example of this would be the MRI scanner in the radiology department. The electromagnetic (EM) fields present in the bore of the magnet are significant and would block most RF communications. There is also the issue

that one would not want ferrous materials near such a device for safety concerns. This problem can be solved by scanning the patient as they enter the room before being placed on the scanner table.

Partial Implementation

Given that RFID cannot be ubiquitously deployed in a hospital overnight, many hospitals are considering partial implementations of RFID. A partial implementation first requires a careful analysis of the workflow of a hospital to determine what activities are compartmentalized. The best areas to implement RFID would be where activities are compartmentalized from the rest of the hospital. For example, if a patient is given a wristband that is dual use or tri-use (i.e., containing bar code, RFID tag, and printed text), then the wristband would allow other departments to perform their work regardless of whether or not those departments have RFID scanners.

RFID Security and Privacy

RFID is secure in that tags are extremely difficult to counterfeit and impossible to read without a reader. In fact, some consider the tags physically tamper-proof (Finkenzeller, 2003). However, a common security concern lies with the radio transmission of the tag when it is interrogated by a reader. Since tags emit omnidirectionally, those with specialized high-gain antennas can intercept tags' radio transmissions over a long distance. An example is where an individual sits in the parking lot and uses a high-gain antenna to listen for radio transmissions of RFID tags in a building (Anteniese, Camenisch, and de Bedeiros, 2005).

One solution is to reduce the transmit power of the tag so that transmission distance is only a few inches. But if an operator is required to be so close to the tag to read it, then the process becomes no different from that of bar coding, and the advantages offered by RFID are negated. The long-term solution is to encrypt the data on the tags. It is possible to read/write tags to store encrypted data on the tags, thus making the data intercepted by third parties difficult to use. This solution still makes it possible for a third party to read what is stored on the tag, but it does require the third party to have additional knowledge to make use of the information.

In addition, there is also the issue of the tag remaining active after it is no longer needed by the hospital. If a patient were to walk out of the hospital with his or her wristband on, the tag in the wristband would continue to transmit data when interrogated by a reader. The solution to this would be to deactivate the tag once it is no longer needed (Juels, Rivest, and Szydlo, 2003).

Operational Issues

The development of RFID as a viable alternative to bar codes is a challenge. Range and accuracy are two technical challenges that RFID must overcome to achieve expected benefits. The effective read/write range of passive RFID readers is quite short, and readers must be within a few feet of the object to accurately read the tag or write to it. Active tags allow for longer ranges. The proximity of reads can be an issue if there are multiple objects too close together making it difficult to read tags. The materials on which the tag is affixed may also affect readability. However, as RFID technology improves, the issues of range and accuracy will be solved. For example, the new-generation Gen2 tags provide greater performance, even when used on containers with liquid and metals, and result in more simultaneous reads (Symbol Technologies, 2006).

CONCLUSION

When implemented properly, RFID can significantly aid the medical staff in performing their duties. This paper first presents an overview of RFID technology, then it examines the patient life cycle from admission to discharge. Based on the patient life cycle, it considers where RFID can be applied in a hospital setting to improve patient care and hospital operations. It is found that RFID offers the ability to reduce manual entry of records, increase security for the patient and hospital, reduce errors in administering medication, assist staff by reducing manual labors involved in tracking materials, and serve as a component of an automatic audit system. In addition, RFID enables a fully automated solution for information delivery at the patient bedside, thus reducing the potential for human error. Finally, the challenges associated with deploying RFID technology in a hospital environment are also presented.

REFERENCES

Anteniese, G., Camenisch, J., and de Bedeiros, B. (2005) Untraceable RFID tags via insubvertible encryption, CCS'05, November 7-11, Alexandria, VA.

BearingPoint (2006) *RFID in Healthcare: Poised for Growth*, BearingPoint, McLean, VA.

Finkenzeller, K. (2003) *RFID Handbook*, Second ed., John Wiley & Sons Ltd., West Sussex, England.

Hancox, D. (2006) Using RFID technology to enhance corporate effectiveness, *IT Audit*, April 10.

Juels, A., Rivest, R., and Szydlo, M. (2003) The blocker tag, selective blocking of RFID tags for consumer privacy, CCS'03, October 27-31, Washington DC.

RedPrairie Corporation (2005) RFID technology: a RedPrairie white paper, RedPrairie Corporation, Waukesha, WI.

Symbol Technologies (2006) RFID and UHF: a prescription for RFID success in the pharmaceutical industry, Symbol Technologies Inc., Holtsville, NY.

Wicks A. M., Visich, J. K., and Li, S. (2006) Radio frequency identification applications in hospital environment, *Hosp. Top*., Vol. 84, No 3, pp.3-8.

A Case Study of a Project-Management-Centered (PMC) Approach to Knowledge Management in Online Learning Environments

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ABSTRACT

The Office of Online Learning at Walsh College takes responsibility for delivering high-quality online programs at undergraduate and graduate levels. The department has adopted a project-management-centered (PMC) approach to knowledge management that has shown demonstrable efficiencies in the amount of resources required and the total time to complete implementations, while realizing gains in overall satisfaction and quality. This paper explores the PMC approach and the advantages realized to Walsh College.

INTRODUCTION

When you are in the business of providing high-quality education to your student body, managing the distribution of knowledge is critical. At the Walsh College School of Accountancy and Business Administration, our motto is "from the boardroom to the classroom," so we constantly need to find ways to make knowledge *flow* from the boardroom to the classroom – whether that classroom is an actual classroom or a virtual classroom delivered through a Learning Management System (LMS).

As Walsh College's Office of Online Learning, our department takes responsibility for delivering the high-quality online programs offered by Walsh College. Within this sphere of responsibility, the department is commissioned with rolling out new degree programs designed to provide our graduates with the tools they need in a competitive job market while continuing to evolve existing programs in lock-step with the current business climate. These two tasks alone involve managing many changes to our knowledge base; courses are being updated on a constant basis. Further, there is a business need to incorporate the most effective online learning pedagogies and technologies available in everything we deliver so that our courses are not only relevant, but effective and of the highest quality.

A final challenge is that there is constant pressure to "do more with the resources at hand," which is a pressure that exists almost everywhere in the current business climate. Tandem with this challenge is speed at which courses are requested to be developed and updated. A recently published article by Eric Park focuses on the decrease in development time for courses and maintains that the rate of course development has already moved from two to four months to one to two months. Utilizing a development process that includes steps for rapid course development and updating is critical (Park, December 2006). Additionally, a study released by Bersin and Associates in 2004 states, "There's a new training category emerging, which we call 'Rapid E-Learning.' It is a whole new approach to Internet-based training - one that changes the development model, leverages new tools, and dramatically changes the economics of content development" (DeVries, 2004). So, the approach used for distributing knowledge to our students needs to be an efficient one that makes maximum use of the resources at hand.

The challenges faced by Walsh College are not unique; there is often a need for businesses to manage the distribution of knowledge that is ever-evolving in such a way that it is relevant and timely to their employees. Often, the question is not "*What* knowledge are we going to deliver?" but "*How* are we going to deliver this knowledge?" Following a project-management-centered (PMC) knowledge management approach has helped the Office of Online Learning deal with this challenge in a systematic way.

What is a PMC Knowledge Management approach? It is an approach that treats knowledge management in such a way that it has a lifecycle similar to a software development lifecycle. That is, PMC Knowledge Management has several *phases* that closely resemble phases used to develop complicated pieces of software. Specifically, the PMC Knowledge Management can be described as having the following phases:

1. Gathering knowledge from a subject matter expert (SME)
2. Defining outcomes for the knowledge
3. Specifying the methods by which knowledge will be delivered
4. Ensuring that methods are consistent with outcomes
5. Development of the knowledge for distribution
6. Review of the materials by the instructional designer and the SME
7. Training the SME in how to maintain and update developed knowledge
8. Maintenance of the knowledge
9. Archival\Re-Use\Destruction of knowledge

All phases of the PMC Knowledge Management approach are managed in a similar way to a client-vendor-customer relationship. In such an approach, a client asks a vendor to solve a particular problem *on behalf* of the customer. In many cases the client knows *what* problem needs to be addressed by the vendor, but not *how* to solve the problem. However, the client and the vendor are both responsible for making sure that the customer is ultimately satisfied.

PMC Knowledge Management in the educational sector works in a fashion where instructors are considered to be "clients," students are "customers", leaving agents of the institution responsible for implementation of knowledge management to be the "vendor." As such, each aspect of a particular knowledge management implementation (in this case course development) needs to be managed in a similar fashion to how a project manager manages a software implementation. One person or team is ultimately responsible for all aspects of the process of delivering a particular implementation, and that person or team is that primary point of contact with the "client" (the instructor). At Walsh College, the team charged with this responsibility is a team of Instructional Designers.

THE INSTRUCTIONAL DESIGNER ROLE IN PMC KNOWLEDGE MANAGEMENT

It is important to understand how the instructional designer working in a PMC Knowledge Management environment is different than that of a traditional instructional designer. Traditionally in education, the instructional designer's role is that of a *guide* who recommends effective teaching and assessment strategies to faculty. In PMC knowledge management, their role is expanded so that they *manage the flow of knowledge* throughout the entire implementation. The instructional designer is involved in *every phase* of a knowledge management implementation; they drive the process from start to finish, building solid instructional design into

every phase of the final product. A more detailed exploration of the instructional designer's role in every phase of the implementation is as follows:

Phase 1: Gathering Knowledge from a SME

During this phase, the instructional designer works with the SME to set timelines for turnover of "raw" content and sets up a framework for how that content will be delivered throughout the knowledge management implementation. Each SME is contacted by an instructional designer, who sets clear expectations for what the SME needs to provide, a timeline for material delivery, and how the instructional designer works with them throughout the entire process. Instructional terminology such as outcomes and objectives is also discussed. This has the effect of immediately giving a SME a clear understanding of what their involvement will be throughout the implementation. The relationship between SME and the instructional designer is approached as a *partnership* where the SME is responsible for developing outcomes, course materials, and assessments. The instructional designer's role is to serve as their primary point of communication and material refinement within the Office of Online Learning. Together, the SME and the instructional designer guide the direction of the implementation through its development.

Phase 2: Defining Outcomes for the Knowledge

It may seem counter-intuitive to determine outcomes for knowledge *after* knowledge is gathered, but in the academic arena, a SME will often have a textbook and publisher supplied ancillary material (PowerPoints, glossaries, test banks, videos, etc.) in hand that needs to be looked at critically and its usefulness determined. The instructional designer works with the SME to *prioritize* what things they want their students to know, develop outcomes based on those priorities, and then (more often that not) go back to phase 1 in order to reconcile any gaps between what has been delivered and what the outcomes are.

Phase 3: Specifying the Methods by which Knowledge will be Delivered

Once the SME and the instructional designer have determined that there is enough delivered knowledge to meet the specified outcomes for the implementation, they work together to build a roadmap (syllabus) of *how* that knowledge will be delivered. The instructional designer assists the SME in breaking up knowledge into manageable "chunks" that address the learning styles of many different types of learners. Best practices and the most effective learning pedagogies are employed in this phase, ensuring that the knowledge is delivered in ways that are accessible to learners in their optimal learning style.

Phase 4: Ensuring that Methods are consistent with Outcomes

A critical review by the instructional designer and the SME is done in this phase that serves as a "reality check" that ensures all outcomes are effectively being met before the actual development of content for delivery begins. The instructional designer and the SME review each "chunk" of knowledge certify that knowledge is consistently and clearly mapped back to predetermined outcomes for the implementation. Failure in completing this step often leads to knowledge that is diluted and unclear, which produces an unsatisfactory learning result.

Phase 5: Development of the Knowledge for Distribution

At this point in the process, the knowledge is ready to be developed for delivery. The instructional designer's role in this step is not so much the actual development, but ensuring that the development team has a clear understanding of how to develop the implementation.

Half of this responsibility involves establishing clear communication of what is to be developed. For this, tools can be employed to help manage the interaction between instructional designers and developers. It is critical that these tools serve as a platform for clear communication of the work that needs to be done for the implementation. It is equally important that these tools allow the instructional designer and the developer to consistently track which pieces of work are being done by whom, so that where an implementation stands is never in question.

The other half of this equation involves setting standards that establish what is appropriate and inappropriate for the implementation. For example, a particular color combination may be inappropriate for people with color blindness. Or, the use of certain animations may be distracting to the learner. Clear documentation of these standards eliminates any confusion in this regard. It is absolutely critical that these factors are established ahead of time so that consistent delivery of knowledge is assured, particularly when multiple developers are working on a particular implementation.

Phase 6: Review of the Materials by the Instructional Designer and the SME

As knowledge is developed and delivered, the instructional designer and the SME go through what has been delivered to ensure it is consistent with what was planned. Developed materials that do not meet expectations are sent back for redevelopment and re-checked when they are once again ready for review. At this point in the process, a knowledge management implementation reaches a stage where it is considered "feature complete". The materials, ancillary materials, videos, etc. are all in an organized and presentable state that is ready for the learner.

Phase 7: Training the SME in How to Maintain and Update Developed Knowledge

Although the knowledge management implementation is "feature complete" at this point, the SME needs to learn how to maintain the knowledge. In academia, it is common for textbook editions to change, or have textbooks that contain old or inaccurate knowledge. The SME needs to be able to update the knowledge as needed.

The instructional designers take on the role of showing instructor how to manage their own knowledge, walking them through the mechanics of how to make their changes. More importantly, they instill a "value set" in the SME that allows them to make good decisions on how to approach making changes. For example, adding an entirely new knowledge topic to an implementation may require the setting of new objectives or obsolescing old objectives.

Phase 8: Maintenance of the Knowledge

At times, it becomes necessary for the instructional designer to work with the SME and evaluate how the knowledge is being maintained and delivered. Two critical evaluations of the knowledge are performed at this point.

The first evaluation involves ensuring that knowledge is still mapping to current outcomes and that currency of presented knowledge is assured. As knowledge is maintained over a period of time, there is a tendency for an implementation to creep beyond its original stated objectives. This will result in knowledge and objectives not being consistently aligned. Further, there is a valid tendency of the SME to never completely discard knowledge that is obsolete, which can create a "clutter" problem throughout the implementation. The instructional designer works with the SME to ensure such issues are resolved.

The second evaluation involves taking a fresh look at the implementation for ways to improve it. For example, there might be a new compression utility available for videos that delivers a higher quality result. Additionally, it is possible that the SME wants to completely alter the way they teach a concept in such a way that the learning becomes more interactive. The instructional designer works with the SME in much the same way as they work in phase 3 of the process to determine the most effective ways to deliver the new ideas for the existing knowledge.

Phase 9: Archival\Re-Use\Destruction of Knowledge

Finally, there will always come a point where knowledge reaches the end of its useful life. The instructional designer works with the SME to determine which pieces of knowledge should be reused in another implementation, archived for further reference, or destroyed entirely. Items that are to be reused or archived are ultimately placed into a library for easy retrieval and have their contents catalogued.

From the more detailed overview of the phases in PMC knowledge management, it is evident that the instructional designer is more than just a "guide" to instructors. Rather, they serve in much the same fashion as project managers do for projects. They manage the whole knowledge management implementation from start to finish, providing critical guidance to the SME and the developers through each phase of an implementation.

Further, the phases outlined in PMC Knowledge Management create a framework for managing change. Knowledge does not often remain static, so establishing an effective and clear framework for managing the changes to knowledge is an

integral part of how quality and consistency are achieved in knowledge management implementations over time.

THE BENEFITS OF PMC KNOWLEDGE MANAGEMENT

The benefits of PMC Knowledge Management realized to Walsh College's Office of Online Learning have been enormous. We are truly able to deliver "more with the resources at hand" consistently and effectively with a relatively small team of highly-motivated people, which is reflective of how market conditions exist today. Further, PMC Knowledge Management has allowed our department to deliver more effectively on our promise to deliver knowledge "from the boardroom to the classroom" at quality levels we had never been able to achieve before, all at a lower cost. This may seem counterintuitive, as a nine-phase process can look unwieldy and expensive at first glance. In reality, however, our instructional designers are finding that they are able to handle several knowledge management implementations at one time by setting clear expectations up front, establishing open channels of communication with each SME, and staying on top of the flow of knowledge into the department.

To further demonstrate the benefits of the PMC Knowledge Management approach, here are some key benefits realized to Walsh College within one year of implementation:

1. Increasing the number of knowledge management implementations (course development) the department is able to handle at one time *five-fold* from 3 – 4 implementations to 15 – 20, with no increase in staff.
2. There has been a drastic reduction in the number of support problems associated with new courses from both new faculty and students.
3. Complete remediation to newer and more effective online learning pedagogies for over 50 existing online courses has taken place.
4. The Office of Online Learning has been able to manage double-digit growth in both the number of courses offered each semester and the number of students taking courses online.
5. Ensuring that student satisfaction with online courses is consistently high across all programs.
6. Increasing overall student satisfaction by an average of 14% for courses running for the first time that are facilitated by a SME who is actively engaged throughout all phases of course development.
7. The Office of Online Learning has created and fostered a culture when change is planned for and managed on a consistent basis.
8. Consistently receiving high levels of satisfaction with the end product from each SME developing new or updating existing courses. This has encouraged many who were skeptical about online learning to delve into creating their own online courses.

CONCLUSION

A PMC Knowledge Management approach can be a very effective tool for managing a large number of simultaneous knowledge management implementations. PMC Knowledge Management can set up a framework for dealing with change consistently and effectively. Finally, PMC Knowledge Management can help manage large knowledge management implementations with greater efficiency than can be achieved without having them in place.

Put together, these factors can create highly successful teams that are charged with managing all phases of knowledge management and create a culture of innovation that pervades an entire program.

REFERENCES

DeVries, J., (2004). Rapid e-learning: what works?: tools, techniques and best practices. Bersin and Associates. Retrieved January 3, 2007, from *Learning & Training Innovations:* http://www.elearningmag.com/ltimagazine/article/articleDetail.jsp?id=102399

IBM. (2006). Model driven development for business performance management. *IBM Systems Journal,* 45, No 3, 2006. Retrieved January 3, 2007, from EBSCO: Business Source Elite database.

Parks, E. R.. (2006). Buried alive: the online learning content challenge. *Learning Solutions*, a publication of Learning Guild. December 11, 2006.

McKeachie, W. J., (1996 and 1997). Helping students learn how to learn. Proceedings of the 17th and 18th Annual Institutes for Learning Assistance Professionals: 1996 and 1997. (pp. 55-57). Retrieved January 3, 2007, from ERIC database ED450864

ProPAM: SPI Based on Process and Project Alignment

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ABSTRACT

Software Process Improvement is one of the main software development challenges. Unfortunately, process descriptions generally do not correspond to the processes actually performed during software development projects. They just represent high-level plans and do not contain the information necessary in a software project. This lack of alignment between the process and project is caused by processes that are unrelated to project activities and failure in detecting project changes to improve the process. Process and project alignment is essential to really find out how process management is important to achieve an organization's strategic objectives. Considering this alignment, this paper presents a software process improvement methodology designed by Process and Project Alignment Methodology (ProPAM).

1. INTRODUCTION

Organizational software process improvement (SPI) is a challenge to organizations to continually improve the quality and productivity of software and to keep up their competitiveness [1]. However, there has been limited success for many SPI efforts. Recent reports concluded that 70% of organizations attempting to adopt the CMM (Capability Maturity Model) failed in achieving the intended goals [2].

Although organizations try to define their process improvement program and get a certification in traditional SPI approaches (e.g. CMM [3], CMMI [4], SPICE [5], and Bootstrap [6]), there is a consensus that software development environments are changing constantly and team members have no obligation to sustain original SPI activities in face of difficulties. The agile software development manifesto contains a principle that supports this idea: "at regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behavior accordingly" [7].

Process modeling community in general base the research work on the assumption that an explicit process representation is the starting point for process understanding, improvement and communication, project teams are communicating in terms of budget overruns, patches for bug fixes and transaction monitors [8]. Other research communities, like the ones that study computer supported co-operative work (CSCW), argue that software development is a creative work with strong co-operation aspects and does not benefit from static process descriptions. So, process information must be combined dynamically with project specific information to create a detailed plan that includes information from all process disciplines with cost, schedule and quality requirements. Since project management is the discipline that controls and monitors deviations from the original project plan and also controls all of the activities from other process disciplines, it is the best way to detect changes in the project that can improve the process. Considering the dependency between project plan and process elements, new SPI approaches have to consider process and project alignment and iterative SPI performed by project team members. Process and project alignment is defined as the degree to which the project goals and plans support and are supported by the process practices. Moreover, it involves a real match between process practices and projects activities, products and actors. However, several modifications in a project can cause misalignments with the development process. These modifications can be management innovations or changes in the way the activities are executed. Furthermore, a modification may regard not only the considered activity, product or actor but it can also affect other elements having a dependence relation with the modified one.

The contribution of this paper is to define not only the process, but also to propose a mechanism to process evolution based on the changing needs of the development organization. This paper proposes a methodology - Process and Project Alignment Methodology (ProPAM) - based on process and project alignment to be applied during SPI projects for detecting misalignment between projects and supporting processes and identifying the process elements to be changed for restoring the alignment.

This paper is organized in the following sections. Section 2 discusses literature on software process modeling, process and project management alignment and traditional and agile approaches to SPI and. Section 3 and 4 presents the meta-models to support process definition and further instantiation of the project. Section 5 briefly sketches the architecture of the proposed methodology to support process and project alignment in iterative (traditional and agile) SPI approaches and also presents details about the process versioning meta-model. Finally, Section 6 presents conclusions and future work.

2. RELATED WORK

Current research on software development processes intends to define the process elements that constitute good practices, leaving implementation and enactment of the process to organizations. Curtis, Kellner and Over discussed some approaches using process modeling to support process improvement, software project management and Process-Centered Software Engineering Environments (PCSEEs) [9].

The Software Process Management System (SPMS) development identified and addressed the need for process models to be reusable, to support multiple views, to recognize process, product and human interactions to support process changes during development projects, and to support historical recording of the process over long periods of time [10]. In the domain of change management, the Problem Tracking System (PTS) is used to track errors and manage change request for the WIS (Wohnungswirtschaftliche Information System), a system build in a process oriented way to support all business processes from the area of house constructing and administration [8]. The Endeavors system is a flexible environment that allows users to create and evolve processes while a project is in progress [11]. Although Endeavors supports most of the features in process definition languages and modification of the process, some problems arise about process coordination and can lead to chaotic and disorganized development processes. The BORE tool and methodology extends the experience factory concept [12] through rule-based process tailoring, support for process modeling and enactment and case-based organizational learning facilities [13]. The AHEAD system also supports the management, versioning and modeling of development processes and provides an integrated set of tools for evolving both process definitions and projects [14].

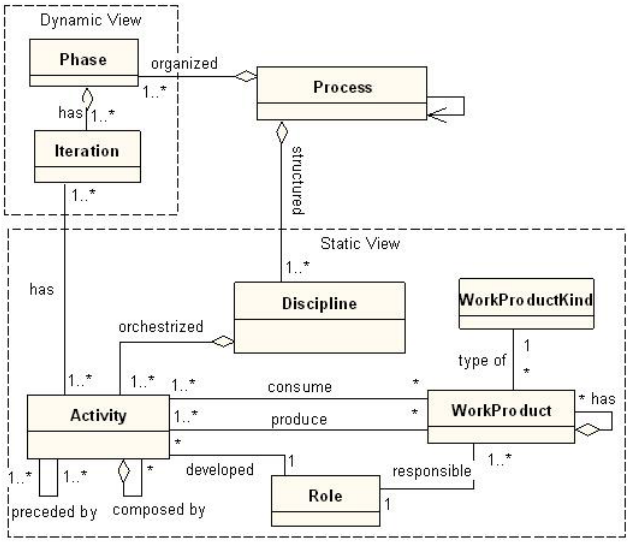
3. PROCESS MODELLING

A process meta-model provides a set of generic concepts to describe any process. Figure 1 presents the ProjectIT Process Meta-model (PIT-ProcessM) that is developed to provide a formal notation for specifying process elements involved in the software process. The meta-model consists of two complementary views: static view and dynamic view.

Static View

The static view represents formal process concepts like disciplines, products, activities and roles.

Figure 1.ProjectIT process meta-model (PIT-ProcessM)



Activity: the atomic unit of work. In operational terms, an activity can be the smallest unit of work, but also can be used to refer to a set of related activities (hierarchy of activities).

Discipline: an organizational unit to group activities according to a common "theme".

Role: describes in an abstract form the set of skills and responsibilities associated with the execution of one or more activities.

WorkProduct: correspond to typical software development objects which are produced and consumed by activities (e.g. design document, source code, test cases, etc) and they have a responsible role. The workproducts must belong to a document type (WorkProductKind).

Dynamic View

Dynamic view of the meta-model represents time and introduces concepts to describe the process lifecycle in terms of goals, pre-conditions and post-conditions and to allow the decomposition of the process lifecycle into phases and iterations.

Phase: Software development work is structured in several stages, called phases. Phases consist of a certain number of iterations and are executed with a series of milestones.

Iteration: Iterations are workflows with minor milestones.

4. PROJECT MODELLING

A project is instantiated from a process, where the process represents reusable process practices at an abstract level. While the process represents the best practices in software development but has no information about timing and resource allocation, the project must specify exactly *who* must do *what* and *when*. But in real world projects, multiple projects share the same process and are differentiated based on their specific characteristics, e.g. actors (`Person`), schedule, deadlines, resources, etc. Considering these differences that are important in a project management perspective, our approach presents a specific project meta-model presented in figure 2, ProjectIT Project Model (PIT-ProjectM).

5. PROPAM METHODOLOGY

In this section we describe the concepts behind the implementation of a process and project management system to support SPI. Figure 3 shows the relation between the four steps in the ProPAM methodology: (1) Process Creation; (2) Project Definition; (3) Project monitoring and control and (4) Process Assessment.

Process Creation

In ProPAM, a process is created as an instance of PIT-ProcessM. A process is defined by a set of phases which are divided in several iterations. Disciplines and respective activities, workproducts and roles define the space of possible choices for projects within a given process practices. Activities can be defined in an activity/sub-activities relationship represented in a hierarchical work breakdown (represented in the meta-model trough the reflexive association "`composed by`"). Activity sequences are defined through the reflexive association designed by "`preceded by`", which are useful to create a project schedule.

Project Definition

In ProPAM, processes are used as a template for creating projects. The project consists of some project elements that are instances of elements from the base process. Not all of the process elements need to be included in the project, but all project elements must be an instance of a process element. An exception is possible if an element is created as result of a change proposed by team members or process group. When a process element is assigned to a project, creating a new project element, all the information in the process element is copied to the project element, including a copy of all the associated elements. As an example, when an `ActivityProject` is created, associated `WorkProductProjects` and `RoleProjects` are also introduced in the project.

Figure 2.ProjectIT project meta-model (PIT-ProjectM)

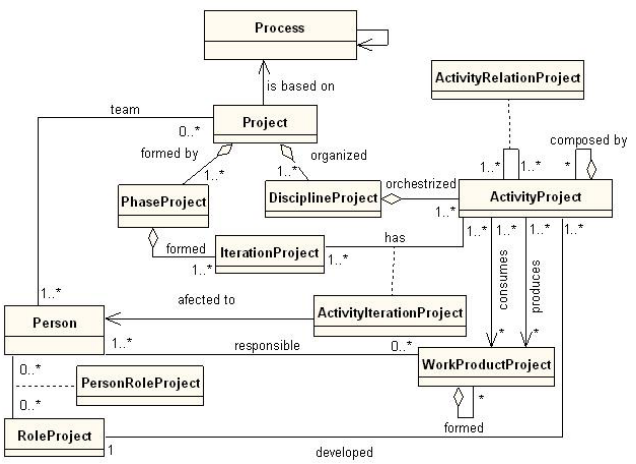
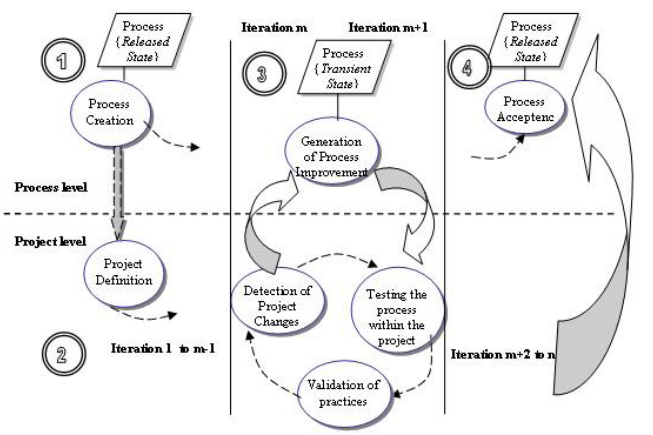


Figure 3.Process and project alignment methodology



In this methodology, after instantiating a process, the initial result is a project plan. This plan represents the initial step to start the project. Projects have certain administrative characteristics like schedule, milestones and deadline, resources, and structure i.e. phases and iterations of the project that will performed based on this initial plan. Team members are assigned to the project and gather information that is useful for the project, like workproducts, from the perspective of their current role.

Project Monitoring and Control

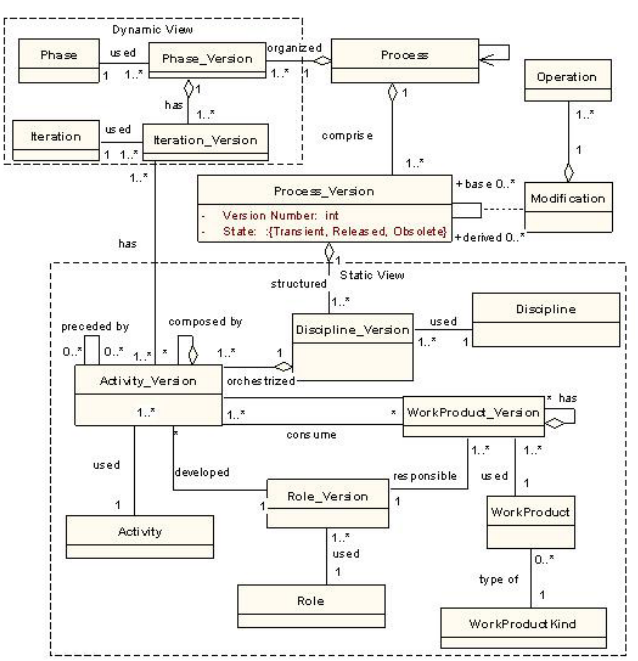
The third step consists in project monitoring and control. Updates and extensions to the initial project plan will be registered, always considering a based process model. Although most project elements are an instance of process elements, project team members have the liberty to create entities specific to a project. These changes are detected through the SPI actions performed by the process group. When a new process or new version is introduced, a validation phase is needed for monitoring their fitness and performance in the whole process. Thus, SPI actions subsume two problems: (1) process modification and (2) ensuring that projects and base process remain aligned with each other.

The project monitoring and control step is composed by two different tasks. The first task (Project Iterations) is about getting knowledge through project change candidates to improve the process and is repeated in all project iterations and phases. The second task (Process Versioning) subsumes that changes are accepted and that it is necessary to keep historical information about several process versions. The versioning schema introduces some changes in the PIT-ProcessM meta-model. The meta-model is extended to support the versioning of process elements (Figure 4).

Process Assessment

In the end of the project, process improvements must be analyzed in a reflection meeting. The main goal is to analyze all the improvement opportunities identified in the project and validate all the SPI actions accepted in workshops. Prospects for success in executing and improving software process activities rise significantly when decisions can be based on quantitative information which can only be obtained by observing and measuring the products, projects and resources involved. But as complex as software development is, there are potentially so many things to measure against organizations visions and plans. In ProPAM, process assessment occurs at two distinct levels: (1) project level and (2) process level.

Figure 4.Process version classification



At project level, SPI assessment in practice can be viewed as the acquisition of data (key indicators) in a project where the new process version was applied followed by data analysis and decisions about the further adoption of this development processes. Key indicators used to evaluate projects success are normally: staff productivity, software quality, cycle time, project costs and costumer satisfaction.

At process level, the entities to evaluate are the different phases of the development processes and the attributes of these phases which include cost, time, etc. In a measurement program, the organization has to identify the areas of measurement. The measurement objectives should be clear and well defined. Since project management is an important discipline in the proposed methodology, the key indicators must align with those used by the project manager to analyze and evaluate a project.

However, SPI key indicators may change and evolve. Over time, process changes can impact the way measurements are defined, the way measurements are collected, or the frequency of measurement collection and analysis activities. To facilitate this evolution and ensure that the measurements and indicators continue to provide meaningful information to managers, the continuous recording of project background information is important to: (1) facilitate the analysis and interpretation of measurements over time; (2) to establish links between measurement data sets over time and (3) to understand exactly how the measurements are evolving.

6. CONCLUSIONS

This paper describes ProPAM, a methodology for process improvement based on process and project alignment and supporting meta-models (PIT-ProcessM and PIT-ProjectM). ProPAM meta-models propose to bridge the gap between process description and development projects. PIT-ProcessM is used to specify the process life-cycle without forgetting that processes and projects are human-centered systems. The communication and collaboration actions are described in the meta-model, at an abstract level, through the role and activities relationship.

Agile and traditional processes are structured in phases and iterations, but actual process modeling approaches don't address this feature that is especially important in agile processes. Agile processes normally just plan iteration by iteration. Further, in approaches like BORE [13], life-cycle descriptions are most often treated as linear sequences, where crucial attributes of the process such as phases and iteration are not represented. PIT-ProjectM is used to plan the project as an instance of the process specified through the PIT-ProcessM with a life-cycle description based on phases and iterations. However, since every project has unique features and requirements, actors must have liberty and creativity to change the project. Recognizing that the most critical problems occur during project activities, we strongly believe that process and project alignment can be a best-practice to get better project results and improve organizations software processes. In our methodology, process versions are represented in a process versioning meta-model as a tree structure that supports mechanisms to allow an evaluation of the process changes along their several versions. The main goal is not only to get a description of the process really performed but, also important, is to analyze the effects on the organization of the improved process.

ProPAM was applied in a case study to help the organization improve its software product development process. The case study revealed that SPI isn't trivial, some improvements need organizations decisions, additional effort and time consuming activities. Sometimes, only after one year the effects of the proposed improvements will be observed. When passed projects data is needed to tune projects activities time and costs, it's important to continuously repeat the proposed improvement in future projects.

Further effort is required for better formalizing the methodology. Moreover, the methodology requires the support of a development environment, as much information has to be gathered and analyzed. Methodology concepts are being integrated in a project management tool (ProjectIT-Enterprise) of the ProjectIT research project. Future work will continue efforts to gather empirical data on its use will help refine the methodology and learn more about how to support the development process.

7. REFERENCES

1. Salo, O. (2005). Improving Software Development Practices in an Agile Fashion. *Agile Newsletter* 2/2005, Agile-ITEA, pp. 8.
2. Krasner H. (1997). Accumulating the body of evidence for the payoff of software process improvement-1997. Krasner Consulting. Retrieved on

September 8, 2006, from http://www.utexas.edu/coe/sqi/archive/krasner/spi.pdf
3. Software Engineering Institute. (1993). Capability Maturity Model for Software (CMM)", Version 1.1. Carnegie Mellon University.
4. Software Engineering Institute. (2002). Capability Maturity Model® Integration (CMMI[sm]), Version 1.1. Carnegie Mellon Software Engineering Institute.
5. SPICE. (1998). ISO/IEC Software Process Assessment Part 2: A model for process management, Version 1.0. SPICE Project.
6. Kuvaja, P., Simila, J., Krzanik, L., Bicego, A., Koch, G. & Saukkonen, S. (1994). Software Process Assessment and Improvement: The BOOTSTRAP Approach. Blackwell Publishers.
7. Beck, K. (2001). Manifesto for Agile Software Development. Retrieved on April 23, 2006, from http://www.agilemanifesto.org/principles.html
8. Gruhn, V. & Urbainczyk J. (1998). Software Process Modeling and Enactment: An Experience Report related to Problem Tracking in an Industrial Project. Proceedings of the 20th international conference on Software Engineering, 13-21.
9. Curtis, B., Kellner, M.I., & Over, J. (1992). Process Modelling. *Communications on the ACM*, 35, 75-90.
10. Krasner, H., Tirrel, J., Linehan, A., Arnold, P. & Ett, W.H. (1992). Lessons learned from a software process modeling system. Communications of ACM, vol. 35, n.9, 91-100.
11. Bolcer, G. & Taylor, R. (1996). Endeavors: A Process System Integration Infrastructure. International Conference on Software Process (ICSP4), Brighton, U.K.
12. Basili, V., Caldiera, G. & Cantone, G. (1992). A Reference Architecture for the Component Factory. ACM Transactions on Software Engineering and Methodology, 1 (1), 53-80.
13. Henninger, S. & Schlabach, J. (2001). A Tool for Managing Software Development Knowledge. Third International Conference on Product Focused Software Process Improvement, 182-195.
14. Heller, M., Schleicher, A., & Westfechtel, B. (2003). A Management System for Evolving Development Processes. Proceedings 7th International Conference on Integrated Design and Process Technology (IDPT 2003).

CEOs Survival: SOX Strategies Over the Long Term

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INTRODUCTION

The Sarbanes Oxley (SOX) Act has renewed business attention to details and financial reporting. Its intent is information protection and securing information, not just from outside intruders but also from hackers informing traders prior to public announcements. Securing all information within a company is an improbable task, although many steps are specified and suggested in the Act itself and supporting committees (Coe, 2005). Ways of benefiting from the SOX Act exist. Build a better company with a controlled environment (Deloitte, 2004).

Strategic goals and guidelines are described in this paper to assist the CEO in benefiting from the SOX Act. Although this paper is broad based, it is neither a comprehensive nor exhaustive coverage of the compliance issues of the Act. The Act is open ended with Section 404. Each company has areas of uniqueness that open new avenues of compliance interpretation. Embracing the Act completely is like sailing the great oceans. In this paper remedies for the CEO are offered to sail this ocean.

INTENDED AUDIENCE AND SCOPE

The audience for the SOX Act is public companies. Companies that are private are not affected by the SOX Act, which excludes many small companies. The scope of the Act is to make certain that the company's financial health is clearly reported for fair-trading of company stocks. Scope of the Act embraces security of information, which can have both legal and SEC violation implications. Non-profit corporations and other non-profit organizations are also free from compliance; however much pressure is put on these companies and organizations to be compliant to receive both private and federal funds.

AFFECTS CEO AND BOARD OF DIRECTORS

The Board of Directors is now in charge of overseeing the internal audit of the company. The CEO who wants to make good on his corporate promises is no longer the reporting officer for the internal audit. It now is the board of directors' responsibility to the stockholders to audit the company internally. The SOX Act ensures independent auditing by forbidding any officer or employee of a public accounting firm from being on a board of directors for which an external audit is performed. The board of directors cannot hold interest in a public accounting firm, that is utilized in auditing the corporation or company where the board member sits.

AUDIT COMMITTEE

The nature of the SOX Act is so expansive it requires an audit committee to manage. The internal audit committee works with the external-auditing firms and any outsourced internal auditing teams and reports directly to the board of directors. This committee is also an audited issue. It must be in place and operational with agenda and people (Deloitte, 2004). The large volume of issues within the SOX Act requires the audit committee to manage and protect the company from compliance failure.

CONTROLS FOR AUDITING PROCEDURES

The important concern is to have all the security requirements of rotation and cross interest checked and to have methods and procedures in place. A security check on entrance to the building and security auditing of all audit participants is a must. Checklists are available for spreadsheets to track and document procedures involved with spurious business activities such as waste control and unused asset removal (Burnett & Friedman, 2005). Five steps in preparing environmental cost estimates (ECE) are according to Berlin and Goldstein as follows (Berlin & Goldstein, 2005):

1. Evaluate any existing ECE, including any notes, reports, or correspondence.
2. Gather data regarding environmental status.
3. Develop/update ECE.
4. Assess the ECE relative to materiality.
5. Provide assessment to CFO/auditors.

Seven common risks that are difficult to account and measure with environmental issues according to Berlin and Goldstein are as follows (Berlin & Goldstein, 2005):

1. New management's lack of knowledge
2. Liabilities hidden in multiple accounts
3. Partial estimates that incorrectly appear immaterial
4. Increasing state enforcement
5. Masking liabilities with minimally effective treatment systems
6. Changing ownership to hide the cleanup problem

USE OR ABUSE THE AUDITOR? PERFECTING THE COMPANY AS A CORPORATE GOAL

The auditor has a job to perform and that job appears negative. Nothing is going to alter this relationship between auditor and company person, more than the SOX Act (Millman, 2005). "Perfecting the company" as a corporate goal is paramount in making the audit process a positive contribution. Protection for whistleblowers was implanted in SOX Act to protect the very nature of auditing, revealing something amiss. Lawyers are also to report to the board when presenting evidence of material violation. They are also protected from losing employment similar to the whistleblowers (Noorishad, 2005).

BUILD AN ETHICS PROGRAM AS CORPORATE GOAL

The SOX Act probes into whether the senior executives, the CEO and CFO, have a code of ethics (Green, 2004). Section 406 requires posting in the financial reports a disclosure of the company's code of ethics (Anand & Sarbanes Oxley Group, 2004). After ethics, behavioral boundaries can be developed and documented within the company (Green, 2004).

POLICIES FOR LEGAL PROTECTION AS PART AND PARCEL TO ETHICS PROGRAM

An appropriate response in legal terms is necessary for the protection of the CEO when a material violation occurs (Noorishad, 2005). It is clear, that preventive actions are appropriate remedial measures. To protect the company in court it is paramount to pile high a set of policy and procedures for ways and means of behavior. A procedure and policy needs to include education, training and policy signature attachment for the employee, who involves assessing material value that effects the financial statement. If the employee is non-compliant, the court will find the company less liable than if no such policy and procedure documented with policy signature, education and training attachments were in place.

AFFECTS MANAGEMENT

In Section 404 of the SOX Act, management must document all policy and procedures for any activities business or related that effect the bottom-line of the financials. This includes any risks or waste removal costing. Vacations that are not taken and airline miles not ticketed create openings for hidden costs to the company that need to be documented. Very few companies realize the extent of this Section 404 impact. The Act is open ended. The rules, such as vacation tracking, are followed haphazardly in many areas around many companies and this documenting activity is part of compliance to the SOX Act. Subsidiaries and other partners or companies with business relationship practices are included in section 404.

Under SOX Act the internal auditors do not report to the CEO; rather, to a board member of the board of directors. Ex-internal auditor specialists are needed to help the CEO comply with Section 404. These auditor specialists are not doing audits, but preparing the company to meet or exceed the internal audit; hence, the external audit.

BEHAVIORAL BOUNDARIES (STEERING) COMMITTEE

The human resource department has handled many difficult situations regarding employee behavior. The process of education, regular training, and employee signing of policy documents falls under the human resource domain. The Behavioral Boundaries Committee is needed to protect the company in its control of management and workers. Issues from sexual harassment, to getting user login permission require a policy and it is to be signed by the employee.

Management in one area of the company joins the Behavioral Boundaries Committee to oversee and enforce another area of the company. A ring of managers can work to oversee each other as committee members with human resource superiors and chairperson. The mixing of management participation, ethics as a company goal promoted by human resource management protects and builds an ethical company. This is the story and plan that goes into the financial statement as a disclosure on an ethics program for the company and SOX Act compliance.

AFFECTS INFORMATION TECHNOLOGY

Corporations are going to have to invest in IT to handle all of the security issues. Projected IT financial spending amounts to 40 billion dollars in 2006 (Swann, 2005). Although mostly for maintenance, SOX Act is putting the IT focus on data security. Securing company information from email to hard disks pregnant with company financial data is paramount to comply with the Act. It refers to the area of managing risks.

The Committee of Sponsoring Organizations (COSO) of the Treadway Commission satisfies the SEC criteria for internal audits. A proactive approach is to go with COSO framework as an institutional strategy that would fund IT with appropriate money and support IT with the needed policy and procedures that meet the COSO framework. CobiT also provides a framework to supply proactive compliance (Coe, 2004).

CONTROLS FOR IT NETWORK SECURITY WITH CHECKLIST

IT networks are to be secure to comply with the SOX Act. COSO includes five levels in its internal controls model, which are control environment, risk assessment, control activities, information and communication and monitoring (The Institute of Auditors, 1998). CobiT from the The Information Systems Audit and Control Foundation (ISACA), Trusted Services, once referred to as SysTrust, from the foundations of the American Institute of Certified Public Accountants (AICPA) and the Assurance Services Development Board (ASDB) of the Canadian Institute of Chartered Accountants (CICA) posted the AICPA/CICA Privacy Framework and two other frameworks that are compliant for information technology management and control (Coe, 2004). A checklist for IT network compliance for the SOX Act follows (Gallegos, Senft, Manson, & Gonzalas, 2004):

Firewall: It is a must for a company or corporation at every entry into internal systems.

Access Control: Every entry into any system from outside or inside the company must have access control and policy and procedures for every access is required.

Authentication: Access authentication systems to protect systems, data, and network and to permit access based on policy and procedures are required.

Cryptography: Choosing cryptography methods with at least a 128 bit key length.

Virus Protection: Anti-virus software and regular updates.

Backup: Loss data protection and replacement is part and parcel to business continuity when accidents and disaster recovery occurs.

Intrusion detection and logging: The computer forensics requirements for corrective action when network intrusion or attacks are detected which requires monitoring software.

Operating Systems and Application protection: The need to secure the operating systems and application systems against intrusions and attacks.

Database and file systems: SOX Act addresses this as an area that involves email data and potential trading advantages via intrusion from gathering material information prior to public announcements, which could affect stock price changes.

Vulnerability Management: Using COPS, Crack, Tripwire software, vulnerabilities can be identified prior to intrusion.

Monitoring: A security professional awareness with the computer security industry is required (Gallegos, Senft, Manson, & Gonzalas, 2004).

SECURITY COMMITTEE

The Security Compliance Steering Committee is a way to set priorities and audit all areas of security and provide suggestions and directions to oncoming issues. Security is an ongoing effort and requires legal participation. A lawyer is needed whose focus is security. The members of the team include human resource people, IT people both in systems, applications and telecommunications, a security lawyer, management in all divisions and corporate executives CIO, CFO. Ex-Auditing specialists are best included for help in the processing of procedures.

Other companies determined the need for an executive officer called the Chief Security Officer (CSO) or Chief Compliance Officer (CCO) (Brady, 2005). This chosen person would improve and protect the company's operations and set policy for advancing compliant requirements from outside government agencies. This Security Committee will work with the Behavioral Boundaries Committee and the Audit Committee. The Security Committee will prepare security policy and procedures with regard to management and workers and supply them to the Behavioral Boundaries Committee to enact and enforce. Education, employee training and policy signatures will have security issues along with others for employee processing. The Audit committee will feed security breaches and risks to the Security Committee for remedy. A security committee protects the company's property and its material financial asset value critical to the CEO, the company and SOX Act compliance.

REFERENCES

References are available upon request.

Simulation of Information Lifecycle Management

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ABSTRACT

In this paper we analyze the effects of the number of storage hierarchies in an ILM system. We describe the model for our simulator used to run the simulations. Afterwards the results are compared and recommendations are made.

Keywords: Information Lifecycle Management, ILM scenarios, storage hierarchies

1. INTRODUCTION

Information Lifecycle Management (ILM) is a strategic concept for storage of information and documents in which the value of the stored objects depends on the underlying business model and processes. Documents are assigned to a storage medium automatically so that the existing storage capacities can be used optimally and more cost efficiently.

For realizing cost potentials it is necessary to obtain a wider knowledge about ILM procedures and scenarios but experience reports do not exist in sufficient form and experimenting and searching in real systems is too expensive. Therefore the aim of this paper is to generate results and experiences by simulation of ILM scenarios.

First we work out the aims of a simulation and then create the corresponding simulation model. The model allows a strategy-orientated analysis. Based on this model a simulator was implemented as an examination tool for the behavior of ILM scenarios. The simulation model uses results of our study conducted in 2006 [1] which analyzed the access behavior on documents of a company database. The study provided a statistical description of the access patterns which is used in the model for the automatic migration of files.

The scientific use of the work consists of providing a model for simulation which generates generally utilizable results concerning ILM behavior and cost optimization.

The results focus on the optimal number of storage hierarchies in an ILM system

The paper starts by listing the objectives of ILM simulations and describing the simulation model. Then the scenarios to be simulated are defined. Simulation results are presented and interpreted. The paper ends with an outlook on further ILM simulations.

2. RELATED WORK

Strange examined the long-term access behavior on files in an UNIX system [2]. His aim was to identify regularities and patterns which can be applied to automated migration strategies for Hierarchical Storage Management (HSM). To verify hypotheses on migration algorithms a simulator was also designed and implemented. His examination is different to our approach on implementation. The simulator developed by Strange served as a tool merely for checking migration algorithms which were verified using observed access behavior. A stochastic simulation of the access behavior was renounced. Instead, the user behavior was generated deterministically from the access protocols. Since only the effect of the migration rules was analyzed, he could restrict the number of feigned storage hierarchies to two. In addition, only very simple migration algorithms were used.

Further work deals mainly with algorithms which can be used for ILM or other storage strategies. Some examinations focus on the analysis of the access behavior and the development of migration strategies. The file migration protocol listing of a supercomputer was analyzed in a study by Miller and Katz. Migration methods were developed for a corresponding system [3].

Schmitz has also analyzed the access behavior on files in a supercomputer to be able to derive an optimal migration strategy [4].

Miller and Gibson examined the access behavior in further studies in UNIX environments and designed a “file aging algorithm” as a migration rule [5].

Today ILM is a strict focus of research. The main results are found on the field of “How” ILM works, i.e. most research was done on the field of procedures and policies. Vendors gave their point of view about ILM understanding [6] Turczyk et. al. gave a formal definition usable for ILM abstraction [7]. Chen focused on the valuation of files [8]. Proposals for policy description of ILM were presented by Beigi et. al. [9] and Tanaka et. al. [10]. Beigi et. al. considered the file system environment. Tanaka et. al. rules are more general and offered a time schedule for migration. Both papers intend to use metadata for ILM realisations.

Our paper is influenced by the analysis of the long-term access behavior of Turczyk et. al. [1]. In contrast to other work, they analyzed Microsoft office files of a company database. In addition, they derived complex statistical rules for the migration of office files and documents.

3. SIMULATION MODEL

Our objectives below list how to implement a simulator as an examination tool for ILM scenarios. The primary objectives are the analysis of fundamental questions of ILM:

- Integral analysis of ILM scenarios (end-to-end)
- Identification of the necessary number of storage hierarchies

The simulator takes into consideration the integral lifecycle, i.e. from the initial situation designed for a company to the point where a stable state is reached. The simulator should offer transferable results concerning the questions mentioned above.

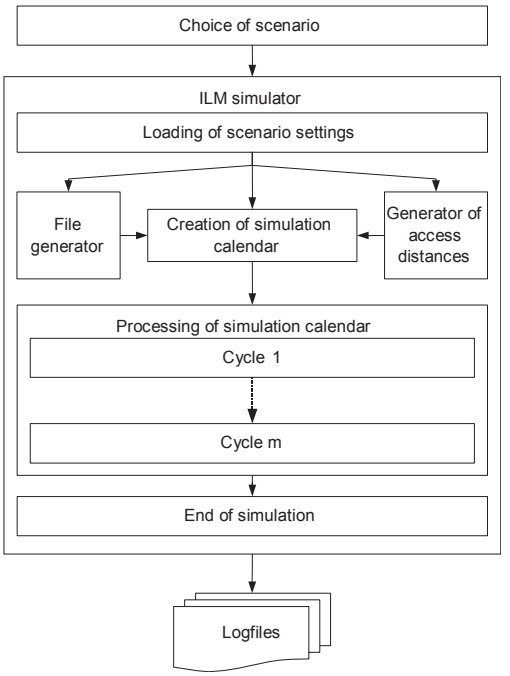
Some aspects of ILM have not been the subject of focus with this simulator and must therefore be considered separately. These secondary objectives are, in particular,:

- Identification of the necessary number of migration rules
- Optimization of the wording of migration rules
- Analysis of the dynamic behavior of ILM scenarios
- Realization of potential for cost reduction

Figure 1 shows the simulation model with its structural layout:

The main component of this plan is the ILM simulator. A scenario is loaded and simulations are executed. As a result the simulator generates logfiles. Any evaluation and interpretation of the results are done externally. How the simulator works is shown in the next section.

Figure 1. Simulation model



4. SIMULATIONS

For the examination of the effect of the number of storage hierarchies four simulation runs are carried out. The assumed data growth is about 20% per annum. The simulator starts the simulation with a data stock of 500 files. The simulation duration is 2,000 days. Ten simulation runs are averaged to one simulation to reduce fluctuations of measurements.

The migration rules used in the simulations are based on our study [1]. As distribution function either the Weibull-distribution (W(α;β)) or Gamma-distribution (G(α;β)) is used (see table 1).

The number of storage hierarchies is the initial variable of the simulations. At every simulation the first level has a threshold probability of p1=10%. The distances of the threshold probabilities dpi of the other levels i are equidistant, i.e. the remaining 10% are split up equally (see figure 2).

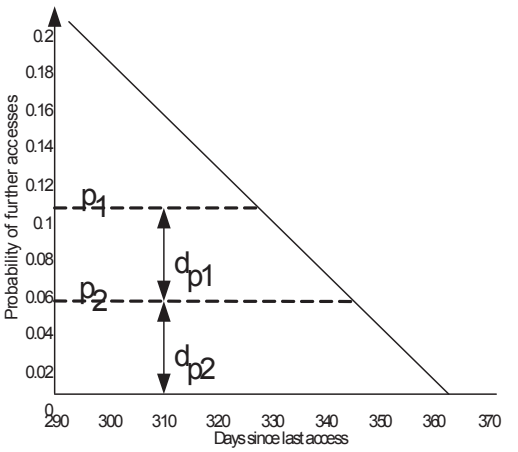
The threshold probability is described as the probability of further accesses on the file, where the file is assigned to a new hierarchy. In the example shown the probabilities of the first and second level are p1=10% or rather p2=5%. When the probability of further accesses on a file stored on hierarchy 1 falls below the threshold probability of 5%, it is migrated to hierarchy 2.

When adding a new storage hierarchy the threshold probabilities are adapted correspondingly so that they are of equal distance to each other again.

Table 1. Applied distribution functions

Number of accesses / File type	1-6	7-14	15-∞
doc	W(0,35;3,5)	G(0,32;183)	W(0,35;3,5)
xls	W(0,25;1,1)	W(0,25;1,1)	W(0,25;1,1)
ppt	W(0,38;14,3)	W(0,38;14,3)	W(0,38;14,3)
pdf	W(0,35;3,5)	G(0,32;183)	W(0,35;3,5)
other	W(0,46;27,7)	G(0,29;181)	W(0,46;27,7)

Figure 2. Equidistant threshold probabilities in case of two hierarchies with p1=10% and p2=5%



The influence on the number of hierarchies is observed by means of the relative capacity-need. In addition the jitter serves as a measure to look at the reliability of the system.

Now the individual simulation-runs and the accompanying results are explained.

At the first simulation there is only one threshold probability of p1=10% which lies between level 1 and 2. Figure 3 shows the result of the simulation.

In simulation 1 the relation between hierarchies 1 and 2 is approximately 1:1, i.e. almost half of the complete data stock is stored on the second, more economical hierarchy level. The average jitter is J(1000)=2.136.

Figure 3. Mean relative capacity-needs for two hierarchies

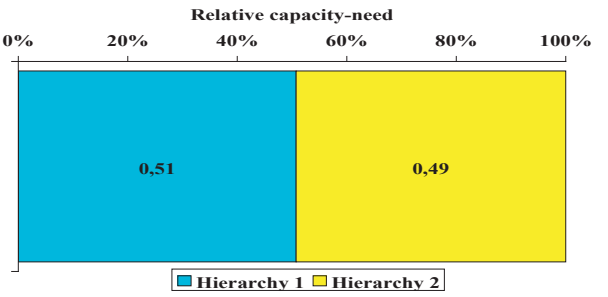
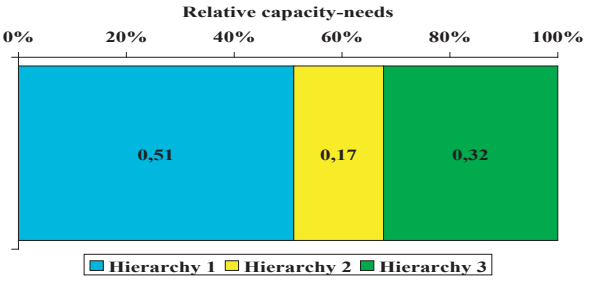


Figure 4. Mean relative capacity-needs for three hierarchies



In simulation 2 three hierarchies are available for the storage of the files. The related value probabilities are p1=10% and p2=5 %.

Figure 4 represents the result of simulation graphically by means of the relative capacity need.

Again approximately 50% of the data are on the first storage hierarchy. On the second hierarchy nearly a sixth of the complete stock is kept and on the third hierarchy nearly a third of the files is stored.

A mean jitter of J(1000)=2.093 was measured.

In simulation 3 the probability values are p1=10%, p2=6.66% and p3=3.33%. The mean capacity values arising from the simulation are represented in figure 5.

Hierarchy 1 keeps 51% and hierarchy 2 keeps 10%. Hierarchies 3 and 4 keep 14% and. 25% respectively.

The average jitter is J(1000)=2.16.

Figure 5. Mean relative capacity-needs for four hierarchies

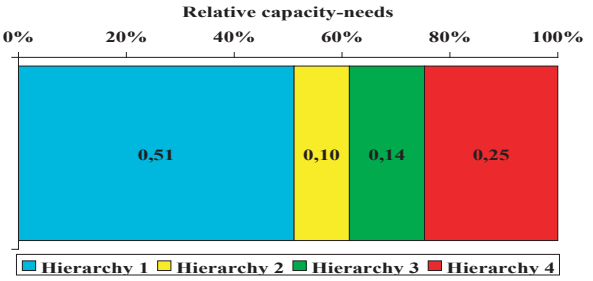


Figure 6. Mean relative capacity-needs for five hierarchies

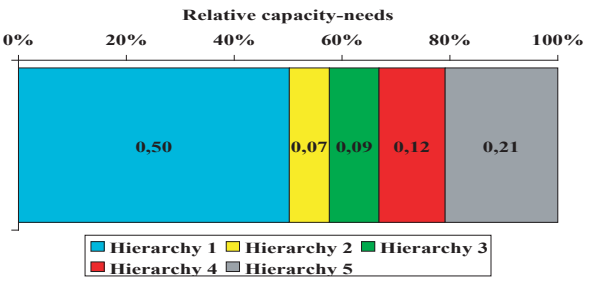
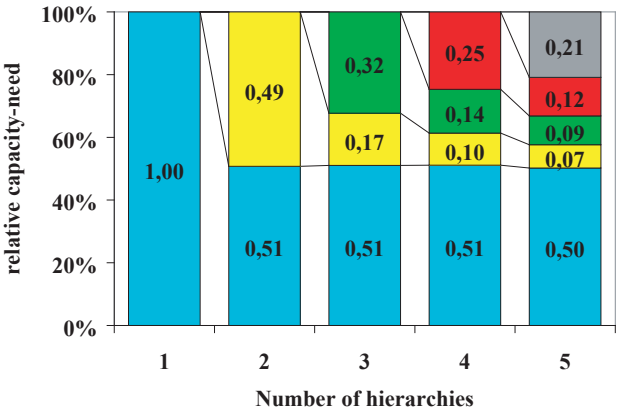


Figure 7. Overview of the mean capacity-needs



In simulation 4 a scenario with 5 hierarchies is simulated. The related probability values are p1=10%, p2=7.5%, p3=5% and p4=2.5%.

The results are shown in figure 6. Hierarchy 1 keeps 51 % and hierarchy 2 keeps 7.4%. Hierarchies 3 and 4 keep 9.2% and 12.3% respectively. Hierarchy 5 keeps 20.9%.

The measured jitter was J(1000)=2.17.

5. RESULTS AND INTERPRETATION

The observed jitter values of the four simulations vary less than 5%. It can be assumed that the reliability of an ILM system is independent of the number of hierarchies.

Figure 7 gives an overview of the capacity-need of the different scenarios.

By applying the sensitivity analysis we examine the effects of a variation in the number of hierarchies.

The storage demand of the first hierarchy remains constant irrespective of changes in the number of storage hierarchies.

The capacity need of the second level is reduced with an increasing number of storage hierarchies.

The reason for this behavior of the ILM system is the specification of the threshold probabilities.

With any added hierarchy the distances of the values change.

If there are only two hierarchies, the second hierarchy stores all files with an access probability of less than 10%.

If three hierarchies are used, the second only keeps files with an access probability of between 5% and 10%. Therefore the relative capacity need of the second level becomes smaller.

Generally speaking from all hierarchies lower than hierarchy 1, the lowest hierarchy always keeps the largest part of the files. Altogether, the greatest share of the information is stored on the top and the bottom hierarchies. This result coincides with the observations in real IT systems and is an essential driver for ILM. [11].

6. SUMMARY AND OUTLOOK

We presented simulation results for Information Lifecycle Management. The objective was focused on the optimal number of storage hierarchies. Although the number depends on the definite business process, the range of numbers of hierarchies could be isolated. In the next step further ILM scenarios will be simulated and compared. The focus will lie on the secondary objectives listed in section 3.

REFERENCES

[1] Turczyk, Lars.; Groepl, Marcel; Heckmann, Oliver and Steinmetz, Ralf: Analyse von Datei-Zugriffen zur Potentialermittlung fuer Information Lifecycle Management, TU Darmstadt KOM Technical Report 01/2006

[2] Strange, Stephen: Analysis of Long-Term UNIX File Access Patterns for Application to Automatic File Migration Strategies. Technical Report UCB/CSD-92-700, EECS Department, University of California, Berkeley, 1992.

[3] Miller, Ethan L. and Katz, Randy H.: An Analysis of File Migration in a UNIX Supercomputing Environment. USENIX Winter, pages 421–434, 1993.

[4] Schmitz, Carolin: Entwicklung einer optimalen Migrationsstrategie für ein hierarchisches Datenmanagement System. Technischer Bericht, Forschungszentrum Jülich, 2004.

[5] Gibson, T. and Miller E.: An Improved Long-Term File-Usage Prediction Algorithm, 1999.

[6] Reiner, David; Press, Gil; Lenaghan, Mike; Barta, David; Urmston, Rich; "Information Lifecycle Management: The EMC Perspective" 20th International Conference on Data Engineering (ICDE'04) 1063-6382/04

[7] Turczyk, Lars Arne; Heckmann Oliver; Berbner, Rainer and Steinmetz, Ralf: A Formal Approach to Information Lifecycle Management. In Proceedings of IRMA ´05, Washington DC, May 2005

[8] Chen, Y.: Information valuation for Information Lifecycle Management. International Conference on Autonomic Computing (ICAC'05), 2005.

[9] Beigi, Mandis; Devarakonda, Murthy; Jain, Rohit; Kaplan, Marc; Pease, David; Rubas, Jim; Sharma, Upendra; Verma, Akshat, "Policy-Based Information

Lifecycle Management in a Large-Scale File System", IEEE International Workshop on Policies for Distributed Systems and Networks (POLICY'05)

[10] Tanaka, Tetsuo; Ueda, Ryoichi; Aizono, Toshiko; Ushimjima, Kazutomo; Naizoh, Ichiro; Komoda, Norihisa; Proposal and Evaluation of Policy Description for Information Lifecycle Management. International Conference on Computational Intelligence for Modelling, Control and Automation, and International Conference on Intelligent Agents, Web Technologies and Internet Commerce (CIMCA-IAWTIC'05) 0-7695-2504-0/05

[11] Gostner, Roswitha; Turczyk, Lars; Heckmann, Oliver; Steinmetz, Ralf: Analyse von Datei-Zugriffen zur Potentialermittlung fuer Information Lifecycle Management, TU Darmstadt TR01/2005

Utilizing Project Management Principles for Successful Six Sigma Project Execution

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ABSTRACT

This paper reviews the American Society for Quality (ASQ) Certified Six Sigma Black Belt Body of Knowledge (CSSBBBOK) and prescribed areas of the Project Management Body of Knowledge (PMBOK) along with industry accepted deliverables deployed in the Six Sigma methodology of Define, Measure, Analyze, Improve, and Control (DMAIC). Each DMAIC phase is compared to the applicable project management process knowledge area of the PMBOK and the CSSBBOK. This paper proposes utilizing project management deliverables to the typical DMAIC tool set to resolve some of the root causes of Six Sigma project failure and to ensure successful Six Sigma project execution.

1.0 INTRODUCTION

Many companies deploy Six Sigma methodologies through selection of improvement projects that are related directly to customer dissatisfaction (warranty) -- things that have gone wrong (Stamatis, 2001).This is typically accomplished by training employees in Six Sigma Define, Measure, Analyze, Improve, and Control (DMAIC) methodology and completing the improvement projects with an emphasis on analytical rigor. However, according to Bertels (2003), Dussharmi (2003), and Goldstein (2003) successful Six Sigma projects also depend upon making sure that all levels of management play an active role in the deployment of the project by actively engaging them in the planning and project review process. In addition, Kowalski (2006) suggests that "90% of Six Sigma practitioners rate the addition of tools for engaging frontline managers and employees as a top priority for improving project results."

Upon examination of the ASQ-CSSBBBOK the Project Management section which describes the project charter and plan, team leadership and team dynamics, performance, change agents and management and planning tools, constitutes less than 10% of the overall ASQ-CSSBBBOK. Could the prescribed areas of the PMBOK offer tools that can be added to the DMAIC methodology that will successfully engage managers and employees? This paper proposes adding project management deliverables to the existing list of Six Sigma DMAIC tool set to resolve some of the root causes of Six Sigma project failure and ensure successful Six Sigma project execution.

2.0 PROJECT MANAGEMENT

Project Management (PM) is the application of knowledge, skills, tools and techniques to project activities to meet project requirements which is accomplished through the application and integration of the PM processes of initiating, planning, executing, monitoring and controlling, and closing. The term "project management" is sometimes used to describe an organizational or managerial approach to the management of projects and some ongoing operations, which can be redefined as projects that is also referred to as "management by projects."(A Guide to the PMBOK, 2004).

This standard describes the nature of PM processes in terms of the integration between the processes, the interactions within them, and the purposes they serve. These processes are aggregated into five groups, defined as the:

PM Process Groups:

- Initiating
- Planning
- Executing
- Monitoring and Controlling
- Closing

The PM knowledge areas are:

- Project Integration Management describes the processes and activities that integrate the various elements of project management, which are identified, defined, combined, unified and coordinated within the PM Process Groups.
- Project Scope Management describes the processes involved in ascertaining that the project includes all the work required, and only the work required, to complete the project successfully.
- Project Time Management describes the processes concerning the timely completion of the project.
- Project Cost Management describes the processes involved in planning, estimating, budgeting, and controlling costs so that the project is completed within the approved budget.
- Project Quality Management describes the processes involved in assuring that the project will satisfy the objectives for which it was undertaken.
- Project Human Resource Management describes the processes that organize and manage the project team.
- Project Communications Management describes the processes concerning the timely and appropriate generation, collection, dissemination, storage and ultimate disposition of project information.
- Project Risk Management describes the processes concerned with conducting risk management on a project.
- Project Procurement Management describes the processes that purchase or acquire products, services or results, as well as contract management processes.

3.0 SIX SIGMA DEFINED

Six Sigma was conceptualized as quality goal in mid—1980's at Motorola. There have been many versions of the Six Sigma definition since it was first coined in Motorola in the year 1987. ASQ defines Six Sigma as a fact-based, data-driven philosophy of quality improvement that values defect prevention over defect detection. It drives customer satisfaction and bottom-line results by reducing variation and waste, thereby promoting a competitive advantage. It applies anywhere variation and waste exist, and every employee should be involved. In simple terms, Six Sigma quality performance means no more than 3.4 defects per million opportunities. Benbow et. al, (2005) discuss differing opinions on the definition of Six Sigma by defining Six Sigma as philosophy , or as a set

of tools and or as a methodology. We will consider the methodology definition which is shown below.

The Six Sigma methodology recognizes the underlying and rigorous approach known as DMAIC. DMAIC defines the steps a Six Sigma practitioner is expected to follow, starting with identifying the problem and ending with the implementation of long-lasting solutions. While DMAIC is not the only Six Sigma methodology in use, it is certainly the most widely adopted and recognized (www.asq.org). Methodologies other than DMAIC are beyond the scope of this paper.

Irrespective of the choice of definition one may make, Six Sigma is always deployed through execution of a series of projects selected by management and driven by black belts. Six Sigma Black Belt leads, inspires, manages, delegates, coaches and "baby-sits" colleagues and becomes almost expert in tools for assessing problems and fixing or designing processes and products. Usually the Black Belts work alongside a team assigned to a specific, Six Sigma project (Pande, Holpp, 2002).

The fact that implementations of Six Sigma are always done through projects raises the logical question of how well is typical Six Sigma practitioner equipped with PM skills?

The criteria for selection of a black belt person vary considerably. Organizations may consider the organizational hierarchy of an employee before selection of the candidate for Six Sigma practitioner role (Revelle, 2001). Bertels, (2003) emphasizes that comfort and proficiency with numerical analysis and computer literacy are "must haves" for Six Sigma black belt roles. Pande et.al (2002) suggest that the black belt must possess strong problem solving, the ability to collect and analyze data, organizational savvy, leadership and coaching experience, and good administrative sense. They also suggest that the black belts must be adept at project management. Organizations assume delivery of these skills through the six sigma training; however this assumption has not been evaluated. The paper evaluates the fulfillment of PM skills by assessing the ASQ Six Sigma Black Belt Body of Knowledge.

Table 1. Knowledge areas prescribed by ASQ

KNOWLEDGE AREA	Specific Topics
I. Enterprise-Wide Deployment	A. Enterprise view B. Leadership C. Organizational goals and objectives D. History of organizational improvement/foundations of six sigma
II. Business Process Management	A. Process vs. functional view B. Voice of the customer C. Business results
III. Project Management	A. Project charter and plan B. Team leadership C. Team dynamics and performance D. Change agent E. Management and planning Tools
IV. Six Sigma Improvement Methodology and Tools – Define A	A. Project scope B. Metrics C. Problem statement
V. Six Sigma Improvement Methodology and Tools – Measure	A. Process analysis and documentation B. Probability and statistics C. Collecting and summarizing data D. Properties and applications of probability distributions E. Measurement systems F. Analyzing process capability
VI. Six Sigma Improvement Methodology and Tools – Analyze	A. Exploratory data analysis B. Hypothesis testing
VII. Six Sigma Improvement Methodology and Tools – Improve	A. Design of experiments (DOE) B. Response surface methodology C. Evolutionary operations (EVOP)
VIII. Six Sigma Improvement Methodology and Tools – Control	A. Statistical process control (SPC) B. Advanced statistical process control C. Lean tools for control D. Measurement system re-analysis
IX. Lean Enterprise	A. Lean concepts B. Lean tools C. Total productive maintenance (TPM)
X. Design for Six Sigma (DFSS)	A. Quality function deployment (QFD) B. Robust design and process C. Failure mode and effects analysis (FMEA) D. Design for X (DFX) E. Special design tools

4.0 ASQ SIX SIGMA BLACK BELT BODY OF KNOWLEDGE

The American Society for Quality (ASQ) has developed a Six Sigma Black Belt Body of Knowledge to use as a basis for certification of individuals as the Black Belts level of performance in applying the Six Sigma methodology. The knowledge areas prescribed by the ASQ are shown in Table 1.

Table 1 shows that 10% (one knowledge area out of ten) of the curriculum is devoted to project management. The question is that of adequacy and if these skills are well embedded within DMAIC phases. In order to assess this we evaluate the tools applied in each of the DMAIC phase and their relevance to project management.

5.0 THE RELEVANCE OF SIX SIGMA BLACK BELT TOOLS TO PROJECT MANAGMENT

The similarities between PM and Six Sigma have been discussed in the past. Tye (2005) suggests using Six Sigma to aid PM when developing a new process or product. Pyzdek (2003) discusses PM requirements for a successful Six Sigma program execution but the discussion is focused at the program level and not at the project level. Stamatis (2001) also discusses PM integration for the Design for Six Sigma (DFSS) methodology (beyond the scope of this paper).

Figure 1. PM knowledge level of integration in DMAIC phases

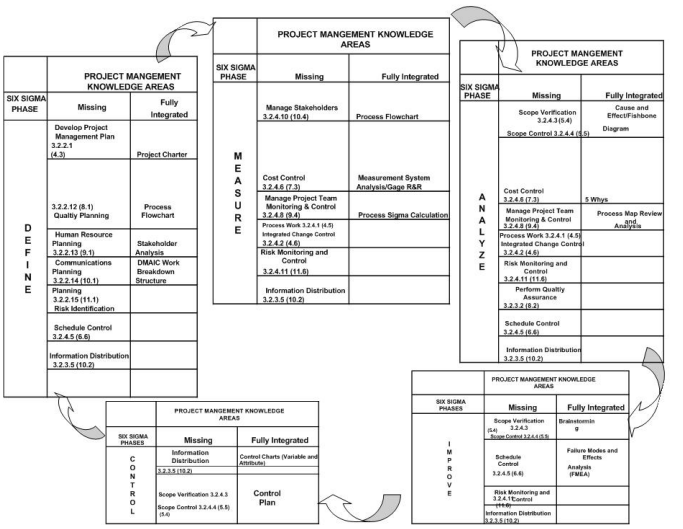
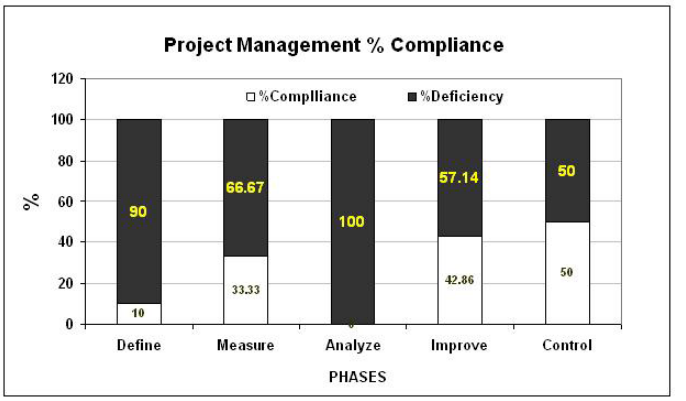


Figure 2. PM gap analysis for each six sigma DMAIC phase



*(% Gap = (missing PM knowledge areas) ÷ (missing PM knowledge areas + fully integrated PM areas) * 100)*

Figure 1 evaluates the tools within DMAIC Phases against PM knowledge areas to determine which Knowledge areas are missing from the DMAIC phases.

Figure 2 displays quantitatively the PM knowledge areas of deficiency within each DMAIC phase as discussed earlier in Figure 1.

The gaps shown in Figure 2 are an indication of the void spaces for PM knowledge areas within DMAIC phases which may adversely affect the project execution and the project success.

6.0 REASONS FOR ADDRESSING THE GAPS

The primary reason for addressing the gaps using PM knowledge areas can found in the root causes of Six Sigma project failures discussed by Goldstein (2001), Underdown (2006), Nilanatasrinivasan (2005) and are summarized in Figure 3: Cause and Effect Diagram: Six Sigma Success Factors. This is in no way a comprehensive list but nevertheless, gives us a glimpse of important root causes of Six Sigma project failures.

Solutions to mitigate the root causes discussed in figure 3 are shown in Table 2.

7.0 PROPOSED SOLUTION

All the root causes listed in Table 2 may be successfully addressed or mitigated by adhering to sound PM principles as prescribed in the PMBOK. Table 2 each specific PM knowledge area that may address or mitigate root causes for each of the Six Sigma project failures. For example, details of the Deployment plan can be addressed or mitigated by adhering to Project Integration Management which defines inputs and outputs, along with standards for developing a sound project charter and developing a preliminary scope statement.

Likewise, the root cause related to communication may be mitigated if the Six Sigma practitioner implementation of Project Communication Management as defined by the PMBOK.

It is important to note that there may be more than one PM knowledge area to addressing or mitigating root causes, but this paper is limited to discussion of the most applicable PM knowledge area.

8.0 CONCLUSION

Root causes of Six Sigma project failures were discussed and it was determined that Six Sigma practitioners rated the addition of tools for engaging frontline managers and employees as a top priority for improving the success of Six Sigma projects. In addition, upon examination of the current ASQ CSSBBBOK it was determined that even though it provides a solid foundation for establishing standards for analytical tools and methodologies used in the DMAIC process, the knowledge area of PM appear to be lacking and does not provide enough tools to ensure successful implementation of projects with the engagement of frontline managers and employees. Integrating PMBOK areas into the DMAIC process may address or mitigate this issue. Further research will be required to evaluate the effects of integrating PMBOK areas into Six Sigma methodology on the success of Six Sigma Projects. The next steps in the research will be to develop a training model that will better address the PM knowledge areas and study the effects of the same on the successful execution of Six Sigma projects.

Figure 3. Cause and effect diagram: Six sigma success factors

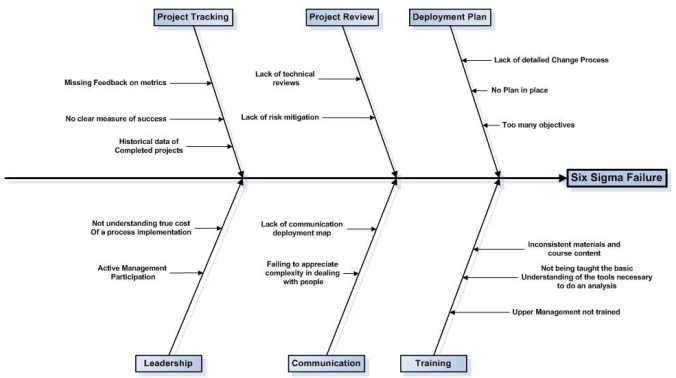


Table 2. Proposed PM knowledge areas for mitigating root causes

Root Causes	Proposed Project Management Knowledge Areas for Mitigating Root causes
1. Deployment plan.	Project Integration Management
2. Active participation of the senior executives.	Project Communications Management
3. Project reviews.	Project Integration Management
5. Full-time vs. part-time resources.	Project Human Rescource Management
6. Training.	Project Human Rescource Management
7. Communications.	Project Communications Management
8. Project selection.	Project Integration Management
9. Project tracking.	Project Time Management

9.0 REFERENCES

A Guide to the Project Management Body of Knowledge, 2004, American National Standard ANSI/PM I 99-001-2004

ASQ, Certified Six Sigma Black Belt of Knowledge, downloaded September 27, 2006 from http://www.asq.org/certification/six-sigma/bok.html

ASQ, downloaded September 27, 2006 from (http://www.asq.org/learn-about-quality/six-sigma/overview/overview.html).

Donald W. Benbow and T. M. Kubiak, The Certified Six Sigma Black Belt Handbook, ASQ Quality Press, 2005, pages 1-2.

Bertels, Thomas (2003). Rath & Strong's Six Sigma Leadership Handbook, 336

Dusharme, Dirk 2006 Quality Digest downloaded from www.qualitydigest.com/nov03/articles/01_article.shtml

Goldstein, Mark (2001), Six Sigma Program Success Factors, Six Sigma Forum Magazine 36-45

Kowalski, Bill downloaded September 29, 2006, downloaded from (www.software.isixsigma.com/libary/content/c030324a.asp?action=print).

Stamatis, Dean H (2001). Six Sigma and Beyond By, 92 downloaded from http://www.qualitydigest.com/feb03/articles/01_article.shtml

Pande, Peter S., Holpp, Lawrence (2002), What Is Six Sigma?

Pyzdek, Thomas 2003, the Six Sigma Handbook, 187

Tye, Rich 2005, Software Six Sigma and PMBOK

The Impact of Information Technology Architecture on Supply Chain Performance

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ABSTRACT

Supply chain oscillations satisfy a sound wave-like dispersion relation when a company responds only to the status of the companies immediately above and below it in the chain. However, when information technology makes it possible for the company to respond to the status of all the companies in the chain, the dispersion relation changes from that of a sound wave to that of a plasma oscillation. The plasma oscillation exhibits Landau damping, and thus the information exchange leads to beneficial suppression of the oscillations.

INTRODUCTION

Supply chains are notorious for exhibiting oscillations in inventories that are both disruptive and costly in resources. Business schools have for several years exposed their students to the phenomena through the widely used simulation game created by J. D. Sterman and his colleagues at MIT (Sterman and Fiddaman 1993).

Sterman and Fiddaman conjectured that the oscillations were due in part to the lack of information exchange between the companies in the change. This lack of information exchange prevents controlled responses and leads to over reaction to perturbations from the steady state.

Recently, a simple model was developed in which each company in the supply chain responded only to the status of the companies immediately above and below it in the chain (Dozier and Chang 2005). The model displayed the types of supply chain oscillations observed in both the simulations and in actual practice. The oscillations satisfied the same type of dispersion relation as acoustic waves in a solid, i.e. the relationship between the frequency of oscillation and the wave number(2π/wavelength) of the oscillation resembled that for a sound wave in a solid.

In a follow-on paper, a crude continuum flowing fluid model of the supply chain was introduced: in the flowing fluid model, the resulting supply chain oscillations were found to satisfy the same dispersion relation as sound waves (Dozier and Chang 2007).

The purpose of this paper is to explore what happens if information exchange occurs between all the companies in the supply chain. This enables each company to respond not just to the inventory status of the layers immediately below and above it in the chain, but to the inventory status of all the companies in the chain. It will be shown that the oscillations change their character and become more like plasma oscillations than sound waves. The dispersion relation for a plasma oscillation can have higher phase velocities and lower group velocities than that for a sound wave. The associated Landau damping of the oscillations suggests that information exchange leads to beneficial suppression of the oscillations.

Section 1 presents a more realistic model of local information exchange a supply chain than our earlier treatments, in order to provide an easy comparison with the treatment of universal information exchange.

Section 2 derives the oscillation dispersion relation for a supply chain in which there is information exchange with all the companies in the chain.

1. SUPPLY CHAIN WITH LOCAL EXCHANGE OF INFORMATION

In (Dozier and Chang 2007), the supply chain was treated in the continuum limit where instead of designating each level in the chain by a discrete label n, the position in a chain was designated by a continuum variable x. Flow of production through each position *x* in the chain was characterized by a velocity variable v. A long supply chain was treated in which end effects were ignored.

We begin by introducing a function of position, production flow rate velocity, and time, f(x,v,t)dxdv that denotes a flow in the number of production units in the intervals dx and dv at a given x and v at the time t. This distribution function can be expressed as a conservation equation in the phase space of x and v:

$$\partial f/\partial t + \partial[f dx/dt]/\partial x + \partial[f dv/dt]/\partial v = 0 \quad (1)$$

This equation simply states that the change of fdxdv is due only to the divergence of the flow into dxdv. This implies that the flow into a volume element dxdv may not the same as the flow out.

By introducing a force F that influences the velocity of the production rate v, this equation can be rewritten

$$\partial f/\partial t + \partial[fv]/\partial x + \partial[fF]/\partial v = 0 \quad (2)$$

Since position x and velocity of the production rate v are independent variables,

$$\partial v/\partial x = 0 \quad (3)$$

If, moreover, the force F does not depend on v,

$$\partial F/\partial v = 0 \quad (4)$$

then Equations (2)-(4) yield

$$\partial f/\partial t + v\partial f/\partial x + F\partial f/\partial v = 0 \quad (5)$$

This is similar to the Liouville equation of classical mechanics, and has the familiar form of the Vlasov equation for collisionless plasmas (Spitzer (1956)).

Now assume that F at the position x is determined only by the level of the inventories of the production units immediately above and below x in the chain.

Assume that the fractional change in the time rate of change of velocity (1/v)dv/dt is proportional to the fractional change in the gradient of the density $N(x,t)$:

$$(1/v)dv/dt \;\mu\; -(1/N)dN/dx \qquad (6)$$

where

$$N(x,t) = \int dv f(x,v,t) \qquad (7)$$

and where the negative sign is explained below.

For local information exchange with the levels immediately above and below the level of interest, the change in the density is observed over only $dx = 2l$, where l is the spacing between levels in the supply chain Thus, we can further write

$$(1/v)dv/dt \;\mu\; -(2l/N)dN/dx \qquad (8)$$

The rationale for this expression is that when the inventory of the level below the level of interest is less than normal, the production rate (v) will be diminished because of the smaller number of production units being introduced to that level. At the same time, when the inventory of the level above the level of interest is larger than normal, the production rate will also be diminished because the upper level will demand less input so that it can "catch up" in its production through-put. Both effects give production rate changes proportional to the gradient of N. It is reasonable also that the fractional changes are related rather than the changes themselves, since deviations are always made from the inventories at hand.

A time scale for the response is missing from Equation (8). We know that a firm must make decisions on how to react to order flows into the firm. Assume that the time scale of response $\tau_{response}$ is given by

$$\tau_{response} = (1/\xi)\tau_{processing} \qquad (9)$$

where $\tau_{processing}$ is the processing time for a unit as it passes through the firm, and for simplification we are assuming ξ is a constant. Most likely, ξ will be less than unity, corresponding to response times being longer than processing times.

Thus, Equations (6) – (9) lead to

$$(1/v)dv/dt \;-(2\xi l/\tau_{processing}\; n)dn/dx \qquad (10)$$

Since by definition production rate *(i.e. velocity)*

$$v = l/\tau_{processing} \qquad (11)$$

this gives finally

$$F = dv/dt = -\; 2\xi v^2(1/N)dN/dx \qquad (12)$$

Insertion of this expression into Equation (5) then yields

$$\partial f/\partial t + v\partial f/\partial x - 2\xi v^2(1/N)(dN/dx)\;\partial f/\partial v = 0 \qquad (13)$$

In the steady state, the equation is satisfied by

$$f(x,v,t) = f_0(v) \qquad (14)$$

i.e. by a distribution function that is independent of position and time: production units flow smoothly through the line without bottlenecks. For a smoothly operating supply chain, $f_0(v)$ will be centered about some flow velocity V_0, a fact that we shall make use of later.

Now suppose there is a (normal mode) perturbation of the form exp[i(ωt – kx)], i.e.

$$f(x,v,t) = f_0(v) + f_1(v)\exp[-i(\omega t - kx)] \qquad (15)$$

On linearizing eq. (13) with this f(x,v,t), we find that $f_1(v)$ satisfies

$$-i(\omega - kv)f_1 - 2\xi v^2(1/N_0)(dN_1/dx)\;\partial f_0/\partial v = 0 \qquad (16a)$$

i.e.

$$-i(\omega - kv)f_1 - ik\,2\xi v^2(1/N_0)N_1\partial f_0/\partial v = 0 \qquad (16b)$$

Solving for f_1:

$$f_1 = \; -2\xi k(1/N_0)\int dv' f_1(v')\; v^2\partial f_0/\partial v(\omega - kv)^{-1} \qquad (17)$$

On integrating this equation with respect to v, we get the dispersion relation relating ω and k:

$$1 + 2\xi k\,(1/N_0)\int dv v^2\partial f_0/\partial v(\omega - kv)^{-1} = 0 \qquad (18)$$

This equation contains a singularity at ω=kv. This singularity occurs where the phase velocity ω/k becomes equal to the velocity of flow v. There are well-defined methods for the treatment of singularities: Following the Landau prescription (Landau (1946); Stix (1962))

$$\int dv v^2\partial f_0/\partial v(\omega - kv)^{-1} = PP\int dv v^2\partial f_0/\partial v(\omega - kv)^{-1} - i\pi(\omega/k)^2(1/k)\partial f_0(\omega/k)/\partial v \qquad (19)$$

where PP denotes the principal part of the integral, i.e. the value of the integral ignoring the contribution of the singularity.

To evaluate the principal part, assume that for most v, ω>>kv. Then approximately

$$PP\int dv v^2\partial f_0/\partial v(\omega - kv)^{-1} \approx \; \int dv v^2\partial f_0/\partial v(1/\omega) \qquad (20a)$$

or, on integrating this by parts, we find

$$PP\int dv v^2\partial f_0/\partial v(\omega - kv)^{-1} \approx -\,2n_0V_0 \qquad (20b)$$

since f_0 is peaked about the equilibrium flow velocity V_0

This gives the sound-wave-like dispersion relation

$$\omega \approx 4\xi kV_0 \qquad (21)$$

Addition to this of the small contribution from the imaginary part yields

$$\omega = 4\xi kV_0 + \omega(1/N_0)i\pi(\omega/k)^2\partial f_0(\omega/k)/\partial v \qquad (22)$$

or, on using the approximate relationship of Equation [21] for the ω's in the second term on the RHS

$$\omega = 4\xi k V_0 [1+(1/N_0) i\pi (4\xi V_0)^2 \partial f_0(4\xi V_0)/\partial v] \quad (23)$$

For the fast response times made possible by first order rapid information exchange, $\xi = O(1)$. Thus, with $f_0(v)$ peaked around V_0, $\partial f_0(4\xi V_0)/\partial v < 0$.

Accordingly, the imaginary part of ω is less than zero, and this corresponds to a damping of the normal mode oscillation. It is interesting to note that since $4\xi V_0 >> V_0$ (where the distribution is peaked), the derivative will be small, however, and the damping will be correspondingly small.

2. SUPPLY CHAIN WITH UNIVERSAL EXCHANGE OF INFORMATION

Consider next what happens if the exchange of information is not just local. (Suppose that information is shared equally between all participants in a supply chain such as in the use of grid computing.) In this case, the force F in Equation (5) is not just dependent on the levels above and below the level of interest, but on the f(x,v,t) at all x.

Let us assume that the effect of f(x,v,t) on a level is independent of what the value of x is. This can be described by introducing a potential function Φ that depends on f(x,v,t,) by the relation

$$\partial^2\Phi/\partial x^2 = -[C/N_0]\int dv\, f(x,v,t) \quad (24)$$

from which the force F is obtained as

$$F = -\partial\Phi/\partial x \quad (25)$$

(That this is so can be seen by the form of the 1-dimensional solution to Poisson's equation for electrostatics: the corresponding field from a source is independent of the source position.)

The constant C can be determined by having F reduce approximately to the expression of Equation (12) when f(x,v,t) is non zero only for the levels immediately above and below the level x_0 of interest in the chain. For that case, take

$$N(x+l) = N(x_0) + dN/dx\, l \quad (26)$$

and

$$N(x-l) = N(x_0) - dN/dx\, l \quad (27)$$

and zero elsewhere. Then

$$F = -\partial\Phi/\partial x = -[C/N_0](dN/dx)\, 2l^2 \quad (28)$$

On comparing this with the F of eq. (12), $F = -2\xi v^2(1/N)dN/dx$, we find (since the distribution function is peaked at V_0) that we can write

$$C = \xi V_0^2 / l^2 \quad (29)$$

Accordingly,

$$\partial^2\Phi/\partial x^2 = -[\xi V_0^2/N_0 l^2]\int dv\, f(x,v,t) \quad (30)$$

With these relations, F from the same value of f(x,v,t) at all x above the level of interest is the same, and F from the same value of f(x,v,t) at all x below the level of interest is the same but of opposite sign.

This is the desired generalization from local information exchange to universal information exchange.

It is interesting to see what change this makes in the dispersion relation. Equation (5) now becomes

$$\partial f/\partial t + v\partial f/\partial x - \partial\Phi/\partial x\, \partial f/\partial v = 0 \quad (31)$$

and again the dispersion relation can be obtained from this equation by introducing a perturbation of the form of Equation (15) and assuming that Φ is of first order in the perturbation. This gives

$$-i(\omega - kv) f_1 = ik\Phi_1 \partial f_0/\partial v \quad (32)$$

i.e.,

$$f_1 = -k\Phi_1 \partial f_0/\partial v\, (\omega - kv)^{-1} \quad (33)$$

Since Equation (30) implies

$$\Phi_1 = (1/k^2)[\xi V_0^2/N_0 l^2]\int dv\, f_1(v) \quad (34)$$

we get on integrating Equation (33) over v:

$$1 + (1/k)[\xi V_0^2/N_0 l^2]\int dv \partial f_0/\partial v\, (\omega - kv)^{-1} = 0 \quad (35)$$

Once again a singularity appears in the integral, so we write

$$\int dv \partial f_0/\partial v\, (\omega - kv)^{-1} = PP\int dv \partial f_0/\partial v\, (\omega - kv)^{-1} - i\pi(1/k)\partial f_0(\omega/k)/\partial v \quad (36)$$

Evaluate the principal part by moving into the frame of reference moving at V_0, and in that frame assume that $kv/\omega << 1$:

$$PP\int dv \partial f_0/\partial v\, (\omega - kv)^{-1} \approx \int dv \partial f_0/\partial v\, (1/\omega)[1+(kv/\omega)] = -kN_0/\omega^2 \quad (37)$$

Moving back into the frame where the supply chain is stationary,

$$PP\int dv \partial f_0/\partial v\, (\omega - kv)^{-1} \approx -kN_0/(\omega - kV_0)^2 \quad (38)$$

This gives the approximate dispersion relation

$$1 - (1/k)[\xi V_0^2/N_0 l^2]\, kN_0/(\omega - kV_0)^2 \approx 0 \quad (39)$$

i.e.

$$\omega = kV_0 + \xi^{1/2} V_0/l \quad \text{or} \quad \omega = kV_0 - \xi^{1/2} V_0/l \quad (40)$$

To assure that ω>0 as k->0, we shall discard the minus solution as spurious.

Now add the small imaginary part to the integral:

$$1 + (1/k)[\xi V_0^2/N_0 l^2][-kN_0/(\omega - kV_0)^2 - i\pi(1/k)\partial f_0(\omega/k)/\partial v] = 0 \quad (41)$$

On iteration, this yields

$$\omega \approx kV_0 + x^{1/2}(V_0/l)\,[1 + i\,\{pxV_0^2/(2k^2l^2N_0)\}\partial f_0/\partial v\,] \quad (42)$$

where $\partial f_0/\partial v$ is evaluated at

$$v = \omega/k \approx V_0 + (x^{1/2}V_0/kl) \quad (43)$$

Since for velocities greater than V_0 , $\P f_0/\P v < 0$, we see that the oscillation is damped.

Moreover, the derivative $\P f_0/\P v$ is evaluated at a velocity close to V_0, the flow velocity where the distribution is maximum. Since the distribution function is larger there, the damping can be large.

Accordingly, universal information exchange has resulted both in changing the form of the supply chain oscillation and in suppression of the resulting oscillation.

DISCUSSION

The purpose of this paper has been to introduce a simple flow model for comparing the impacts of local information exchange to universal information exchange in a supply chain. The local information exchange has been described by a term that describes the interaction of a company with those immediately above and below it in the supply chain. The universal information exchange has been described by introducing a potential that satisfies a Laplace equation. This potential corresponds to each company above the company at the location of interest contributing equally to that company's actions, and to each company below the company at the location of interest contributing equally but oppositely to that company's actions.

It has been demonstrated that for local information exchange, the dispersion relation that describes the relation between frequency of oscillation and the wave number of the oscillation, resembles that for a sound wave in a flowing fluid, i.e. the wave velocity of the perturbations is proportional to the wave number, and is greater than the production flow velocity. These waves are damped, but the damping can be small because the phase velocity is so much larger than the flow velocity.

It has also been shown that for universal information exchange, the dispersion relation resembles that for a plasma oscillation. Instead of the frequency being proportional to the wave number, as in the local information exchange case, the frequency now contains a component which is independent of wave number. The plasma-like oscillations for the universal information exchange case are always damped. As the wave number k becomes large, the damping (which is proportional to $\partial f_0(\omega/k)/\partial v$) can become large as the phase velocity approaches closer to the flow velocity V_0.

Accordingly, the simple flow model of supply chains has demonstrated that universal information exchange both changes the character of the supply chain oscillations and suppresses the oscillations. This supports Sterman and Fiddaman's conjecture that IT will have beneficial effects on supply chains.

The conclusions of this paper have been based on a rather crude flow model of supply chains and on some rather approximate treatments of the associated equations. Nevertheless, it is hoped that the model has helped develop an intuitive understanding of the different effects.

Future work will create numerical simulations that compare the slightly damped oscillations incurred by serial communication to the predicted largely damped oscillations of grid communication.

REFERENCES

Dozier, K. and Chang, D. (2005). Cybernetic Control in a Supply Chain: Wave Propagation and Resonance. *The 11th International Conference on Information Systems Analysis and Synthesis: (ISAS 2005)* and *The 2nd International Conference on Cybernetics and Information Technologies, Systems and Applications: (CITSA 2005)*. Orlando, Florida.

Dozier, K. and Chang D. (2007). The Impact of Information Technology on the Temporal Optimization of Supply Chain Performance. *Proceedings of the Hawaii International Conference on System Sciences* ***HICSS****-40 (2007)*. Hilton Waikoloa Village, Big Island,Hawaii.

Landau, L.D. (1946) On the Vibrations of the Electronic Plasma. *J. Phys*. (U.S.S.R.) 10:25

Spitzer, L. (1956). *Physics of Fully Ionized Gases*. New York: Interscience Publishers, Inc.

Sterman, J.D. & Fiddaman, T. (1993). *The Beer Distribution Game Flight Simulator, Software (for Macintosh) and Briefing Book.* Sloan School of Management, MIT E53-351 Cambridge, MA 02142

Stix, T. (1962). *The Theory of Plasma Waves.* (p 146).New York: McGraw-Hill.

The Future of Real Time Communications in Online Learning

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ABSTRACT

There is a clear trend in Web content from text-rich to media-rich and it is logical to expect Learning Management Systems (LMSs) of the future to not only increase media-rich content but also integrate media-rich Real Time Communications technologies (RTCs). This will enable a range of new activities to be undertaken and to take advantage of the LMSs organizational capabilities. Videoconference has been used in distance learning for many years. Video Chat and Access Grid are newer RTCs that have the potential for online learning. While these three technologies are similar, a comparison of them will provide direction for their future use.

INTRODUCTION

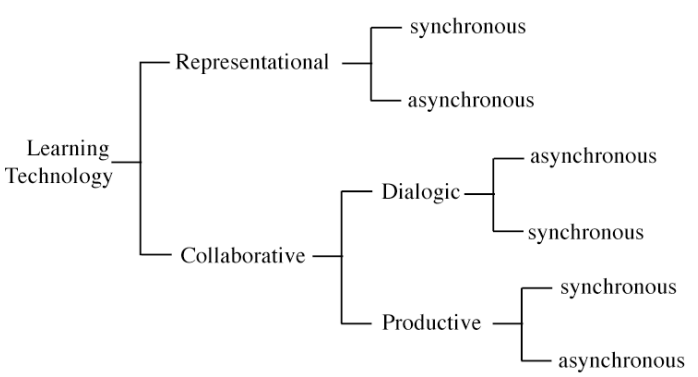
Distance education in the past was generally characterised by independent learning and little dialog between teacher and student. In the 1970s Moore introduced the theory of transactional distance (Moore and Kearsley 1995, p. 197). Transactional distance is measured by the degree of structure and the amount of dialog in a distance education course. Moore argues that communications between teachers and students in distance education "must be facilitated by print, electronic, mechanical or other devices" (Moore 1972, p, 76). RTCs are used to facilitate audio and video communications between teachers and students and include, videoconference, Access Grid, Web Conference and Video Chat.

TAXONOMY OF LEARNING TECHNOLOGIES

The Taxonomy of Learning Technologies (Caladine 2006) categorizes technologies as Representational or Collaborative (see figure 1). The term, Representational describes the communication in the one-way representation of material. Collaborative technologies facilitate two-way communications and are divided into the sub-categories of "Dialogic" or "Productive". Dialogic learning technologies are those that are confined to the support of dialog. Productive learning technologies combine two-way communications and the creation of products.

Videoconference is classified as Collaborative, Dialogic and synchronous. This contrasts to Access Grid when it is used as the host for collaboratively produced materials, in which case it is Collaborative, Productive and Synchronous.

Figure 1. The taxonomy of learning technologies (Caladine 2006)



VIDEOCONFERENCE

Videoconference can be thought of as two parallel, counter-directional closed circuit television systems. In the 1980s dedicated videoconference technology appeared on the market that could take advantage of the then new digital telecommunications networks such as ISDN (Integrated Services Digital Network). At this time videoconference use in distance education took a decided upturn. Today the trend is for videoconferences to use the Internet as the connecting network.

WEB CONFERENCE

Since Microsoft launched NetMeeting in the 1990s, other Web Conference tools have been developed and are now commercially available for use in higher education. Typically Web Conference tools are defined as combining synchronous video and/or audio communications with a shared computer application or presentation. Examples of Web Conference tools include: WebEx, Macromedia Breeze and Elluminate.

VIDEO CHAT

Instant Messaging applications were first limited to text interchanges and were generally free of charge. They evolved into voice applications and have become almost ubiquitous. After voice, video was a natural progression. Video Chat is defined as an application of computer technology that allows two-way audio and video communications. Thus Video Chat can be thought of as videoconference on a computer. Applications like Apple's iChat AV indicate that the future direction of Video Chat is a multipoint video communications tool with integrated file exchange and sharing, referred to here as "Enhanced Video Chat".

Video Chat is rather simple and inexpensive to set up, as all that is needed is a computer, a Web camera, a headset and an Internet connection of sufficient bandwidth. Most broadband connections are ample for this.

ACCESS GRID

Researchers have used the Access Grid as a communications and collaboration technology since its development in the mid 1990s. The Access Grid takes advantage of the Internet's multicast ability to send and receive multiple video and audio streams while keeping bandwidth to a minimum.

While Access Grid, Video Chat and videoconference are similar in that they all facilitate the two-way exchange of video and audio, Access Grid is differentiated by the multiple video streams sent and received from each endpoint or "node" and by a number of additional software modules. These modules include, shared presentation, shared browser, true application sharing and many more. Some commercial products that claim to offer application sharing in fact use the term to describe the transfer of files between participants. True application sharing allows participants to work on the same file at the same time. While room-based nodes on the Access Grid usually contain a wall of projected video images, as shown in Figure 2, smaller installations are possible. These are referred to as Personal Interfaces to the Grid or PIGs, and require similar technology to Video Chat.

COMPARING VIDEOCONFERENCE, ACCESS GRID, WEB CONFERENCE AND VIDEO CHAT

The role of videoconference in distance education is quite clear, as it has been

Figure 2. Multiple video streams of the access grid

used for the past fifteen to twenty years for communications between students and teachers.

The literature (Caladine 1999, Daunt 1997, Kobayashi et al 1997, Mitchell 1993) concurs that videoconference is best used as an interactive technology in teaching and learning and it is reasonable to extend this generalisation to Access Grid, Web Conference and Video Chat.

Access Grid and Video Chat are newer technologies and are yet to become established in teaching and learning. However, due to the low costs of Video Chat and

Table 1. Comparing technologies

	Video-conference	**Web Conference**	**Access Grid**	**Video Chat**	**Enhanced Video Chat**
Functions	Video and audio of participants	Audio (and video in some cases) of presenter - some have capacity for audio of participants	Video and audio of participants	Video and audio of participants	Video and audio of participants
	Presentation of computer images (eg PowerPoint) by participants	Presentation of computer images (eg PowerPoint) by one participant	Presentation of computer images (eg PowerPoint) by participants		Presentation of computer images (eg PowerPoint) by participants
			Control of computer images by any participant		
		Document or presentation transfer	True application sharing (eg spreadsheets, documents, movie viewers and others)		
		eWhiteboard sharing	eWhiteboard sharing		
			Computer desktop sharing		
Hardware costs	Endpoint - medium Bridge - high	Server - medium	Room based node – medium Personal Interface to the Access Grid - low	Low	Low
Software costs	Included - firmware	Licence – medium/high	Open source	free	free
Support costs	Technician - low	Technician – low (server support)	Technician - medium	none	none
Bandwidth required	Medium	Medium	Medium-high	Medium	Medium

the enhanced functionality of Access Grid, both technologies have the potential to play major roles. A comparison of the technologies on the criteria of functions and costs helps predict the future of these technologies.

While the technologies are all similar, they differ in the type and level of functions they facilitate. Videoconference and Video Chat are characterised by two-way video and audio. By comparison Web Conference in many cases cannot fully support two-way audio and video as well as deliver images from a participant's computer. Access Gird can be configured to do both and Video Chat is defined as two-way video and audio. Table 1 provides a comparison of the functionality of the technologies.

The equipment required for the technologies ranges from the simple to the complex, and hence the costs ranges from low to high. However, the initial cost of the technology is only one part of the costs criterion. Other elements of the technologies that incur costs are software, personnel to support the technology and the network traffic created.

Videoconference technology has improved in reliability and quality of picture and sound. Perhaps the change that has had the greatest impact on the way in which videoconference is used is the change from ISDN to the Internet. The Internet has reduced the need for designated videoconference studios; however, videoconference required bridging technology for the connection of multiple parties. Access Grid uses no local, bridging technology.

Given that videoconference endpoint and bridging technology is expensive, it is reasonable to predict that its use will contract to specialist areas such as, high definition uses for medical imaging, microscopy and motional analysis, and high level board-meeting-style, immersive videoconferences. As students are used to Video Chat technology and as there are great costs saving to be had it is reasonable to predict that the use of Video Chat in distance and online learning will grow and eventually displace videoconference. As enhanced Video Chat has the functionality of Web Conference software, without the expensive price tag it is reasonable to suggest that enhanced Video Chat will replace these.

Cost alone is enough of a driver to see institutions replace expensive videoconference endpoint equipment with the cheaper Video Chat. As well the enhancements of file sharing, and using Video Chat in conjunction with a shared application will see it develop into a Collaborative, Productive learning technology. This will allow students no matter where they are located to undertake a range of collaborative tasks such as, build resources, compile reports, debate issues, brainstorm ideas and more.

While Access Grid has been used for some years in research collaboration its potential for teaching and learning is only now becoming clear. Due to the multiple video streams sent and received, the Access Grid learning experience is visually much richer than videoconference and Video Chat. When Access Grid takes advantage of software modules that allow participating students to control the size of the received video windows and to control the cameras at other endpoints, the experience can be tailored to suit participants on a level beyond that of videoconference and Video Chat. Access Grid also has software modules that facilitate true sharing of files and applications and hence is described by the taxonomy mentioned earlier as Collaborative-Productive.

CONCLUSION

It is reasonable that future students will expect video and other examples of media-richness in their online learning experience. Learning Management Systems have played a significant role in learning for the past six to eight years and have been text-rich in both content and interactions. Their communications have generally been limited to text. Students could use the LMS email system, engage in a chat session or send a message to a forum. As Video Chat is fast displacing text as the preferred medium for Instant Messaging, it is expected that Video Chat will be integrated with Learning Management Systems. The integration will allow templates for their use and secondary applications that elevate simple video communications to rich learning events. For example a debating team could consist of students from different locations and the debate could be held in a virtual room on the LMS. If a shared eWhitboard, hosted within the LMS was combined with Video Chat a brainstorming session could be held between geographically dispersed students and other examples abound. Further it is not inconceivable that the Access Grid could be integrated with the LMS. Such an integration would allow the flexibility to have a small group at a regional Access Centre and larger group at a room-based node on campus and individuals at home on a personal interface.

REFERENCES

Caladine, R. (2006) A Taxonomy of Learning Technologies: Simplifying Online Learning for Learners, Professors and Designers, in Khosrow-Pour, M. (ed.) *Emerging Trends and Challenges in Information Technology Management.* Proceedings of the 2006 Information Resources Management Association, International Conference, Washington DC, Idea Group: Hershey.

Caladine, R. (1999) *Teaching for Flexible Learning: Learning to Apply the Technology.* GSSE: Monmouthshire.

Daunt, C. (1997) Is Teleteaching Different? in Osborne, J. et al (Eds.) *Open, Flexible and Distance Learning: Education and Training for the 21st Century.* Proceedings of the 13th Biennial Forum of ODLAA; Launceston.

Kobayashi, T., Tanaka, K. Yamaji, H. and Otsuka Y. (1997) Crosscultural Joint Classes Between Japan and Australia Using ISDN in Osborne, J. et al (Eds.) *Open, Flexible and Distance Learning: Education and Training for the 21st Century.* Proceedings of the 13th Biennial Forum of ODLAA; Launceston

Moore, M and Kearsley, G. (1996) *Distance Education a Systems View.* Wadsworth: Belmont, USA.

Moore, M. (1972) Learner Autonomy: The Second Dimension of Independent learning. *Convergence* 5(2), 76-88.

IT Tools Supporting Public Relations Campaigns

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1. THE ROLE OF INFORMATION IN PUBLIC RELATIONS

One of the most important economical theories recently is the theory of information asymmetry. As Arrow and Akerlof independently indicated (Arrow 1963; Akerlof 1970) the common situation on the market is that one party is better informed than the other. Due to this phenomenon, dubbed information asymmetry, markets can deteriorate and even disappear. A detailed analysis of the importance of information in economy has been proposed by Stiglitz (Stiglitz 2000).

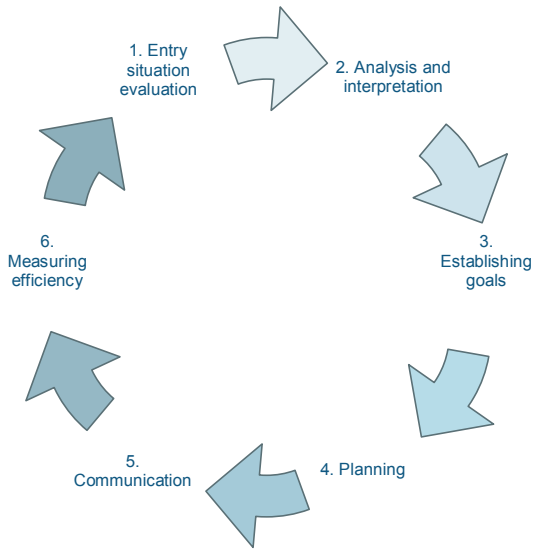
Research in the fields of economics and PR is clearly indicating that proper information is crucial in order to make the most appropriate business decisions e.g. during PR campaigns even minor decisions made may largely influence the outcomes. Moreover, recent research indicates that Internet contributes to reduction of information asymmetry (Levitt i Dubner 2005). In general, the influence of information technology on information overload and information asymmetry has been analysed by Kriebel and Moore (Kriebel i Moore 1982).

At the same time we are facing an overburdening growth of the number of reliable information sources on the Internet (Klapp 1986; Feather 1998). The basic assumption of awareness of all available alternatives and ability to assess all possible outcomes clearly cannot be met anymore (Balcerowicz 1997).

1.1. PR Process

PR campaign is a process that consists of a set of activities which in turn should lead to fulfilling PR aims such as creation of attitude towards the organization, providing effective corporate publicity, formation of image of the organization (Wojcik 2001).

Figure 1. Public relations campaign



In-depth analysis of stages of Public Relations campaign leads to one important remark – stages 1., 2. and 6. are strongly related to collecting, processing and analysing information from different sources. These phases are often referred in the literature as research phases (Stacks 2002):

2. IT TOOLS

There are many Information Technology tools that can help in running efficient PR campaigns. Here, we focus on three groups of such tools: information retrieval and filtering tools, information aggregation tools, and information integration tools. They are mostly to be used in the research phase of PR campaigns, where efficient access to relevant information is especially important.

2.1. Information Retrieval and Filtering Tools

Information filtering (IF) is a constant process that enables acquiring documents that match user preferences. In opposite to it, information retrieval (IR) is about finding documents that are relevant to user query in collection of documents. However, there is one common idea in both processes. Both approaches need documents as well as user needs to be properly described. These descriptions may be viewed as certain contexts that are taken into account when analysing documents.

2.1.1. Contexts for Information Filtering

Context is defined as information characterizing situation of a person, place or object, that cooperates with user or application (Dey and Abowd 1999). There are several types of contexts described in the literature: computing context, physical context and user context (Schilit 1995), human factors and physical environment contexts (Schmidt et al. 1999).

In order to be able to provide user with information that matches each of type of context documents need to be properly described (i.e. indexed). Therefore, the following methods of documents' indexing were differentiated:

- Cognitive indexing - providing description of documents subject e.g. real estates, vehicles, etc. In other words cognitive indexing is about assigning categories to a document.
- Time indexing - identifying all dates that the article is relevant for. However time indexing is not only about extracting dates from a given document – it's also about identification of verb forms and reference date of an article.
- Geographical indexing - discovering all geographical places mentioned in a document and assigning the document to right place in hierarchy of geographical places.
- Proper names indexing - this context is connected to all organization product or person names that appear in the document content.

2.2. Information Aggregation Tools

The information extracted from numerous sources needs to be put together. In data and information integration systems it is usual to integrate the extraction results, which includes identifying data that refer to the same real world entities,

normalizing it, equalize the measures, format etc. and remove redundancies. This is, however, hardly possible or even not desired for content aggregation. While data integration tries to find corresponding entity descriptions and remove duplicate information, content aggregation just brings the information together. Content is subjective in nature and therefore it may be important to retain this subjectivity and preserve the meta-information about the source. We hypothesize that application areas of data integration and content aggregation are separate. While the former is limited to bringing together the information about the same or similar entities from different sources, the latter can be applied to gather information of less homogeneous nature.

Information aggregation is a concept that has not been very well researched so far. There are very few scientific publications regarding this concept. One and most significant of the few is a research work of Stonebraker and Hellerstein (Stonebraker i Hellerstein 2001). They define the term content integration to refer to the integration of operational information across enterprises. The authors understand content as semi-structured and unstructured information, and content integration deals with sharing such information. Stonebraker and Hellerstein describe a Cohera Content Integration System, helpful in content integration, which consists of the following components: Cohera Connect, providing browsing and DOM based wrapper generation functionality, Cohera Workbench for content syndication, and Cohera Integrate for distributed query processing.

Application areas of information aggregation technologies may include news aggregation from multiple sources, in order to be able to compare different sources. However, what is really necessary is a simple solution, since there is already a wealth of approaches that did not receive deserved attention, probably due to their complexity.

2.3. Information Integration Tools

The main problem with accessing data nowadays is that the sources are dispersed, they are not searchable and the process of obtaining data may be tedious. All these issues are tackled with information integration technologies.

A typical data source on the Web exposes some forms to ask queries – examples would be search form on the main Amazon.com page or similar forms found on governmental census bureaus' pages. These forms are very often of limited functionality and they differ from source to source. Moreover, when we get the results, they come in the form of a Web page, which is not very convenient for manipulating data or comparing them. The purpose of information integration tools is to overcome these issues, to ease obtaining the data and manipulating them. They provide single interface for posing queries (or even allow to automatically query) and gather data in unified, ready for reuse form.

Information integration has several steps that have to be performed before data sources can be used:

- source description – each of the sources to be accessed needs to be introduced to the system, showing its structure, access means and special features
- integration – after all the sources are introduced, they have to be integrated to be seen under single view – this step allows later on to ask a single query that will be forwarded to all the sources without the need to query each of them separately.
- query translation – this activity occurs each time the query is posted – it has to be automatically translated for each source
- extraction – data is gathered from Web pages delivered by the source. It is crucial for this step that it is exact and robust – no garbage is gathered and all what is required is extracted.
- consolidation of the results – the final step includes merging the results from all the sources and presenting them to the user.

With the advent of such tools it is possible to monitor any Web enabled data source, track changes or periodically obtain relevant information necessary to guide PR activities.

3. SUMMARY AND CONCLUSIONS

For different types of content that appears on the Web, different accessing techniques have to be applied. When user likes to receive information about certain product, in certain period of time, for a specific location, he should use a browser that enables him to search for information depending on contexts.

When PR analyst likes to monitor web pages of his business partners or opponents, he should use some content aggregation tools. However, sometimes there is a need to compare business offers of a group of real estate sellers – then the best idea would be to use information integration tools that enable user to integrate data coming from various Internet databases.

IT tools supporting organization of PR processes enable employee-time savings and at the same time improving the quality of information that PR analysts are supplied with. Moreover, the tools enable accessing information sources that are otherwise hard to browse (internet databases) or information that is difficult to find in a certain limit of time (because of its overload).

4. REFERENCES

Akerlof, G. A. (1970). "The Market for 'Lemons': Quality Uncertainty and the Market Mechanism." Quarterly Journal of Economics **84**(3): 488-500.

Arrow, K. J. (1963). "Uncertainty and the Welfare Economics of Medical Care." The American Economic Review **LIII**(5): 941-973.

Balcerowicz, L. (1997). Socjalizm kapitalizm transformacja. Szkice z przełomu epok. Warszawa, Wydawnictwo Naukowe PWN.

Baeza-Yates Ricardo, Ribeiro-Neto Berthier (1999). Modern Information Retrieval. ACM Press. New York 1999.

Dey A. K., G. D. Abowd. "Towards a better understanding of context and context-awareness". In Proceedings of the 2000 Conference on Human Factors in Computing Systems, The Hague, The Netherlands, April 2000.

Feather, J. (1998). The information society: A study of continuity and change. London, Library Association.

Grunig, J. E. (1966). The role of information in economic decision making. Austin, Texas, USA, Association for Education in Journalism.

Holtz S. (2002). Public Relations on the Net: Winning Strategies to Inform, & Influence the Media, the Investment Community, the Government, the Public, & More. American Management Association, 2002.

Kaczmarek-Śliwińska, M. (2005). Internet jako narzędzie public relations przedsiębiorstw okresu transformacji w Polsce. Wydział Ekonomii. Poznań, Akademia Ekonomiczna w Poznaniu.

Klapp, O. E. (1986). Overload and boredom: Essays on the quality of life in the information society. Connecticut: Greenwood Press.

Kowalkiewicz, M., M. Orlowska, T. Kaczmarek and W. Abramowicz (2006). Towards more personalized Web: Extraction and integration of dynamic content from the Web. Proceedings of the 8th Asia Pacific Web Conference APWeb 2006. Harbin, China.

Kriebel, C. H. and J. H. Moore (1982). "Economics and Management Information Systems." Data Base(Fall 1982): 30-40.

Levitt, S. and S. J. Dubner (2005). Freakonomics: A Rogue Economist Explores the Hidden Side of Everything, William Morrow.

Ławniczak, R. and M. Kaczmarek-Śliwińska (2004). Internet PR in a Transition Economy – The Case of Poland. BledCom 2004 The 11th International Public Relations Research Symposium. Bled, Slovenia, BledCom.

Ławniczak R. (2003), The Transitional Approach to Public Relations. in B. van Ruler i D. Vercic (eds.) Public Relations and Communication Management in Europe. Mouton de Gruyter, Berlin 2003.

Schmidt Albrecht, Hans-Werner Gellersen, Michael Beigl: Matching Information and Ambient Media. CoBuild 1999: 140-149.

Schilit, W. N. System architecture for context-aware mobile computing. PhD thesis, Columbia University, 1995.

Simon, H. A. (1978). "Rational Decision-Making in Business Organizations. Nobel Memorial Lecture, 8 December, 1978." Economic Sciences **1978**: 343-371.

Stacks, Don W (2002). "Primer of Public Relations Research". Guilford Press, 2002.

Stiglitz, J. E. (2000). "The Contributions of the Economics of Information to Twentieth Century Economics." The Quarterly Journal of Economics(November 2000): 1441-1478.

Stonebraker, M. and J. M. Hellerstein (2001). "Content Integration for EBusiness." ACM SIGMOD Record **30**(2): 552-560.

Wojcik, Krystyna (2001). „Public Relations od A do Z". Placet Agencja Wydawnicza, Warszawa 2001.

Acquiring Problem-Solving Experience in the Multimedia Domain

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ABSTRACT

Issues of sharing knowledge in distributed environments where people pursue the same interests and work in the same domain, often independently from each other, are becoming increasingly important. In this study the established process for elicitation of problem-solving experience from independent sources was studied and adapted to suit the multimedia domain. The resulting process facilitates domain-wide acquisition of best practices. The quality of the problem-solving experience is ensured by applying formalized approach to data analysis and by domain-wide inclusion of practitioners in capturing their design experience.

1. INTRODUCTION

Knowledge acquisition together with organizational learning, is an essential ingredient of knowledge management in organizations (Davenport and Prusak 1997). However, as modern organizations grow and become geographically distributed, knowledge acquisition and sharing challenges the traditional time and space barriers, and removes demands for direct employee contact and their face-to-face communication (Alavi and Leidner 2001). Issues of sharing knowledge in distributed environments, where people pursue similar interests, work in the same application domain, and yet are independent of each other, are becoming more important and attract growing researchers' attention (Stenmark et al. 1999).

There exists a number of well-known and accepted methods of knowledge and experience acquisition and sharing (Kalfoglou 2000; O'Leary 1998; Rising 1999). One of such methods – pattern mining – is the primary object of this investigation. Apart from the software development field pattern mining has not been applied to large domains. Most frequently it has been employed within the scope of a team or an organization. Therefore, this study aimed at introducing changes to the pattern crafting stage of pattern mining by expanding its scope to domain-wide as well as minimizing other identified deficiencies.

2. EXPERIENCE CAPTURE AND PATTERN MINING

Pattern mining is an approach for eliciting and recoding practitioners' problem-solving experience (Appleton 1997; Coplien 1996). The formalized best practices can be very effectively represented as patterns, a special literary form that helps problem-solvers understand the solution and its consequences (Alexander 1979; Appleton 1997; Gamma et al. 1995).

The pattern mining process (depicted on Figure 1) that has been adopted by the international pattern mining community commonly involves the following stages (Manns 2001):

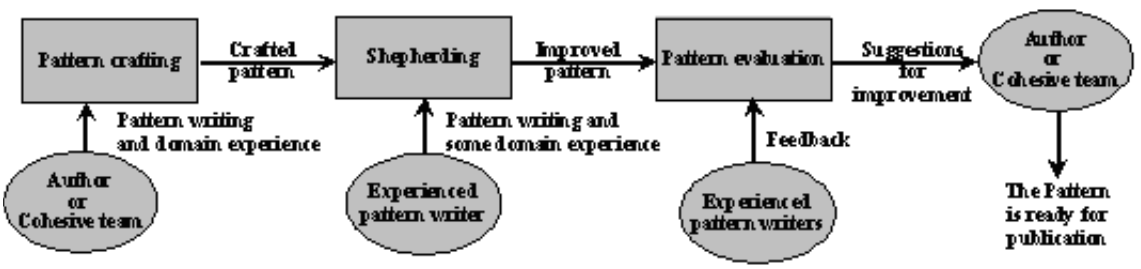
- Pattern crafting, or drafting the initial pattern, as done by an expert in the field or by a cohesive group of experts (e.g. members of the same development team).
- Shepherding – the process when the author(s) gets help from an experienced pattern writer in order to improve the quality of the pattern(s).
- Pattern evaluation at the workshop where experienced pattern writers share their opinions on positive aspects of the pattern and suggestions on the pattern improvement.
- Pattern improvement and publication.

The first stage - crafting the first draft of a pattern or sometimes a pattern language, can be done in many ways. Experienced practitioners always have best practices or at least commonly used practices to share. The most obvious and most frequently used one is "mining one's own experience" where pattern writing becomes a matter of organising and communicating personal knowledge (Manns and Rising 2002). However, often practitioners do not want to spend time or effort on the pattern writing process. Most knowledgeable people are frequently the busiest ones. However, there exist several other approaches where an experienced pattern writer with some knowledge of the domain, called 'ghost-writer' (Rising 1999), can do the formal writing, but the experience should still come from practitioners. A 'ghost-writer' can do Mining by Interviewing, Mining by Borrowing and Mining in Meetings (Rising 1999).

As previously reported (Linden and Cybulski 2006), after a thorough study of the pattern mining process it was determined that its earliest stage – pattern crafting – is in need of urgent attention. In particular, the following deficiencies have been identified (ibid):

- Produced patterns and pattern languages often reflect opinions of a relatively small and most likely cohesive group of people, whose practices may not even represent the best in the domain. Wider involvement of domain practitioners in experience sharing is desirable.
- Shepherding and evaluation relies on active participation of pattern writers, however quite often they have only superficial knowledge of the field.
- To participate in the current process, a practitioner has to learn pattern writ-

Figure 1. Stages in the pattern mining process



ing and become a patterns' author – it is time consuming and not everyone is interested.

Due to lack of domain experts participation in all stages of the pattern mining process, there is a need to address the identified deficiencies beginning with the first stage of the process, i.e. pattern crafting, where patterns originate.

3. EMPIRICAL WORK

Previous studies of the pattern mining process were limited in their scope and poorly formalized (Rising 1999). Research literature alone was not capable of offering many insights on the issues of pattern crafting. Therefore this study focused on the in-depth understanding of the pattern crafting process, ultimately refining it through a series of iterations.

The study centered on a domain that has suffered from multiple problems and where pattern mining has not been applied systematically. The multimedia domain met these criteria, however since there are too many aspects to a multimedia, it was decided to focus on a sub-domain of front-end web design.

Since there is not much prior knowledge to build upon, the understanding of the phenomena was constituted through the subjects' and researcher's live experience. Therefore this research took interpretivist stance (Myers 1997) with the following research objectives:

O1. Apply the principle of 'contextualization' (Klein and Myers 1999) – understand the domain under study.
O2. Since patterns are about recording problem-solving experience, identify problem situations as viewed by multimedia practitioners; discover the context for these problems and approaches to their resolution.
O3. Investigate the feasibility of representing data collected from multimedia practitioners into patterns that are ready for evaluation.
O4. Derive a formalized process for crafting patterns.
O5. Evaluate the resulting pattern crafting process by comparing it with the existing pattern crafting approaches.

Since interviewing and focus groups have been used in pattern mining in the past (Rising 1999), these two research approaches were selected as data collection tools for this study.

The following activities were undertaken as corresponding to the objectives (see Figure 2):

A1. A ghost-writer collects via interviews practitioners' stories describing design tasks, problems associated with those tasks and decision-making in relation to these problems (Objectives 1-2).
A2. Domain understanding and finding common problem issues related to design tasks. A ghost-writer categorizes concerns around design tasks performed by practitioners. The outcome consists of pattern languages outlines and categorized excerpts of problem-solving experience (Objectives 1-2).
The research method and activities A1 - A2 are described in detail in (Linden and Cybulski 2006).
A3. For step 3 two alternatives were investigated (Objectives 3-4).
   a. A category of concerns structured into a pattern skeleton (i.e. a pattern with some sections having large gaps due to unavailable details) was presented to a focus group of domain practitioner and experienced pattern writers for pattern crafting under the guidance of an experienced ghost-writer.
   b. Sessions with single practitioners were organized to explore an option of filling in the gaps in pattern skeletons.

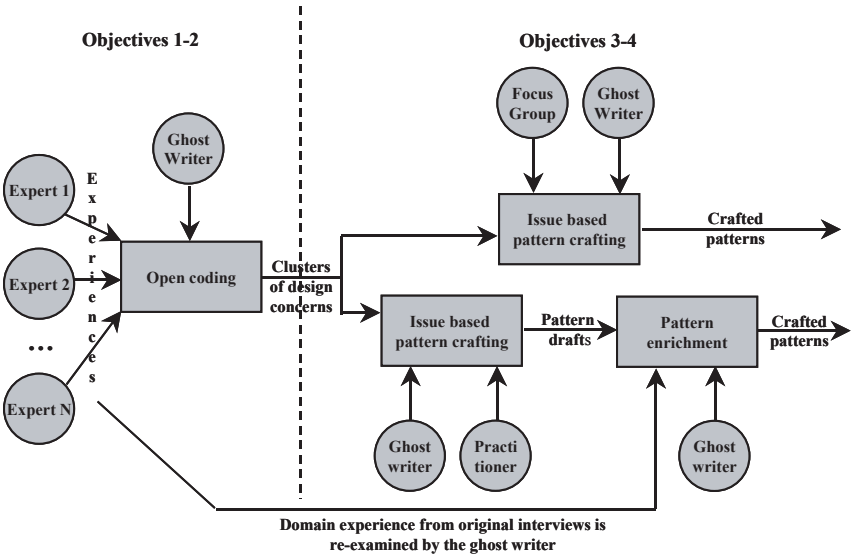
   The patterns developed in the stage 3(b) were subject to enrichment and refinement since practitioners provided only content which needed to be refined to meet the pattern style requirements and due to limited number of interviews in this stage additional content could be sought from the original interviews.

The focus group session (A3a) involved four participants (two domain practitioners and two experienced pattern writers). They were presented with a problem situation (presented as a set of practitioners' statements resulting from activities 1-2). The objective of the focus group participants was to draw upon their domain experience and pattern writing skills and to produce a full pattern (or patterns) based on the provided problem situation.

The participants discussed options of re-arranging provided statements by splitting or merging them in a different manner. Pattern writers worked on the pattern style as well as queried the domain practitioners for knowledge on the subject matter while sharing their pattern mining skills with the practitioners. The participants carefully worded the problem, discussed forces and context, reworded the solution and named the pattern.

An alternative approach involved pattern crafting sessions with individual multimedia developers (A3b). Three such sessions were conducted. The participant's handout included brief explanation of what patterns are, pattern format to be used and problem situations (presented as a set of practitioners' statements resulting from activities 1-2). The task of the participant was to examine one of the problem situations and attempt pattern crafting using presented excerpts of data and their personal experience. However, since it was the practitioner's first introduction to the concept of patterns, the ghost-writer had to ask questions aiming at eliciting missing information, such as "In what context normally this question is raised?", "What is causing this problem?", "Are there any negative consequences of applying this solution?". For all three sessions the same handout

Figure 2. Derived pattern crafting process



was used and four full patterns were produced as a result of these session (Linden and Cybulski 2005).

While conducting the sessions the ghost-writer had to be very careful and restrict her contribution to pattern writing only, whereas content of the pattern was sourced solely from the domain experts.

Since individual practitioners could only contribute domain experience but not proper wording of the patterns, the data from the sessions required additional work. The resulting patterns required considerable editing to meet the pattern format requirements. Also the ghost-writer checked whether it was possible to enrich the patterns by analyzing again the interviews conducted in the first stage of the empirical work, this time by searching for comments relevant to the drafted pattern. This analysis resulted in some additional excerpts of experience that were added to the patterns. These resulting patterns the ghost-writer discussed with the second researcher who at this stage put on the "ghost-writer's hat". This experience of filling in the gaps showed that involvement of an additional ghost-writer could also be beneficial for the quality of the patterns. In the end the produced full patterns reflected experience of various practitioners with different work scope in the multimedia field.

As a result of the empirical work the following findings were noted:

- Open coding (borrowed from grounded theory) was very helpful with discovering real issues and clustering designer concerns. These clusters were used as the source of inspiration for participants contributing their experience in the focus group and in the individual pattern crafting sessions.
- In the focus group and in an individual session all participants were eager to share their knowledge. However, during the focus group session participating practitioners also gained deeper understanding of what patterns are and obtained some pattern writing skills. In the sessions with the individual practitioners they only discovered patterns as a new format for knowledge recording and sharing but did not gain any pattern writing skills. Therefore, a special set of questions aiming at filling in pattern sections without overloading the practitioner with the pattern-specific terminology was required.
- In the discussion focus group participants may point to potential patterns not noted by the ghost-writer in the preparatory data analysis.
- The focus group transcript shows that group members spent considerable time on careful wording of each statement thus ensuring that patterns follow the format requirements. This effect could not be achieved in the session with an individual practitioner and therefore the follow-up refinement of patterns was necessary.

Although both approaches resulted in good quality patterns the focus group approach was found to have additional benefits:

- It results in high quality patterns that are ready for evaluation without additional work by the ghost-writer.
- Domain practitioners get more intimate involvement with the pattern mining and obtain some pattern mining skills.

Although an impression may be that patterns produced by the focus group or by interviewing the individual practitioners reflect the opinions of the small number of practitioners, it was the activity 1 where large number of practitioners from a variety of backgrounds contributed their problem-solving experience. This activity guarded for identifying design problems important to the majority and for quality of the applied practices in solving the problems.

4. EVALUATION OF THE PROPOSED PROCESS

In this section the fifth objective is being addressed. The three approaches to pattern crafting are compared in relation to the identified problematic issues as described earlier in this paper (see Table 1). The problematic issues include the scope of involved practitioners, whether the stages of each approach are formalized or ad-hoc, whether the required knowledge restricts participation in pattern mining and how the process ensures the quality of patterns. Since some inspiration for this pattern crafting approach was drawn from the past experience described by Rising (1999), her approach was the obvious choice for comparison.

Rising took on the role of the ghost-writer and with the small group of assistants interviewed the company gurus and produced patterns reflecting best practices in the organizational procedures. Her work was restricted by clearly identified organizational boundaries. Rising's team attempted to verify the crafted patterns by going back to their sources, however not always successfully due to the sources being very busy.

Unlike Rising this study proposed and tested a formalized approach to data analysis based on coding in order to translate collected data into patterns. Although the pattern crafting approach applied by Rising (1999), improves the scope and involvement of domain experts within an organization, the proposed process brings the benefit of capturing into patterns cross-domain experience that is not limited by organizational boundaries. The proposed approach also resolves problems with engaging practitioners in the process, their ineffectiveness as pattern writers, their lack of time to formalize their design experience, and their inability and unwillingness to attend design sharing events outside their normal workplace.

5. CONCLUSIONS

Issues of knowledge acquisition in distributed environments are becoming increasingly important. Since patterns have proven successful in representing problem-solving knowledge, and in disseminating best practices in software development, this study explored application of patterns to sharing development experience in yet another domain – multimedia. As the currently adopted pattern mining process is normally unable to utilize multiple practitioners as a direct

Table 1. Comparison of the three pattern crafting approaches

Pattern crafting approach	**Current, widely used**	**Rising**	**The Proposed Process**
Pattern crafting process	Ad-hoc	Special informal process	Meta-process to find the domain-specific process
Scope of involved practitioners	Cohesive group of people	Organization	Domain
Data collection	Mining own experience	Interviewing In meetings	Interviewing
Data analysis	Informal	Informal	Formal coding
Patterns refining	Own experience	Iterations with practitioners – interviews with the purpose of verification (not always possible due to gurus busyness)	Iterations with practitioners – semi-structured and structured interviews, focus groups
Knowledge of patterns	Participating practitioners must have it.	Participating practitioners may not have it, however a ghost-writer must have both domain knowledge and pattern writing skills.	Participating practitioners may not have it, however a ghost-writer must have both domain knowledge and pattern writing skills.

source of such experience, the pattern crafting stage was targeted to minimize the process' deficiencies.

Involving individual practitioners in the experience sharing activities provides richer content for patterns, helps select really best practices as accepted by majority of practitioners and therefore improve the overall quality of patterns. Moreover, practitioners may discover patterns as a useful source of domain knowledge and participate in sharing their experience through pattern mining.

While the applicability of the refined process still needs to be empirically tested on a wider scale (future work), the results obtained so far indicate that this approach has strong benefits compared to the currently employed processes.

6. ACKNOWLEDGMENTS

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7. REFERENCES

1. Alavi, M. and D.E. Leidner (2001): "Review: Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues." *MIS Quarterly.* ***25***(1): p. 107-136.
2. Alexander, C. (1979): "The Timeless Way of Building." Oxford University Press.
3. Appleton, B. (1997): "Patterns and Software: Essential Concepts and Terminology." *Object Magazine Online.* ***3***(5).
4. Coplien, J.O. (1996): "Software Patterns." New York, New York: SIGS Books & Multimedia.
5. Davenport, T. and L. Prusak (1997): "Working Knowledge: How Organizations Manage What They Know." Boston, MA: Harvard Business School Press.
6. Gamma, E., R. Helm, R. Johnson, and J.M. Vlissides (1995): "Design Patterns: Elements of Reusable Object-Oriented Software." Reading, MA: Addison-Wesley.
7. Kalfoglou, Y. (2000): "On The Convergence of Core Technologies for Knowledge Management and Organisational Memories: Ontologies and Experience Factories." in proceedings of *ECAI'00 Workshop on Knowledge Management and Organizational Memories (KMOM'00)*. Berlin, Germany, p. 48-55.
8. Klein, H.K. and M.D. Myers (1999): "A Set of Principles for Conducting and Evaluating Interpretive Field Studies in Information Systems." *MIS Quarterly.* ***23***(1): p. 67-93.
9. Linden, T. and J.L. Cybulski (2005): "Colour Issues in Web Development." in proceedings of *10th European Conference on Pattern Languages of Programs (EuroPLOP 2005)*. Irsee, Germany: to be published.
10. Linden, T. and J.L. Cybulski (2006): "Refining the Process of Sharing Problem-Solving Experience across Domain: A Hermeneutic Study." in proceedings of *AMCIS 2006*. Acapulco, Mexico.
11. Manns, M.L. (2001): "Patterns: A Promising Approach to Knowledge Management." in proceedings of *First Annual ABIT Conference*. Pittsburgh, Pennsylvania, USA, p. 31-40.
12. Manns, M.L. and L. Rising (2002): "What Makes Pattern Languages Work Well." in proceedings of *7th European Conference on Pattern Languages of Programs (EuroPLOP 2002)*. Irsee, Germany.
13. Myers, M.D. (1997): "Qualitative Research in Information Systems." *MIS Quarterly.* ***21***(2): p. 241-242.
14. O'Leary, D.E. (1998): "Using AI in Knowledge Management: Knowledge Bases and Ontologies." *IEEE Intelligent Systems.* ***13***(3): p. 34-39.
15. Rising, L. (1999): "Patterns Mining," in *Handbook of Object Technology*, S. Zamir, Editor. CRC Press. p. Chapter 38.
16. Stenmark, D., M. Klang, and S. Olsson (1999): "A Critical Look at Knowledge Creation." in proceedings of *22nd Information Systems Research Seminar in Scandinavia (IRIS 22)*. Keuruu, Finland.

E-Commerce Practices in the Public Administration: A Spanish Case

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ABSTRACT

The Spanish National Tax Agency (SNTA) has been a good initial example for web applications in Spain. This paper tries to describe how the Spanish National Tax Agency (SNTA) is using web technologies to improve transactions with all citizens and collaborators. Through Internet, citizens and firms can develop lots of their main operations with the SNTA by benefiting themselves of better time responses and comfort.

Keywords: Internet, processes, Spanish National Tax Agency (SNTA)

INTRODUCTION

The Spanish National Tax Agency (SNTA) constitutes one of the Spanish organisations in which we can observe how, in a short period of time (since 1997), web based technologies have been successfully implemented in terms of the number of daily users of the different services via Internet.

Today, the relationship between citizens and Tax Administration can be performed through a greater number of communication channels: phone, fax, ordinary mail and Internet. Therefore, citizens and firms can choose in any moment the most appropriate way in view of the circumstance needs.

In the short period of time that the SNTA has been using web technologies, it has turned into a clear example to imitate in the rest of the public and private European and Spanish firms.

MAIN OBJECTIVES AND REASONS FOR THE SPANISH NATIONAL TAX AGENCY TO USE INTERNET

Amongst the main reasons why the SNTA has decided to use web technologies considering the customers needs, we can stress,

1. The Public Administration feels it must have a greater presence in the Spaniards social life. In this sense, the Tax Agency Initiative is an answer to the objectives shown by the Spanish Government about the development of the information society "INFO XXI" that we have already referred to.
2. To add value. To widen the access time for the search of tax information and the rest of the offered services.
3. To get efficiencies of a proper use of information technologies, since it is legally possible.
4. The massive use of these technologies in the Spanish citizens is demanding an adaptation of firms and the Public Administration to these new infrastructures.

Table 1. Number of Internet visits (SNTA, 2005)

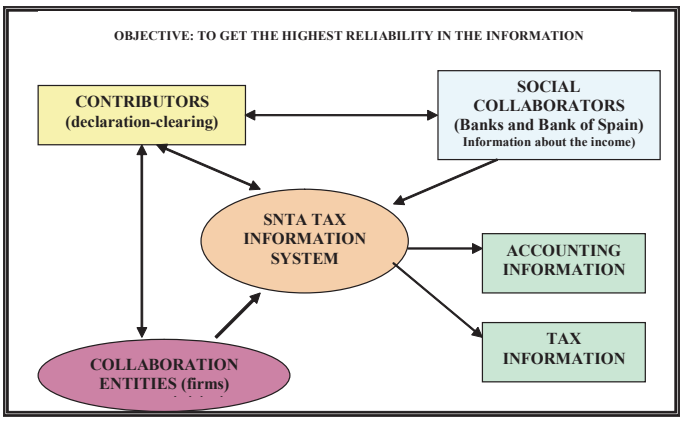
YEAR	HELP PROGRAMS	TAX INFORMATION (APPLICATION INFORMA)	TOTAL VISITS	VIRTUAL OFFICE	TOTAL SNTA
2005	9.240.669	948.723	17.932.702	27.475.309	45.408.011

YEAR	HELP PROGRAMS	TAX INFORMATION	SELF-SERVICE	TOTAL VISITS	DIRECT ACCESS SELF-SERVICE	TOTAL SNTA
2004	8.000.063	901.148	3.374.751	9.720.442	8.601.602	18.332.044
2003	2.341.766	252.103	878.918	2..962.995	5.145.949	8.108.944
2002	951.101	355.433	649.358	2.466.962	3..310.552	5.777.514

Table 2. Number of declarations presented via Internet in the last three tax-year periods (SNTA, 2005)

	TAX YEAR 2005	TAX YEAR 2004	TAX YEAR 2003
INFORMATIVE AND YEARLY VAT SUMMARY DECLARATIONS (390 MODEL)	435.656	110.848	10.811
IRPF (PERSONAL RETENTIONS)	1.151.313	500.151	115.244
FIRMS TAX (201 MODEL)	41.000	9.328	225
SEMESTRE SMES SELF-CLEARINGS	435.051	115.314	31.231

Figure 1. Information flows in the tax agency (The Computer Tax Department, 2003)



5. To break the tradition in the unilateral relationship inherited from the Tax Agency and the rest of Public Administrations. The use of web technologies allows a higher feedback between the SNTA and the Spanish contributors.

STAGES IN THE IMPLEMENTATION OF INFORMATION AND COMMUNICATION TECHNOLOGIES IN THE SNTA

In the implementation of information and communication technologies in the firm, some typical stages have been traditionally distinguished (Zuboff, 1988; Davenport, 2000; Quinn, 2000), the mechanisation or automation, processing and transforming ones.

The Tax Agency, by introducing information technologies, has passed in time through all of them.

In the following figure we show all the relations that the Agency maintains with different entities.

The Tax Agency develops every year a planning of actions concerning to the use of Internet and, for that purpose, there is a work group especially constituted that allows to develop this planning and promote the needed changes.

From the first time, this Organisation has seen in Internet a great opportunity of access and has highly bet on this technology. All the information systems in the Agency have been internally developed and implemented.

SERVICES OFFERED IN INTERNET

The services that the Tax Agency offers to the contributors can be divided (Segarra Tormo, 2001) in two types, opened and personalised services.

The first ones are free entrance services for all the users and the second ones, are services oriented to offer personal information to each contributor. For that reason, in order to access to these second ones, an electronic identification is required.

Table 3 offers a summary of both services,

ADVANTAGES AND DISADVANTAGES OF INTERNET IN COMPARISON TO ANOTHER CONVENTIONAL COMMUNICATION CHANNELS

Each tax campaign, the SNTA circulates a survey to know main opinions coming from contributors and users. This is a very important tool, since it is permitting the Agency the needed feedback to improve their services via these tools.

This survey pays a special attention to the aspects collected in the following table.

Now we show the main advantages that these services are implying for the user and the people working in the Agency.

Table 3. Personalised and opened services offered by the SNTA through Internet

MOMENT IN THE SERVICE DEVELOPED	OPENED SERVICES	PERSONALISED SERVICES
BEFORE TAX DECLARATION	• Tax legislation • Maternity deduction • IRPF retentions • Declarations on line • Help programs • Leaflets • Informa Application • Pre-paid consultancy • Apply for tax data • Apply for labels	• Obtain of tax data • Change of personal, familiar and address data • VIES (European Union Taxes, VAT)
DURING TAX DECLARATION		• Presentation of a declaration • Payment: achievement of NRC • Apply for devolutions • Certification of declaration presentation
AFTER TAX DECLARATION	• Checking the state of all declarations	• To obtain the detailed information about the state of the declaration
OTHERS	• Web Call services	• Certificate of declaration presentation • Fulfilment certificate • Resources and complaints • On line auctions

Table 4. Main aspects to consider in the Internet survey (2005)

1.	Technologies that the users utilise for their relationship with the Agency via Internet
2.	Places where one can access
3.	Level of complexity when developing some actions from the SNTA web pages, • To get the PADRE program • To apply for the certification • The installation of the certification • The performance of the declaration • Preparation of the declaration to send it via Internet • The tax payment, in case the declaration has turned into positive • The transmission of the declaration • The reception of the conformity by the SNTA
4.	Level of satisfaction with the system of rent declaration presentation via Internet
5.	The main reasons for the satisfaction
6.	Evaluation of the SNTA services. Opinions about the most useful considered ones
7.	Services that should be included in the surveyed opinion

WHERE DOES THE SPANISH NATIONAL TAX AGENCY GO TO?

The Tax Agency intends to improve and widen the services that offer today to reach more tax-payers. This way, the Agency promotes an auction system via Internet. It allows any person that wants to take part in an auction to do it without a previous translation to the place where it is being held. Any offer can also be presented via the web whenever the user is interested in a good or service. And besides, it allows the constitution of the needed deposits to participate in the procedures of disposal by means of the adhered collaboration entities, and be able to get "on line" devolution, in case the holder is not the bidder.

The closest future objectives that the SNTA has thought about are: in the first place that the contributor can value and evaluate if the administration is properly working. It is tried to promote a more multilateral relationship between the Administration and the contributor. The customer should take part each day more in an interactive conversation with the Administration.

In the second place, an "electronic address" is pretended to be created. It would identify the customer with one unique electronic address. It would make feasible the sending of the electronic certifications that are demanded. So far, any person that applies for an electronic certification can automatically get it. With this electronic address, the sending of messages can be improved, and one of the main Internet advantages would be achieved.

This way the relationship between the SNTA and the citizen can be also standardised. The sent data will have a greater security; message confidentiality and the Tax Agency signature will be achieved.

When dealing with new improvements and the achievement of some challenges, the Agency is finding as main problem that the legislation must be changed in some aspects. Therefore, sooner the creation of an electronic address will be approved. It will improve the sending of notifications.

And third and lastly, it is tried to have a direct access from the SNTA to other web pages in the Public Administration, as for example the Social Security or the Only Window System for firms. This service is born with the main objective of making easier to the society the access to the needed information. The information can be related to any aspect that has to do with the relationship between the Spanish Administration and the citizens, from any place and at any moment.

CONCLUSION

The Spanish National Tax Agency has promoted the use of web technologies amongst citizens by putting in practice some government initiatives on the development of the information society in Spain, INFO XXI.

The Tax Agency, by offering services in Internet, enables all citizens a better relationship. The number of communication channels provided can be widened and the user will be able to choose the one that best fits his/her needs each moment.

Through this communication channel, a great variety of services are offered: the application for tax data, the solution to any doubt or question related with any tax or problems in the confection of the declaration, the downloading of the help

Table 5. Advantages and disadvantages of the SNTA web page

ADVANTAGES		DISADVANTAGES	
CITIZEN	**AGENCY**	**CITIZEN**	**AGENCY**
To widen customer's attention timetable (24 hours)	The offering of alternative communication channels	Changes in the society culture: adaptation to n ew technologies	To update infrastructure and web page
To avoid movements in the Agency	Self -service: it is the citizen who performs all the process of information searching and elaboration and sending of documents	The need of infrastructure adaptation	Lack of habits in the customers
To access from any place	To improve the process of document elaboration	To apply for electronic identification certificates	
To get a faster return in the information sent by Internet	A decrease in the long run costs by in termediaries decrease	Bottleneck problems and lack of network in some places	
Feedback: the Agency values all kind of suggestions or claims coming from citizens in order to improve their services		Change of responsibility to the customer: it is the citize n who performs the whole process	

Source: Own elaboration from the information coming from the Agency and the one published in their own web page (2004)

programs, the information about customs, auctions on line, queries on the state of the declarations, presentation on the declarations and so on.

The Tax Agency is very interested in the inter-activity with the citizen and that it is the reason why it develops periodical surveys with the main aim of obtaining information about the contributor's opinion. The results that the Tax Agency reaches in these studies are of great help for the improvement of the services that it offers. They show a great acceptation and a high degree of user's satisfaction (comfort, fastness and better time responses are positive stressed).

Despite the positive experience of this project in the Spanish National Tax Agency, there are still some barriers in the procedures that put in touch the Tax Agency with other Institutions. It will imply changes in the short term procedures that will allow benefiting from the possibilities that today web-based technologies are offering to government, firms and citizens.

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REFERENCES

Davenport, T. H. (2000) *Mission Critical: Realising the Promise of Enterprise Systems*, Harvard Business School Press, Boston.

Quinn, J. B. (2000) Services and Technology: Revolutionising Economics, Business and Education in *The Internet and the University 2000 Forum* (Eds, Devlin, M., Larson, R. and Meyerson, J.) Forum for the Future of Higher Education and EDUCAUSE, Boulder CO.

Segarra Tormo, S. (2001) Las nuevas tecnologías en la Administración Tributaria Española. Descripción, análisis y dinamización, *Economía Industrial*, 338, 105-118.

Zuboff, S. (1988) *In the Age of the Smart Machine: The Future of Work and Power*, Heimann, Oxford, UK.

Web page from the SNTA (AEAT): www.aeat.es

Web page from the National Fabric for the Spanish Coins (FNMT): www.fnmt.es

Web page from the Ministry of Science and Technology on the Information Society: www.sociedadinformación.es

Creating Flexible and Reusable Learning Resources

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ABSTRACT

This article describes a tailored made learning platform which emphasizes the sharing and reusing of teaching materials. Users can select any section of digital material to create synchronized learning materials without the need for any sophisticated software packages. The unique features of the learning platform and the feedback from seventy eight pre-service teachers who have had hands-on experiences are discussed in detail. The participants are very positive regarding the functionalities and capabilities of the learning platform, though only a quarter of them used it to create learning materials as part of their assignments. This finding suggests that there is a need to take into account matching pedagogies when implementing new initiatives.

1. INTRODUCTION

The Internet has made a huge difference to our daily lives ever since it rapidly gained popularity in the mid 1990s. Using the Internet, people around the globe are able to connect with each other and have access to a vast amount of information within seconds. The flexibility of Internet access has had a substantial influence on education (Gaspar & D, 1995) whether for complementing face-to-face lectures or for delivering courses completely online (Harasim, 1999; Hiltz & Wellman, 1997). The flexibility of online teaching and learning lies with its accessibility and time and pace independence. Indeed, most higher education institutes recognize that incorporating technology into the classroom was the "the single most important issue" over the next few years (Carlson, 2000).

Many universities use online learning platforms (Boggs & Shore, 2004; Freeman, 1997; Palloff & Pratt, 2001) to assist course delivery. Despite their popularity, most learning platforms do not allow the same resources to be shared between multiple courses. Similarly, the teaching materials uploaded or created for a lesson cannot be reused for another course during the same or the following semesters. The limitations can be very frustrating to academics, and the problem is exacerbated when only a part of the learning materials is required for reuse. Another problem with existing platforms is that they do not support mixing and matching files of different formats. Teaching materials such as videos and slides are played independently and users are only able to browse the materials one at a time.

In view of the limitations of existing platforms, we have put forward a grant proposal and developed a platform, named PILOT (Promoting Interactive Learning in an Online environmenT) to tackle these inadequacies. PILOT allows users to use and reuse uploaded materials on demand, to select segments of materials, and to synchronize various formats of teaching material. However, it is not intended to replace face-to-face classroom interactions nor existing learning platforms. In fact, the goal of developing PILOT was to enable our student teachers to have an authentic experience of using different platforms and to make it easier to create synchronized learning resources from existing resources.

2. FEATURES OF PILOT

Producing good teaching materials requires a considerable amount of time, effort and financial commitment. It would save a significant amount of human and computer resources if materials could be reused. PILOT is more than a learning platform, it is a resource repertoire which enables users to tailor learning resources using simple steps using an existing pool of resources. The platform consists of five areas, namely, material, presentation, quiz, forums and personal information.

If a person wants to create any online resources using PILOT, he/she must have an account to log into the system. After successful login, the user can choose any materials in the materials section that have been uploaded by other users. Alternatively, the user can upload any multimedia format or PowerPoint format materials which can be designated as "shared" or "not shared" with other users. Research into multimedia and related instructional technologies over the years has indicated positive effects on learning (Hede, 2002). Moreover, learning in multiple modes is more engaging due to increased learner interest levels, and learners are stimulated by sounds and images (Jonassen, Peck, & Wilson, 1999).

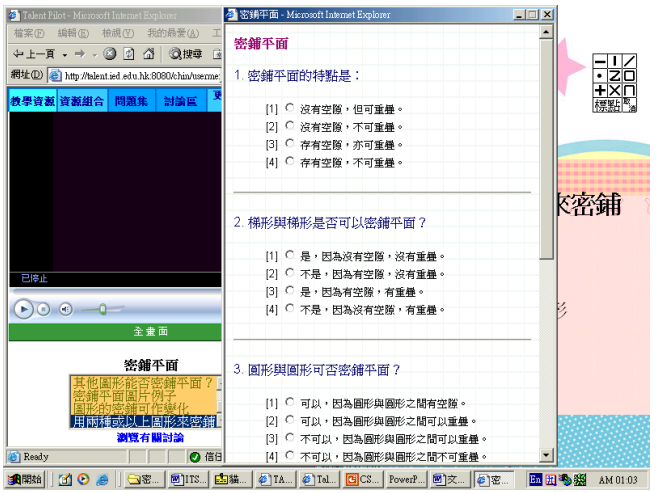
Many existing platforms do not fully utilize the capability of multi-tasking computer resources as these platforms are mainly designed for sequential processes. However, PILOT users can subscribe to one video file and one PowerPoint file or slides created by Slider Editor to form a *presentation* which displays two synchronized files. The Slide Editor not only enables users to type information directly on it but also to copy and paste HTML materials into it.

When creating a *presentation,* the creators are only required to input or get the start time/end time from the video and select the appropriate PowerPoint slide for that time interval, and a section will be created (a slide with the related video interval). That means the unwanted slides or video sections could be skipped. For example, the user can select 5 relevant slides from a 15 slide PowerPoint file and select 5 matching video sections of varied duration from a video file to form a *presentation.* Hence, *presentation* creators can construct the presentation materials according to the intended usage and their background. When a learner watches a *presentation*, he/she can watch the presentation sequentially or to select the interested section and the corresponding video time and slide contents will be displayed (Fig. 1). The advantages of displaying two files concurrently include the complementary synergy of information and to further prompt and stimulate learners to think whilst watching video content. Thus, the intended learners can have full control of the time, place and pace of viewing a presentation. Furthermore, they are provided with additional flexibility such as in selecting or revisiting any section of the video at any time.

Similarly, a user can create his/her own quiz or subscribe to another's' quiz in the quiz section. The user can specify when the quiz will be displayed anytime

Figure 1. A presentation which is synchronized with video and PowerPoint file

Figure 2. Synchronize questions with a "Presentation"



during the *presentation* display. This flexible approach aims to promote active learning and enable interactivity with the material, as an essential combination in determining the extent of learning is the actions and interaction of the learners (Laurillard, 2002; Oliver, Omari, & Herrington, 1998).

The *discussion forum* is an arena for exchanging and discussing pertinent problems and to form a learning community (Scardamalia & Bereiter, 1996; Tu & Corry, 2002). When a new *presentation* is created, a new thread can also be opened in the forum. Learners can share their comments and raise questions about that *presentation* when browsing or whenever they are logged into PILOT. Finally the personal section enables users to change passwords.

3. A STUDY

3.1 Background

The study took place at the Hong Kong Institute of Education (HKIEd) which is the largest teacher training institute in Hong Kong. We have recently adopted the Blackboard platform in order to facilitate learning, but none of its programmes are offered completely online. The participants of this study were pre-service student teachers studying at HKIEd taking a module called Information Technology Supported Learning Environment (ITSLE). They took the module in their second year after taking two other information technology modules. The participants had to attend a mass lecture and two tutorials per week. The learners had some hands-on practice with popular IT software and had knowledge of some popular ITSLEs. It was believed that the concept of ITSLE would be best learnt through modeling the concepts by adopting IT as a learning environment. All the teaching materials were posted on the Blackboard learning platform which they had to familiarize themselves with during the first tutorial session. The mass lecture mainly covered ITSLE theories and examples.

3.2 Data Collection and Discussion

The learners were given a brief introduction and demonstration of PILOT during the fourth week of the tutorial sessions. The participants then followed the instructor to create a synchronized *presentation*. They were also given an online user manual and a hardcopy to follow the procedures and to scaffold their learning (Oliver, Omari, & Herrington, 1998). They used the platform for about 50 minutes. Upon completion, they were prompted to answer an online questionnaire which was divided into three areas, namely, fostering learning, the user interface, and system functionality.

The results were encouraging as the least rated question showed a 66% agreement or strong agreement with value. Most of the respondents (98.72%) believed that PILOT provided a comprehensive learning environment, followed by (97.44%) who responded that it had a consistent interface, and (93.59%) indicated that it flexibly enabled users to edit and use teaching materials. Although learners were positive concerning the questions that PILOT could foster active learning and develop independent learning, there were some other diverse views. This was probably due to the fact that they did not use the platform long enough to appreciate all of its functions. Even though they rated highly on the consistence of the user interface, one third of them did not find the platform easy to use. One plausible reason for this was that they did not have sufficient time to fully explore and experience the system prior to answering the questionnaire.

4. CONCLUSIONS AND FUTURE DIRECTIONS

The Internet has transformed teaching and learning, from being bounded by physical and time limitations, to learning at the discretion of learners. PILOT learning platform not only provides general e-learning features such as teaching materials management, discussion forum, quizzes and user tracking but also facilitates material sharing and reuse. The simple click and pick function of the platform has escalated different learning materials from a one-to-one relationship to a more flexible many-to-many relationship. The distinct features of the PILOT platform not only enhance the efficiency and effectiveness of teaching and learning but also minimize server load, which results in higher performance.

Our student teachers appreciated the functionalities of PILOT but not many of them adopted the system to create *presentations*. This finding suggested that there was a great need to take into account appropriate pedagogical considerations when introducing new ideas and implementing new initiatives (Oliver, and McLoughin, 1999). It will be interesting to compare the findings of this study with future results when we introduce PILOT over the following years. To ensure this is continued, however, there is a great need for continuous financial support so that the project can have a successful and lasting effect.

5. ACKNOWLEDGMENTS

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6. REFERENCES

Boggs, S., & Shore, M. (2004). Using e-Learning Platforms for Mastery Learning in Developmental Mathematics Courses. *Mathematics and Computer Education, 38*(2), p.213-220.

Carlson, S. (2000). Campus survey finds that adding technology to teaching is a top issue. *The chronicle of higher education*(47), A46.

Freeman, M. (1997). Flexibility in access, interaction, and assessment: The case for web-based teaching programs. *Australian Journal for Educational Technology, 13*(1), 23-39.

Gaspar, R. F., & D, T. T. (1995). Current trends in distance education. *Journal of Interactive Instruction Development, 8*(2), 21-27.

Harasim, L. (1999). A framework for online learning. *The virtual U. IEEE Computer, 32*(9), 44-49.

Hede, A. (2002). An integrated model of multimedia effects on learning,. *Journal of Educational Multimedia and Hypermedia, 11*(2), 177-191.

Hiltz, S. R., & Wellman, B. (1997). Asynchronous learning networks as a virtual classroom. *Communications of the ACM, 40*(9), 44-49.

Jonassen, D. H., Peck, K. L., & Wilson, B. G. (1999). *Learning with technology : a constructivist perspective*. Upper Saddle River, N.J.: Merrill.

Laurillard, D. (2002). *Rethinking university teaching : a conversational framework for the effective use of learning technologies*. London: Routledge/Falmer.

Oliver, R., Omari, A., & Herrington, J. (1998). Investigating implementation strategies for WWW-based learning environments,. *International Journal of Instructional Media, 25*(2), 121-139.

Palloff, R., & Pratt, K. (2001). *Lessons from the cyberspace classroom: The realities of online teaching.* San Francisco: Jossey-Boss.

Scardamalia, M., & Bereiter, C. (1996). Engaging Students in a Knowledge Society. *Educational Leadership, 54*(3), 6-11.

Tu, C.-H., & Corry, M. (2002). eLearning Communities. *The quarterly review of distance education, 3*(2), 207-218.

E-Collaboration for Quality Assurance in Higher Education

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ABSTRACT

The purpose of this study is to describe and analyse how the electronic collaborative technologies can support decision-making and quality assurance. The study describes how the approaches of strategic management and quality assurance can be integrated into the management information system in a higher education institution. The management information system provides an open platform for the integration of different management approaches and e-collaboration facilitation. The characteristics of the management process and the procedures of quality assurance, chosen by top management, affect the way operations are planned on the lower organisational levels. This study contributes to the knowledge and practice of quality assurance. It introduces the concept of the quality map, which is useful in describing the interface between the quality assurance system and the management process. In addition, the study provides outlines for the planning of management information systems.

Keywords: management information system, e-collaboration, evaluation, quality assurance, quality audit, higher education

1. INTRODUCTION

Quality assurance is a key element in constructing the European Higher Education Area by 2010. European countries are developing their own national solutions for evaluating and demonstrating the quality of degrees (FINHEEC, 2006). The higher education institutions are accountable for the quality of their education and other activities in counterbalance to their autonomous situation and responsibility to define their own management and quality assurance systems. The institutions are required to regularly evaluate their own activities and performance, and also to participate in external evaluations (Ministry of Education, 2005).

The relationship between the institutional management and quality assurance of higher education institutions has recently attracted much attention. The quality assurance systems of all higher education institutions will be audited by 2010. The aim of the audit is to determine if the quality assurance system produces useful information needed to improve operations and leads to effective improvement measures (FINHEEC, 2006). Beckford (2002) argues that without adherence to a quality management system, it is impossible for any organisation to know how well it is performing.

The interface between the quality assurance system and management has proved out to be a predominant weakness. When developing the quality assurance system at the Turku University of Applied Sciences (TUAS), we tried to strengthen and improve the implementation of the interface between quality assurance and the management process. We also examined how to support utilisation of information produced within the quality assurance system to further improve processes.

The purpose of this study is to describe and analyse how electronic collaborative technologies can strengthen the interface between the quality assurance system and the management process.

The management information system (MIS) can be an improvement-oriented tool in strategic management and quality assurance. In addition, this study introduces the new concept of the quality map. The quality map helps management to describe the quality assurance system to the personnel, external evaluators and other stakeholders.

The study presents the case of TUAS, which has planned and implemented an MIS tailored to meet the requirements of the institution's management process. The data warehouse transforms various source data and provides reliable information for the MIS. The information is shown in action plans, which contain scorecards. These features strongly support directors and managers in their evaluation and planning tasks. However, the MIS is more than a conventional management scorecard. It is an electronic platform which effectively supports the integration of strategic planning and quality assurance. The management portal includes strategic plans, which are then translated into more concrete budgets and annual action plans including balanced scorecards, and human resource (HR) plans.

This study is organised as follows: First the concepts related to quality assurance in higher education are introduced. Secondly, the main characteristics of the management process are described. Then the information technology architecture of the MIS is presented. Thereafter the new concept of the quality map is introduced and the utilisation of evaluation knowledge in decision-making, action plans and the MIS is outlined. Finally, the results of the study are summarised and discussed in the concluding section.

2. QUALITY ASSURANCE

The word quality has often been associated with excellence or outstanding performance. In this study, however, we have adopted the fitness for purpose definition of the quality, because according to Woodhouse (1999) it is the most commonly accepted definition of quality in higher education. Fitness for purpose is based on the ability of an institution to fulfil its mission in its environment or of a study programme to fulfil its aims (Harvey & Green, 1993). Thus, at the institutional and faculty level quality is defined in the institution's mission, strategic plan and annual action plans. Quality is then confirmed by achieving the goals defined in strategic planning and quality work.

The concept of quality assurance has been given various definitions. According to Woodhouse (1999), quality assurance refers to the policies, attitudes, actions and procedures necessary to ensure that quality is being maintained and enhanced. Sometimes the term is used in a more restricted sense. Quality assurance is seen as the process of establishing stakeholder confidence that the provision (input, process and outcomes) fulfils expectations or measures up to threshold minimum requirements (Analytic Quality Glossary, 2006).

At the level of HEIs, quality assurance system refers to "the entity composed of the quality assurance organisation, respective responsibilities, procedures, processes and resources" (FINHEEC, 2006). In this study, we have adopted the wider meaning of the concept which includes both quality management and quality enhancement. Quality assurance is seen to cover all the activities and processes of the institution. The same interpretation of the concept has also been given by FINHEEC (2006).

John Oakland has captured the essence of quality assurance: "Quality must be managed, it does not just happen" (Beckford, 2004). This entails that the management's commitment to quality is of crucial importance. To be effective, the quality assurance system must provide managers with useful information needed to improve operations. Then, managers must interpret different evaluation findings and feedback information. They must identify weaknesses and decide which weaknesses need improvement measures. Managers possess the power to allocate the resources needed for carrying out the planned improvement measures. In other words, it is the interface between the quality assurance system and the management process which really counts.

3. COLLABORATION IN THE MANAGEMENT PROCESS

Electronic collaboration (e-collaboration) is broadly defined as collaboration among individuals engaged in a common task with the help of electronic technologies (Kock, 2005). The core of e-collaboration is about sharing information within an organisation and also between organisations for the purposes of planning, coordinating, decision making, process development and improving effectiveness.

This study presents a case describing the collaborative use of the MIS to support the management process and quality assurance in higher education. If the MIS was only a diagnostic control system, used by managers to monitor organisational outcomes and correct deviations from the standards of performance, it would not be worth the investment. Superiors should expect their subordinates to produce intelligent self-assessments and action plans. If the high level managers do not expect high quality planning from their subordinates, high quality planning will not take place and probably the unit performance will be only mediocre at best. The e-collaboration should include communication, dialogue and collaboration, which are the essential features of any management process.

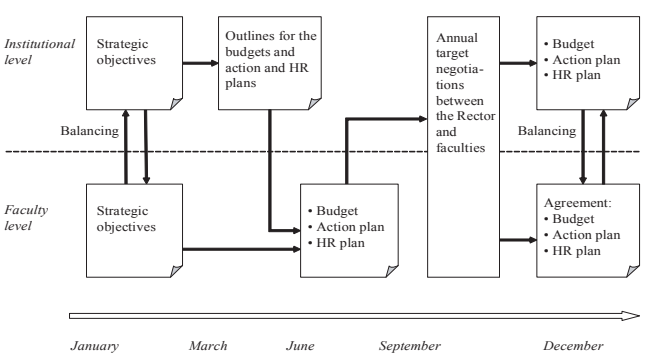
Figure 1 describes the interactive management process of the TUAS between the institutional level and faculties. Important communication and dialogue is found in the annual agreements about the targets between the institution and faculty. The figure illustrates only some of the main phases omitting many minor details of the interactive process. The budgets and action and human resources (HR) plans must be consistently balanced to achieve a consensus for the planning period. The Balanced Scorecard approach introduced by Kaplan and Norton (1996, 2001) is a used as a framework for the MIS. The scorecards included in the action plan define strategic objectives, measures and their target values, which must be consistently planned for the institution, faculties and degree programmes. -

Both the Rector's top management group and the faculties draft their own strategic objectives and draft their preliminary action plans in the strategic seminars during the first half of the year. The Rector issues all the faculties with the outlines for the budgets and action and HR plans. These outlines are based on the education policy, demand for labour and the other factors in the environment. These plans are prepared at the faculty level.

The most important event in the management process is the internal target negotiation between the Rector's management group and the respective faculties. The negotiations include the evaluation of major results achieved, allocation of funds to implement the strategy and the balancing of the target values of the measures. The negotiations are strongly supported by the management portal, where the dialogue takes place. The financial resources and action and HR plans of the administrative units are determined in the negotiations.

It is important to recognise that the internal target negotiations are not primarily about checking whether the target values of the measures have been achieved and looking for remedies to correct deviations from target values. The negotiations can be seen as an important forum for internal self-evaluation which can at its best lead to organisational learning and development. The communication and dialogue can produce new insights, initiatives and solutions to problems.

Figure 1. The interactive management process of the TUAS



4. MANAGEMENT INFORMATION SYSTEM

The Balanced Scorecard approach was introduced in 2002 at the TUAS to help management in communication and in the implementation of strategic plans (Kettunen, 2004, 2005). The new approach was initially introduced without any specific information system. It was clear from the beginning that the collection of data and aggregation of the scorecards to the upper organisational levels would be troublesome, because the existing information systems did not support the new approach. In large organisations with many organisational levels information technology support is necessary.

The planning of the new MIS started at the beginning of 2004. The management process was described and developed in detail. The description of the management process facilitates the timetables so that they take into account the steering of the Ministry of Education, the budgeting process and the internal target negotiations between the Rector's management group and the faculties of the institution. The detailed description of the management process produced a large sheet, which was put on the wall. A large number of more detailed process descriptions (workflows) was written to be used as specifications for the services with which the management portal provides its users. About 700 concepts were defined and the data model was developed.

The architecture of the MIS was planned and the new system was incrementally implemented. The e-collaboration of the management process is supported by the portal, which is also open to the personnel. The first services of the management portal were launched in autumn 2005 for the use of the management group. The portal utilises the data warehouse where the existing data of the various operational systems is collected. The data warehouse has been in operational use since summer 2006. The MIS was planned to stimulate dialogue in the net and encourage innovations and development activities. The reciprocal open discussion about strategic objectives supports the commitment of the personnel to the strategic plans and quality assurance.

The e-management portal was planned to directly support the management process. Usually the concept of the portal refers to an access to information and services in the net (White, 2000, Rose, 2003, Zhou, 2003, Smith, 2004). The portal, however, is much more than mere access. Individuals at the different organisational levels use the portal as a platform to draft their strategies, budgets, action and HR plans and reports. Individual have diverse user rights and roles in the portal.

The data warehouse is a consistent, consolidated and refined collection of data, which compiles and integrates data from the existing operational data sources (Inmon, 1996; Guan et al., 2002). The data warehouse is used to produce manysided reports, statistics and analyses about the performance of the organisation. The strategies, action plans with balanced scorecards, HR plans and budgets produced by the managers and others are stored in the portal database. The data warehouse and the portal database are the common memory of the organisation.

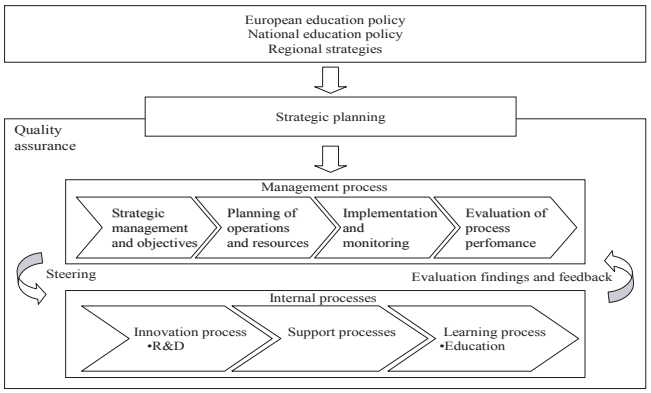
The operational data systems include the accounting and HR systems and the study and student register. The raw data of these source systems are extracted and transformed into a unified and recognisable form and then loaded to the data warehouse (ETL processes). Before the introduction of the data warehouse the data from various sources were undocumented and scattered, which led to unreliable reports.

5. QUALITY MAP

The concept of the quality map is introduced to describe the interface between the quality assurance system and the management process. The quality map is a visual representation of the relationships between the environment, strategic planning, the management process and the quality assurance system. It also provides an insight into the management process and internal processes of an organisation, both of which have essential roles in strategic management and quality assurance. We have derived the concept of quality map from the strategy maps introduced by Kaplan and Norton (2004). A strategy map is a visual representation of the causal relationships among the components of an organisation's strategy. Analogically, the quality map describes the main characteristics of the quality assurance like a road map, omitting the minor details. The new concept helps the managers, personnel, external evaluators and other stakeholders to get the big picture regarding the quality assurance system.

Figure 2 describes the comprehensive quality map of the TUAS. The changes in the environment have been outlined by the European and national education policies and regional strategies. The strategic planning is essentially the strategy process,

Figure 2. The quality map of the TUAS



which produces the strategic plan and strategic objectives for the planning period. The management process includes the sequential processes consisting of

- strategic management and updating of strategic objectives
- planning of operations and resources
- implementation and monitoring,
- evaluation of process performance.

The purpose of the management process is to steer the development of internal processes to achieve the strategic objectives. The main internal processes include the innovation process (research and development), the support processes (support services) and the learning process (education).

The steering of internal processes is achieved by different methods. First, the operations of the internal processes are aligned with the budgeting and HR plans. Second, and even more relevant to our analysis are the action plans, which are drafted at every organisational level including those of the institution, the faculties, the degree programmes and other administrative units. Third, the linkages between the management process and internal processes emphasise the importance of using relevant information in the management process as a prerequisite for effective quality assurance. The information produced by internal and external evaluations and feedback systems to support management in decision-making especially is extremely important in quality assurance.

6. UTILISATION OF EVALUATION IN DECISION-MAKING

The quality assurance system should produce and contain information about the process performance and the achievement of the goals. The system also should encourage management and personnel to clarify the measures needed to improve the internal processes. In order to continuously improve the operations it is important to emphasise the utilisation of evaluation findings in management's decision-making and strengthen the interface between the quality assurance and management processes.

According to Patton (1997), evaluation findings can serve three main purposes: providing judgments, facilitating improvement and generating knowledge. The utilisation of evaluation findings may be instrumental or conceptual. Instrumental use of evaluation findings occurs when decisions or action follow from the evaluation. Judgment-oriented evaluation is aimed at determining the overall value of the issue. Passing judgment on merit or worth supports major decisions about whether a programme should be continued, enlarged, disseminated or terminated. By contrast, decisions on how to improve programmes, following improvement-oriented evaluation, seem to be made in small, incremental steps based on specific evaluation. The conceptual use of evaluation findings means that evaluations contribute by increasing knowledge among decision-makers and stakeholders.

If the MIS is primarily used for judgment-oriented accountability reporting, the system may have negative and disincentive effects. It is better to build the system for improvement-oriented decision making to monitor performance and outcomes and to provide feedback to facilitate continuous improvement. The information provided can then be utilised for minor reallocation of resources and increasing effectiveness.

The management portal is used at the TUAS mainly for the needs of the institution's internal management process. Even though in every hierarchical organisation with superior-subordinate-relationships there is inevitably at least a certain degree of accountability, we do not consider the use of the MIS at the TUAS to be judgment-oriented and accountability-driven. Rather, it has been emphasised that the action plan is essentially every manager's own plan to balance the different strategic objectives in the different organisational units. To summarise, the action plan of the MIS should be seen as an improvement-oriented self-evaluation and planning tool.

The MIS and management portal of the TUAS include strategic plans, which are annually translated into more concrete budgets and action and HR plans. The format of the action plan is based on the Balanced Scorecard approach (Kettunen & Kantola, 2005). The action plan includes 13 strategic objectives, which are described using about 35 measures having target values for the three-year planning period. The action plan also identifies the essential strategic initiatives which follow from strategic objectives. On the other hand, the action plan also defines, communicates and stores the improvement measures which follow from the weaknesses identified during the self-evaluation.

When performing the self-evaluation the manager is expected to take into consideration the findings and recommendations of internal and external evaluations, the implications of curriculum evaluation and feedback from students and employers. The deans and managers are expected to plan the timetables and identify the individuals responsible for the improvement measures and other envisaged tasks.

From the viewpoint of organisational self-evaluation the most important feature of the action plan is not the Balanced Scorecard with data from the data warehouse, but the procedure which initially guides managers to a self-evaluation on a broad level. The manager is expected to evaluate the status quo and evaluate to what extent the unit has achieved the agreed strategic objectives.

7. CONCLUSIONS

This study shows that the different approaches of management can be integrated using an interactive and collaborative MIS which supports the management process and the internal processes of the organisation. The system integrates the strategic planning, action plans with Balanced Scorecards, budgets and HR plans. The MIS is also an important tool of the quality assurance system, because it helps the organisation to continuously improve its activities and know how well it is performing.

The concept of the quality map was introduced in this study to describe the interface between the quality assurance system and the management process. The quality map describes the essential characteristics of the quality assurance system. It is a visual representation of how the changes in the environment are taken into account to define the strategic plans and how strategic outlines are planned in detail in the management process. It is also a description of how the plans are implemented in the internal processes of an organisation. In an educational institution the quality map helps management, employees, students and external evaluators to understand the main elements of the quality assurance system and the interface between the quality assurance system and the management process.

The collaborative and interactive use of the MIS supports the instrumental evaluation purposes consisting of judgment-oriented and improvement-oriented evaluation. It also supports the conceptual use of evaluation, where the evaluation contributes by increasing knowledge among decision-makers or stakeholders. If the MIS is used only diagnostically as a monitoring device concentrating on deviations from the set targets without face-to-face interaction and negotiation, the full potential of the MIS to support quality assurance will not be achieved.

The interactive use of the MIS supports organisational self-evaluation and helps management and employees to improve the quality of operations. In order to be capable of designing an MIS which genuinely supports the integration of improvement-oriented self-evaluation into the institution's management process, developers of the MIS must have a profound and realistic understanding of the utilisation of evaluation in decision making. Designers should take careful note of the interactive features of the management process under scrutiny when developing the MIS.

REFERENCES

Analytic quality glossary (2006). Retrieved November 27, 2006, from http://www.qualityresearchinternational.com/glossary/

Beckford, J. (2002). *Quality*. London: Routledge.

FINHEEC (2006). *Audits of quality assurance systems of Finnish higher education institutions. Audit manual for 2005-2007*. Publications of The Finnish Higher Education Evaluation Council 2006: 4. Tampere: Tammer Paino Oy.

Guan, J., Nunez, W., & Welsh, J.F. (2002). Institutional strategy and information support: The role of data warehousing in higher education. *Campus-Wide Information Systems*, 9(5), 168-174.

Inmon, W.H. (1996). *Building the data warehouse*. New York: John Wiley & Sons.

Harvey, L., & Green, D. (1993). Defining quality. *Assessment and Evaluation in Higher Education*, 18 (1), 9–34.

Kaplan, R., & Norton, D. (1996). *The Balanced Scorecard*. Boston, MA: Harvard Business School Press.

Kaplan, R., & Norton, D. (2001). *The Strategy-focused organisation*. Boston, MA: Harvard Business School Press.

Kaplan, R., & Norton, D. (2004). *Strategy maps*. Boston, MA: Harvard Business School Press.

Kettunen, J. (2004). The strategic evaluation of regional development in higher education. *Assessment and Evaluation in Higher Education*, 29(3), 357-368.

Kettunen, J. (2005). Implementation of strategies in continuing education. *The International Journal of Educational Management*, 19(3), 207-217.

Kettunen, J., & Kantola, I. (2005). Management information system based on the Balanced Scorecard. *Campus-Wide Information Systems*, 22(5), 263-274.

Kock, N. (2005). What is E-Collaboration?, *International Journal of e-Collaboration*, 1(1), i-vii.

Ministry of Education (2005). *OECD thematic review of tertiary education, Country background report for Finland*. Publications of the Ministry of Education, Finland, 2005:38. Helsinki: Helsinki University Press.

Patton, M. Q. (1997). *Utilization-focused evaluation. The new century text*. London: Sage.

Rose, J.G. (2003). The joys of enterprise portals. *Information Management Journal*, 37(5), 64-70.

Simons, R. (1995). *Levers of control. How managers use innovative control systems to drive strategic renewal*. Boston, MA: Harvard Business School Press.

Smith, M.A. (2004). Portals: Toward an application framework for interoperability. *Communications of the ACM*, 47(10), 93-97.

White, M. (2000). Corporate portals: Realizing their promise, avoiding costly failure. *Business Information Review*, 17(4), 177-184.

Zhou, J. (2003). A history of Web portals and their development in libraries. *Information Technology and Libraries*, 22(3), 119-128.

Woodhouse, D. (1999). Quality and quality assurance. In J. Knight & H. de Wit (Eds.), *Quality and Internationalisation in Higher Education* (p. 29-44). Paris: OECD.

Health Information Provision on the Web via Comparison-Shopping: A Preliminary Investigation

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INTRODUCTION

The public access to health service information is critical for the general welfare of the society. In the United States, there are many efforts being spent by the government and independent non-profit organizations on improving the *quality* and *accessibility* of such information. Recently, comparison-shopping as an innovative way to increase the efficacy of health service information access is emerging. Depending on the geographic location, an individual could conduct comparison-shopping on health service information ranging from health insurance cost, service quality of hospitals and physicians, to price of prescription drugs.

This new way of obtaining healthcare information may have important social consequences. Essentially, it empowered individuals (including new immigrants) to obtain health information and making comparison with zero searching cost. If such practice is being widely adopted, it may increase the efficiency of the whole health system by reducing cost of patients, increasing service quality of health providers, and improve the welfare of the society in general.

Currently, comparison-shopping for health services and health related information are being provided by various entities like commercial enterprises, non-profit organizations, and government agencies. We see forces converging to make such services available in more sectors of the health system. So it is both academically interesting and practically relevant to study this phenomenon and predict the future development of this phenomenon.

To analyze this topic, we need to address the complex structures of the U.S. health system. This complexity makes both the momentum and impact of comparison-shopping in health industry different from its counterpart in electronic commerce market.

For the remaining of this paper, we first introduce the concept of comparison-shopping and how it is being used to provide health related information on the Web. Then we reviewed the major stakeholders of the system. We analyzed the competing forces of comparison-shopping in healthcare industry and compare them to those in electronic commerce industry. Finally, we proposed future research directions. Since this is a preliminary investigation, our focus is not proposing theory but identifying empirical facts and aims at providing basic references for interested practitioners in this field. We also hope this paper may draw interests of academic researchers.

WEB-BASED COMPARISON-SHOPPING AND HEALTH INFORMATION PROVISION

Web-based comparison-shopping refers to the comparison of product and service information from different online sources in the same Web interface via aggregation and pre-processing work done by comparison-shopping agents or Shopbots (Maes, 1994).

As early as in 1995, we witnessed the first online comparison-shopping service, BargainFinder, developed by then Andersen Consulting in the United States. BargainFinder became a killer app and gained public attention almost instantly (Krulwich, 1996). The success of BargainFinder stimulates more sophisticated comparison-shopping services subsequently like mySimon.com and Pricescan.com in late 90's. Comparison-shopping entered into the mainstream B2C market when the second generation services like shopping.com and pricegrabber.com came onto the stage. Recent survey statistics indicate comparison-shopping ranked among Yahoo, eBay and Amazon as the most visited websites (Nielsen//Netratings, 2004).

In health industry, though comparison-shopping had been used in some sectors like health insurance in very early stage of WWW, most other sectors are lagging behind due to its distinctive market structure compared with commodities.

The health insurance field becomes the pioneer in the U.S. health system to provide comparison-shopping service. Actually this is a natural business extension for insurance agents since they already have the various insurance products data in hand and all they need is to make them available online for the general public to use. Further, this move could actually improve their reach to potential customers, reducing their operation costs in hiring new agents and employees in customer services. Thus, we found established comparison-shopping services in this field emerged quickly like insurable.com, healthinsurance.com, ehealthinsurance.com, etc. from 1995.

Other sectors of health industry were not influenced by this comparison-shopping way until late into 2000. It was not until in the last 2 years, we observed comparison-shopping service on prescription drugs, hospitals, and physicians.

The comparison-shopping service on prescription drugs is mainly due to the rising cost of healthcare. The service providers are mainly non-profit organizations and government agencies like:

1. The U.S. Department of Health and Human Services provides comparison information on hospitals. (www.hospitalcompare.hhs.gov/)
2. The Joint Commission provides information on hospitals as well as other health care service providers (www.jcaho.org)

Some state governments have begun to provide state specific hospital information for their resident patients. Massachusetts Health Quality Partners (MHQP), for example, is an independent state agency that looks at the quality of health services in Massachusetts. It provides side-by-side comparisons on clinic data via different search criteria based on different information needs[1]. MHQP also looks at the quality of health service through the patient experiences. This information is then used to compare patient experiences across the state via a tabular comparison-shopping format for easy comparison on the Web[2].

Comparison-shopping on physician services is also provided by some state governments. For example, New York State provides such service and allows individuals to review a physician's profile information which includes the medical education, legal actions taken against the doctor, translation service at the doctor's office, etc.[3]

Probably, the most widely available comparison-shopping services are prescription drugs due to the cost issue patients experienced in recent years, which are mainly provided by state governments. For example, the Connecticut attorney general's office provide a comparison-shopping services on prescription drugs and allows patients to compare pharmacy prescription drug prices across the state of Connecticut[4]. The State of Illinois makes similar comparison-shopping information available to its residents[5].

THE HEALTH SYSTEM IN THE U.S.

The foundation for our understanding of the complexity of the health information provision is the overall structure of the health system in the US, which can be illustrated from the three basic groups of stakeholders, the *patients*, the *providers* and the *payers*.

The patient population consists of the general public seeking health services. The health providers include physicians, clinical technicians, pharmacists, nurse practitioners, allied health specialists and many other healthcare professionals. Most of them provide the health service via hospitals or similar health service facilities. The payers include self-pay patients, private insurance companies, indemnity plans and government payers (such as Medicare and Medicaid). The majority of the stakeholders are connected via three basic organization forms: HMO (Health Maintenance Organizations), PPO (Preferred Provider Organizations), and (POS) Point of Service Plans.

There is a variety of health services available to patients. They include the ambulatory care, assisted living, behavioral health care, and home care & hospice. The most frequently used health services are provided and received in hospitals. The hospital system in the US is very complex and there are several ways to classify them. Overall, there are over 6,500 hospitals in the United States. The majority of them are general hospitals set up to deal with the full range of medical conditions most people require treatment for. However, more than 1,000 hospitals specialize in a particular disease or condition (cancer, rehabilitation, psychiatric illness, etc.) or in one type of patient (children, the elderly, etc.).

Among these hospitals, some are *teaching or community hospitals* that are affiliated with medical schools. Some are *voluntary hospitals,* which are nonprofit community facility operating under religious or other voluntary auspices. There are also for-profit commercial hospitals or *proprietary hospitals*. They are profit-making institutions and owned by corporations or, less often, by individuals such as doctors who practice at the hospital. Finally, there exist *government-supported hospitals*, which government owned facilities and can include facilities such as the VA (Veterans Administration health facilities).

The different origins and operation styles of these hospitals makes their motivation of providing health information to the public varied. For example, teaching hospitals are usually in the position of providing cutting-edge new health services so they have the motivation to compare their service to others to let the patient know their advantage. Proprietary hospitals might have higher motivation to compare their quality of service information than those government-supported hospitals because they want to attract more patients.

On top of the physical structure of the health system, public policy and accreditation are two other forces that shaped this market.

The public policy for health related information is mainly protecting privacy and patient health information[6]. It has not direct influence on adoption of comparison-shopping for health information provision because the latter is mainly in public information domain.

To regulate the quality of health service, there are also accreditation organizations in the US. The Joint Commission on Accreditation of Health Organizations is the primary accreditation body in the US[7]. It evaluates and accredits approximately 16,000 health care organizations in the United States. The information collected in the Joint Commission surveys is of benefit to the healthcare facility, and is especially beneficial to the Patients considering utilizing a healthcare facility.

The Joint Commission Survey Teams composed of health care professionals gather information by visiting health facilities, interviewing staff and patients and examining records and procedures. The survey performance is compared to Joint Commission's standards and quality expectations. Hospitals must meet or exceed the requirements in order to achieve or maintain accreditation.

The accreditation decisions are assigned in different categories based on their level of compliance. They range from fully accredited, provisional accreditation and conditional accreditation to denial of accreditation.

Another important evaluation survey is conducted by Center for Medicare and Medicaid Services (CMS). In order for a health care organization to participate in and receive payment from Medicare or Medicaid programs, it must be certified as complying with the standards set forth in federal regulations, which is based on a survey conducted by a state agency on behalf of the CMS (JCAHO, 2006).

Organizations seeking Medicare approval may also choose to be surveyed by Joint Commission or other accrediting organizations. In this case, CMS may grant the accrediting organization "deeming" authority and deem each accredited health care organization as meeting Medicare and Medicaid certification requirements. For the time being, the deemed status options are available for ambulatory surgical centers, clinical laboratories, critical access hospitals, HMOs and PPOs, home health, hospices, and hospitals.

To monitor the quality of health service, CMS conducts random validation surveys and complaint investigations of organizations with deemed status through Joint Commission accreditation. In addition, the Joint Commission is obliged to provide CMS with a listing of, and related documentation for, organizations receiving conditional accreditation, preliminary denial of accreditation, and accreditation denied. The Joint Commission also provides CMS with accreditation decision reports for hospitals involved in CMS validation surveys and any other survey report CMS requests. (JCAHO, 2005)

As described above, the health system in the US is very complex in structure. Ordinary patients usually have difficulty obtain the specific service quality information about the providers like doctors or hospitals, not to mention comparing them. In addition, the useful evaluation information mainly comes from a few accreditation organizations or government agencies. These evaluation surveys are targeting the bottom line of the service quality and, beyond which, there is no information to make a more informed decision.

THE CHALLENGE OF HEALTH INFORMATION PROVISION TO THIRD PARTY COMPARISON-SHOPPING SERVICE PROVIDERS

A constant issue facing the American population is continuity of care when changing physicians, insurance plans and locations. Finding new health service providers for their health needs is a constant demand especially with the spiraling cost of health insurances and costs (Baker et al., 2003). The society calls the expertise in providing convenient health information to support individual health service selections. Though there are emerging online comparison-shopping services available in health service selection as we investigated above, we identified a few challenges that could hinder the momentum and sophistication of information delivery in this direction. We summarize them below.

First, unlike comparison-shopping in ecommerce industry, health information provision especially information on hospitals, physicians, and prescription drugs price comparison provided by non-profit organizations does not have similar commercial motivations behind them to support their further development.

In the ecommerce industry, the product information providers (online retailers) actually pay to participate in comparison-shopping because of the potential revenue it could bring back. The more online retailers join the comparison-shopping, the more the remaining online retailers also have to join to maintain their competitiveness – as a result, it forms a positive feedback loop and established the prosperity of comparison-shopping service providers. At the same time, competing comparison-shopping service providers have to improve their technology of information delivery to remain in the market.

In health service information provision, such commercial motivation is not strong for a majority of the entities especially public ones though some private hospitals and doctors who own their clinic may be interested in such comparison. In addition, the ways a health service provider (usually non-profit in nature) operates to attract patients are traditionally different from those in business world. So we might not be able to see a change in near future. In other words, the sophistication and breadth of comparison-shopping on health services may not develop as fast as its counterpart in ecommerce industry.

Second, intertwined with first challenge, the intellectual property especially copyright issues for information on the Web are still pending in many aspects (Lindberg and Humphreys, 1998). For the time being, the health information provided on the Web is mostly owned by non-profit organizations and government agencies, which may not have the commercial motivation or right to sell it or allow it to be used by commercial organizations to generate profits. Without such mechanism, the core technology of comparison-shopping, which is aggregating data from multiple sources and presenting them in a value-added way to users, can not be conducted efficiently. Again, in ecommerce field, comparison-shopping service providers also experienced copyright issues in the beginning when they retrieve data from different online vendors for comparison. However, when online vendors found comparison-shopping could actually increase their revenue, they changed their attitude and begin to pay to participate (Plitch, 2002).

But in health service industry, this change is unlikely due to the non-profit nature for most part of the system. So how to protect a third party comparison-shopping service provider from being sued via appropriate public policy is important.

There are some moves in this direction recently. For example, Illinois enacted a law in 2005 (The Prescription Price Disclosure Act) and ensure that consumers can compare-shop to find the lowest price for their prescription medications. It requires pharmacists to disclose the current retail price of any brand or generic prescription drug or medical device that the pharmacy offers for sale. As we can see from this case – if we lack the invisible hand of the market to encourage the voluntary participation as in ecommerce industry, the state government could step out and use the visible hand of legislation to force the participation (basically sharing the drug price data) of comparison-shopping by drug vendors.

We expect more public regulations will have to be enacted as a compensation for lacking commercial motivation of comparison-shopping by health service providers in the near future to promote the services.

FUTURE RESEARCH DIRECTIONS

We think the first priority in research of this field is establishing a proper framework on the classification of health information as needed by patients. This framework should include all aspects of health information a patient needs to make healthcare decisions.

We also need research on how to standardize health information so as to make the electronic transaction of information retrieval and aggregation by comparison-shopping search engines easier to perform. A related project that has been underway for quite a while is the concept of regional health exchanges (Havenstein, 2005). In this plan, the U.S. Government hopes to provide a backbone for a national health information infrastructure where all hospitals will be connected and patient information is stored electronically in real time. The comparison-shopping search engine could utilize such a network to retrieve necessary information in the future.

Another imperative topic in future research might be a detailed analysis on the impact of public policies on health information provision in comparison-shopping mode. In health information provision, the motivation of providing comparison information is both non-commercial and complicated. So the impact needs to be investigated in detail.

CONCLUSION

In this paper, we investigated comparison-shopping as a new way for health information provision in the United States. We introduced the emerging field of comparison-shopping and its application in several aspects of health information provision such as health insurance, hospital, physician, and prescription drug selection.

We identified the challenges of the development of this field by contrasting it with comparison-shopping industry in electronic commerce world, where a more efficient mechanism is driving the sophistication and maturity of this new mode of decision support. We argue that public policy is the most effective way currently in health information provision to influence the development of comparison-shopping on health services.

Finally, we proposed several future research directions in this new field.

REFERENCES

BAKER, L., WAGNER, T. H., SINGER, S. & BUNDORF, M. K. (2003) Use of the Internet and E-mail for Health Care Information: Results From a National Survey. *JAMA,* 289**,** 2400-2406.

HAVENSTEIN, H. (2005) Regional health exchanges slowly start to share data. *Computerworld*.

JCAHO (2005) 2004 General Public Quality Report User Guide. Joint Commission on Accreditation of Healthcare Organizations.

JCAHO (2006) Federal Deemed Status and State Recognition

KRULWICH, B. (1996) The BargainFinder Agent: Comparison

Price Shopping on the Internet. IN WILLIAMS, J. (Ed.) *Bots, and Other Internet Beasties.* Indianapolis, Macmillan Computer Publishing.

LINDBERG, D. A. B. & HUMPHREYS, B. L. (1998) Medicine and Health on the Internet: The Good, the Bad, and the Ugly. *JAMA,* 280**,** 1303-1304.

MAES, P. (1994) Agents that reduce work and information overload. *Communications of the ACM.*

NIELSEN//NETRATINGS (2004) Web Surfers Comparison Shop Online For Mother's Day Gifts. NetRatings, Inc.

PLITCH, P. (2002) Are Bots Legal? *Wall Street Journal,* 240**,** R13.

ENDNOTE

1. This service is available from their official site: http://www.mhqp.org/quality/clinical/cqSearch.asp?nav=032400
2. This service is available from following URL: http://www.mhqp.org/quality/pes/pesSearch.asp?nav=031600
3. The service is available from URL: http://www.nydoctorprofile.com/welcome.jsp
4. Available via URL: http://www.dir.ct.gov/ag/DrugSearchGIS.asp
5. Available via URL: http://www.consumeraffairs.com/news04/2006/01/il_drug_shop.html
6. According to a recent survey by Forrester Research (which is a follow up to a similar survey conducted by California Health Foundation in 1999) to detect if there is any reduction for individuals in concerns over their privacy, there are still 67% of national respondents "somewhat" or "very concerned" about the privacy of their personal medical records (Bishop et al., 2005). In line with such concern, the Health Insurance Portability & Accountability Act of 1996 (or HIPAA) are probably the most well known and widely sweeping of the continuous effort by government to regulate access, transport and availability of patient health information. HIPAA has brought about more sweeping changes in health transactions and administrative information systems than any other regulation in recent times.
7. More information about this organization could be obtained from their official website: http://www.jointcommission.org/

Business Process Optimization Using Simulation

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ABSTRACT

In this paper we study a Pharmacy that recently went through a major IT initiative. With the acquisition of the new software, the Pharmacy had more flexibility to rearrange its flow of activities. We used several "what if" scenarios and applied a simulation tool to study the impact of each scenario on the performance of the pharmacy and search for a maximum optimization given the resources available. An issue that we investigated was that a simulation tool would be of less use if it is not preceded by a profound conceptual modeling. In turn, modeling alone is not sufficient to get insight into the dynamic behavior of a system. For the pharmacy business process modeling we used a method that is introduced and discussed in a separate paper.

Note: Due to space restriction, this paper represents application part of another paper "Business Processes Modeling as Social Systems", published in these proceedings, where the modeling method itself and its constructs are discussed. For the understanding of this paper, readers are strongly recommended to read the first paper where the method is described and discussed.

INTRODUCTION

For a thorough analysis and study of business processes, both modeling and simulation should play in concert. Only modeling may not reveal sufficient information about the processes (Hlupic & Vreede, 2005). For significant results and accuracy, business process optimization and modeling need simulation. On the other hand, only simulation provides little help if there is no profound conceptual modeling preceding it. It would be like "expedition without a map".

Continuous competition, increasing capabilities and features of emerging technologies and growing customer demands require organizations to keep current, i.e., adapt changes in order to gain market share, improve performance, increase customers and incorporate "best practices". In such an environment, process optimization is no longer a competitive advantage but a requirement of doing business (Rivera & Marovich, 2001). Obviously any change is risky and may invoke serious consequences for organizations. Early mitigation of these risks is undoubtedly a prerequisite of success and survival in risky changes with unforeseen variables. Here is where business process simulation plays a significant role in process optimization. Simulation is a safe and inexpensive way of studying the impact of changes and revealing hidden behaviors of a complex system.

Since changes would be a driving force for *the 21st century enterprises*, business process optimization and simulation is not a question of *"to be or not to be"*, but a navigational compass to set the right course for sailing into the storms of rapid change. According to some experts (e.g.: Paul & Serrano, 2003; Seila, 2005; Kleijnen, 2005; Hlupic & Vreede, 2005) the potential and full capacity of business process simulation still have yet to be revealed. Although one may argue that the diligent efforts of researchers have fairly advanced the research in this area, simulation as an effective tool should still be widely accepted and adapted by businesses.

Since this paper is an application part of another paper that contains detailed description of the method, here we only focus on the application – case study.

CASE STUDY: PHARMACY

The case study reported here is not intended to be exhaustive, it is a simplified version to demonstrate how the proposed method is capable of capturing the dynamic behaviour of business processes and serve an input for simulation. This case study was conducted at a time when a Pharmacy was planning to acquire and implement a new system and extend its business with e-commerce. This case study using modelling and simulation, was assumed to provide an insight into the business and help to understand the Pharmacy's operations and requirements for a new system.

Prescription Filling Process

Upon arrival at the Pharmacy a patient proceeds to the pharmacy counter and requests prescription refilling. If it is a new patient, the technician asks the patient to fill out a short information sheet, which includes information such as the patient's name, address, telephone number, allergies, and whether or not the patient has any type of insurance or medicine coverage. When the profile is created, the technician selects medicine according to the prescription.

The software automatically checks the current medicine for interactions. Then the user transmits a claim to the patient's insurance. If no insurance coverage, a cash price is assigned.

The computer generates a label and sends the information to the 'robot' for automatic filling. The medicine is then checked one final time visually by a pharmacist. Once verified, the prescription is bagged and then sent out to the cashier for pick-up by the patient. The entire process normally takes no more than 10-15 minutes. The end of this process is related to another process called inventory control. Inventory must be accurately maintained because QuickScrip uses an automated ordering system which examines the current quantities of medicine in stock and networks with the wholesaler company to ensure proper levels are maintained. Although the inventory control process and its interrelation with the prescription filling process were also studied in the case study, here we skip this part due to space restrictions.

Identification of Business Transactions

The process of "Prescription Filling" starts when a patient presents a prescription to be filled. Thus, the first transaction (T1) is "prescription filling". Actually, this is a super transaction that nests many other transactions. This transaction is initiated by a "patient" and executed by the "pharmacist". The result of this transaction is a filled prescription. In this manner we identify all other transactions:

T1:	prescription filling
Initiator:	patient
Executor:	pharmacist
Result:	prescription is filled
T2:	creating profile
Initiator:	pharmacist
Executor:	patient
Result:	profile is created
T3:	checking medicine interaction
Initiator:	pharmacists (software agent)
Executor:	QuickScrip
Result:	interaction is checked

T4: claim processing
Initiator: pharmacist
Executor: insurance company
Result: claim is processed

T5: automatic dispensing
Initiator: pharmacist
Executor: robot
Result: medicine is dispensed into bottle

T6: paying for the medicine
Initiator: pharmacist
Executor: patient
Result: medicine is paid

Now, based on the above transaction, we build a detailed model as shown in Figure 1. By disclosing Transaction T1 (splitting its three phases), all other nested transactions are revealed. This figure shows all the transactions as an interrelated network. It also shows that once medicine is issued (T1/R), the inventory control process is activated. As the inventory control process is out of the scope, which itself is a network of transactions, we just illustrate it as a composite transaction (T#).

Within the scope of our model, only Transaction T1 is a composite transaction and, therefore, we decompose it. All other transactions (T2, T3, T4, T5 and T6) are simple transactions and, therefore, they are shown in a compact form to keep the model compact.

In Figure 1, the Pharmacy is considered as a composite actor delegating the role of a few other actors such as "pharmacist", "technician", "robot (A2)" and "software agent (A1)" for checking medicine interaction. In order to better understand the above figure, it should be read from left to right and from the top to down, just as the arrows indicate. It would be easier if the reader has a list of the transactions, previously identified, ready when reading the model: The patient requests prescription filling (T1/O) and with this request the execution by a pharmacist or technician starts (T1a/E). If it is a new patient, the technician requests them to fill in a form to create a new profile (T2). This is an optional transaction indicated with a small diamond-shape at the connection point. Then, within the pharmacy system (QuickScrip), a request is made to check the current medicine for any interaction (T3) (if an interaction is detected, the process terminates here). Through an online application, the claim for this medicine is transmitted to the patient's insurance company to define the price of the medicine (T4), if the patient is covered by an insurance plan. Then the robot is instructed to fill in the prescription (T5). At this point the patient is requested to make their portion of the payment or arrange for later billing (T6), and only then the medicine is issued to the patient and the process is completed (T1/R). Notice, the completion of this process triggers a transaction in the inventory control process (T#) making sure the issued medicine is subtracted from the inventory and checks if this medicine should be ordered for restocking.

Figure 1. The pharmacy detailed model (constructed with MS Visio software)

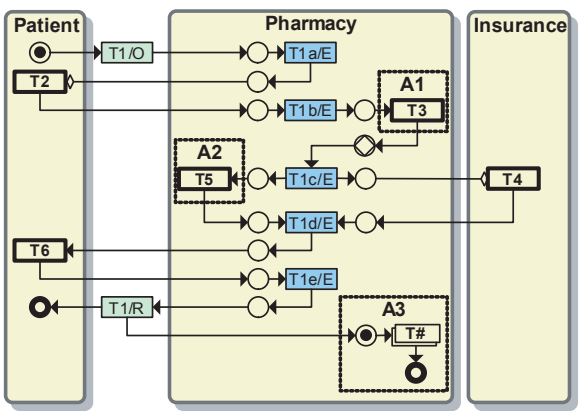
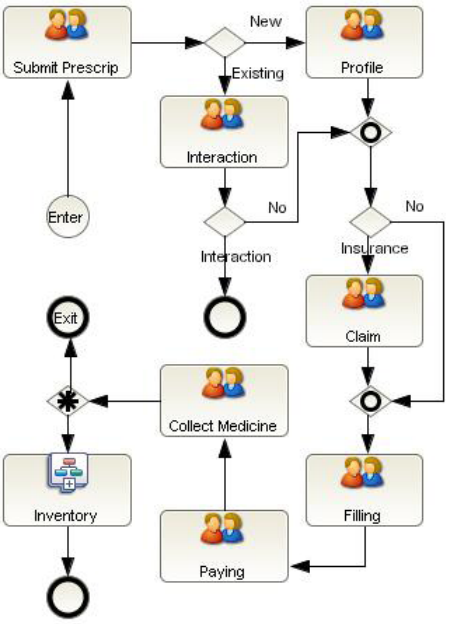


Figure 2. Screenshot of the "pharmacy" simulation model



SIMULATING THE PHARMACY MODEL

We developed a simulation model of the Pharmacy based on the detailed model presented in the previous section. For the simulation purpose we use Savvion Process Modeler to show the usefulness of the developed models as an input to be used by simulation packages other than Petri net tools. This way, it is demonstrated that the Petri net models are easily portable to different environments and can be adequately represented by other models, although some minor adaptations are needed. By adequately we admit one essential compromise – the interaction part of the models are largely omitted and the model is reduced to merely execution phases, where the actual actions take place. One of the typical adaptations required, concerns composite transactions. A composite transaction should have both start and finish parts, e.g., the "prescription filling (T1)" is divided into submitting a prescription for filling (Submit prescription) and collecting the medicine (Collect medicine) parts, while all other transactions can be represented as a single activity, as shown in Figure 2. This figure depicts an animated simulation model of the Pharmacy using Savvion Process Modeler.

Savvion Process Modeler has its own graphical editor for constructing models using a set of artifacts. The figure below is a screenshot of the Pharmacy model in the Savvion Process Modeler graphical editor.

The model contains 6 transactions each representing an atomic process. In the Savvion simulation model above, these transactions are represented as worksteps (grey rectangles: e.g., Submit & Collect, Profile, Interaction, Claim, Filling and Paying). Each workstep corresponds to one transaction (more precisely, the execution phase of a transaction), however, the first transaction, the composite one, is divided into two parts (Submit, Collect). In addition, the simulation model illustrates how the last transaction 'Paying' is linked to the 'inventory control' process. This process is represented through a *subprocess* element without revelation of its inner structure (transactions), which by itself is a model.

For accurate analysis and comparison, Savvion Business Modeler provides analysts with features such as generating a report on the simulation results in either HTML or Excel format. The following few lines and the corresponding Table 1 are excerpts from a complete simulation report (2-4 pages). These excerpts are about the bottlenecks in the process and warning about activities that never occurred:

***Filling*:** A bottleneck was detected for Filling (avg. queue length was 0.15, max. queue length was 5.0).

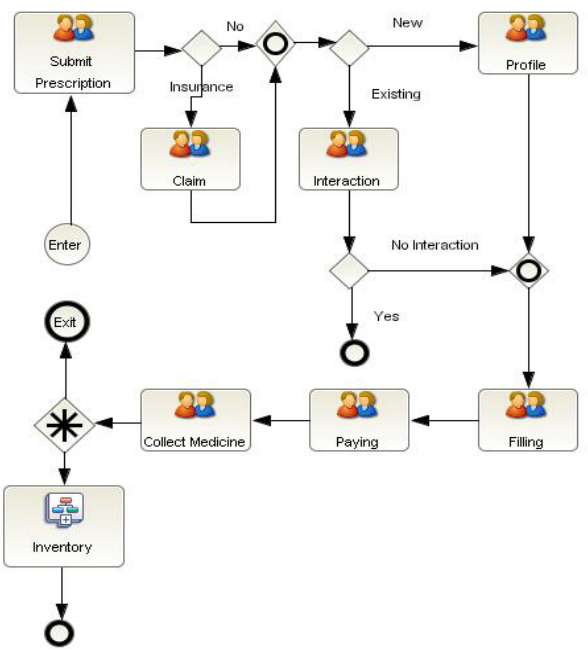
Table 1. A part of the simulation report

Pharmacy					
Scenario	*Original*				
Instances	*60 instances*				
Activity	Performer	Occurs	Waiting Time	Time to Complete	Total Time
Claim	Insurance	57	1:58:00	4:45:00	6:43:00
Collect Medicine	Patient	57	2:10:00	0:57:00	3:07:00
Filling	Robot	57	0:00:00	4:45:00	4:45:00
Interaction	Technician	57	0:00:00	0:57:00	0:57:00
Paying	Patient	57	1:23:00	4:45:00	6:08:00
Profile	Patient	3	0:05:00	0:15:00	0:20:00
Submit Prescription	Patient	60	1:57:00	1:00:00	2:57:00
Inventory	Generic	57	0:00:00	0:00:00	0:00:00

***Profile*:** Profile was never activated. Try increasing the number of instances.
***Submit*:** A bottleneck was detected for Submit (avg. queue length was 0.029, max. queue length was 1.0).

A complete report of the simulation outcome includes 2-4 pages in HTML format detailing average times, queues, busy and idle times for each performer, and other related information about the model behavior. All this is generated in a series of tables one of which is illustrated above (we skip the rest due to space restriction). The simulation package also has a kind of expert system that provides recommendations of how to improve the process or which components need to be redesigned for better performance.

Figure 3. Screenshot of the revised "pharmacy" simulation model



"What if" Scenario A
To improve the model, reduce bottlenecks and decrease wait time we put the model through several "what if" scenarios two of them reported in this paper. In our first such scenario (see Figure 3) the issue of the bottleneck during the filing of insurance claims was addressed. Our first step was to assess the current sequence of the "Claim Process" and optimize its position in the flow. The claim process being in itself a complex process involving the insurance company may take longer than some other actions and resulted in bottlenecks at its beginning and also was thought to be responsible for other process in the model. Our evaluation led us to believe that placing the claim at the beginning of the model instead of in the middle could help to reduce the bottleneck in that location and by doing so on a subsequent simulation run the model was made more efficient. Included below are excerpts from the results of the simulation run.

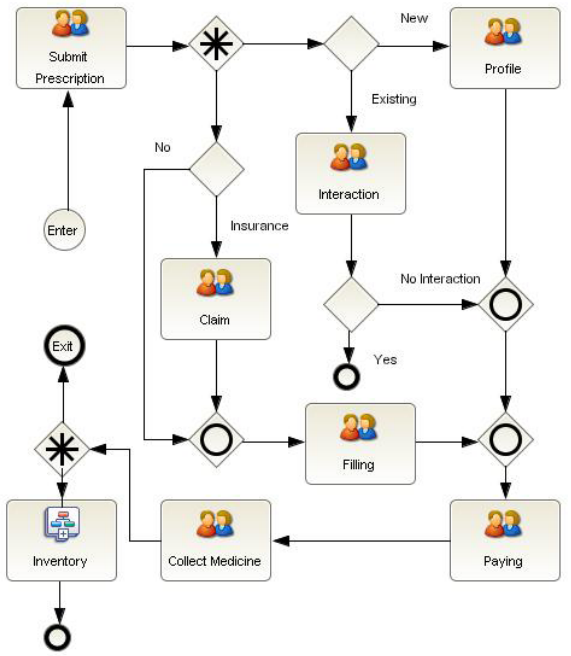
Collect: A bottleneck was detected for Collect Medicine (avg. queue length was 0.032, max. queue length was 1.0)
Profile: A bottleneck was detected for Profile (avg. queue length was 0.0090, max. queue length was 1.0)
Submit: A bottleneck was detected for Submit (avg. queue length was 0.071, max. queue length was 1.0)

"What if" Scenario B
To further reduce wait time and the overall length of the process we decided to incorporate mass parallelization (see Figure 4). Utilizing this feature allows for the claim to begin processing at the start of the simulation and to have the other performers continue on with the interaction check and information profile for new customers. This model proved to be an improvement for overall processing time compared with the original and the previous scenario.

Filling: A bottleneck was detected for Filling (avg. queue length was 0.0010, max. queue length was 1.0)
Paying: A bottleneck was detected for Paying (avg. queue length was 0.047, max. queue length was 1.0)
Submit: A bottleneck was detected for Submit (avg. queue length was 0.022, max. queue length was 1.0)

Comparison of "What if" Scenarios
As we revised the models it was easy to gather data from the software that allowed us to gauge the effectiveness of each model. Our efforts in creating and revising the models were in order to determine a successful way to reduce wait time for customers to streamline the business process. Each "what if" scenario was investigated with the same set of variables regarding the number of customers arriving as well as their frequency. The Original scenario (model) was compared to each of the two "what if" scenarios to see which model was the most effective (see Table 3). The Original model had an overall simulation run time of 15 Hours

Figure 4. Screenshot of a revised "pharmacy" simulation model incorporating mass parallelization



and 21 minutes. There were six Bottlenecks detected the sum of which created an average waiting time of 0.3697 hours for each customer.

The second model in which the insurance claim process was initiated immediately upon the submission of a prescription had a total run time of 15 Hours. In this model three Bottlenecks were detected the sum of which created an average waiting time of 0.106 hours for each customer. This scenario reduced both overall runtime and the waiting time for customers.

The third scenario incorporated mass parallelization into the model. The overall simulation run time was 14 Hours and 20 minutes. There were four bottlenecks detected, their averages totaling 0.274 hours. This model was found to be effective by reducing the overall time a full hour compared to the Original scenario and also reducing the wait time when compared to the Original scenario.

While both of the scenarios proved effective and each had their own strengths it is always up to the business to decide which is more valuable; reducing customer wait time or overall work time of the establishment. Regardless of the organizational choice, business process modeling is an exceptionally useful and unambiguous tool for assisting with managerial decisions.

CONCLUSION

In this paper we discussed application of simulation as a tool for business process optimization. We studied business processes in a pharmacy that has recently gone through an IT initiative.

This relatively non-complex example revealed a number of valuable conclusions:

- Only modelling is not sufficient to get insight into intricate business interactions.
- It is hard to see the impacts of changes unless the models are executed.
- Experimenting with simulations may prevent s from expensive trial-and-error designs.
- As for the users, simulation (animated) models are more easily communicated to users than static models.

REFERENCES

Hlupic, V.; de Vreede, G-J. (2005). Business process modeling using discrete-event simulation: current opportunities and future challenges. *International Journal of Simulation and Process Modeling*, 2005 - Vol. 1, No.1/2 pp. 72 – 81

Kleijnen, J.P.C. (2005). Supply chain simulation tools and techniques: a survey. *International Journal of Simulation and Process Modelling*, 2005 - Vol. 1, No.1/2 pp. 82 - 89

Paul, R.J., & Seranno, A. (2003). Simulation for Business Processes and Information Systems Design. *Proceedings of the 2003 Winter Simulation Conference*. New Orleans, Louisiana, USA, December 7-10

Rivera, A., & Marovich, J. (2001). Use of six sigma to optimize cordis sales administration and order and revenue management process. Proceedings of the 2001 Winter Simulation Conference, pp. 1252-1258.

Seila, A.F. (2005). The case for a standard model description for process simulation. *International Journal of Simulation and Process Modeling*, 2005 - Vol. 1, No.1/2 pp. 26 – 34.

Table 2. Table depicting the results of each simulation

Simulation	Average Wait Time	Total time to Completion
Original Process	0.3697	15 Hours 21 Minutes
What if Scenario A	**0.106**	15 Hours
What if Scenario B	0.274	**14 Hours 20 Minutes**

Reducing the Digital Divide in Mexico: Analyzing the Impact of Telecenters

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ABSTRACT

Developing Countries have tried to reduce the impact of unbalanced technology access through the creation of telecenters in which low-income users can learn and get used to IT. In Mexico this effort has led to the implementation of the e-México project (electronic-Mexico). This project deals with the installation of Digital Community Centers (DCC), a kind of telecenter which provides users with Internet-enabled PCs. This paper presents a preliminary analysis of the impact of such DCC. We focus our attention on the State of Mexico, a densely populated state located in the center of Mexico. We describe the factors taken into account to install DCC and analyze whether or not the location of these telecenters is expected to positively impact low-income counties.

Keywords: digital divide, telecenters, IT Management in developing countries.

Since Internet became a communication tool for the public it established a difference between those countries with Internet access and those without it. The main outcome of this division is the unequal distribution of decision-making information among people. Unequal access to IT and high quality information is what we call the "digital divide".

This research analyzes an initiative of the federal Mexican government aimed at reducing the digital divide: the e-México (electronic México) project. We analyze the counties of the State of Mexico with higher index of poverty which have access to IT. The article is divided in four sections. First, we provide a general description of the digital divide problem; the second part describes the e-México project in further details; we continue by defining our methodology of study and end with a discussion of results and future research directions.

I. THEORETICAL FRAMEWORK: THE DIGITAL DIVIDE

According to the Internet World Stats, as of November 2006 there were 1,706 billion Internet users. This corresponds to a 16.6% world penetration rate, a small percentage of the global population. This shows the huge challenge represented by the digital divide. Larry Irving, quoted by Dragulanescu (2002) was the first author to use this term, he defined "digital divide" as:

"the existing gap in access to information services between those who can afford to purchase the computer hardware and software necessary to participate in the global information network, and low-income families and communities that cannot"

There are other definitions Johnson (2002), Cullen (2001) and Dewan et. al (2005) which propose different approaches to the digital divide term. The OCDE (2001) states that digital divide is "a term that refers to the gap that exists in the opportunities to access advanced information and communication technologies between geographic areas or by individuals at different socio-economic levels".

The digital divide concept is still on debate, there is no definitive consensus on whether this unequal access to technology refers to computers only or should also consider telephone lines. Norris (2000) and Del Álamo (2002) consider telephone lines, television and radio as information technologies. Some others like Kenny and the OCDE (2003) include the previous technologies but also consider Internet access.

We consider that digital divide can be understood as an unequal access to information that promotes human development and increases quality of life. Information Technologies are the main way to reach this goal. Internet access, phone lines, radio or television do not guarantee that information circulates with the same quantity and quality. Our research is focused on measuring the impact of national initiatives targeted at increasing access to IT for low-income populations. Our long-term research goal is to find a reliable measuring methodology to estimate the impact that access to IT has on reducing the digital divide and as a consequence come up with concrete proposals and recommendations to enhance the efficiency of both government and private projects and initiatives. Our first objective is to measure the amount of people that gets access to IT and how this can help reducing the digital divide. Next section continues by describing the e-México project: an effort of the federal Mexican government aimed at reducing the digital divide.

II. E-MÉXICO PROJECT

The digital divide in Mexico is analyzed by Curry and Kenny (2006), their study includes data about Mexican infrastructure: online domains, computer access and number of Mexican Internet users. The Asociación Mexicana de Internet AMIPCI (2006) publishes an annual study of Mexican online consumers and their habits. In 2006, only 20.2 millions of Mexicans had Internet access, less than 20% of the total population of the country.

The project called e-México (http://www.e-México.gob.mx/) was initiated in 2001 by the federal government. e-México intends to provide Internet access together with online services like education programs, health, trade and online transactions to 10 thousand communities representing 85% of the Mexican population, before the end of the current administration (December 2006).

Statistics show that DCC are being used by a large number of users in Mexico. As of October 2004, 29.8 millions of web pages were consulted through the network; 240 thousand hours of surfing is the accumulated total of countryside DCC. In the State of Mexico, a densely populated entity located in the center of the country, subject of this study, 13,300 hours of Internet surfing were registered in 2004 (Perez, 2004).

We will focus our study on the DCC located in the State of Mexico. According to official data, there are 345 DCC in this state, but we do not know whether they are distributed following a particular criterion like poverty index, literacy or lack of technological infrastructure. Officially, there are no established criteria to determine actual DCC locations. We assume that as far as they are controlled by the micro-regions program of the Ministry of Social Development (SEDESOL) they are using the poverty index to locate the centers.

Poverty index is a measure provided by the Mexican National Council of Population: "…this index is a summary measure to differentiate states and counties according

to the global impact on population caused by: lack of access to education, living conditions, income, and context in small counties". (CONAPO, 2004)

In order to measure and evaluate the impact of DCC on reducing the digital divide, we started by finding out the main criteria applied when installing a DCC in a particular county. Interviews with personnel from the federal government in charge of this project revealed that there is no official criterion for the location of DCC, a methodology to measure their impact is still to be defined. Next section describes our approach to these problems.

III. METHODOLOGY

The core methodology consists on evaluating the statistical data with the poverty index. We selected the State of Mexico for this study because it concentrates more than 10% of national population. According to the National Census Bureau of Mexico (INEGI), on 2005 the population of this state was about 13 million 58 thousand and 611 people living in 125 different counties, mostly urban areas. Thus, we consider that studying the impact of DCC in this federative entity will be highly representative at a national scale.

The Hypothesis on which we focus this work are:

1. The poverty index calculated by Mexican government as a normalized measure for qualifying the overall degree of poverty of a population is a meaningful indicator. This is important since the second hypothesis is based on poverty index as an indicator of expected impact of DCC for reducing digital divide.
2. Digital divide will be reduced if DCC are located in populations with a strong poverty index.

In order to proof these hypotheses we proceeded as follows: In the first stage we collected information about poverty index and DCC in the State of Mexico. In the second stage we validated the poverty index with its components (see table 1) before attempting to find any correlation between this index and the DCC locations. The third stage did a correlation analysis between the poverty index and the DCC location in the counties belonging to the State of Mexico. Finally, we discussed and analyzed the obtained results.

Table 1. Components of poverty index

Poverty Index Indicators
Percentage of analphabets aged 15 or more
Percentage of population aged 15 or more with incomplete primary school
Percentage of population living in private houses without tap water
Percentage of population living in private houses without drainage and private toilets
Percentage of population living in private houses with earth floor (unconditioned floor)
Percentage of population living in private houses without electricity
Percentage of overcrowded private houses
Percentage of population living with less than 10USD per day
Percentage of population living in places with less than 5000 inhabitants

Source: CONAPO (www.conapo.gob.mx)

IV. DISCUSSION AND RESULTS

The first result is that the poverty index is valid. According to the results of the multiple regression (see table 2 and table 3) there is a strong correlation (R2 = 0.9341). With the exception of total population, the rest of the components are meaningful enough. Correlation between components and poverty index was tested with a 5% significance level. As a conclusion we can state that there is enough evidence of linear relation of the index and its components: Mexican poverty index is a strong indicator that supports statistical test.

As second result, we can affirm that there is no evidence of lineal correlation between poverty index and the number of DCC in the case of State of Mexico (see table 4 and table 5). If we consider that the digital divide will be reduced by means of providing Internet access through telecenters – DCC – this work shows that the current location of the DCC is not properly done to achieve this goal.

However, with the available information we can not really measure the impact of DCC on the Mexican digital divide. This preliminary research explores the idea that the DCC locations are important to reduce the digital divide on Mexico, we need to provide more elements, for instance, by means of a longitudinal study in order to complement this research.

CONCLUSIONS AND FUTURE RESEARCH

This is a pioneer work that contributes to the research of the telecenters – DCC – and their impact on reducing the digital divide on low income populations. Our results showed the poverty index as a strong and valid measure to understand and quantify poverty; moreover, our tests demonstrate that the component of total population has not significant impact on the computation of the poverty index, and thus can be omitted.

Table 2. Low-income counties and their indicators used to compute the poverty index

TABLA 3. Indice de Marginación y Municipios del Estado de México												
Municipio	*POBLACI*	*ANALFABE*	*PRIMINCO*	*SINSERVS*	*SINENERG*	*SINAGUA*	*HACINAMI*	*PISOTIER*	*MENOSHAB*	*POB2SMIN*	*INDMARGI*	*CCDS*
ACAMBAY	58,389.00	20.09	48.00	54.84	9.91	20.91	56.00	21.47	91.07	75.49	0.31	4.00
Aculco	38,827.00	16.78	46.34	57.70	20.46	14.24	57.85	13.87	100.00	73.13	0.31	3.00
Almoloya de Alquisiras	15,584.00	15.44	46.21	44.08	6.97	28.78	57.23	20.45	100.00	71.51	0.16	3.00
ALMOLOYA DE JUAREZ	110,591.00	15.41	40.95	46.49	9.31	29.65	59.35	23.48	85.55	63.13	0.06	4.00
AMANALCO	21,095.00	23.13	54.03	52.98	7.91	17.69	65.34	38.05	100.00	77.50	0.63	1.00
AMATEPEC	30,141.00	24.80	50.17	43.50	10.60	53.70	49.19	20.04	100.00	71.45	0.43	3.00
CHAPA DE MOTA	35,068.00	18.34	50.32	40.32	6.66	17.31	58.31	23.15	81.44	76.47	0.17	2.00
COATEPEC HARINAS	22,828.00	18.45	46.12	52.91	6.97	11.62	61.53	17.22	100.00	66.82	0.15	4.00
DONATO GUERRA	28,006.00	27.45	60.85	51.07	18.33	40.75	68.43	41.05	100.00	72.39	0.99	1.00
IXTAPAN DEL ORO	6,425.00	20.80	55.10	52.23	8.56	23.83	62.10	21.74	100.00	82.54	0.55	2.00
IXTLAHUACA	115,165.00	17.17	38.07	44.13	5.93	22.44	58.80	27.90	59.95	64.51	-0.09	7.00
JIQUIPILCO	56,614.00	19.28	44.57	48.10	5.32	8.48	56.25	28.32	88.79	71.18	0.09	4.00
MORELOS	26,971.00	26.05	51.62	54.99	11.64	22.42	56.03	26.73	100.00	80.14	0.57	2.00
Oculilán	25,989.00	13.07	44.63	29.71	3.76	5.24	62.89	29.42	100.00	76.78	0.02	2.00
OTZOLOAPAN	5,196.00	24.24	52.98	32.70	4.50	15.07	61.87	32.66	100.00	71.60	0.31	2.00
SAN FELIPE DEL PROGRESO	177,287.00	27.06	59.59	61.79	17.27	44.70	70.43	34.47	100.00	67.82	0.99	11.00
SAN SIMON DE GUERRERO	5,436.00	19.20	43.01	44.53	5.75	22.86	54.45	21.61	100.00	67.49	0.08	1.00
SANTO TOMAS	8,592.00	18.17	44.35	36.32	1.48	23.22	58.64	17.82	100.00	59.97	-0.07	2.00
SULTEPEC	27,592.00	27.53	54.81	69.79	20.66	38.93	62.85	43.02	100.00	66.24	0.96	5.00
TEJUPILCO	95,032.00	23.94	48.49	37.88	8.29	33.88	56.07	22.46	67.59	54.75	0.03	6.00
TEMASCALCINGO	61,974.00	19.78	46.72	49.65	5.33	10.78	58.69	20.47	70.74	67.53	0.02	5.00
TEMASCALTEPEC	31,192.00	16.68	45.61	57.54	8.12	19.16	63.60	33.40	100.00	77.21	0.43	4.00
TEMOAYA	69,306.00	17.32	48.61	40.61	3.59	1.16	69.10	38.03	84.79	70.74	0.18	3.00
TEXCALTITLAN	16,370.00	17.21	46.77	47.80	6.82	26.35	61.47	25.55	100.00	68.90	0.26	2.00
TLATLAYA	36,100.00	26.77	49.48	55.39	6.00	51.59	53.09	26.50	100.00	65.55	0.50	4.00
VILLA DE ALLENDE	40,164.00	22.36	54.15	60.18	19.84	28.42	69.76	27.23	87.29	66.90	0.68	2.00
VILLA DEL CARBON	37,993.00	18.76	46.19	54.08	9.90	10.40	62.40	22.03	80.05	67.49	0.16	2.00
VILLA VICTORIA	74,043.00	26.26	59.70	68.33	22.16	58.48	69.39	34.84	100.00	60.44	1.08	7.00
ZACUALPAN	16,101.00	19.55	53.29	60.44	10.14	49.48	60.59	31.23	100.00	67.39	0.63	2.00
ZUMPAHUACAN	15,372.00	21.93	52.21	44.95	4.11	28.86	66.15	42.48	100.00	81.27	0.63	1.00
Fuente: Elaboración propia con datos del CONAPO y SCT												

Table 3. Regression analysis of poverty index and its components

Regression Statistics	
Multiple Correlation Coefficient	0.9665
Determination Coefficient R^2	0.9341
Adjusted R^2	0.9199
Typical Error	0.2892
Samples	122

ANOVA

	Degrees of freedom	*Squares sum*	*Square's average*	*F*	*F critical value*
Regression	10	132.78	13.28	158.81	6.26E-61
Residuals	112	9.36	0.08		
Total	122	142.15			

Table 4. Low-income counties and DCC

Low-income Counties and DCC			
County	**population**	**Poverty index**	**#DCC**
ACAMBAY	58389	0.30771	4
ACULCO	38827	0.3116	3
ALMOLOYA DE ALQUISIRAS	15584	0.16479	3
ALMOLOYA DE JUAREZ	110591	0.06082	4
AMANALCO	21095	0.62671	1
AMATEPEC	30141	0.42755	3
CHAPA DE MOTA	22828	0.14749	2
COATEPEC HARINAS	35068	0.16786	4
DONATO GUERRA	28006	0.99409	1
IXTAPAN DEL ORO	6435	0.54971	2
IXTLAHUACA	115165	0.09407	7
JIQUIPILCO	56614	0.09192	4
MORELOS	26971	0.57121	2
OCUILÁN	25989	0.01908	2
OTZOLOAPAN	5196	0.31451	2
SAN FELIPE DEL PROGRESO	177287	0.9929	11
SAN SIMON DE GUERRERO	5346	0.07743	1
SANTO TOMAS	8592	0.0712	2
SULTEPEC	27592	0.96099	5
TEJUPILCO	95032	0.03437	6
TEMASCALCINGO	61974	0.02196	5
TEMASCALTEPEC	31192	0.43085	4
TEMOAYA	69306	0.18225	3
TEXCALTITLAN	16370	0.25935	2
TLATLAYA	36100	0.49559	4
VILLA DE ALLENDE	40164	0.6792	2
VILLA DEL CARBON	37993	0.15923	2
VILLA VICTORIA	74043	1.07649	7
ZACUALPAN	16101	0.63044	2
ZUMPAHUACAN	15372	0.63397	1

Source: CONAPO, SCT

Table 5. Regression analysis of DCC located in low-income counties

Regression Statistics	
Multiple Correlation Coefficient	0.102472462
Determination Coefficient R^2	0.010500605
adjusted R^2	0.002254777
Typical Error	0.780983337
Samples	122

ANOVA

	Degrees of freedom	*Squares sum*	*Square's average*	*F*	*F critical value*
Regression	1	0.776718388	0.776718388	1.273444585	0.261372511
Residuals	120	73.19219678	0.609934973		
Total	121	73.96891516			

A question remains unanswered: How does Mexican government determines the number and location of DCC to reduce the digital divide in the country? The data we collected and the statistical analysis we performed in this study show that there is not correlation between the poverty index and DCC location. What is the main reason to locate a DCC into a specific community? Is it a political reason?

This research shows that there are no definitive criteria to locate a telecenter. We consider the poverty line as one valid criterion; however, there are other international measures to validate poverty. A future contribution of this research could be the definition of a set of criteria related to literacy, poverty line or digital literacy – computational skills – which could be used as indicators to decide the location of a DCC.

Finally, this exploratory research is only focused on publicly available data about Mexican DCC. There is a need for exploring more detailed information such as: number of computers in each location; real number of computers in operational conditions –the amount of broken equipment after some months of use can be rather high; computers with internet access –not every computer in a DCC has a working Internet connection; number of users in the telecenter at different times of the day; activities performed in every center, technical problems faced and how they are solved.

Future research includes extending this study to a national scale, analyzing different regions or states. We recommend the continuous application of this test in the next years to better understand the evolution of DCC and their impact on digital divide.

REFERENCES

CONAPO (2006) Poverty Index tables. http://www.conapo.gob.mx/00cifras/2000.htm , last access date: 2006-06-27.

Cullen, R. (2001) *Addressing the digital divide*. Online Information Review Vol. **25**, Issue 5. www.emerald-library.com/ft , pp 311-320.

Curry,J; Kenney, M. Digital **Divide or Digital Development? The Internet in Mexico.** http://www.firstmonday.org/issues/issue11_3/curry/index.html#c7 last access date: 2006-12-14

Del Álamo, Oscar (2003) *El desafío de la brecha digital*. Instituto Internacional de Gobernabilidad. Desarrollo Humano e Institucional en América Latina Vol. **41**, online: http://www.iigov.org/dhial/?p=41_01 last access date: 2003-05-13

Dewan, S. (2005). "The Digital Divide: Current and Future Research Directions." Journal of the Association for Information Systems **6**(12): 298-337.

Dragulanescu N.G (2002) *Social impact of the digital divide in a central-eastern European country*. International Information & Library Review Vol. **34**, Issue 2. 139-151.

INEGI (2005) http: //www.inegi.gob.mx , last access date: 2005-06-27

Internet World Stats. http://www.internetworldstats.com/ last access date: 2006-12-14

Johnson (2002) *Narrowing the digital divide: initiatives undertaken by the Association of South-East Asian Nations* (ASEAN). Program Electronic library and information systems Vol. **36**, Issue 1. online: www.emeraldinsight.com/033-0337.htm pp 13-22.

OCDE (2001) bridging the "digital divide": issues and policies in OECD by the countries directorate for science, technology and industry committee for information, computer and communications policy**,** July 2001. online: http://www.oecd.org/dataoecd/10/0/27128723.pdf , last visit: 2005-10-04

The SOX-HIPPA Impact on the Legal System: A Case Study of a Law Firm

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ABSTRACT

Ongoing research was conduced on the impact of technology on a law firm handling tort (civil) cases in the U.S. legal system. The firm used in the study is heavily involved in mass tort litigation and was the subject of a study previously reported at the IRMA 2005 International Conference [1]. The current research is the third of several planned studies on individual law firms and the legal system usage of technology. Specifically this segment of the research is to determine the potential implications of the Sarbanes-Oxley Act of 2002 (SOX) and the Health Insurance Portability and Accountability Act (HIPPA) of 1996 regarding a law firm ensuring a security repository database for confidential client information that is subject to the sections of these two acts. All professional firms, especially law firms, have a legal and ethical obligation to protect clients' interests including documents. Both acts have increased the work (data) flow of professional firms due to increased need for the documentation of singed permission by individuals to access "sensitive" data from every source.

ORGANIZATION BACKGROUND

Research being conduced is limited to four areas of interest related to tort law within the category of civil law within the U.S. legal system: (1) to develop an initial descriptive technology-usage-and-trend benchmark for a single law firm handling tort (civil) cases in the U.S.; (2) to determine the costs and time currently known to provide existing professional services in the tort (civil) case area in the U.S. (cost versus benefit); (3) to use the findings in (1) and (2) as a basis in expanding the study into a study of representative, comparable firms with similar practices in the area of tort law; and (4) to collect and analyze data on the nature of the impact of technology on the U.S. legal system. The law firm in this study is identified only as the Professional Law Firm (PLF). It was chosen because it was accessible, and it is heavily involved in mass tort litigation which is one of the major health and litigation issues in the U.S. This phase is intended to develop insight into one illustrative intrusion issue that might have legal implications for a law firm as well as their clients.

REVIEW OF LITERATURE

In the May 2004 issue of Government Technology, the National Consortium for Justice Information and Statistics or SEARCH recommendations for nine milestones is presented. These milestones are: (1) Initiate the process and institutionalize a governance structure, (2) continue planning, (3) develop and use performance measures, (4) analyze information exchange, (5) adopt or develop standards, (6) create sound integration architecture, (7) develop the infrastructure, (8) improve agency and organization applications, and (9) establish interfaces [3].

The Dennis Kennedy.com web site that is immensely popular within the legal profession describes the complexity of issues facing the legal firm and justice system as a whole. Two quotes are worth repeating and allow the researchers to drill down through the justice system to the level of the law firm and the environment in which a firm operates. "The courts are very serious about moving to e-filling and judges want to get attorneys moved to electronic systems." "Computer forensics and electronic discovery tools have become standard tools for some of the best litigators. Increasingly, the evidence you may need exists in the form of e-mail or never was printed out onto paper." [4] Additionally, law firms and others must ensure their IT efforts are compatible with their clients' efforts to meet the changing expectations regarding transparency and accountability in business processes and corporate accounting designed to improve public confidence in publicly regulated businesses. [5]

As part of the ongoing research to understand the impact of technology on legal firms and thus on the entire legal system we selected one intrusion tool for illustrative purposes that if not detected and protected against within the law firm's networked system that contains confidential privileged client information could compromise client corporations under the SOX and HIPPA acts. In short, the authors wanted to examine the issues related to protecting clients' interests (documents, access to documents, etc.) in a law firm that has a legal as well as ethical obligation to ensure that sensitive client data is well protected. No effort in this study was made to explore the potential legal implications to a law firm that fails to adequately protect sensitive data of its clients.

The intrusion tool examined in this segment of the study is the use of port knocking. The networked environment of today requires that information technology (IT) professionals utilize virus scanning tools, firewalls, network operating system features to manage the access to a given company's networked system. Most of the attention is focused on the use of well-known tools or procedures such as matching user names to passwords and the use of firewalls to reduce the intrusions by hackers.

This third phase of the ongoing study is an attempt to describe the technical issues and the related implications of several approaches (tools) available to those who wish to enter without authorization into a network and those that use such approaches for financial gain, illegal activities or for other reasons, areas with significant fraud prevention and detection implications – in short to compromise a law firm's client database. Intrusion tools which may be used by individuals engaged in fraudulent activities the authors describe how "port knocking" could be used as an intrusion tool to gain entry into a firm's network and thus allow someone to obtain (without authorization) corporate data (client, employee, financial, etc.) and/or be used by users (having authorized access) to the data electronically transfer classified or sensitive corporate data to others located internally and externally to the organization.

In simple terms port knocking refers to the technical interactions between two computers as one attempts to open a closed port and thus pass through the second's firewall. Managerial issues for the IT professional range from the routine management of the networked system including the firewall (good) to the use of the port knocking method to pass messages between computers (individuals) in a manner that bypasses or circumvents the normal network security features (bad). Port knocking as presented in the Linux Journal is a process for a remote user to connect to a server when the port (service) is closed and a firewall is in place. The remote user sends a sequence of requests to the server. All of the ports are closed and the firewall logs the attempts. Software is in place that monitors the firewall's logs. When a correct sequence of port attempts are detected by the software, then a given port will be opened and the remote user can then access the requested port. This is a form of "a stealthy method of authentication and information transfer to a networked machine that has no open ports". Port knocking also "…can be extended to transmit any type of information encoded in a port sequence." [6]

CASE DESCRIPTION

The law firm [PLF] used as the basis for this case study is considered a specialty firm that coordinates litigation efforts by legal firms located in thirty-five states that are involved in class action suits related to health care. The required legal documents (paperwork) and information change exponentially with the addition or deletion of new plaintiffs to existing litigation. A concurrent requirement is a database to permit the firm to manage the required coordination between separate suits in each separate legal jurisdiction. Thus, a law firm has a need to ensure that all client data held in repository for pending and past litigation is managed as if it was held in the client's own computer system.

Phase I: Strategic Considerations

The PLF at the beginning of the study phase reported that it was studying the potential that intrusion tools could have on its ability to provide a secure environment for its clients that find themselves under the guidelines of the sections of the Sarbanes-Oxley Act of 2002 and the privacy provided by the Health Insurance Portability and Accountability Act of 1996.

- Professional and non-professional staff (internal) access accountability
- Client and other non-firm parties (external) access accountability to reduce to a zero intrusion level to ensure confidential client data would not be compromised.

Phase II: Intrusion Effort Study

The researchers with the assistance of the law firm undertook an effort to demonstrate the electronic passing of text information between two networked machines using port knocking to bypass the network monitoring system in place for the law firm. This implementation did not require a firewall be used by the receiver. We illustrate this process with a sender (server) and client (receiver-law firm) software written in Perl. The server took the message, mapped the characters to predefined ports and sent the message to the client (external party). The client had the same port mapping information and decodes the message. One very important aspect is this process is meant to be "invisible" as possible, so the information was not sent all at once. Rather it was sent over (perhaps) a lengthy period of time. Thus, monitoring software at the sender's site will not detect a pattern of unusual behavior. At most, a stray packet here and there may be detected if the sender's organization uses a sniffer program as a component of its monitoring system since fraudulent activities can occur under the noses of those whose responsibility it is to prevent.

The PLF strategic planning was delayed due to aftermath of Hurricane Katrina but remains as a priority for the firm. The PLF has identified an initial set of issues since its recovery from the impact of Hurricane Katrina that must be included in the strategic planning and include the following areas of interest by the firm:

- Client data retention,
- Repository database management to ensure potential issues under SOX and HIPPA coverage for clients are met, and
- Increased intrusion detection

The partner in charge of operations management (POM) at the PLF currently has the IT staff developing a set of alternatives for consideration by the firm. These alternatives include, but are not limited to, the use of additional SOX and HIPPA compliant software guidelines and the development of an additional intrusion layer of security in the existing network firewall structure. Once the IT staff presents the alternatives including costing and capabilities to the POM the professional staff will be given an opportunity to provide input to the partners that will ultimately make the decision.

There is heightened awareness by the firm that as it moves past the recovery efforts related to Hurricane Katrina other issues will once again have significant ramifications on the decisions to be made by the firm. Since many of the court document repositories have been damaged or destroyed, the recovery effort undertaken by the courts for filing and maintaining records will shape the opportunities that exist to fundamentally change the legal system; this will, in turn, impact the direction individual firms will need to go regarding the filing and processing of tort litigation. An integral consideration is that of ensuring that law firm practices do not raise additional liability exposure issues for firm clients.

CONCLUSIONS

Currently the PLF is actively involved in strategic planning that is designed to allow the firm to address potential SOX and HIPPA issues concurrent to its representation of its clients. No specific time-frame was identified by the firm since the legal system in the area impacted by Hurricane Katrina is still addressing continuing recovery needs.

REFERENCES

[1] Lewis, Stan; King, Ernest W.; Hsieh, Chang-Tseh; and Chen, Kuo-Lane; "Impact of Technology on the Legal System – An Initial study of a Law firm;" 2005 Information Resources Management Association International Conference Proceedings; San Diego, California; May 15-18, 2005; pages 922-923.

[2] "Outline of the U.S. Legal System: The Civil Court Process," http://usinfo.state.gov/products/pubs/legalotln/civil.htm

[3] Harris, Blake, "Building Blocks," Government Technology, Vol. 17, Issue 5, May 2004, 27-28.

[4] Kennedy, Dennis, "2004 Legal Technology Trends: Do We Stand on the Threshold of the Next Legal Killer App?," http://www.denniskennedy.com/pred2004.htm.

[5] Logan, Debra and Mogull, Rich, CIO, "Sarbanes-Oxley: Gartner on the Role of Technology," http://www.insidesarbanesoxley.com/sarbanes_oxley_articles," October 2006.

[6] Krzywinski, http://www.linuxjournal.com/article.php%3Fsid%3D6811)

A Competitive Intelligence (CI) Value Model for Companies

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ABSTRACT

Competitive Intelligence (CI) is a relatively new business process that has been implemented in many large companies in recent years. In many companies it is now a separate unit that reports directly to the CEO. Competitive intelligence practitioners gather public data, analyze it, and report on actionable findings with the intention of improving their company's competitive position in the marketplace. Best practices in competitive intelligence include strict adherence to a code of ethics as published by the Society of Competitive Intelligence Professionals. Also essential are executive support, education, and integration within the organization's planning and strategic development process. Use of competitive intelligence by medium and small companies is less prevalent in part because of difficulty in determining value from the process and justification for the cost. In this paper, a value model for competitive intelligence is presented as a means for companies to evaluate the benefits and justify the costs associated with establishing a competitive intelligence unit.

INTRODUCTION

It has been well established in the literature (Fuld, 2006; Miree & Prescott, 2000) that well-organized, mature CI programs can lead to sustainable and profitable growth. CI in fact helps to protect what a company has, and what the company wants to become. It is essential that CI be a regular input into normal corporate processes. New product development, sales proposals, strategy development, and other business functions all benefit from this intelligence input.

Basically, CI information and analysis processes answer questions about competitors. These answers help reduce risk and increase profits. CI as a discipline is a work in progress. Despite twenty plus years as a recognized business methodology, it has only been within the last 10 years that it has approached the mainstream of business thought. The Society of Competitive Intelligence Professionals (SCIP) was established as a support for CI and has been instrumental in its development.

CI is different from Business Intelligence (BI), Knowledge Management (KM), Market Research (MR), and other similar programs. Although the distinctions can be fine, the differences are in perspective and scope. KM is generally focused on internal knowledge. MR focuses more on customers, not competitors. BI is a broader term that can include aspects of competition that can refer to similar ideas as in KM but can also refer to non-competitive issues. CI is much more focused and defined. Although CI is focused within the organization, the scope is defined by the need to gather, analyze, and act on competitor intelligence.

The international aspects of business and markets have had a profound effect on competition. The great enabler is the internet. The internet has greatly accelerated globalization, but in the matter of competitive intelligence, the internet has made available to large and small businesses alike, unprecedented information access. The internet (and the corporate intranet) provides the accessibility, but information technology has provided the means for companies to utilize CI more effectively.

BEST PRACTICES

There are several key requirements necessary for a best-practice CI program. Of fundamental importance is defining a clear role for CI. CI must have clear objectives and goals or the program will wither and die. The role assigned must be significant and integral to business functions at the tactical and strategic levels where it can positively impact business performance.

It is also essential that CI programs have top management support. A high-ranking champion of CI is essential. Few CI programs are initiated proactively. The reason most CI programs are started is based on executive identification of underperforming assets (Prescott and Miller, 2001). The need is to maintain and strengthen the executive support that the program began with.

Gaining executive backing isn't the only support necessary for the CI program. A common denominator in successful CI programs is the involvement of all employees in the intelligence function (Prescott and Miller 2001). To do this well, the value of competitive intelligence needs to be promoted within the company. This need goes beyond the necessary training. A larger cultural change is required to get employees to embrace the value that CI can give to the company as well as to themselves. (Fleisher and Bensoussan, 2002).

Of utmost importance to the CI program, new or mature, is that it be ethically based. The professional organization for competitive intelligence, SCIP has a code of ethics that each member agrees to support and abide by. It is vital to the future of CI that companies comply with all applicable laws, respect confidentiality, and avoid conflicts of interest. (Prescott and Blenkhorn 2003).

The CI organization is most often embedded within the larger marketing and planning function. This practice is consistent with the need to assign a role to CI where it can best integrate with and improve performance. To a much lesser degree, CI might be found in the finance area (Prescott and Miller 2001). Although on the surface this might make some sense, marketing and planning is a better home for CI. A better home also requires the acceptance by those already in the marketing area.

If a competitive intelligence capability is to have any lasting effect on a company's performance, it should have its own organization and administration. How that organization may look is most dependent on how strategy and tactics are employed in the company. Should CI be centralized? Should CI be dispersed throughout the organization? If business units are mostly autonomous, with different needs, different products, and a different customer base, a decentralized CI function will probably be most appropriate and effective (Prescott and Miller 2001). On the other hand, if most of the strategy, planning, and tactics come from corporate headquarters, centralizing the competitive intelligence function is the correct approach. The most likely CI organization would be a hybrid of centralized and decentralized staff functions (Prescott, and Miller 2001). Regardless of where a company's CI function falls in this spectrum, ensuring the coordination between strategic and tactical intelligence is vital for enduring success.

VALUE MODEL FOR COMPETITIVE INTELLIGENCE

Determining the value returned by CI is problematic since only the costs of a CI program can be known with certainty, whereas the value returned is often speculative and circumstantial.

In an attempt to quantify the value of a CI program, the following model is proposed:

V (CI Program) = V (Opportunities) + V (Vulnerabilities) – CI Program Cost

Where:

V (Opportunities) is defined as the value of the opportunities discovered by CI and implemented by the company

V (Vulnerabilities) is defined as the value of the vulnerabilities exposed by CI and mitigated by the company

CI Program Cost is the total of the direct and indirect cost items attributed to the CI program.

V (Opportunities)

The value of discovered opportunities is defined as:

*Value (Opportunities) = CIPstrength / IndustryCompetitiveFactor * Company-Margin *AverageIndustry Sales*

Where:

CIPstrength measures managerial support, the level of IT infrastructure, and the competency of the company's CI program.

CIPstrength = ManagerialSupportFactor * ITinfrastructureFactor * Program-CompetencyFactor

ManagerialSupportFactor is the product of factors measuring CEO support, Officer support, and mid-level manager support.

Managerial support, especially at the CEO or Officer level, is an important and essential contributor to CI value.

ITinfrastructureFactor is defined as the product of assigned factors indicating Intranet (Yes or No), and the size of the IT department.

Intranet factor ≡ Yes =1.0, No = 0.5

An intranet is not essential to a CI program but the existence of one serves as an enabler of CI value.

IT infrastructure factor ≡ small = 0.5, medium = 1.3, large =1.5

More IT resources enable greater CI value, but diminishing returns play a role.

ProgramCompetency is the product of factors measuring program maturity, program staff size, staff experience, CI distribution, and CI culture.

Program maturity ≡ New = 0.9, Developing = 1.3, Experienced = 1.5

New programs may have missteps that actually diminish value, but developing and experienced programs are positive factors in measuring competency.

Staff size ≡ Small = 0.4, Medium = 1.0, Large = 1.5

Too small a staff can be overwhelmed by the enormity of the task – a larger staff is better (to a point).

Staff experience ≡ Low = 0.9, Experienced = 1.5, Expert = 1.9

The value of an experienced staff cannot be overstated.

CI distribution measures the degree of program centralization in relation to the number of strategic business units and is defined as:

*(CIfieldOfficeCount * CIfieldStaffCount / SBUCount*

A company with a diverse portfolio should be more decentralized than a company with only a few offerings.

CI culture ≡ Low = 0.2, Medium = 1.0, Strong = 2.0

The more CI is ingrained into the company culture, the better.

IndustryCompetitiveFactor is a factor that measures the degree of competitiveness in the particular industry. It is defined as the count of competitors in the top 50% of the market, divided by the difference between the market shares of the market leader and the market trailer in the top 50%.

IndustryCompetitiveFactor = CompetitorCount(top50%) / (LargestMktShare – SmallestMktShare)

Competition within an industry is good for the economy, but has an eroding effect on value. Competition is greater with a greater number of competitors, or where the difference in market shares between the market leader and market laggard is small.

CompanyMargin is the company's operating profit margin.

AvgIndustrySales is the average, per company sales within the industry.

V (Vulnerabilities)

The value of discovered vulnerabilities is defined as:

*Value(vulnerabilites) = IndustryCompetitiveFactor * CompanyMargin * AvgIn-dustrySales*

Full Model: **V (CI Program) = V (Opportunities) + V (Vulnerabilities) – CI Program Cost**

This model is one theoretical means for evaluating the value of CI for companies and is based on current thought and practice. There is a need for validation, testing and revision of the model.

CONCLUSIONS AND FUTURE RESEARCH

CI can no longer be ignored. It does, however, still struggle for mainstream recognition. Large businesses have embraced it to varying degrees, but medium and small businesses haven't yet accepted the idea and process of competitive intelligence. Another convergence will be necessary to firmly establish CI in the lexicon of business thought and process. Education in CI, and small business use of CI are separate issues, but together they will be the basis of the next leap forward for competitive intelligence.

From the small business perspective, typically there are limited resources, limited time, and little cushion to absorb strategic mistakes. CI can help avoid those mistakes, but CI consumes resources and takes time and therein lies the catch-22 facing small business and CI today. This is not to say that small business does not use CI, but given that small businesses comprise the largest segments of most free economies, CI is underutilized. The benefits and value from CI are not just under

the purview of large business – when small business recognizes this potential, CI will become an enduring means in the business world.

This paper provides a model for evaluating value to companies for establishing competitive intelligence initiatives. Future research might focus on empirical testing and analysis of this model for practical utility for companies. As more companies move in this direction it will become more imperative for companies to evaluate the cost/ benefit for their particular operations. Competitive intelligence will continue to play an important role in companies as global competition becomes even more apparent.

REFERENCES

Fleisher, Craig and Bensoussan, Babette, *Strategic and Competitive Analysis: Methods and Techniques for Analyzing Business Competition*, Prentice Hall, 2002

Fuld, Leonard. *The Secret language of Competitive Intelligence*, 2006.

Herring, Jan P., "Key Intelligence Topics: A Process to Identify and Define Intelligence Needs", Competitive Intelligence Review, Vol. 10(2) 4-14 (1999)

Miree, Cynthia and Prescott, John, "'TAP-IN' to Strategic and Tactical Intelligence in the Sales and Marketing Functions", Competitive Intelligence Review, Vol. 11(1) 4-16 (2000).

Prescott, John and Miller, Stephen, *Proven Strategies in Competitive Intelligence: Lessons from the Trenches*, Wiley, 2001.

Prescott, John and Blenkhorn, David, *Controversies in Competitive Intelligence: The Enduring Issues*, Praeger, 2003.

The Society of Competitive Intelligence Professionals online at www.spic.org.

Critical Features in Business Processes Modeling

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ABSTRACT

There are quite few models in the literature for the analysis and modeling of business processes. However, there is not a model that is general enough to include all practical aspects of business processes for analysis. This is one of the major drawbacks for these models. The goal of this paper is to identify a set of critical features under which real business processes may be adequately represented and addressed. The paper first provides a brief review of definitions of business processes and workflows; next the assumptions contained in major models, and then propose a set of desired features in modeling.

INTRODUCTION

Business process (BP) management has been a very active area both in academia and software industry in the last two decades. Some of the reasons are: (1) value - every organization has the desire to improve the efficiency and effectiveness of BPs, (2) dependency – BPs are highly dependent on technologies, information technologies (IT) in particular, (3) opportunities - the fast paced progress in information technology (IT) over the same period of time creates opportunities for business process improvements, and (4) IT/Business alignment - a competitive business today requires IT to be aligned with core business processes. The BP software industry responses to the needs of businesses; over two hundred BP management software are available in the market place. Recently, business processes extend functions from internal processes to cross organizational processes, such as supply chain process. Further more by taking advantage of the Internet, the software industry is developing "Web services" standards; business process modeling languages (BPML) and business process modeling notation (BPMN) are two important standards for constructing business process over the Internet. However, BP software have not been lived up to its expectations because of limited capabilities and weakness of methods employed. Workflow management - a closely related field of BP - despite much research, it still lacks of conceptual frameworks and theoretical models (Kumar and Zhao, 1999). One critical issue underlying the weaknesses is the absence of a commonly agreed upon framework that more completely characterizes the modeling environment of BP or workflow. This paper represents an attempt to identify the set of important assumptions under which real complex business processes can be analyzed and modeled.

WHAT ARE BP, BPM, AND BPMS?

Interestingly, the phrase "business process" is easy to understand but difficult to define. At this time there does not exist a universally acceptable definition. Part of the reason may be attributable to the ever expanding scope of BP – scope creep as in systems analysis. Mackenzie (2000) describes "processes" consisting of *events*, a *time-dependent sequence of events, entities, elements, relationship between a pair of elements, links to other processes, resources, and outcomes.* Zur Muehlen (2004) describes a (general) *process* as "a discrete, holistic, temporal and logical sequence of those *activities* that are necessary to manipulate an economically relevant object." He views "*business process"* as a specific process and a workflow a specific representation of a process. Hammer and Champy (1994) define BP as a set of partially ordered activities aimed at reaching a well-defined *goal*. So there is a wide spectrum of definitions of BP.

On the phrase "Business Process Management (BPM)"? Aalst, ET al (2003) define it as : "Supporting business processes using methods, techniques, and software to design, enact, control, and analyze *operational processes* involving *humans, organizations*, *applications*, *documents* and other sources of *information*." BPM emphasizes the integration and management of business processes and *resources* across applications and business boundaries. And then there is the phrase "Business Process Management System (BPMS)". Weske, ET al (2004) proposes the following as the definition of BPMS: "A generic *software system* that is driven by explicit process designs to enact and manage *operational* business processes."

WHAT ARE "WORKFLOW SYSTEMS"?

Frequently in reading BP literature it is not uncommon that workflows were treated synonymously with BPs. According to the Workflow Management Coalition (WfMC) the *workflow* is:

"The automation of a business process, in whole or part, during which documents, information or tasks are passed from one participant to another for action, according to a set of procedural rules."

A *Workflow Management System* (WfMS) is defined as: "A system that defines, creates and manages the execution of workflows through the use of software, running on one or more workflow engines, which is able to interpret the process definition, interact with workflow participants and, where required, invoke the use of IT tools and applications."

Thus, a "workflow" defines who is next to performing the action according to a set of rules within a business process; a WfMS is a software system supports enactment of multiple workflows. Clearly there is a considerable similarity between the notion of BP and workflow, so does BPMS and WfMS. From now on workflow is viewed as a specific representation of BP (Muehlen, 2004). Next, we provide a review of the dimensions under which current BP/workflow models assume.

FEATURES IN BP AND WORKFLOW MODELS

1. Features of Business Process and Workflow Models Discussed Above.
   BP and WF discussed above involve such features as: *events*, *entities, elements, relationship between a pair of elements, links to other processes, resources, humans, organizations*, *applications*, *documents*, *information, goals, and outcomes.* A more comprehensive modeling of BP should have all those features although at the expense of higher complexity. Curtis, Kellner and Over (1992), and Kwan and Balasubramanian (!997) describe a framework for process and workflow modeling. They classify majority of these features into four critical dimensions, namely; *functional, behavioral, organizational, and informational.* However, their modeling is carried out by using separate modeling tools as opposed to an integrated setting.
2. Classification of Business Processes and Workflows
   Different categorization of BPs has been proposed. Melao and Pidd (2000) articulate pluralistic and multidisciplinary modeling approaches to BP. They classify BP into four categories; *deterministic machines, complex dynamic systems, interacting feedback loops, and social constructs* (BP is viewed as a subjective construction of the minds of people); not necessarily mutually independent. Other classifications of BP exist, for example; strategic, tactical, and operational processes; and system-to-system, system-to-human (and vice versa) processes. However, work/research has been done mainly on operational processes. Other categories of workflows are: *production workflow, administrative workflow, ad hoc workflow, and collaborative process.*
3. Competing BP Modeling Methods and Languages
   Depending on the purpose of the business process/workflow model, researchers propose different modeling techniques. They range from graphical languages to formal mathematical constructs. Here are major models/languages:
   i. **Petri Net**

The classical Petri net (Petri 1962) is a graphical process modeling language.

Workflow processes can be mapped to Petri nets and it is possible to incorporate resources (Aalst, 1994). However, modeling workflow systems with classical Petri net has many limitations. Three well-known Petri net extensions have appeared: (1) the extension with color to model data, (2) the extension with time, and (3) the extension with hierarchy to structure large models. This belongs to the category of complex dynamic process modeling.

ii. **Pie Calculus**

The founder of the Pi calculus is Robin Milner (1999). Briefly, the Pi calculus is a formal language for defining concurrent, communicating processes, including, but not limited to, business processes. Smith H. and Fingar P. (2003a, b) claim that Pi calculus inspires a breakthrough in the representation and execution of business processes, and is used by the new Business Process Management Systems (BPMS). A written detailed proof of this claim is not available (to the author's knowledge) at this time.

iii. **The Language/Action Perspective**

The language/action perspective (LAP) as originally introduced by Winograd and Flores (1986) has been applied to BP and workflow modeling (Weigand and Moor, 2003; Goldkuhl, 1996). The theme of the perspective is BP and workflow models contain *coordination* activities that use *communication process* that can address at the social level as the central means for achieving it; not simply by using data (viewed as a form of limited communication) analysis as in Petri nets.

iv. **State-Oriented Business Process Modeling**

Bider applies mathematical system theory to model business processes. He envisions business processes as dynamic goal-seeking processes in which process control acts as a mechanism for choosing activities that can move from the current state to the nearest final goal state.

v. **Trigger Model**

The trigger model (Joosten, 1994) is developed to describe a workflow as a dynamic system in terms of triggers. An event "e" *triggers* an activity "a" if the occurrence of "e" causes "a" to be performed. The trigger can be an event, activity and actor. A workflow system consists of *activities, roles* and *triggers* and activities are related to one another by a trigger relation, or triggered by external events. The trigger model can be mapped to a Petri-net.

vi. **Metagraphes**

Basu and Blanning (2000) utilize a graph-theoretic construct called a metagraph to analyze connectivity and interactions issues of activities, information and resources between workflow components. The approach may also model activity procedural constraints.

vii. **Event-Driven Process Chains**

A modeling approach (Scheer, 1998) adopted by SAP as the key component of SAP's enterprise resource planning system. Modeling includes analysis of: responsible entities and their relationships function (activity) flow, output flow, information flow, control flows, resource flows, human output flows, consolidated business process model, and a business process meta-model.

viii. **Business Process Modeling Language (BPML) and Business Process Modeling Notation (BPMN)**

As parts of the Web Services technology, BPML and BPMN provide standards for constructing business processes over the Internet. It has modeling elements: Events, activities, data objects, message flows (the flow of messages between two entities), and associations (to associate information and artifacts with flow objects). The area is new and is predicted to have a huge impact in business, industry and software sectors.

ix. **Unified Modeling Language (UML)**

UML is developed as a computer aided software engineering (CASE) tool, but it can also be used for general business process modeling capable of representing all important features. However, it lacks the theoretical basis.

CRITICAL FEATURES IN SUMMARY

To summarize, critical features for a modeling system should consider the following:

i. Key elements in modeling

Common elements used in modeling are: Procedure, task, information object, role, actor, goal, resource, event, responsibility/authority, state, constraint, rule…

ii. Modeling perspectives

It would be desirable to include multiple perspectives and functionalities in the modeling environment; for example, function, behavior, organization, information, social constructs, coordination, and system dynamics.

iii. Graphics and rigor

Because of the complexity of BP and workflow systems, any modeling approach would be made easier if it is accompanied by a graphical support tool. In addition, it is imperative that a model is created with a sound theatrical basis.

CONCLUSION AND FUTURE RESEARCH

Business process and workflow systems are important and practical. Knowledge of this area has grown significantly and is rather broad for study and research. A critical pre-condition for defining area of study/research is to define the required features of the modeling environment. This paper has come up with a recommendation of a set of features that a modeling environment should provide. Current developments by software industry are in standardizing business process language and notation under the Web services platform. Also, they are expected to impact the design and construction of new BP systems, cross organizational systems in particular.

REFERENCES

van der Aalst, W.M.P. (1994). Putting Petri nets to work in industry. *Computers in Industry*, 25(1):45–54.

van der Aalst, W.M.P. (1998). The application of Petri nets to workflow management. The Journal of circuits, systems and computers. 8 (1), 1998, 21-66.

Basu, A, and Blanning, R. W. (2000). A Formal Approach to Workflow Analysis. Information Systems Research, 1(11), pp. 17-36.

Bider, Ilia. State-Oriented Business Process Modeling: Principles. Theory and Practice. Ph.D. Thesis. Department of Computer and System Sciences, Royal Institute of Technology and Stockholm University, Kista Sweden.

Curtis, B., M, Kellner, and J. Over. (1992). Process Modeling. Communications of the ACM, 35(9), Septermber, pp. 75-90.

Kwan, M. M. and Balasubramanian, P. R. (!997). Dynamic Workflow Management: A Framework for Modeling Workflows. Proceedings of the Thirtieth Annual Hawwaii International Conference on System Sciences. IEEE Computer Society.

Joosten, S. (1994). Trigger Modeling for Workflow Analysis. In G. Chroust and A. Benczur, editors, *Proceedings CON'94: Workflow Management, Challenges, Paradigms and Products*, pages 236–247, Vienna.

Leymann, F. and Roller, D. (1994). Business process management with flowmark. In Proc. of COMPCON Spring, IEEE.

Lawrence, P. editor. (1997). *Workflow Handbook 1997, Workflow Management Coalition*. John Wiley and Sons, New York.

Melao, N. and Pidd, Michael. (2000). A conceptual framework for understanding business processes and business process modeling. Information Systems Journal, 10:105-129. Blackwell Science Ltd.

Milner, Robin (1999). Communicating and mobile systems: the Pi calculus, Cambridge University Press.

C.A. Petri. (1962). *Kommunikation mit Automaten*. PhD thesis, Institut f˙ur instrumentelle Mathematik, Bonn, 1962.

Smith H. and Fingar P. (2003a). Workflow is just a Pi process. www.bpm3.com/picalculus.

Ross-Talbot, Steve (2006). A conversation with Steve Ross-Talbot. ACM Queue, 4(2).

Smith H. and Fingar P. (2003b). Business Process Management: The Third Wave. Meghan-Kiffer Press.

Scheer, A-W. (1998). ARIS – Business Process Frameworks. Springer.

Weigand, H., and Aldo de Moor (2003). Workflow analysis with communication norms. Data & Knowledge Engineering 47, 349–369.

Winograd, T., and F. Flores, (1986). Understanding Computers and Cognition: A New Foundation for Design, Ablex Publishing.

ICT Management Issues in Healthcare Coopetitive Scenarios

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ABSTRACT

In this paper we will outline some issues that the management should address in ICT projects framed within networks of healthcare delivery. Networks of independent healthcare service providers (e.g. specialized hospitals, laboratory analysis, family doctors) are getting very common. In such scenario, data sharing activities among different actors are very common and ICT is a pregnant technology. Concerning the ICT project management, the traditional hierarchical management model is not feasible for network contexts. The management can't rely on traditional hierarchical approaches, but should switch to a negotiation model, through which the desired goals has to be reached by means of negotiation with the independent actors involved in the project. We will illustrate these topics through a case study, afterward we will outline some requirements that a project manager profile should have in order to manage appropriately ICT projects framed in network of independent actors.

1. INTRODUCTION

Healthcare processes are very complex, even a simple one (e.g. the request for medical analysis) may involve different actors (family doctors, analysis laboratories, specialized physicians, administrative staff) providing several services. More complex services are present in a network scenario. "Currently, the situation of healthcare in Europe and in the U.S. is characterized by a process of transition, where isolated hospitals and individual practices are merging into networks of healthcare delivery" (Kuhn, Giuse, 2001).

From one hand, ICT can play a big role in this scenario: it can improve the coordination and the information sharing among the several providers involved in a healthcare process, whereas these tasks traditionally have been committed to the citizen/patient. E.g. the citizen contacts a service provider and asks for a service (e.g. she/he books for laboratory analysis), collects the analysis results and reports them to the family doctor. This is just an example, some more can be provided.

On the other hand, "it has even been stated that there is an 'absence of real progress [...] towards applying advances in information technology to improve administrative and clinical processes" (Hurtado et al., 2001).

In the sequel of the paper, we point out that in large ICT based healthcare projects (especially in the context of networks of healthcare delivery), some project management issues may frustrate a positive application of ICT technologies.

In Sec. 2 the peculiarities of networks of healthcare delivery will be analyzed, in Sec. 3 we will provide an example framed in a network context that will be used as a reference in the following sections, in Sec. 4 some project management issues will be outlined, and finally Sec. 5 will draw some conclusions.

2. COOPETITIVE NETWORKS OF HEALTHCARE DELIVERY

Healthcare scenarios where different actors and institutions (hereafter entities) collaborate in providing healthcare services are examples of the network model described in management literature. The network model is characterized by a set of independent, loosely coupled nodes that collaborate to provide complex services.

The network model has advantages and drawbacks, that we will illustrate shortly. The companies, actors, organizations (hereafter nodes or actors) being part of the network may easily build ad hoc relationships, therefore very different actors can get in touch and collaborate. Furthermore, the nodes can easily replace partners with similar ones. This fosters innovation, creativeness, and competitiveness. Considering the network model drawbacks, the loose relationships requires a lot of coordination effort among the involved actors, which are characterized by different cultural background, different interpretation framework, and different information management capabilities.

Frequently the coordination effort among the several actors involved in the provision of a healthcare service is up to the final customer, an example has been cited in the previous section, where a citizen books for analysis, later she/he has to collect the results and bring them to the family doctor. The shift of coordination effort from the patients to the service providers requires to establish collaboration among the healthcare service providers, which however are competitors.

Such a interaction among the competitors may be modelled by making use of a "coopetitive behaviour". The term coopetition is used in management literature to refer to a hybrid behaviour where the actors cooperate in some areas while compete in some others. In a healthcare networked scenario, collaboration concerns the patient data sharing among different providers to coordinate combined healthcare processes, while competition concerns the research of customers to which provide services. Some authors (Brandenburger et al., 1996) (Gnyawali et all., 2001) (Lado et al., 1997) have recently emphasized the increasing importance of coopetition for today's inter-firm dynamics.

Information management is a strong issue in the just introduced scenarios, and can be addressed by the federation of information systems. Federated information systems for coopetitive settings have been studied in (Cesarini, Mezzanzanica, 2006).

Next section will describe a case study and an ongoing ICT project that will be used as reference in the subsequent sections.

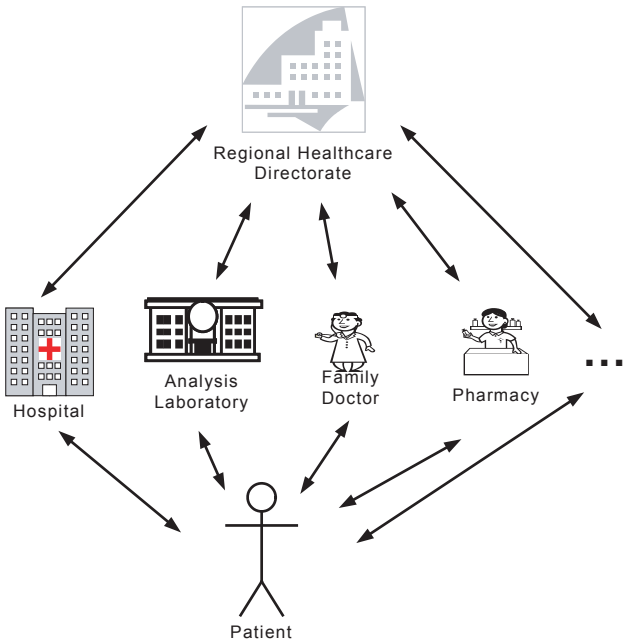
3. THE LOMBARDY CASE STUDY

In this section we are presenting the healthcare model actually deployed in Lombardy (a region in Italy), which is an example of a networked healthcare setting, as well as an ICT project that is currently ongoing. The actual healthcare model in Lombardy is the result of the evolution of a public (state based) healthcare provisioning model. The healthcare services are delivered both by public structures and by private ones. Citizens are free to select the service provider, which is paid by the state on a reimbursement basis. The citizens do not pay directly for receiving healthcare services (except a minimal pay-per-use fee). In this context, the private and public actors providing healthcare services, share administrative information with the Regional Healthcare Directorate (the public administration responsible for the healthcare service provisioning) in order to compute the total expenditures and the reimburses (Lombardy H.C. Directorate, 2003).

The coordination among the different entities involved in the provision of a combined service is actually up to the patient, especially concerning the medical information sharing, as reported in Fig. 1.

An ongoing project, whose name is SISS (Sistema Integrato Socio Sanitario, which is the Italian for "Social Healthcare Integrated Information System"), is experimenting a new way of sharing patient medical information among different service providers. The core of the SISS project is a federated information system, which connects all the entities offering healthcare services in Lombardy,

Figure 1. Before the introduction of the SISS. The patient was the responsible of sharing information



and which can be used to share medical information (e.g. clinical records, medical prescriptions, x-rays pictures, laboratory analysis), as showed in Fig. 2. For example, the SISS will allow a family doctor to access the patient data (e.g. the x-ray analysis committed to a laboratory or the clinical records related to the last hospitalizations) hosted by other entities directly by its PC.

In addition to sharing medical data, the SISS can be used to reserve physical examinations and laboratory analysis by each entity connected to the system. Furthermore, the SISS is used to provide statistical information in real time to the Regional Healthcare Directorate.

The project is structured on three phases: prototyping (performed on a small area), validation, and large deployment (on the whole regional area). The project is on-going and it is currently on the large deployment phase. The project is managed by a project management committee (central project management or CPM hereafter) and the management activities involve the local ICT managers (LPMs hereafter). The latter are people responsible of the ICT facilities within the connected entities (e.g. hospitals, laboratory analysis, pharmacies, family doctors). In case of simple actors (e.g. pharmacies and family doctors) the ICT manager role is carried out either by the actor her/himself or by a representative. In most cases the local project manager is a person already present in the local organization structure.

4. MANAGEMENT IMPLICATIONS

Some critical issues emerged during the prototyping and validation phases of the SISS project, as reported by the project management and audit documentations.

Some considerations should be drawn before analyzing the emerged issues. The SISS is an information system created with the aim of supporting the circulation of medical information and more generally the provision of complex healthcare processes, where different actors, not necessarily having already established relationships, are involved. The processes provided by means of the SISS relies on the carry out of "local tasks" (i.e. local business processes), a single local task failure is likely to cause the failure of the whole aggregate process (e.g. should a laboratory not provide analysis results to the SISS for any reason, the processes relying on this information cannot start). The local tasks should be supported by both the local information system and by the local business processes, which should have been adapted to the requirement of the SISS project.

The issues emerged during the project phases, the reasons, and the actors involved have been shortly summarized in Tab. 1.

The emerged issues were mainly ICT related, however a deeper investigation showed that the main problem was a lack of communication among the CPM and the LPMs, which was caused both by an inadequate project governance model and by some cultural gaps.

Concerning the project governance, the local managers have not been effectively involved, they were just consultant and not decision makers during the planning and prototyping phases, consequently the central project management underestimated the impact that the decisions would have had on the local involved entities (especially the large and complex ones) and on the time necessary to carry out changes. Although the CPM performed a deep survey and evaluation of the local entities, ICT infrastructures, and processes, the scarce implication of the local ICT Managers in the decision making activities resulted in a poor project management.

Considering the cultural gap, the novelty of the exploited technologies, created difficulties for the local ICT managers[1]. A lot of local ICT managers were

Figure 2. After the Introduction of the SISS. The Patient's data can be accessed by every actor

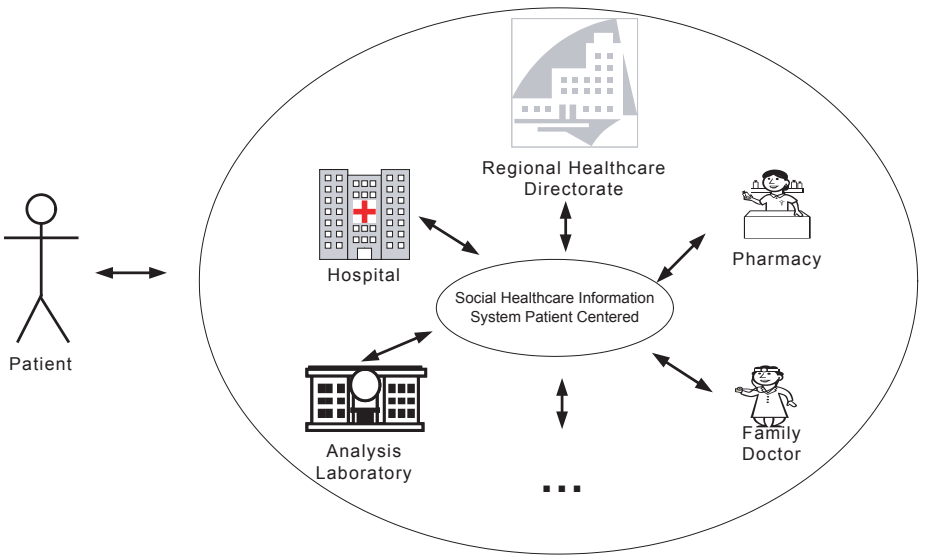


Table 1. Chronological report of the project phases, actors involved, emerged issues, their rationale, the corrective actions carried out. Differences from a phase to the following one have been highlighted. The non relevant cells have been left empty

Project Phase	Actors and Interpretation Framework GAP (IFG)	Emerged Issues	Reasons	Corrective Actions
Project Planning	• CPM (Decision Making Role) o No IFG on technology o High IFG on local organizational impact • LPMs (Consulting Role) o High IFG on technology o Low IFG on local organizational impact			
Prototyping	• CPM (Decision Making Role) o No IFG on technology o High IFG on local organizational impact • LPMs (Consulting Role) o High IFG on technology o Low IFG on local organizational impact • Users (Entities) • Users (Patients)	• Long service inactivity time • Long malfunction time • Huge users disappointment • Huge delays • System low performances • Not adequate improvement of local processes and ICT infrastructures • The delay and malfunction times were **quite higher with respect to the time necessary to implement technical and organizational changes in the local entities**	• Distance among the interpretation schema of CPM and LPMs about o Change processes o Technologic innovation processes o Time and expected results • Poor involvement of the LPMs in the project global decision making activities • Poor feed back activities to the CPM • Lack of project vision understanding by the LPMs	• Improvement of the management model o Actively involve the LPMs in the CPM decision making activities o Substitution or training of some LPMs • Project timelines modification to take into account the time necessary to perform the local changes
Validation	• CPM o No IFG on technology o High IFG on local organizational impact • LPMs o High IFG on technology o Low IFG on local organizational impact • Users (Entities) o High IFG on technology o Low IFG on local organizational impact ~~o Users (Patients)~~			
Large Deployment	• CPM o No IFG on technology o **Low** IFG on local organizational impact • LPMs o **Low** IFG on technology o Low IFG on local organizational impact • Users (Entities) • Users (Patients)	Work in progress	Work in progress	Work in progress

involved, each having different skills and knowledge, however some of them were unable to understand the project vision and the changes to enforce on the local infrastructures and business processes. Some local information systems not properly connected could be considered a negligible topic, however we recall that a failure in the provision of a local process is likely to cause the failure of any related global process. The cultural problems can be summarized by saying that there was a high gap among the interpretation framework of the CPM and the interpretation framework of the LPMs.

The CPM decided to focus initially on the governance and cultural gap issues and to address later on the ICT ones. Two corrective action were adopted: the LPMs have been effectively involved in the central level decision making activities; some of the LPMs have been replaced or trained. The participation to the decision making activities helped the CPM and the LPMs to fill the gap among their interpretation framework. In the large deployment phase the local ICT managers (of the new entities involved) were able to understand the project vision and to correctly modify the existing local ICT infrastructures and business processes. Furthermore, they correctly estimated the impact of the SISS projects on the local entities, so they were able to provide feed backs to the CPM about delays and project improvement, that could affect the global project timeliness and deployment. The governance approach initially adopted contradicts the logic underlying the network scenario where the project is enacted. The initial approach relies on hierarchical relationships that are not present among the CPM and LPMs, while the approach adopted later relies on negotiation among CPM and LPMs, which is a far better approach in a network of loosely coupled entities.

We will outline briefly the requirements that the ICT management should satisfy, in order to be able to manage appropriately ICT projects in healthcare (and in other fields as well) framed within networks of loosely coupled entities. The project manager should identify the most significant management profiles involved in the

project. Meetings should be established as well as other ways of sharing knowledge among the identified people. The goal is to fill the people interpretation schema gaps and to integrate their different competences into a steering committee, in order to support the project design and enactment. The project manager could also encourage the involved people to participate to training activities in advance.

The cooperation management is a very important risk factor as well. The traditional hierarchical management model is not feasible in a network context (of loosely coupled institutions), because there are no direct hierarchical relationships among the involved entities. The management should switch to a negotiation model, through which the desired goals has to be reached by means of negotiation with the involved actors. In this streamline, it could be useful to negotiate in advance with the involved people that the project organizational logic should be different from the local (most probably hierarchical) ones.

5. CONCLUSIONS

In this paper we described some requirements that a project manager profile should have in order to successfully manage large healthcare projects having an ICT characterization. We focused on a specific scenario, called networked scenario, where a network of loosely coupled actors (both people and institutions) operate to provide healthcare services. Such a scenario has been identified as the direction of an emerging trend in the healthcare market, therefore it deserves special attention. Furthermore, many promising projects in such a scenario are ICT based. An important risk factor in those projects is not technological related, but concerns communication among the decision makers within the nodes involved. The cultural gaps are strong barriers to the cooperation, which is necessary to carry out projects in networked scenario. We claim that the managers' poor ability to handle appropriately these factors may cause the failure (or the poor revenue) of an ICT project. We have briefly pointed out the skills that a project manager should have in order to successfully manage ICT based projects in networked scenarios (framed in the healthcare domain). We can summarize them by saying that the manager should identify the most significant management profiles involved in the project, should actively involve them in the project management committee and should overcome all the cultural gaps. The traditional hierarchical management model is not feasible in a network context cause the absence of direct hierarchical relationships among the network nodes. The manager should be able to negotiate with the involved actors in order to reach the project goals.

REFERENCES

(Brandenburger et al., 1996) Brandenburger, A.M. and Nalebuff, B.J, Co-opetition. Doubleday & Company, New York, 1996

(Cesarini, Mezzanzanica, 2006) Cesarini M. and Mezzanzanica M. Policy making for coopetitive information systems. In Proceedings of the International Conference on Information Quality, ICIQ, Boston, USA, November 2006.

(Gnyawali et all., 2001) Gnyawali, D.R. and Madhavan, R., Cooperative Networks and competitive Dynamics: a structural embeddedness Perspective. Academy of Management Review, 26(3) 2001, pp. 431-445.

(Hurtado et al., 2001) Hurtado MP, Swift EK, Corrigan JM, editors; Crossing the quality chasm: a new health system for the 21st century. Washington, DC: National Academy Press; 2001.

(Kuhn, Giuse, 2001) Kuhn K. A and Giuse D. A.. From hospital information systems to health information systems. Problems, challenges, perspectives. Methods Inf Med, 40(4):275–287, 2001.

(Lado et al., 1997) Lado, A.A., Boyd, N. and Hanlon, S.C., Competition, Cooperation, and the search for economic Rents: A syncretic model. Academy of Management Review, 22(1) 1997, pp. 110-141.

(Lombardy H.C. Directorate, 2003) http://www.sanita.regione.lombardia.it/pssr/health_care_direc.pdf

ENDNOTE

[1] Web services and digital signatures were not well experienced by the practitioners and local ICT managers at the beginning of the project (year 2000)

Concurrent Engineering: A Roadmap to Software Engineering, Database, and Data Warehouse Technology

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ABSTRACT

Software engineering, database and data warehouse technology are closely related to each other despite being separate disciplines. In this paper we discuss how software engineering, database and data warehouse technology are inter-related and gain benefits from each other. We also examine the critical technical and managerial issues required to enhance potential benefits used in structure and/or object-oriented paradigms. We present recommendations and guidelines for applying Concurrent Engineering (CE) principles to software engineering, database and data warehouse technology.

1. INTRODUCTION

Engineering is defined as [1]: The *profession* in which a knowledge of the *mathematical* and *natural sciences* gained by study, experience, and practice is *applied with judgment* to develop ways to *utilize*, economically, the *materials and forces of nature for the benefit of mankind.* Software (including the user interface), database, and data warehouse engineering are by definition a kind of engineering, and therefore carry the same set of social responsibilities as all of the other kinds of engineering [2]. Common engineering processes, such as requirement analyses, design, implementation, testing and maintenance are applied to software, database, and data warehouse engineering in the same way as other branches of engineering including civil, electrical or chemical engineering. However, software, database, data warehouse engineering are subject to particular frequent changes, including those imposed while a product is under development [2].

Software, database, and data warehouse engineering are different disciplines with common related issues and processes. We examine the differences among these disciplines and relationships and provide some of the potential benefits. This paper discusses how concurrent engineering is applied to software, database, and data warehouse technology. Comparisons of software and database technology have been made in the literature [3, 4]. In this paper we extend the research to 1) data warehouse engineering; 2) uses of structure and/or object-oriented paradigms; and 3) the role of concurrent engineering.

2. RELATED DISCIPLINE AMONG SOFTWARE, DATABASE, AND DATA WAREHOUSE ENGINEERING

Various methodologies and principles are proposed for software, database, and data warehouse technology [2, 5, and 6]. However, they are related in many aspects as mentioned below:

a. Project Planning – All three disciplines are required to do the project planning. A *SWOT analysis* that examines a company's strength (S), weaknesses (W), opportunities (O), and threats (T) can be used in software project analyses. The questions asked often lead to information technology related issues, which in turn requires further review, analysis, and planning [7]. Other techniques such as 1) understanding the problem or opportunities, 2) defining the project scope and constraints, 3) performance of fact-finding, 4) evaluating feasibility-operational, technical, economic and schedule feasibilities, 5) estimating project development time and cost, and 6) readiness "Litmus test" [6], can apply to all disciplines. Front end and risk reduction analysis is usually applied to large projects and are also applicable to all three disciplines.
b. Requirement Analysis – Techniques to obtain requirements such as interview, questionnaire, sampling (systematic, stratified, or random) as well as modeling (such as the use of a UML use case diagram or activity diagram) is similar in software, database, and data warehouse technology. Note that in many instances, a database or data warehouse requirement starts when the software engineering requirements are finished. We discuss this issue in more detail in section 3 with recommendations of concurrent requirements for all disciplines involved.
c. Design – If object-oriented methodology is used, then the class diagram is a *superset* of the E-R diagram or dimensional diagram. Therefore, the class diagram should be used for both the logical and physical model of a database or data warehouse. The database and/or data warehouse modeler should become familiar with the class diagram and not use an E-R diagram and/or dimensional diagram. If there are design conflicts between the disciplines involved, then concurrent engineering techniques should be applied to resolve the issues as discussed in section 3.
d. Implementation – There should be a single coding, database and data warehouse standard that can be shared among these disciplines.
e. Testing – Use case scenarios can be used as testing scenarios in each of the software engineering, database and data warehouse technology disciplines. Other methods used in unit, integration, system, acceptance and regression test can also be applied in all disciplines
f. Maintenance – Procedures and guidelines (such as: traceability) used to maintain a software engineering project can apply to database or data warehouse technology projects.
g. Tools – There are various tools that cover different spectrums of SDLC. The selection of CASE tools is discussed in the literature [8, 9]. However, one should attempt to obtain a CASE tool that can be used in a multi-discipline environment.
h. Versioning and Configuration Management – Appropriate versioning techniques and metrics are required to map different versions of the software, data base schema and data warehouse schema. The techniques and tools for configuration management can be shares among these disciplines.

3. CONCURRENT ENGINEERING

There are many definitions of CE such as [10, 11 and 12]: systematic approach to integrated and concurrent development of a product and its related processes. Concurrent engineering emphasizes a response to customer expectations and embodies team values of cooperation, trust, and shared-decision making. It proceeds with large intervals of parallel work from all lifecycle perspectives, and is synchronized by comparatively brief exchanges to produce consensus. Concurrent Engineering can be defined as the integration of interrelated functions at the outset of the development process in order to minimize risk and reduce effort down-stream in the process, and to better meet customers' needs. Multifunctional teams, concurrency of product/process development, integration tools, information technologies, and process coordination are among the elements that enable CE to improve performance.

Software systems architecture has four basic components, namely: 1) *presentation* component which is a system interface with the user such as a web, graphical user interface, or voice response unit. The user interface engineer works on this component. 2) *process* component which defines what software component (or objects in the case of object-oriented systems) to be processed by the business rule component. A software engineer works on this component. 3) *business rule* component processes the business rules of the organization dictated by a process component. Business rules are usually dynamic and implemented by a rule engine. Software engineers work on this component. 4) *data access* component retrieves, inserts, updates, or deletes data from the database and/or data warehouse. All SQL (Structure Query Language) commands are written in this layer if a relational database is chosen for the system. Database and data warehouse engineers work on this component. Database and data warehouse engineers are also responsible for the logical and physical design of a database and/or data warehouse. Normalization techniques (usually a third normal form) is used to avoid redundancy in the database design. A *dimensional* model is used in a data warehouse that allows redundant data. Figure 1 shows typical software components. This process is *sequential:* the activities from one activity are handed off to the next only after completion. There is little or no cross-communication among various functions [13].

Figure 2 shows concurrent engineering applied to in software, database and data warehouse engineering. This process has extensive overlap and the team structure is multifunctional. For example, when a UI engineer is working on the design of a screen, the database engineer reviews and gives its feed back to UI engineer to ensure appropriate criteria is met. That may include information such as, if the implementation of the screen requires a nine way join between the underlying tables, then the database engineer recommends the screen be changed to one that requires a smaller number of joins (like two or three) to meet the performance criteria. Although concurrent engineering requires challenging coordination, it reduces the time to market, major iterations and increases overall project performance. Concurrent engineering requires extensive use of information technology tools including coordination tools.

The recommended guidelines for concurrent engineering are [13]: 1) define and formalize the CE process. 2) define all overlapping of activities. 3) identify process ownership. 4) set clear, quantitative goals.

Figure 1. Software system components

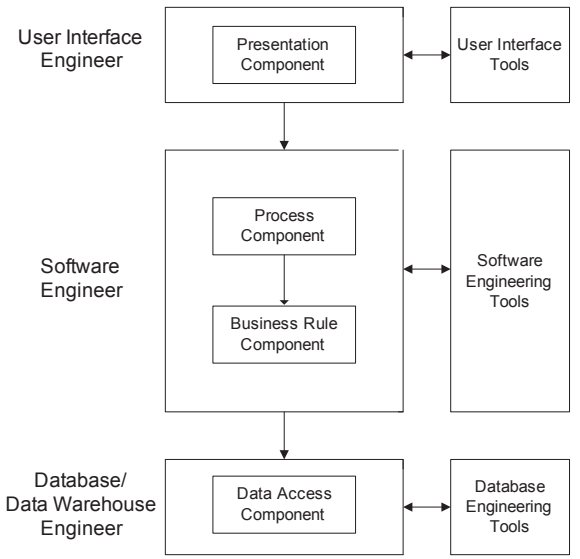
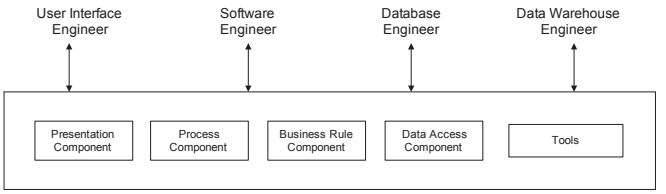


Figure 2. Concurrent engineering: Software, database and data warehouse engineering



4. CONCLUSION

Software engineering, database, and data warehouse technology are three different disciplines. However, these technologies are in many ways related to each other and can benefit from each other. We survey what has been done regarding this issue, and discuss what else can be done to further clarify the roadmap. Concurrent engineering is widely used in manufacturing. The application of concurrent engineering principles in software engineering, database, and data warehouse technology were discussed. Further research is required to obtain numerical data (such as time to market, reliability, and maintainability) for projects that are implemented using concurrent engineering verses traditional engineering methods.

REFERENCES

1. Accreditation Board for Engineering and Technology (ABET), 1996.
2. Eric J. Braude, "Software Engineering: An Object-Oriented Perspective", John Wiley & Sons, 2001.
3. Hassan Pournaghshband and Shahriar Movafaghi, "Software Engineering and Database Technology", The Association of Management / International Association of Management Conference, 2005.
4. Klaus R. Dittrich, et. al., "Databases in Software Engineering: A Roadmap," Proceedings of the Conference on the Future of Software Engineering, Ireland, 2000.
5. Ramez Elmasri, et. al., "Fundamentals of Database Systems," Addison-Wesley, 2000.
6. Ralph Kimball, Laura Reeves, Margy Ross, and Warren Thornthwaite, "The Data Warehouse Lifecycle Toolkit, Expert Methods for Designing, Developing, and Deploying Data Warehouses", John Wiley, 1998.
7. Shelly, Cashman, and Rosenblatt, "Systems Analysis and Design", Course Technology Co. 2006, 6th Edition.
8. Hassan Pournaghshband and Shahriar Movafaghi, "A Practical Approach to the Evaluation and Selection of CASE Tools", International Conference on Software Engineering Research and Practice (SERP'03: June 23-26, 2003, Las Vegas, Nevada, USA).
9. Hassan Pournaghshband and Shahriar Movafaghi, "Evaluation and Selection of CASE Tools for Educational Purposes", IRMA International Conference, May 15-18, San Diego, California, USA.
10. www.sei.cmu.edu/opensystems/glossary.html
11. Winner, R.I.J.P. Pennel H. E. Bertrand and M. M. G. Slusarezuk, 1988. The Role of Concurrent Engineering in Weapons System Acquisition. The Role of Concurrent Engineering in Weapons System Acquisition. Institute for Defense Analyses, Alexandria, VA, U.S.A. IDA Report R-338.
12. Bessant J. 1991, New product Development: The New Time Wars, in J. Blackburn (ed.). Time-Based Competition: The Next Battleground in America Manufacturing. Homewood: Business One Irwin.
13. Bhuiyan, N., Thomson, V. and Gerwin D., "Implementing Concurrent Engineering", January-February 2006, Research – Technology Management.

Collaborative Business Process Engineering "CPBE" Across Multiple Organisations in a Cluster

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ABSTRACT

This paper introduces the concept of Collaborative Business Process Engineering (CBPE) within the context of multiple organisations in a cluster. Collaborations are facilitated by the technologies of Web Services (WS) and Mobile Technology (MT). This paper demonstrates how the interoperability of WS results in electronic collaboration of businesses. Furthermore, this paper uniquely describes how cluster-based processes of multiple organisations can be engineered so that they are integrated even when the organisations are not necessarily known to each other. The subsequent effects of this interoperability on their business processes of the collaborating group of organizations including the business structures and the mechanisms to reengineer those business processes are discussed.

Keywords: Collaborative Business Process Engineering, Web Services, Mobile Technologies, Collaboration.

INTRODUCTION

This paper introduces the concept of Collaborative Business Process Engineering (CBPE) as distinct from the traditional Business Process Reengineering (BPR). Engineering of collaborative business processes does not appear to have been addressed previously in the formal literature. Furthermore, the impact of Web Services and Mobile Technologies on engineering collaborative business processes is also studied. Finally, an approach to transitioning to collaborative business processes is mentioned.

The approach to this research encompasses creation and validation of the model for CBPE. This initial paper outlines the model and approach to its validation. Selected methodologies for this study are the combination of *Interpretivist* and *Constructive* approach. Interpretivist approach is a combination of descriptive and interpretive research. It will focus on group of objects under investigation. The interpretivist approach confronts the difficulties presented by the nature of the research domain, and in particular the intangibility of many of the factors and relationships of the researcher within the research domain.

Action research is also considered to be one of the suitable methodologies for this study. By observation and recording the daily activities of the organisations the research can evaluate the existing business processes to identify what kind of business processes will be affected after the engineering process. Furthermore, action research aids this study to evaluate how to get these organizations to collaborate with each other and how people, process, technology and the infrastructure of the organizations will be affected.

Constructivist approach is the fundamental tenet of constructivist philosophy indicating that interpretivism is about contextualised meaning, and that reality is socially constructed. The constructivist paradigm, therefore, provides the assumptions, the rules, the direction, and the criteria by which research is conducted. The solution recommended by this study will use constructive methodology to present the new designed model of collaboration by multiple organizations.

This study will investigate the impact of the collaboration on social system (people *"trust"*, reward *"why collaborate"* and authority structure *"who is in charge of the collaboration"*) as well as technical system (processes *"before and after engineering"*, tasks *"security*, *convenience and availability of the channels"* and technology *"web services" and "Mobile Technology"*).

RESEARCH AIM

The aim of the research is to identify how Web Services could facilitate interoperability amongst multiple organizations that result in collaboration of business processes.

Arising from the research aim there are several research questions that need to be studied. They are as follows:

- What is the interoperation nature in existing practice (model) of collaboration?
- What is the impact of interoperability emanating from Web Services on organizations that collaborate electronically? (Here we study the dynamic aspect of collaborations wherein organizations can enter and exit the collaboration at will)
- What are the characteristics and the mechanisms to model collaborative business processes that transcend organizational boundaries as against business processes within a single organization?
- What are the factors influencing collaborative business processes? (such as trust, security, confidence level and availability of channels)
- Is the constructed model efficient and profitable for these organizations?
- Are there viable alternatives?

BUSINESS PROCESS RE-ENGINEERING

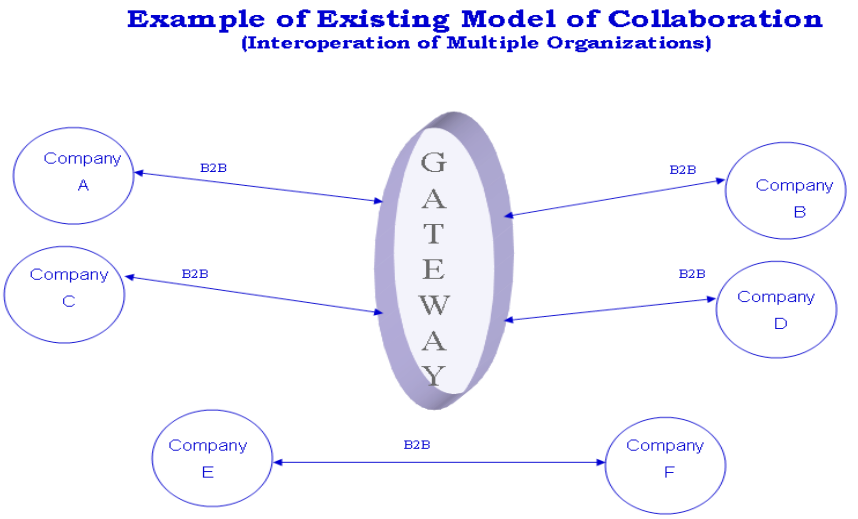
A business process is a continuous stream of business activities. Every process has some linkage to other processes. An isolated process that has no relevance to any other process in delivering a product or a service to a customer may have little business value to the organisation (Australian Computer Society).

Hammer and Champy (2001) describe the term "Reengineering" as a fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in a critical, contemporary measure of performance such as cost, quality, services and speed. Reengineering a company's business processes ultimately changes practically all aspects of the company including people, jobs, managers and values that are linked together. These impacts on businesses seem to have been studied under reengineering thus far.

However, the main focus of this study is to investigate into the collaboration of business processes that transcend beyond the processes of a single organisation. Bergenti et al (2002) defines collaboration as an activity of a group of people, which is a virtual team that exchanges information among members. This collaboration between multiple organisations is not taking place in a formal manner in the existing technical and business environment that requires "engineering" of new processes that are integrated across multiple business organisations.

Most re-engineering discussions until now concentrated on the business processes internal and belonging to a single organisation. All investigations related to a process within the boundary of the business that extended to another "known" business, resulted in what is described Business to Business (B2B). An alternative collaboration in regards to multiple organisations is possible when a gateway is

Figure 1. Existing environment of collaboration



sitting in facilitating the interactions amongst the organisations as illustrated in Figure 1.

This demonstrated gateway in figure 1 is the only existing channel of collaboration between the two organisations (ordinary B2B model). The model presented in figure 1 clearly demonstrates the shortcoming of collaboration since the organisations are not in direct contact with each other. The Gateway (an individual organisation) can collaborate with many other organisations. For example, your bank (Gateway) can pay different bills to different service providers (electricity, water, phone service) through their BPay addresses. Figure 1 is an illustration of the existing environment of collaboration based on the authors' observations.

Conversely, this study focuseses on cross-organisational processes. The new engineered processes must be able to collaborate and negotiate with the organisations that are not necessarily known to each other and that may have different technical environments. Processes running through multiple organisations are the main concentration of this research. Goethals and Vandenbulcke (2006) explain that Web Services may be used for integrating systems for unknown parties. In this type of situation the infrastructure used should be built in such a way that it can easily be adapted to new requirements.

Curbera et al (2003) state that Web Services provide generic coordination mechanisms that can be extended for specific coordination protocols. Such coordination includes the execution of short-running transactions within an organisation (similar to traditional distributed transactions) and long-running transactions across organizations.

Furthermore, Fong (2005) arguess that the limited empirical evidence of successful e-collaboration is attributed not only to the short history of e-collaboration and software, but also to the challenges associated with this revolutionary way of operating and sharing information.

The challenges of e-collaboration are mainly classified where individual organisations use varying technologies and data standards that give rise to islands of networks that now need to be integrated and coordinated. Web Services can solve this problem since the WS is a new kind of web application. WS are the independent application components that take the web to new stage of development in which the other software applications can transmit and receive the required data disregard to their existing platform under operation.

As per Ghanbary and Arunataileka (2006) the technology has increased the connectivity all around the globe. Organization are globalizing faster than ever before. The global technology advancement has raised the expectations of people in their work conditions and living standards. The customer is better informed with the availability of information at their finger tips over the Internet. The Internet also has offered a window of opportunity for users to purchase products and receive services on a global scale.On the other hand the WS gives the opportunity to web applications to be discovered by other software components to conduct their business transaction.

Table 1 distinguishes between existing collaboration and the recommended way of collaborating by this study.

Table 1. Recommended investigations of the study (based on Ghanbary, 2006-Innovation Conference UWS)

Existing Model of Collaboration	CBPE (Research)
Web Services *(Dedicated)*	Web Services *(Open for research)*
No interoperation amongst organisations	Identify the issues involved in *interoperation*
Organisation must know each other to collaborate (B2B)	Organisations collaborate without knowing each other
	Their business processes will be "Engineered" in a way to collaborate
Pre-Qualification is necessary for collaboration	Identify the channels of collaboration (No qualification is required)
	Investigates trust issues between multiple organisations
	Create security for the *Engineered* channels
	Investigate the availability of the channels

Table 1 identifies that in the existing model of collaboration the full potential of the WS is not extracted, while the study will develop a model in order to exploit the full potential of WS for CBPE. Goethals and Vandenbulcke (2006) address the shortcomings of WS by arguing that many WS standards have been developed, but most of these are still immature and do not fully answer the expected challenges.

FACILITATION BY TECHNOLOGY

Emerging technologies, such as information and communication technologies (including future versions of the Internet), microelectromechanical systems, nanotechnologies, genomics, robotics, artificial intelligence, and sensors, provide enormous opportunities for enhancing health and quality of life (Eng, 2005).

The communication technologies are providing the basis for most business processes reengineering. On the other hand, mobile technologies and web services are the technologies that can be considered as the emerging technologies of today. They are creating dramatic transformation in all aspects of business and personal lives around the globe. The specific issues to be considered in the context of this study are, of course, the manner in which these technologies are influencing the business world. However, since the business world itself is a part of the overall socio-cultural fabric of the society, it is also worth considering the impact of these emerging technologies on the society in general.

As correctly pointed out by Unhelkar (2005) mobility has had a significant impact on the quality of life of individuals and the society in which they live. While the location-aware mobile connectivity has dramatically increased the ability of individuals to communicate, it has also produced challenges in terms of privacy and new social protocols. The effect of globalization now needs to be further considered in the context of a global-mobile society. Stacey and Unhelkar (2004) describe WS as a promise to expand and enrich the existing distributed computing arena with their ability to connect disparate systems and allow communication between them from anywhere and on any platform. Web Services promise to revolutionise the way in which companies interact with each other and also how they come together or discover each other to form business alliances.

The need arises to consider multiple aspects of the technological transformation, as mentioned above, due to the fact that the current transformation could be considered as one of the most thorough and significant changes to people and society since, perhaps, the industrial revolution of the 18th century. These major socio-cultural changes will also definitely affect the next and upcoming generations of businesses in various ways that may not be obvious at this stage. For example, business processes transgressing organisational boundaries would require unique business arrangements and agreements in order to carry them through.

The phenomenal growth of mobile technology has created a new culture in the business world. The use of mobile and Web Services (WS) has passed their boundaries to a business revolution. The new technology has capabilities of text, voice and videoconferencing using wireless devices as well as the ability to connect to the World Wide Web. Pashtan (2005) indicates that Web Services can replace less-flexible methods for information exchange. He also states that with Web Services multiple WSDL interfaces can be defined for accessing a service and multiple clients can make use of the provided access methods.

The application of the WS will give this study the opportunity to implement the cross-internal organisational boundaries, beyond the simple exchange of information considering that Web Service's main purposes are basic request and response functionality. Linthicum (2004) states that WS deliver additional value to application integration, including a standard application for publishing and subscribing to software services, local and remote. XML provides a common data-exchange format, encapsulating both data and metadata. This allows the various applications and databases to exchange information without having to understand anything about one other.

The expansion of Mobile Technologies will also provide a robust basis for the organisation's desire to reach a wider customer and corporate base. This study will concentrate on the assessment of a business in the context of WS and MT and discusses the approach of transitioning to a new collaborative mobile organisation with the aid of emerging technologies. Figure 2 represents the explained model in more detail.

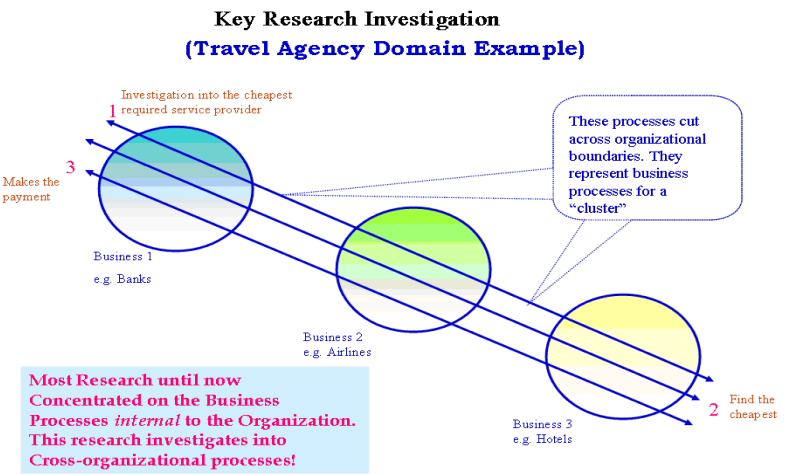
With the aid of mobile and web services technologies (Mobile Web Services), the proposed application, demonstrated in Figure 2, will give the opportunity to multiple organisations to communicate with each other in one transaction if desired. Considering Davies et al (2004) stated that the Web Services initiative effectively adds computational objects to the static information of yesterday's Web, and therefore offers distributed services capability over a network. Web Services have the potential to create new paradigms for both the delivery of software capabilities and the models by which networked enterprises will trade.

As shown in Figure 2, an individual business process could cross different organisations until one request is complete. In order to purchase airline tickets and book for hotel rooms or other related queries, Collaboration and communication will take place within these organisations until the initial request is completed. These collaborating organisations that have m-enabled WS make it possible for sale/service providers to benefit all people involved in the process.

KEY RESEARCH INVESTIGATION

As it could be seen in Figure 2, the businesses are collaborating across each other even on different platforms/frameworks with the aid of XML, WSDL and UDDI. With the aid of mobility (Location Based Services) the communication could take place without the consideration of geographical and time boundaries. (Anywhere at anytime).

Figure 2. Key research iInvestigation – Business processes across a cluster of organisations (In this example, Travel Agency of a Cluster)



Firstly, in order to purchase the numbers of airline tickets and hotel bookings, the transaction could take place with a request that could even happen with the aid of mobile devices.

Secondly, the request can go to the airline portals and make sure that the tickets for the destination are purchased. The purchase does not have to be from one specific airline and could be purchased from many airlines that are not even known to each other. Prior to this collaboration between their business processes they probably did not even know about one another's existence. With the recommended system their business processes can collaborate with the aid of WS or Mobile Web Services (MWS).

Thirdly, the same processes could take place in order to book the hotels in the destination city.

Fourthly, the bank has the capability to pay them and integrate with their processes without any prior agreements.

IDENTIFIED CHALLENGES INCORPORATING CBPE

To incorporate this proposed new world of collaboration there are many identified issues and difficulties. These issues include:

- Technical – Methodological – Social issues of ***interoperability***
- What are the ***requirements of the "manager"*** of the Directory Services
- The basis for ***trust*** amongst participant businesses and between the businesses and the manager
- The basis for a ***successful business model*** for the manager of the collaboration.
- The ***benefits*** for the participated organisations.
- The ***concerns*** of the participating organisation.
- The best technical ***model for CBPE***.
- The ***security***, ***convenience*** and the ***availability*** of the channels.
- To ***convince the organisations to adapt*** Web Service considering the limitation of WS. (Eg: slow speed of XML)
- Identify the ***dynamic aspect of collaborations*** wherein organisations can enter and exit the collaboration at will
- Identification of the ***factors influencing collaborative business processes*** such as issues involving the trust.
- The limitation of business or ***technological issues*** to create the best environment of collaboration.

THE ELEMENTS INVOLVED IN THIS STUDY

Today, mobile devices have surpassed the numbers of personal computers in use. The number of WAP enabled devices has also surpassed the numbers of PC enabled Internet users. As outlined by Pashtan (2005) over 100 million wireless Internet users were recorded as at September 2003. The majority of users are in Japan and Korea, while fast growth rates are being experienced in Europe.

Therefore the MT, which are a convergence of communication, computer and Internet technologies with mobility is a relatively new but fast growing area. The impact of mobility is an important element of the mobile transition process that is felt at both business and personal levels (Ghanbary, 2006).

Jamalipour (2003) explains that current network architectures used in either the wired Internet or the cellular networks would not be appropriate and efficient for any future wireless mobile Internet, even if we assume that the cellular network will provide the major infrastructure for the mobile Internet. He finalises by saying that the access to the mobile Internet is slow, expensive and confusing.

The access and connection to the Internet and the functionality of the WS or MWS have also become very simple and ubiquitous. These facilities have opened up opportunities for organisations to revolutionise their business processes. Undoubtedly, improvement of the communications technology has impacted not only the business domain but also the socio-cultural domain. The reason that the service model is so attractive is its ability to incorporate standards and open protocols for calling services and transmitting data (Unhelkar and S'duk, 2005). WS make software functionality available over the Internet so that programs can request a service running on another server (a web service) and use that program's response in a web site, Wireless Application Protocol (WAP) services, or other applications. The possibilities are endless.

Normal day-to-day activities become more related to the way we communicate with each other. Faster transfer of data, transactions and communications, which are independent of location and time, and with the identified functionality of mobile devices has become the mainstay of all challenged business processes.

The impacts of ICT (such as Internet, mobile and so on) on people's lives has been an evolutionary transformation. For example, at the beginning of the Internet age, with the aid of its communications capabilities, businesses were transformed to e-businesses. Ranjbar (2005) states that many technological products that were first considered by people as luxuries were later consumed as necessary items in daily life. IT products are of no exception. If the computer was an item of luxury in the 1980s, it has since established itself as an essential component of most contemporary homes. Like electricity, water and gas, information seems a necessary commodity for running everyday home life in a modern society. As one may turn on a tap for water and press a switch for light, one can also switch on the computer and obtain information and numerous IT-based services.

The Internet is described as the most powerful tool that brings information to our homes and offices like water and electricity that come by power lines and pipes (Ghanbary, 2003). Now, MT are allowing the information to be accessible anywhere and anytime with the aid of advanced mobile gadgetry.

Thus Mobile Technologies along with WS would form a formidable front in tomorrow's technology. As far as the emerging technologies are concerned the major areas of investigation would be:

- Technological issues such as modeling of the WS applications (extracting the full potential of Web Services)
- The issues and challenges in incorporating Web Services in businesses with the aid of Mobile Technologies.
- The subsequent mentioned issues and challenges of CBPE.
- The software applications that would facilitate business processes to collaborate across multiple organisations.

The methods to transit from already e-transformed businesses into collaborative may be m-enabled collaborative business process engineering is an important part of this study. In order to find the most suitable transformation method, the authors are investigating the suitable organisations to have the capability of demonstrating the smoothest transition.

As per Ghanbary (2006) it is very crucial for all parties involved in the process to know that there are some changes to take place since people must be prepared to adjust themselves. The training is the most suitable method for internal parties of the organizations however it is very important to provide sufficient information to external parties and advise them about the change.

CONCLUSION

The introduction of CBPE was described in this paper, and also the technologies supporting the recommended concept were identified. At the same time other important issues such as challenges faced by organisations participating in such a collaborative environment and studying the environment were also outlined. However, further research is in progress to construct and re-construct the model across multiple organisations to explore this concept to create better collaboration and interoperation amongst multiple organisations. The authors strongly believe that the organisations, as well as their customers, can greatly benefit from CBPE.

REFERENCES

Australian Computer Society, "Business Process Basics", ACS Learn, www.acs.openlab.net.au/content.php?article.35. Accessed 10/11/2005. Australian Computer Society.

Bergenti, F. & Poggi, A. & Somacher, M. (2002). A Collaborative Platform for Fixed and Mobile Networks. *Communications of the ACM* , 45(11), November.

Curbera, F. & Khalaf, R. & Mukhi, N. & Tai, S. & Weerawarana, S. (2003). The Next Step in Web Services. *Communications of the ACM,* 46(10) October

Davies, N. J., Fensel, D., & Richardson, M. (2004). The Future of Web Serivces. *BT Technology,* 22(1), 118-127.

Eng, T R (2005) Emerging technologies for cancer prevention and other population health challenges, Journal of Medical Internet Research 7(3) www.jmir.org/2005/3/e30/ . Accessed 19/09/2005

Fong W. L. M. Editor (2005). E-Collaborations and Virtual Organisations,. USA. IRM Press an Imprint of Idea Group Inc. ISBN: 1-59140-231-X

Ghanbary, A. (2003). Effects of Computers on Family and Leisure Time. B. Applied Science, Honours Thesis. Australia, Sydney: University of Western Sydney.

Ghanbary, A. (2006). Evaluation of Mobile Technologies in the Context of Their Application, Limitation and Transformation, book chapter in Handbook Resources of Mobile Business, Ed. Unhelkar, B., IdeaDEAS Group Publication, USA. ISBN: 1-59140-817-2

Ghanbary, A. and Arunatileka, D. (2006). Enhancing Customer Relationship Management Through Mobile Personnel Knowledge Management (MPKM). Proceedings of IBIMA International Conference. Bonn, Germany. June 19-21, 2006. ISBN: 0-9753393-5-4

Goethals, F. & Vandenbulcke, J. (2006). Using Web Services in Business-to-Business Integration, book chapter in *E-Collaborations and Virtual Organizations*, Ed. Fong, M. IdeaDEAS Group Publications, USA. ISBN: 1-59140-285-9

Hammer, M., & Champy, J. (2001). Reengineering the Corporation, A Manifesto for Business Revolution. UK: Nicholas Brealey Publishing. ISBN: 1-85788-097-8

Jamalipour, A. (2003). Wireless Mobile Internet: Architectures, Protocols and services. Hobokon, NJ: J. Willey. ISBN: 047084468X

Linthicum, D.S. (2004). Next Generation Application Integration. From Simple Information to Web Services,. USA: Pearson Education Incorporations. ISBN: 0-201-84456-7

Pashtan, A. (2005). Mobile Web Services,. UK: Cambridge University Press. ISBN: 0 521 83049 4

Ranjbar, M. (2005). Contemporary Computing., University of Western Sydney

Stacey, M. and Unhelkar (2004). Web Services in Implementation. Proceedings of ACIS International Conference. Hobart, Australia. December 2004.

Unhelkar, B. & Saddik, R., (2005). Web Services Extending BPR to Industrial Process Reengineering. Proceedings of Information Resource Management Association, International Conference. San Diego, California. May.

Unhelkar, B. (2005). "An Initial Three Dimensional Framework for Mobile Enterprise Transitions",. Cutter IT Journal, 18(8), August 2005

Generic Query Toolkit: A Query Interface Generator Integrating Data Mining

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ABSTRACT

Construction of flexible query interfaces constitutes an important part in the design of information systems. Either developers or end-users of information systems can build new queries. This paper presents progress towards a Generic Query Toolkit (GQT) that automates the query interface generation process. GQT consists of a parser and an interpreter for a newly defined Generic Query Script Language, a background query processing unit, a presentation layer service provider and the presentation layer component. Data mining querying features have been integrated into this query language.

Keywords: Business Intelligence, Query Automation, Data Mining

1. INTRODUCTION

The original idea for developing a Generic Query Toolkit (GQT) arose from projects for building data mart and report systems for business clients. In these projects, user requirements (business logic) are constantly changing. There is need to build prototypes quickly to speed up the communication cycle between developer and end users. To meet this requirement we developed a software solution to automate the query interface generation process and, thereby, make the prototyping process more efficient. In this solution, we defined an SQL-like query language called Generic Query Language (GQL). A language parser parses the GQL script and extracts elements for constructing a query interface, such as criteria input fields, display attributes and so on. These elements can be serialized into XML schema and stored in the database. GQT generates the query interface based on this schema and then binds end user inputs to generate sequences of target GQL statements that are processed by an interpreter in order to generate final query results. Lastly, a set of presentation tools renders results to the end user interactively.

The current version of GQL script supports not just SQL statements. We have added flow control, variable declaration and other statements to create a functional script language, and a set of language features to support XML based dataset manipulation and data mining functionalities (Han & Kamber, 2001).

The proposed GQT provides solutions for building queries for end-users quickly. Compared with other commercial solutions, our method is fairly lightweight and it can be widely integrated with software projects of various scales. Indeed, this toolkit has been integrated already with information systems ranging from small, personal desktop Management Information Systems to commercial distributed large data marketing and data warehouse systems, and from fat-client applications to web-based applications.

The rest of the paper is organized as follows. Section 2 summarizes relevant related work. Section 3 presents the design of GQT and GQL, its development and testing environment. Section 4 discusses the integration of data mining querying and algorithms into this toolkit. Section 5 presents conclusions and future work.

2. RELATED WORK

The ultimate goal of GQT is to provide more effective interface solutions to support Business Intelligence (BI). BI software typically includes data warehousing, data mining, analysis, reporting and planning capabilities (Golfarelli, Rizzi & Cella, 2004). Existing commercial BI solutions include BusinessObjects (Business Objects, 2006), Cognos (Cognos, 2006), and Oracle Business Intelligence Suite (Oracle Business Intelligence, 2006). Most current commercial BI tools are rather complicated heavyweight and expensive systems requiring significant time to learn for development and configuration purposes.

Some open source projects related to our work include: the Pentaho Business Intelligence Project (Dixon, 2005), Mondrian OLAP server (OLAP Server, 2006), JPivot project (JPivot Project, 2006), and the Weka Data Mining project (Witten & Frank, 2005).

3. THE DESIGN OF GENERIC QUERY TOOLKIT

3.1 Introduction of the GQL Script

This paper proposes GQL script language for customizing user querying processes to a backend database system. The GQL script language can be used to specify two broad tasks of:

1. User interface definition: Users can describe the data presentation patterns as *Field Attribute* and define the query criteria as *Condition Attribute* with this script.
2. Process or Service specification: Users can control business workflow and invoke various services (e.g., data mining services like Classification, Association Rule using WEKA or other mining algorithms and SQL statements) using this script.

The syntax to define data presentation pattern or display attribute list (*Field Attribute*) is a collection of semi-colon delimited fields enclosed in curly brackets "{}" as :

```
Field Attribute ::=   {Field Name;
                      Field Description;
                      Field Type;
                      Display Attribute [;
                      [Aggregate Attribute];
                      [Key Attribute]] }
```

where "[]" means optional attributes. **Field Name** is unique name of column to be displayed, **Field Description** is the display label of the column, **Field Type** is the SQL data type of the column, **Display Attribute** specifies the default display attribute of the column, which can be SHOW/HIDE, The optional **Aggregate Attribute** specifies the aggregation method like COUNT, MAX, MIN, SUM and AVG and **Key Attribute** indicates whether the column is used for grouping. For example, we can use "{*catalog; Category; STRING; SHOW; ; GROUP*}" to specify the display attributes for column *catalog*. The display label is *Category*. The data type is String. The column can be selected to appear in the SQL-GROUP clause.

To define the query criteria (*Condition Attribute*), we use a collection of semi-colon delimited fields enclosed in angular brackets "<>" as:

Condition Attribute ::= <Condition Expression;
Condition Description;
Condition Type [;
[Value Domain];
[Required Attribute];
[Default Attribute];
[Hint]] >

Condition Expression is unique name for query criteria, **Condition Description** specifies the display label of the criteria. We can specify "#sequence number" in this field to tell the parser that the current criteria share the same input value with the query criteria as the sequence number. **Condition Type** is the SQL data type of the column. **Value Domain** is specified as comma-delimited *"value|description"* pairs or *"#select value, description from tablename where-clause"* to generate a pick list for input field.

The query process written in GQL script contains a collection of semi-colon delimited GQL statements. Currently, the language consists of (a) eleven types of statements (SQL statement, Declare, Assignment, If-elif-else, While, Exit, Break, Continue, Call, Display and Mine statement), (b) two built-in functions (today, substring) and (c) one built-in object (DataSet). The detailed language specification can be found from the online user guide [http://kent1.galab.uwindsor.ca:8088/gqlview/pages/GQTUserGuide.html].

For example, to construct a GQL script for displaying the tuples of a database table called *t_dace*, would entail replacing columns in the regular select-list with Field Attribute placeholders, replacing criteria elements in the where-list with Condition Attribute placeholders to get the following:

```
select
{id;Item;INTEGER;SHOW;;GROUP},
{mark;Type;STRING;SHOW;;GROUP},
{catalog;Category;STRING;SHOW;;GROUP},
{cdate;Date;DATE;SHOW;;GROUP},
{sum(income) incom;Credit;MONEY;SHOW;SUM},
{sum(outcome) outcom;Debit;MONEY;SHOW;SUM},
{sum((income-outcome)) net;Net;MONEY;SHOW;SUM}
from t_dace
where
<id;Item;INTEGER;#select id,name from t item
        where id between 500 and 999 order by id> and
<note;Description;STRING> and
<mark;Type;STRING;#1> and
<catalog;Category;STRING;#3> and
<cdate;Date;DATE> and
<income*exrate;Credit;MONEY> and
<outcome*exrate;Debit;MONEY>
group by #1, #2, #3, #4
order by #1, #2, #3, #4;
```

Once the above script is submitted, the GQT system would generate a query interface shown as Figure 1, a type of input form that allows the user enter ranges of values for query input criteria of the SQL *where* clause.

After one inputs the query criteria (including conditions and summary groups, also shown in Figure 1) and submits the query, the parser generates the following target statement.

Figure 1. Generated query interface


```
select mark, catalog, sum(income) incom, sum(outcome) outcom,
sum((income-outcome)) net
from t_dace
where id between 501 and 512 and
mark = 'P' and cdate >= '01-01-2006'
group by mark, catalog
order by mark, catalog
```

Please note that those input criteria whose values are empty from the interface form the user filled out, will be removed from the where clause of the final GQL statement. This target query is evaluated to retrieve query results that are presented to the user through *CheckResult* form.

3.2 Architecture of the GQL Toolkit

The java-based architecture has five major components: Metadata repository, GQL Parser, GQL Daemon, GQL Server and GQL Viewer.

1. Meta data repository: Consists of Query Repository table for all pre-defined queries and the Task Queue Repository for submitted query tasks history.
2. GQL Parser: is a two-phase parser engine developed using java based lexical analyzer generator Jflex and java based LALR parser generator Java Cup (Java LARL Parser, 2006). The first-phase parse happens at the time that user generates a new query task. The second-phase parse happens at the time that GQL Daemon executes the submitted task in the background. It performs macro replacement to generate and interpret target GQL statements in sequential order, submits SQL statements to database server .
3. GQL Daemon: acts as the background query-processing unit. It awakes every few seconds to browse the task queue, looking for tasks in waiting status. When a waiting task is detected, the daemon program creates a thread to execute the task. It also performs the house-cleaning task, e.g., removes outdated query instances.
4. GQL Server: The GQL Server module provides service interfaces used by the presentation layer. Therefore, it can be called directly or via web service connection. Two major services currently provided are *Access Service* (for system related services such as user authentication) and *GQL Service* (for providing GQL related services like GQL script parsing, extracting query directory, query submission, query result extraction and query annotation).
5. GQL Viewer and Client Application: The GQL Viewer and Client Application represent the presentation layer of GQT system. There are seven major functions provided by the viewer: user authentication interface, presenting query directory to the user, generating query input form after user selects a query, binding user input into GQL XML schema and calling GQL Server to submit new queries, monitoring the task queue, annotation or task removal, displaying the query result to the screen, and finally reporting, data export and other interactive data analysis support.

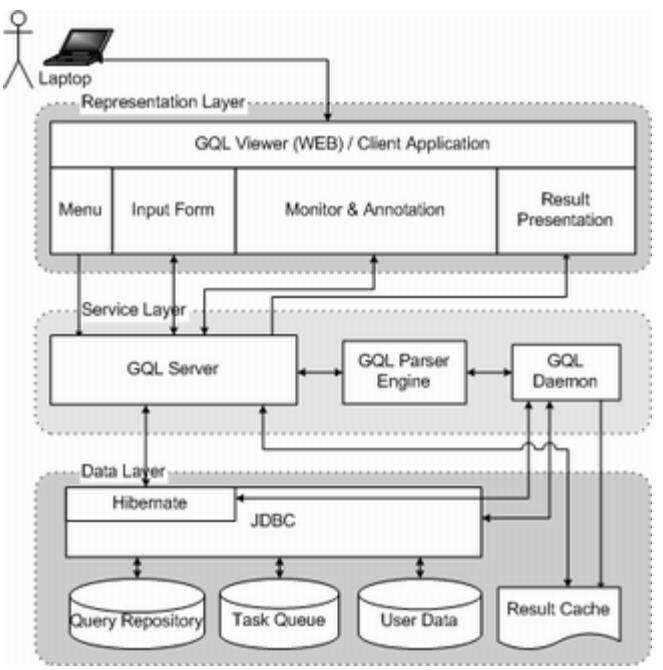
3.3 The GQT Querying Process

One main advantage of the GQL script is that it gives us the flexibility to use one generic set of pre-defined scripts to meet user's multiple requirements through the GQT query interface. The two types of users are: administrators who define and edit GQL scripts and edit existing queries; end users who may know nothing about SQL or GQL and simply use the interface to query the data. To use the system, administrators type in the GQL script and save it in the Query Repository table of the metadata database (in a column with TEXT data type) in advance if it is a new query. After they setup the new query in the database, if users log into GQT testbed system, they see the new query item in the left side menu of Figure 1. After they select the query item, the detailed information about the query is shown in the "View" form, including query name, description and GQL script. Clicking "Next" button switches the page to the "Input" form. The input query items or summary group list inside the Input form are dynamically generated based on the definition of GQL script.

The complete process for GQT querying processing is shown as Figure 2. The querying sequence contains four major steps.

1. Query Interface Generation:
   - User selects a query from menu that is generated from the Query Repository.
   - GQL Server extracts GQL script using GQL Parser Engine to generate the Query Schema, which contains input form elements (XML format).
   - The Input Form module generates input form webpage from the query schema.
2. Query Submission:
   - User inputs criteria from the Input Form, then clicks "Submit" to submit the query.
   - The GQL Viewer analyzes user's input and embeds the input value into the Query Schema, and then sends a *CheckCachedQuery* request to find matches in history queries.
   - If matches are found and user accepts cached result , GQL Server extracts cached result from Result Cache and returns it to Result Presentation module to display the query result. Otherwise, if matches are not found or user selects to ignore cached result, GQL Server creates a new query task in Task Queue using its *ApplyQuery* operator. User's requests are redirected to the Monitor & Annotation web module.
3. Background query processing:
   - GQL Daemon wakes up every five seconds (configurable) to check whether there are newly submitted tasks. If it finds new tasks, it spawns a thread to process the new query task. The status of the task will be turned to "Running".
   - The GQL Daemon thread sets the status of the task to "Success" or "Error".
4. Monitor and result presentation:
   - User refreshes the webpage to check the status of their submitted task.
   - If the status of the task turns to "Success", user can click "View" to view the query result, click "Delete" to remove the query instance, or submit "Change Notes" to append annotation to an existing query instance.

Figure 2. GQT querying process



3.4 The Development and Testing Environment

We have set up a GQT development and test bed environment on a PC environment (CPU: Pentium III, Memory: 256MB, OS: Fedora Core 4) that can be accessed via http://kent1.galab.uwindsor.ca:8088/gqlview. One can use the test user: zlc, password: 9999 to access this system. Because the whole application is developed using java, it can be deployed to various platforms. Currently, the backend database is Informix Dynamic Server 10.

4. INTEGRATING DATA MINING FEATURES INTO GQT

The GQT prototype in an embedded mining approach, integrates data classifier by applying classifier from WEKA data mining toolkit (Weka, 2006), which provides mining algorithms like Classifiers, Clusterers and Association rule miners.

The following example describes how to use WEKA classifier to first analyze the data in the GQT system. Then, the WEKA generated classifier model is exported as a serialized java object, which contains all the details of the algorithm and parameters. In the second stage, the generated model (*.model) file and training data (*.arff) are copied into the template directory of the GQT system. Then, in a GQL script, Mine statement is used to classify the data using pre-generated mining model file for classifying unlabeled data.

This example data is extracted from a cardholder's database that contains cardholder's demographic information and summarized purchase amounts. The original cardholder table contains 7 columns as (CID, SEX, AGE, MONTHIN, PURCHASE, BAD, VIP). Here, SEX, AGE, MONTHIN, PURCHASE and BAD are the predictor attributes while VIP is class attribute. First, we collect training records with VIP column already specified. Next, we load the training data into WEKA explorer, and analyze the data by comparing different classifier algorithms and different sets of parameters. At last, we export the analyzed result as a model file saved in the template directory on server, configurable as a system parameter. In this application, we select the J48 algorithm, an enhanced decision tree classifier that supports both nominal and numeric predictors and the exported model file is "j48.model".

Here, the given **Query Goal** is: Apply J48 classifier to all cardholders having age between 30 and 35 to classify based on their VIP. Next, we use the generated J48. model file to classify the data. The generic mining GQL script for this query is given below, all the non-SQL statements are marked with a prefix "$":

```
1. $declare ads Dataset;
2. select cid, sex, age, month in, purchase, vie, bad from cardholder where
       <cid;ClientId;integer> and
       <vip;VIP;integer;0|False,1|True> and
       <purchase;PurchaseAmt;Money>and
       <age;Age;Integer>
   into temp t1;
3. $set ads = Dataset.readtable('t1');
4. $mine ads classifier using sex, age, month in, purchase, bad class vip_j48
   model 'j48.model';
5. drop table t1;
6. $display ads using
       {cid;ClientId;Integer;SHOW},
       {sex;Gender;String;SHOW},
       {age;Age;Integer;SHOW},
       {monthin;MonthlyIncome;String;SHOW},
       {purchase;PurchaseAmt;Money;SHOW;SUM},
       {vip;VIP;integer;SHOW},
       {bad;Bad;integer;SHOW},
       {vip_j48;VIP_J48;String;SHOW};
```

Figure 3. Query result for test classifier

Test Classifier

ClientId	Gender	Age	MonthlyIncome	PurchaseAmt	VIP	Bad	VIP_J48
36	M	30		2642.00			FALSE
37	M	30	3. 2000-4000	4518.51			FALSE
38	F	30		62219.27	TRUE	FALSE	TRUE
47	M	30	5. 8000-16000	1014.00			FALSE
51	M	30	6. 16000-32000	6043.78			FALSE
60	M	30	5. 8000-16000	4859.40			FALSE
73	F	30	4. 4000-8000	10671.81			FALSE
75	M	30	6. 16000-32000	11.70			FALSE
90	F	30		1306.00			FALSE
94	M	30	6. 16000-32000	4646.00			FALSE

After submitting and processing the query, the result is shown in Figure 3. The client with id 38 has a value of TRUE for VIP and FALSE for Bad. The computer generated classification results are shown as column "VIP_J48". The above script uses SQL statement in No.2. to extract the required data from database, then uses Dataset.readtable statement to load the intermediate data into the Dataset object, then uses Mine statement to classify the intermediate data using specified model j48.model (the result of classification algorithm will be stored in vip_j48 column as specified), at last displays the calculated data stored in the dataset to the user.

5. CONCLUSIONS

We present the Generic Query Toolkit as an economical solution for building reporting and data analysis focused applications. Data mining features have been integrated into GQT. We introduced the Generic Query Language to automate the query and display of results. We can integrate easily the user-defined business logic, together with back-end services and front-end presentation modules, to extend the system flexibility.

Future work will include providing OLAP features where user is able to display the data set as a cube, perform slice, drill down, roll up actions interactively is a future addition to the system. Further, we plan to support more data mining features at the query language level, including data clusterer statements and association rule mining statements. Other algorithms, such as those provided by WEKA, or self-designed algorithms like PLWAP tree (Ezeife & Lu, 2005), will be included in the system scope. Another important task is to expand the GQL Server web service, and integrate OGSA-DAI (OGSA-DAI, 2006) data service to support accessing distributed data sources.

REFERENCES

Business Objects Website. 2006. *http://www.businessobjects.com*.

Cognos Website. 2006. http://www.cognos.com.

Dixon, James. 2005. Pentaho Open Source Business Intelligence Platform Technical White Paper. http://sourceforge.net/project/showfiles.php?groupid=140317.

Ezeife, C.I. and Lu, Yi. 2005. Mining Web Log Sequential Patterns with Position Coded Pre-Order Linked WAP-Tree. The International Journal of Data Mining and Knowledge Discovery, Kluwer Academic Publishers, Vol.10, pp.5-38.

Golfarelli, M., Rizzi, S., and Cella, I. 2004. Beyond Data Warehousing: What's next in business intelligence. Proceedings of the 7th International Workshop on Data Warehousing and OLAP Washington DC.

Han, Jiawein and Kamber, Micheline. 2001. Data Mining Concepts and Techniques. Morgan Kaufmann.

Java Cup LALR Parser Generator. 2006. http://www2.cs.tum.edu/projects/cup/.

JPivot Project. 2006. http://jpivot.sourceforge.net/.

Mondrain OLAP Server. 2006. http://mondrian.sourceforge.net/.

Oracle Business Intelligence Suite. 2006. http://www.oracle.com/appserver/business-intelligence/index.html.

The OGSA-DAI Project. 2006. http://www.ogsadai.org.uk/.

W3C Simple Object Access Protocol (SOAP). 2006. http://www.w3.org/TR/soap.

WEKA Data Mining Project. 2006. http://www.cs.waikato.ac.nz/ml/WEKA/.

Witten, Ian H., and Frank, Eibe. 2005. Data Mining: Practical machine learning tools and techniques, 2nd Edition. Morgan Kaufmann, San Francisco.

Usability and Emotional Obstacles in Adopting E-Learning: A Case Study

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ABSTRACT

Emotions are important in interaction and open a vital perspective to e-learning. E-learning courses have higher dropout rates than the traditional courses taught in classrooms, and it seems logical to ask whether emotional processes could explain a part of them. This research investigates how emotions are involved in students' behavior during e-learning courses. As human emotions are not independent of human cognitions and appraisal, we also consider here how cognitive difficulties affect emotional stances in e-learning on the ground of feedback collected from an e-learning course. However, here the main focus of emotion relevant cognitive processes is related to competence and usability. Usability problems lead either to frustration and shame or pride or self-confidence. It seems that the usability threshold divides subjects emotionally in e-learning environments.

1. INTRODUCTION

E-learning is a still fast growing area in education, but the complexity of the field makes it necessary to look for new perspectives. Much of e-learning research has concentrated on technical and software aspects (Annapoomima & Soh, 2004; Brusilovsky et al. 2005). Recently, increasing interest has been directed to user problems, and consequently, to emotional aspects of e-learning (Branco et al. 2005, De Villiers, 2004; Yu et al. 2002).

The possibilities that e-learning opens up for social development makes this area important, and, therefore, it is vital to ask what kinds of things may prevent people from using this new method for improving their lives. Undoubtedly, some of the obstacles are related to emotions and should be explained on the basis of human emotional processes (Hiltz & Wellman, 1997; O'Regan, 2003; Rosen & Weil, 1995). One can even think that technophobia is involved in the adoption of earlier services (Branco et al., 2005; Lam, 2000; Pickering & King, 1992). It is thus important to investigate how emotional processes are involved in the use of e-learning.

However, cognition appears before emotions (Power & Dalgleish, 1997). Therefore, it is logical to ask, what kinds of cognitive factors may lead to negative emotional stances towards e-learning and eventually to its abandonment. It is particularly interesting to look at the relations of competence and usability in this context as emotions provoking factors.

2. RESEARCH METHODS

Case description: The Connet human technology network was established in 2001. It is a part of the Finnish Virtual University program as a cognitive science and cognitive technology teaching network. Connet has eight Finnish universities in this network. All the students from these participating universities are allowed to study in the network. These eight universities form a multidisciplinary teaching network. The background curricula include cognitive science, cognitive technology, psychology, philosophy, information systems science, computer science, work science, education, educational psychology and new media. The curriculum is very strongly problem-based. The most frequently used technologies in the Connet courses are Internet and e-mail. Also whiteboard, blogs and chat boards are being used. Each teacher can choose what technique to use in their course.

Data and analysis: The Connet students answered to the questions during two academic years, in 2002 and 2004. The students answered these open questions through e-mail and were asked to comment with their views on and experiences of the Connet network study and development ideas. Questions were sent to all the students in the Connet network by e-mail. All in all there were 50 students´ answers included to the analysis. The groups of students were not the same in both years. Students took different types and amount of courses during their Connet studies. Their answers were qualitatively analyzed to identify the cognitive reasons for emotional reactions behind dropping out from the e-learning courses. The most frequently cited reasons and emotions in the students´ answers in both years are discussed below.

3. RESULTS

In both years, the most frequently mentioned reason for dropping out from a Connet course was lack of time. The students regarded their own time management skills inadequate, and the e-learning courses seemed to be the easiest to drop. In their opinion, e-learning courses are not seen as binding as the traditional classroom courses due to the anonymity of the students in e-learning courses.

3.1. Problems with Competence in Technology

Technology was a source of frustration for the students but also gave them sense of pride for their competence. These kinds of feelings were reported in 20 out of 50 students' answers, or in 44%. Students had problems with the e-learning environment, e-mail and also experienced a need for home equipment. E-learning environment problems were related to the usability of tools. The software used for the courses was changed quite frequently and this created a lot of frustration but also positive reactions. Here are three of the students' comments: ***"After finally having learned the old software, I had to start learning a new one."***, ***"The tool is not user friendly", "I had problems finding what I was looking for".***

Course materials also divided the students. For some they were a source of frustration, for others irritation and also of joy. These kinds of emotions were reported in 30 out of 50 students' answers, or in 60%.

There were opinions about the material availability and quality. Availability of the books was sometimes very poor. Here are two of the students' comments: ***"It was hard to get the material; all the books you need for the course were not available in the library. You have to do special arrangements to get them, but might not have money to buy them after all.", "The courses were mostly based on traditional books, and those books are not available in the local library."***

Apart from the book availability problem, the students were pleased with the material and also with its availability, especially on the web. Here is what two of the students said: ***"The availability of the material has been excellent and has been corresponding to the content of the courses. Also the quality.", "The web material was good. Material gave a good overall picture and gave new thoughts for working with my essay."***

4. DISCUSSION

The data implies that usability problems have their emotional consequences, but that they are not straightforward. When students come across usability or organizational problems such as those reported above, their reactions are emotional, and this leads them to negative participation decisions. We can mostly characterize the negative emotions in terms of frustration.

Frustration is a common phenomenon among people using computers (Drennan et al. 2005; Hara & Kling, 2000; Shneiderman et al. 1995; Zhang et al. 2004). As the data suggests, frustration arises from failures while using the technology, from

not finding what one is looking for and not getting from the teaching what one is expecting. Often frustration leads to dropping out from the course undertaken. This effect, which is due to emotions, can take place in traditional classroom teaching courses (Weare, 2004), and as the results suggest it also can take place in e-learning courses. Other negative emotions include irritation, embarrassment and shame. Students get irritated when they cannot find what they need or want, when material availability is poor or the technology does not work properly or when it makes it hard or even impossible to study.

On the other hand, a sense of pride for succeeding in an e-learning course was notable. This may be due to the fact that e-learning demands more from the student (Hiltz & Wellman, 1997; Kumar et al. 2001) than traditional teaching and requires more work in an unfamiliar learning environment; the students take pride for their own accomplishments. Feelings of embarrassment were prevalent at the beginning of the e-learning experience, but the successful students got used to the new systems and the required learning habits, and consequently less embarrassment was felt afterwards. Embarrassment / shame emotion has been associated with the felt difficulty and therefore it is a significant factor in the beginning of learning (Ingleton, 1995). A successful learning process turns shame and negative emotions into pride and self-confidence.

5. CONCLUSION

This study focuses on the emotions that arise from an e-learning experience and on how these might affect students who drop out from the courses. The study doesn't attempt a straightforward comparison between traditional classroom teaching and e-learning, i.e., how all the found results would have affected students in traditional courses. The results show that emotional aspects of computing are important to analyze when introducing an e-learning course. The outcome may be shame and frustration with dropout on the one hand, and pride and self-confidence with success on the other.

REFERENCES

Annapoomima, M. S., & Soh, P. H. (2004). *Determinants of Technological Frames: A Study of E-learning Technology.* 2004 IEEE International Engineering Management Conference, Singapore.

Branco, P., Firth, P., Encarnacao, M., & Bonato, P. (2005). *Faces of Emotion in Human-Computer Interaction.* CHI 2005, Portland, OR, USA.

Brusilovsky, P. (2004). *KnowledgeTree: A Distributed Architecture for Adaptive E-Learning.* WWW 2004, New York, NY, USA.

De Villiers, R. (2004). *Usability Evaluation Of an E-learning Tutorial: Criteria, Questions and Case Study.* SAICSIT 2004, Stellenbosch, South Africa.

Drennan, J., Kennedy, J., & Pisarski, A. (2005). Factors Affecting Student Attitudes Toward Flexible Online Learning in Management Education. *Journal of Educational Research, 98*(6), 331-338.

Hara, N., & Kling, B. (2000). Students' distress with a web-based distance education course. *Information, Communication & Society, 3*(4), 557-579.

Hiltz, S. R., & Wellman, B. (1997). Asynchronous learning networks as a virtual classroom. *Communications of the ACM, 40*(9), 44-49.

Ingleton, C. (1995). Gender and Learning: Does Emotion Make a Difference? *Higher Education, 30*(3), 323-335.

Kumar, A., Kumar, P., & Basu, S. C. (2001). *Students perceptions of virtual education: An exploratory study.* IRMA 2001, Toronto, Ontario, Canada.

Lam, Y. (2000). Technophilia vs. Technophobia: A Preliminary Look at Why Second-Language Teachers Do or Do Not.. *Canadian Modern Language Review, 56*(3), 389.

O'Regan, K. (2003). Emotion and E-learning. *Journal of Asynchronous Learning Networks, 7*(3).

Pickering, J. M., & King, J. L. (1992). *Hardwiring weak ties: individual and institutional issues in computer mediated communication.* CSCW '92: Proceedings of the 1992 ACM conference on Computer-supported cooperative work, New York, NY, USA.

Power, M., & Dalgleish, T. (1997). *Cognition and Emotion*: Hove: Psychology Press.

Rosen, L. D., & Weil, M. M. (1995). Computer availability, computer experience and technophobia among public school teachers. *Computers in Human Behavior, 11*(1), 9-31.

Shneiderman, B., Alavi, M., Norman, K., & Borkowski, E. Y. (1995). Windows of opportunity in electronic classrooms. *Communications of the ACM, 38*(11), 19-24.

Yu, F. Y., Chang, L. J., Liu, Y. H., & Chan, T. W. (2002). Learning preferences towards computerized competitive modes. *Journal of Computer Assisted Learning, 18*, 341-350.

Zhang, D., Zhao, J. L., Zhou, L., & Jr., J. F. N. (2004). Can e-learning replace classroom learning? *Communications of the ACM, 47*(5), 75-79.

A Human-Centric Approach to Simulation of IS Security Dynamics

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ABSTRACT

This paper outlines a new approach to computer security using simulation to study computer security policy. We suggest that understanding the interactions between humans and information systems is central to creating effective security policy. Most previous research has focused on technical issues of system vulnerability or computer security tools. Our approach employs simulation models in order to understand how attackers and users react to varying levels of parameters such as computer security and system value.

1. INTRODUCTION

Computer security is a human-centric problem with humans actively involved in both the attack and defense of systems. Consequently, we believe that a new approach is needed that places human activity at the center of a model that shows trade-offs between human choices as security is varied.

In this paper, we develop a simple economic model to examine interactions between users and attackers. Despite its simplicity, the model is too complex to provide clear policy recommendations. Hence we advocate simulation as a means of further study of these systems. We develop a framework for that simulation which should allow managers to experiment with policies before implementation. This paper does not provide simulation results as we do that elsewhere (Pendegraft and Rounds 2006, Pendegraft, Rounds, and Frincke 2005) and is intended as an apologia for the approach.

Subsequent sections of the paper cover some background (Section 2), our modeling approach and background on users and attackers (Section 3), and research agenda (Section 4).

2. BACKGROUND

The security literature has grown significantly in the last decade. However, the focus of most researchers has been on technology: intrusion detection, encryption, system management, etc. There has been relatively little discussion of the behavior of the humans involved or of the interactions between them. Even Saltzer and Schroeder (1975), who recognize that humans play a role, focused on the technological issues of security rather than the interactions of the system with its users and attackers.

Security imposes a cost on the user. According to Sasse et.al (2001) and Sasse (2003), complex multiple passwords are beyond the capability of human memory. This increase the need for user support which imposes further costs. Fixes to this problem, i.e. writing down passwords or automated password retrieval have security and cost issues of their own. These issues have not received enough attention from the security community. Recognizing the cost of security, many firms engage in cost benefit analysis of security measures before imposing them (Gordon et.al. 2006),

There is a considerable literature examining the impact of system quality on user behavior which supports our belief that system value increases use. The Technology Acceptance Model (Davis 1989) offers a means of analyzing the impact of ease of use upon usage. The IS Success model (ISM) explicated by DeLone and McLean (1992) includes constructs of information and system quality and posits that system and information quality lead to increased user satisfaction and increased use which in turn leads to net benefits. DeLone and McLean (2003) recently revised that model to expand measure of quality to include service quality and to explicitly include a feedback loop from net benefits to intention to use. Wixom and Todd (2005) recently integrated the two models and their results suggest that there is a link between system and data quality and the one hand and system usage on the other. Zhu and Kraemer (2005) argue that firm value is increased by IS usage in E-business applications.

3. MODELING APPROACH

3.1. Preliminaries

Our research uses an economic point of view rather than that typical of the computer security literature. In the economic analysis if crime typified by Becker's landmark work (1968) a system of equations is developed which describes in some aggregate way the behavior of criminals. Block and Heineke (1975) extend that work to consider the labor cost incurred by the criminal.

This approach focuses attention on societal value using a utility function about which only limited assumptions are made. In our context this translates to looking at system value rather than maximizing security or minimizing attacks. It also translates into response functions which are inherently inexact. Such ambiguity is seems inherent in the approach. For example Block and Heineke (1975, p315) use one term to represent the "failure, capture, or arrest rate" with criminal behavior. While the ambiguity is unfortunate, it does focus attention on aspects of the problem that are not well understood and therefore suggests fruitful avenues for future research.

In the next section we develop a simple two player model patterned on Becker's economic analysis of crime. As will be seen the model becomes very complex and is inherently static. In response, we will argue for simulation as a preferred mode of inquiry. Simulation offers the addition advantage of allowing us to investigate non linear behavior. Given the apparent interaction between users and attackers, it seems likely that computer security will have non linear interactions.

3.2. Economic Model

We assume that users and attackers both are motivated by the current value of the system and by the current level of security. We also view the problem of IS security as essentially dynamic, that is, we assume that the behavior of the system over time is of interest; hence we use time as an independent variable.

We adopt the following notation.

U : level of use by user	=U(V,S)
A : level of attacks	=A(V,S)
V : current value of the system	=V(T)
S : current level of security	=S(T)
T : time	

We assume that these functions are sufficiently well behaved that we may determine their derivatives. We will use the following notation: X' = dX/dT and X_y will be the partial derivative of X with respect to Y.

We calculate the time rate of change of each player's action:

$$\frac{dU}{dT} = \frac{\partial U}{\partial V}\frac{dV}{dT} + \frac{\partial U}{\partial S}\frac{dS}{dT}$$

$$\frac{dA}{dT} = \frac{\partial A}{\partial V}\frac{dV}{dT} + \frac{\partial A}{\partial S}\frac{dS}{dT}$$

At equilibrium these must both be 0 so we have

$$\frac{\partial U}{\partial V}\frac{dV}{dT} + \frac{\partial U}{\partial S}\frac{dS}{dT} = \frac{\partial A}{\partial V}\frac{dV}{dT} + \frac{\partial A}{\partial S}\frac{dS}{dT}$$

$\frac{V'}{S'} = \frac{A_S - U_S}{U_V - A_V}$. Hence,

$$\frac{dV}{dS} = \frac{A_S - U_S}{U_V - A_V}$$

Now this means that dV/dS > 0 in two cases.

1. $U_v > A_s$ and $U_s < A_s$
2. $U_v < A_s$ and $U_s > A_s$

Since $U_v > 0$, $A_v > 0$, $U_s < 0$, and $A_s < 0$, this gives

$U_s < A_s < 0 < A_v < U_v$
$A_s < U_s < 0 < U_v < A_v$

We take the second to be the more common situation. In that case, attackers are more sensitive both to the value of the system and to the security level. There is a possible policy implication here, in that if neither of these conditions obtains, addition security may be counter productive.

Now we extend to consider a dynamic model. First consider the case where the security policy is static, i.e.

$$\frac{dS}{dT} = 0$$

Then

$$\frac{dA}{dT} = \frac{\partial A}{\partial V}\frac{dV}{dT}$$

Since we have assumed the first term positive, this means A' has the sign of V_t. If we allow dynamic security, then $A' = A_v V' + A_s S'$. Since $A_s < 0$, $S' > 0$ will cause a reduction in A' (Note that it does not directly affect A, rather the time rate of change of A.) This suggests the following policy:

If A'>0 then increase S (ie make S'>0)

If A'<0 then decrease S (ie make S'<0) This follows since it will apprarenlty result also in increased usage which is assumed to be a good thing.

Now, it seems reasonable to assume that V'=V'(A,U,V). In particular, we assume that

$\frac{\partial V'}{\partial A} < 0, \frac{\partial V'}{\partial U} > 0, \frac{\partial V'}{\partial V}$ indeterminate in sign.

The attacker's problem is now

$$\frac{Max}{A}\alpha(V, S, A)$$

And the user's problem is

$$\frac{Max}{U}\beta(V, S, U)$$

Block and Heineke's analysis follows these lines for only the attacker, and leads to results of limited utility for our scenario. Their results apply at equilibrium which seems inappropriate for us and excluding the impact of usage on a system is clearly not realistic in our case because it is precisely the use of these systems that makes them valuable. Note also that we are not concerned with the direct interaction between user and attacker. Rather the attacker affects the user only indirectly by reducing the value of the system, thus reducing the user's level of use.

The net result is that is seems unlikely that the sort of analysis demonstrated here will lead to generally useful insights. It is well know that solving complex systems of differential equations is hard, and the standard way to study dynamic systems is via simulation.

3.3. General Simulation Model

Our approach to simulation is consistent with Senge (1990) which in turn drew from Forrester's work at MIT on systems dynamics (1961). Like the forgoing analysis, this approach takes a top down point of view.

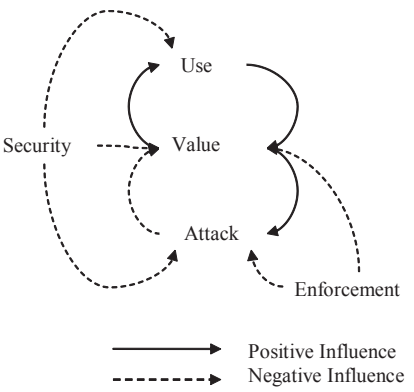
Systems dynamics models use two types of objects: reservoirs and flows. Reservoirs represent constructs whose values change over time, and the flows represent changes in the values of those constructs. In effect, the flows are derivatives of the reservoirs. Our modeling tool IThink, (High Performance Systems) converts these models into a set of finite difference equations which are solved numerically. Our models are simple because as Senge and IThink point out, simple models are much easier to understand. There is also the problem of exploding state space as models become more complex.

The basic model is illustrated in Figure 1. The main constructs are value, use, and attacks. Solid lines indicate a positive or increasing influence; dashed lines indicate a negative influence. The model shows that increases in value cause increases in use and attacks. Use increases value while attacks decrease value. Security reduces both use and attacks and has a cost (i.e. reduces value). Enforcement acts only against attacks, also at a cost.

3.4. Value and Security

System value is the key parameter in our model. Previous work (Sasse 2001, 2003, Pendegraft and Rounds 2006) has shown that value is a complex parameter. A user may assign a value based on the amount of data the system holds and the ease with

Figure 1. Value model



which it can be extracted. For a customer, the ability to carry out a transaction quickly, accurately, and securely may also enter into their view of value.

Some attackers are motivated by money (Richmond 2004). An attacker may view value as the number of records that can be extracted for sale. An attacker with a political agenda may care more about the identity of the system owner than the intrinsic value of the data. Clearly a major item in our agenda will be to clarify the aspects of system value that drive human behavior. In some sense, this extends the work of Jonsson and Olovsson, (1997) and relies upon the definition of information system value (Walters and Lancaster 1999).

Similarly, our notion of security is simple. We model security as a single parameter ranging from 0 to 1 reflecting a completely open system to one which is inaccessible. Like value, security is multifaceted and clarifying what security is must be an essential item in our agenda.

3.5. Impact of Security and Value on Behavior

We model the impact of security and value on attackers and users as S shaped. While there is some support for this idea in the error detection literature (Yamada, Ouba, and Osaki, 1983) it remains to confirm the idea experimentally. Figures 2 and 3 illustrate this postulated behavior. Figure 2 illustrates the idea that use and attacks increase with increasing rate at low levels of value, and then with decreasing rate. Figure 3 shows use and attacks decreasing slowly with increasing security at low levels of security, and then decreasing rapidly, and finally decreasing at a reduced rate. Note that we do not assert (nor believe) that these curves are identical for users and attackers, rather that they have the same general shape.

For the purposes of this research we model attackers as rational criminals with a common response curve. While there are many sorts of attackers this simplification makes the results much more understandable. We base the rational activities of our attacker upon the economics of criminal activity (Becker 1968). Finally, it is clear that attacks on a system reduce its value. While firm value is only part of our notion of value, there is evidence that firm value can be reduced by cyber attacks (Garg, Curtis, and Halpner 2003; Miora and Cobb 1998; Saita 2001, Olavsrud, 2001).

3.6. Enforcement and Security

We understand security to be actions which reduce the likelihood of success and severity of attacks. We also understand that security imposes costs on users. Enforcement includes active steps taken to reduce the number of attackers. It includes law enforcement and actions taken by targeted companies.

Traditional law enforcement has not been especially successful in dealing with cyber crime, (Jayaswal, Yurcik, and Doss, 2002) and may impose additional costs on the victims. Department of Justice's (2002) guidelines call for seizure of the victim's hardware under certain circumstances hardware seized from the victim is reclaimed only with much difficulty (Holtzman 2003).

There are reports that some firms have engaged in direct efforts to retaliate against hackers and reduce their numbers. (Schwartau 2000, Radcliff 2000, Thayer 2005).

Figure 2. Value

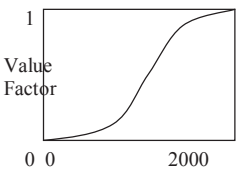
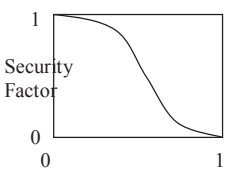


Figure 3. Security



There are a number of products available to facilitate counterattacks (Farber 2002, Secure Computing 2005).

4. CONCLUSION AND FUTURE WORK

Despite increasing expenditure on computer security computer crime continues to be a problem. The traditional computer security literature focuses on technical issues. We have developed a complementary point of view which emphasizes system value and the interactions between the system and its users and attackers. We continue to examine these questions via simulation.

We have made a number of simplifying assumptions. Clearly these are open to challenge. To validate and expand our models some of these assumptions will require experimental examination of some issues like the response of attackers and users to changes in system value and security. Our goal, as described in our introduction, is to focus on interactions in hopes of gaining new and interesting insights into the security problem. We hope that other researchers will find these questions interesting and join us in our efforts to investigate them.

5. REFERENCES

Becker, Gary S. (1968). Crime and Punishment: An Economic Approach. Journal of Political Economy 78, 169-217.

Bindview. (2005). http://www.bindview.com/Services/RAZOR/Utilities/Unix_Linux/ZombieZapper_form.cfm

Block, M.K. and Heineke, J.M.. (1975). Labor Theoretic Analysis of Criminal Choice. American Economic Review 65, 314-325.

Davis, F.D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. MISQuart 13(3), 319-340.

DeLone, W.H. and McLean, E.R. (1992). Information System Success: The Quest for the dependent Variable. ISR 3(1) 60-95.

DeLone, W.H. and E.R. McLean, E.R. (2003). The DeLone and McLean Model of Information Systems Success: A Ten-Year Update. JMIS 19(4) 9-30.

Department of Justice. (2002). "Searching and Seizing Computers and Obtaining Electronic Evidence in Criminal Investigations" http://www.usdoj.gov/criminal/cybercrime/s&smanual2002.pdf.

Farber, D. (2002). "Miracle cure for security woes?". ZDNet August 5th, 2002, http://techupdate.zdnet.com/techupdate/stories/main/0,14179,2876552,00.html.

Forrester, Jay W. (1961). Industrial Dynamics, MIT Press.

Garg, A., Curtis, J., and Halper, H. (2003). "The Financial Impact of IT Security Breaches: What Do Investors Think?". Information Systems Security, March/April.

Gordon, G.,A., and Loeb, M. P. (2002). The Economics of Information Security Investment. Transactions on Information and System Security (TISSEC). Volume 5 , Issue 4 November 438-457.

Gordon, G., Loeb, M., Lucyshyn, W., and Richardson, R. (2006). CSI/FBI Computer Crime and Security Survey. Computer Security Institute.

High Performance Systems, IThink / Stella Technical Documentation, Lebanon NH.

Holtzman D. (2003). "If You Can't Stand the Heat, Don't Call 'Em" CSO Magazine. July 2003.

Information Security Oversight Office (ISOO) (2004) Information Security Oversight Annual Report, http://www.archives.gov/isoo/reports/2004-cost-report.html

Jayaswal V., Yurcik, W., and Doss, D. (2002). "Internet Hack Back: Counter-Attacks as Self-Defense or Vigilantism." Proceedings of the IEEE International Symposium on Technology and Society, Raleigh, USA, June

Jonsson, E. and Olovsson, T. (1997). "A Quantitative Model of the Security Intrusion Process Based on Attacker Behavior," IEEE Trans. Software Eng., Apr. 1997, pp. 235-245.

Olavsrud T. (2001). "Egghead Files for Bankruptcy, Plans to Sell Assets", Internet News August 15th 2001 www.internetnews.com/ec-news/article.php/866871.

Pendegraft, N., Rounds, M. (2006). "A Simulation of IS Security with Variable Attacker Populations", working paper.

Pendegraft, N., Rounds, M., and Frincke, D. (2005). "A Simulation Model Of IS Security". 43rd ACM Southeast Conference, March 18-20, 2005, Kennesaw, GA

Radcliff, D. (2000). "Should You Strike Back?". Computer World Nov 13,

Richmond, R. (2004). Money Increasingly Is Motive For Computer-Virus Attacks. Wall Street Journal, 19 Sept., B5.

Saita, A. (2001). "On the Cutting Edge" Information Security, February 2001 http://infosecuritymag.techtarget.com/articles.february01/departments_news.shtml.

Saltzer J., and Schroeder, M. (1975). "The Protection of Information in Computer Systems, Proc. IEEE, vol. 63, no. 9, 1975, pp. 1278-1308.

Sasse, A., (2003). "Computer Security: Anatomy of a usability disaster, and a plan for recovery", Proceedings of CHI 2003 Workshop on HCI and Security Systems, Fort Lauderdale, Florida.

Sasse, A., Brostoff, S., and Weirich, D. (2001). "Transforming The Weakest Link – A Human Computer Interaction Approach To Usable Effective Security". BT Technological Journal, No 19, pp 122-131.

Schwartau W. (2000). Can You Counter-Attack Hackers?. NetworkWorld. April

Secure Computing, (2005). http://www.securecomputing. com/index.cfm?skey=1303

Senge, P.M. (1990). The Fifth Discipline, Currency Doubleday, New York.

Thayer, R. (2005). "Hack … hack back … repeat". Network World. August 9th, 2004, http://www.networkworld.com/news/2004/080904defcon.html.

Walters D., and Lancaster, G. (1999) "Value And Information: Concepts And Issues For Management". Management Decision. Volume 37 Issue 8, pp 643.

Wixom, Barbara and Todd, Peter, A. (2005). A Theoretical Integration of User Satisfaction and Technology Acceptance. ISR16(1) 85-102.

Yamada, S., Ouba, M., and Osaki, S. (1983). "S-Shaped Reliability Growth Modeling for Software Error Detection," IEEE Transactions on Reliability, R-32, 5, December 475-478.

Zhu, K. and Kraemer, K. L. (2005). Post-Adoption Variation in Usage and Value of E Business by Organizations: Cross-Country Evidence from the Retail Industry. ISR 16(1) 61-84.

The Effect of Gender on Performance in a Web-Based Knowledge Communication Task

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ABSTRACT

This study was conducted in a mid-sized University in the southern part of the U.S. Eighty subjects participated in an experiment that assessed their performance in learning about international trade terms through a series of web-based screens. The objective of the study was to test the relationships between age, motivation to do well in the task, gender, scholastic ability, (GPA) and performance in a knowledge communication task. Performance was assessed through the participants' ability to learn about international trade terms (content performance), and to recall aspects of the web-based screens through which those terms were learned (details performance). The results suggest that age positively influences motivation, females have better details performance than males, and GPA positively influences content performance.

INTRODUCTION

The assessment of the influence of motivation on task performance has been a topic of study for a number of years (Ryan & Deci, 2000). Some of the first studies of the relationship of motivation and performance date back to the 1930's and some studies are still being conducted today (Seo et al., 2004 on Kanfer, 1991). These studies have led to the proposal of a number of motivation theories (Robbins & Coulter, 2005).

Another factor which can moderate task performance is gender. There have been a number of studies which use gender as the differentiating variable in the learning patterns as well as the outcomes produced by individuals in the academic and corporate worlds (Meyers-Levy, 1989; Graham et al., 2002; Chung & Monroe, 2001). In a number of these studies the results indicate that women have the tendency to be more detail oriented than men (Graham et al., 2002).

In addition, the types of motivation often differ for women and men. Women tend to be intrinsically motivated as opposed to extrinsically motivated (Liping, 2000). While men and women may have similar expectations for the future, women tend to be goal setters, often focusing on deeper, more personal goals than men and these differences may lead to different performance levels between the two (Greene & DeBacker, 2004). In other words, through existing studies one can see that there are relationships between motivation, gender and performance.

The study presented here was conducted in a mid-sized university located in the south of the United States. The learning performance of a group of subjects was assessed at two levels: content performance and details performance. Both content performance and details performance of the participants was evaluated though the use of web-based screens in order to test the relationships between age, motivation, gender, GPA and performance. The objective of this study was to develop, as well as test, a theoretical model which can help clarify the nature of these relationships.

BACKGROUND AND HYPOTHESES

Motivation can be defined as the degree to which an individual seeks to achieve a goal, while fulfilling a personal need (Robbins & Coulter, 2005). There are two types of motivation which can influence an individual: intrinsic and extrinsic. Intrinsic motivation acts as a reflection of human nature. It relates to the innate tendency in human beings to engage in certain actions. This kind of motivation cannot be enhanced through tangible rewards because the reward, consists of a feeling of accomplishment or satisfaction which is provided by the action itself (Ryan & Deci, 2000). Deci & Ryan (1991) believe that those who are intrinsically motivated tend to "have more interest, excitement, and confidence" than those who are extrinsically motivated (p. 69).

Extrinsic motivation, on the other hand, relates to an expectation of an outcome or a fulfillment of a requirement as the reason for performing an action. That is, the activity is not performed "just for fun." The individual has an interest in the outcome of the activity as well as in the associated rewards (Ryan & Deci, 2000). Both intrinsic and extrinsic motivation may lead to increased learning levels as well as improved performance (Ryan & Connell, 1989; Deci & Ryan, 1996).

Because motivation is related to performance, researchers have been interested in finding out what motivates individuals (Ryan & Deci, 2000). Several motivation theories have resulted from this interest, some dating back to the 1930's (Seo et al., 2004 on Kanfer, 1991). Well-known motivation theories include Maslow's (1954) hierarchy of needs theory, Skinner's (1971) reinforcement theory, Vroom's (1964) expectancy theory, and Adam's (1965) equity theory.

These theories are all related to performance and convey the idea that in order to achieve a desired outcome there should be some type of motivation in place. Therefore, it is expected in this study that a student with higher motivation will also have an increased performance. Since this study uses content and details-related performance measurements, the following is hypothesized:

***H_1**: Higher motivation will lead to higher content performance.*

***H_2**: Higher motivation will lead to higher details performance.*

A number of studies have also explored the relationship between age and motivation. In these studies age has been found to influence attitudes and motivation in the work environment (Schamback, 2001 on Igbaria & Greenhaus, 1992; Warr & Birdi, 1998). Wolfgang and Dowling (1981) studied the differences in motivation between young and adult college students and Digelidis and Papaioannou (1999) studied the difference in motivation between different age groups of students. These studies recognize that a relationship exists between different age groups and their motivation levels. Since much of the existing research suggests that age is likely to have a positive effect on motivation, the following is hypothesized:

***H*$_3$**: *More years of age in an individual will lead to increased motivation.*

Chen et al. (1997) found that motivation levels in men and women can be equally high. However, women tend to be more goal oriented than men and their goals tend to be of a more intrinsic nature than those of men (Greene & DeBacker, 2004). Because women's goals are of a more personal nature, female students in this study are expected to have higher motivation levels.

Gender is another factor which can affect the learning process. Pearsall et al. (1996) found that gender mediates biology students' learning processes and Rochford & Mangino (2006) found that gender and achievement level can cause differences in a student's learning needs. Studies such as these have found that males and females learn differently, due to biological as well as social factors (Bevan, 2001; Miller et al., 2001; Giordano & Rochford, 2005). Taking such differences into consideration can help students increase their learning abilities (Rochford & Mangino, 2006).

A number of researchers have also found that males and females differ in the way they process information (Honingsfeld & Dunn, 2003; Bevan, 2001; Ablard & Lipshultz, 1998). Males look for simpler patterns of information which may stand out, while women look at more subtle details in the information (Meyers-Levy, 1989; Graham et al. 2002; Chung & Monroe, 2001). In addition, females tend to pay more attention than males to certain details. Because these studies lead to some expectations regarding the relationships between motivation, gender and performance the following is hypothesized:

***H*$_4$**: *Female students will have higher motivation.*

***H*$_5$**: *Female students will NOT have a higher level of content-oriented performance.*

***H*$_6$**: *Female students will have a higher level of detail-oriented performance.*

Finally, in this study, grade point average (GPA) is used as a control variable because of its relation to academic performance (Zheng & Saunders, 2002). In African-American females, a high GPA has been linked to a better perception of the self (Saunders, et.al. 2004). Having an increased self-perception, which is related to having a high GPA, is likely to positively affect the performance of males as well as females. Figure 1 presents the complete model of this study including this control variable.

RESEARCH METHOD

This study was conducted through a web-based experiment involving 80 subjects. All the subjects were business students from a mid-size university in the southern part of the United States. The sample included both graduate and undergraduate students. More than 80 percent of the subjects were undergraduates. Slightly over 50 percent of the subjects were female and the average age was 25.

The experiment was divided into a learning module section and a survey section. The first section consisted of ten learning modules containing ICC Incoterms 2000. Context details, consisting of four different capital letters individually framed by a colored square, were also included in each one of the modules. The second section of the experiment consisted of a web-based survey which subjects were required to complete after reading the time-controlled modules.

The instrument was designed to measure content performance, details-oriented performance, and perceived motivation. In order to measure content performance, three multiple-choice questions were asked for each module. The subjects' performance was assessed by dividing the number of correct answers by thirty (which was the maximum number of correct answers). The details performance was calculated in a similar way since the options for the colors and letters were provided in drop boxes from which subjects could choose.

This study lasted approximately one hour; twenty-five minutes were spent on the learning module section, and the remaining time was spent on the survey. To serve as motivation, the subjects were offered extra credit points which were dependent on their performance in the experiment.

DATA ANALYSIS

One of the best known variance-based SEM methods is the partial least squares (PLS) method (Chin et al., 1996; Chin, 1998). The flexibility (relaxed statistical assumptions for the data, inclusion of control variables, and definition of formative constructs, etc.) and robust significance tests make PLS a good choice for the analysis of the data collected through this study. Therefore, this method was used to assess the relationships of the model presented in this study.

The model presenting the latent variables and the different relationships as well as the calculated coefficients can be seen in Figure 2. Motivation, represented by an oval is a latent variable which is connected to the remaining variables by arrows which represent the causal relationships between the variables. The significance of the results determines the type of connectors used. A solid arrow was used when the relationship was found to be significant and a dotted arrow was used when the relationship was found to be non-significant. For those relationships that were found to be significant, the β coefficients are displayed. These coefficients are not shown for the relationships that are not significant. In this model the path coefficients are represented by β and the variance explained by the model is shown through the R^2.

Notes:
NS Non significant links
H Supported Hypothesis
* Link significant at the .10 level
** Link significant at the .05 level
*** Link significant at the .01 level

Figure 1. Model of gender and motivation effect on performance

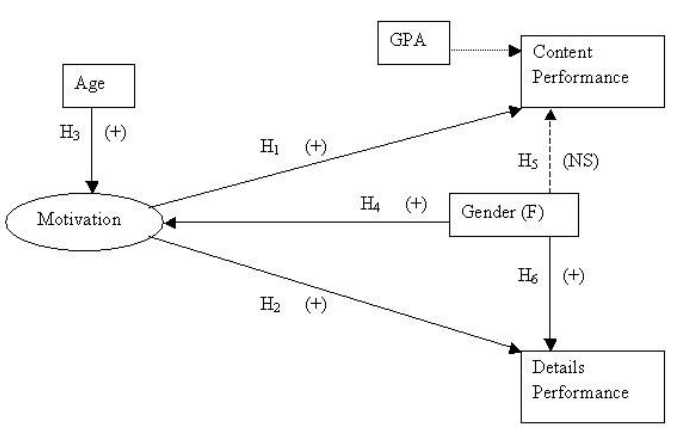
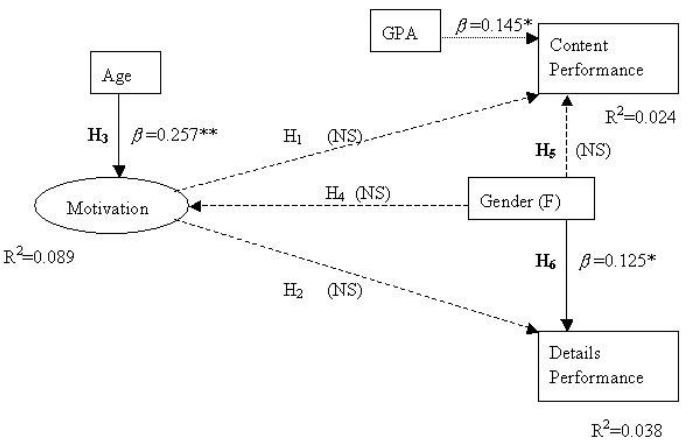


Figure 2. Results of gender and motivation effect on performance



The path coefficient for "Motivation" to "Content Performance" is slightly negative (β=-0.007) but not significant. The coefficient for "Details Performance" is positive (β=0.132), as expected, but not significant either. These results go against hypotheses H_1 and H_2. The relationship between "Age" and "Motivation" is positive and significant (β=0.5257) at the 0.05 level. This indicates that the older the student the more motivated he/she will be, which lends general support for hypothesis H_3.

In regards to "Gender", results show a positive ((β=0.137) but not significant influence on "Motivation" (contradicting hypothesis H_4). The results also show a very low (β=0.055) and non significant influence on "Content Performance" (supporting hypothesis H_5), and a positive (β=0.125) and significant (at the 10% level) influence on "Details Performance" as predicted in hypothesis H_6.

The above results allow us to conclude that while female students are more detail oriented than male students, the performance in content does not differ based on gender. It is important to note that the relationship of the control variable (GPA) with the content performance was significant at the 0.10 level.

CONCLUSION AND DISCUSSION

In this study, the content and details performance of a group of individuals was assessed in order to develop a theoretical model which may clarify the nature of the relationships between age, motivation, gender, GPA and performance. This study assessed the effect which age and gender can have on the motivation to perform well on a given computer-aided learning task. The influence that motivation and gender have on performance was also assessed. The results suggest that older subjects perceive themselves as being more motivated than younger subjects. The results also suggest that females are more detail-oriented than males, leading to the conclusion that females can perform better in tasks which require the recall of detail-oriented information.

There was no significant difference between males and females regarding the content performance. An unexpected result was that motivation level did not significantly affect either content related or details related performance of the subjects. A possible explanation for the lack of influence motivation had over performance may be the fact that the individuals were extrinsically as opposed to intrinsically motivated, decreasing the likelihood that the subjects would have an increased level of learning and performance (Ryan & Connell, 1989; Deci & Ryan, 1996).

REFERENCES

Ablard, K.E. & Lipshults, R.E. (1998). Self-regulated learning in high-achieving students: relations to advanced reasoning, achievement goals, and gender. *Journal of Educational Psychology*, 90, 94-101.

Adams, J. S. (1965). Inequity in social exchange. In L. Berkowitz (Ed.), *Advances in Experimental Social Psychology* (Vol. 2, pp. 267–299). New York: Academic Press.

Bevan, R. (2001). Boys, girls and mathematics: beginning to learn from the gender debate. *Mathematics in School*, 30(4), 2-6.

Chen, C.C., Yu, K.C. & Miner, J.B. (1997). Motivation to manage: A study of women in Chinese state-owned enterprises. *The Journal of Applied Behavioral Science*, 33(2), 160-173.

Chin, W.W. (1998). Issues and opinion on SEM. *MIS Quarterly*, 22(1), vii-xvi.

Chin, W.W., Marcolin, B.L., & Newsted, P.R. (1996). *A partial least squares latent variable modeling approach for measuring interaction effects: Results from a Monte Carlo simulation study and voice mail emotion/adoption study*. DeGross, J.I., Jarvenpaa, S., & Srinivasan, A. eds. Proceeding of the 17th International Conference on Information Systems. New York, NY: The Association for Computing Machinery, 21-41.

Chung, J. & Monroe, G.S. (2001). A Research Note on the Effects of Gender and Task Complexity on an Audit Judgment. *Behavioral Research in Accounting*, 13, 111-125.

Deci, E.L., & Ryan, R.M. (1990). A motivational approach to self: Integration in personality. In R. Dienstbier (Ed.), Nebraska Symposium on Motivation: Vol.38. *Perspectives on motivati*on (pp.237-288). Lincoln: University of Nebraska Press.

Digelidis, N. & Papaioannou, A. (1999). Age-group differences in intrinsic motivation, goal orientations and perceptions of athletic competence, physical appearance and motivational climate in Greek physical education. *Scandinavian Journal of Medicine in Science and Sports*, 9(6), 375-380.

Giordano, J. & Rochford, R.A. (2005). Understanding business majors' learning styles. *The Community College Enterprise*, 11(2), 21-39.

Graham, J.F., Stendardi, E.J., Myers, J.K. & Graham, M.J. (2002). Gender differences in investment strategies: an information processing perspective. The International Journal of Bank Marketing, 20 (1), 17-27.

Greene, G.A. & DeBacker, T.K. (2004). *Gender and Orientations Toward the Future: Links to Motivation. Educational Psychology Review*, 16(2), 91-120.

Honingsfeld, A. & Dunn, R.S. (2003). High School Male and Female Learning-Style Similarities and Differences in Diverse Nations. *The Journal of Educational Research*, 96(4), 195.

Kanfer, R. (1991). Motivation theory and industrial and organizational psychology. In M.D. Dunnette & L.M. Hough (Eds.), *Handbook of Industrial and Organizational Psychology*, 1, 76-170.

Igbaria, M. & Greenhaus, J.H. (1992). Determinants of MIS Employees' Turnover Intentions: A Structural Equation Model. *Communications of the ACM*, 35(2), 35-49.

Liping, L. (2000). Study of the level and orientation of women college students' motive to achieve. *Chinese Education and Society*, 33(3), 58-67.

Maslow, A. (1954). *Motivation and Personality*. New York: Harper & Row.

Meyers-Levy, J. (1989). Gender differences in information processing: A selectivity interpretation. In Cafferata, P. and Tybout, A. (Eds.), *Cognitive and Affective Responses to Advertising*, Lexington Books, Lexington, MA, pp.219-60.

Miller, L.M., Schweingruber, H. & Brandenburg, C.L. (2001). Middle school students' technology practices and preferences: re-examining gender differences. *Journal of Educational Multimedia and Hypermedia*, 10(2), 125-140.

Pearsall, N.R., Skipper, J.J. & Mintzes, J.J. (1996). Kowledge Restructuring in the Life Sciences: A Longitudinal Study of Conceptual Change in Biology. *Science Education*, 81(2), 193-215.

Robbins, P.S. & Coulter, M. (2005). *Management* (8th ed.). Upper Saddle River. Pearson Prentice Hall.

Rochford, R.A. & Mangino, C. (2006). Are You Teaching the Way your Students Learn? *Radical Pedagogy*, 8(1). Retrieved on July 5, 2006 from http://radicalpedagogy.icaap.org/content/issue8_1/rochford.html.

Ryan, R.M. & Connell, J.P. (1989) Perceived Locus of Causality and Internalization: Examining Reasons for Acting in Two Domains. *Journal of Personality and Social Psychology*, 57 (5), 749-761.

Ryan, R.M, & Deci, E. L. (2000). Self-Determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-Being. *American Psychologist*. 55(1), 68-78.

Saunders, J., Davis, L., Williams, T. & Williams, J.H. (2004). Gender differences in self-perceptions and academic outcomes: A study of African American high school students. *Journal of Youth and Adolescence*, 33(1), 81.

Schamback, T. (2001). Age, Motivation, and Participation in Professional Development. *Journal of Computer Information Systems*, 41(4), 57-44.

Seo, M., Barret, L.F. & Bartunek, J.M. (2004). The Role of Affective Experience in Work Motivation. *Academy of Management Review*, 29(3), 423-439.

Skinner, B. F. (1971). *Beyond freedom and dignity*. New York: Alfred A. Knopf

Vroom, V. H. (1964). *Work and motivation*. New York: Wiley.

Warr, P. Birdi, K. (1998). Employee Age and Voluntary Development Activity. *International Journal of Training and Development*, 2(3), 190-204.

Wolfgang, M.E. & Dowling, W.D. (1981). Differences in Motivation of Adult and Younger Undergraduates. *Journal of Higher Education*, 52(6), 640-648.

Zheng, J.L., Saunders, K.P. & Shelley, M.C. (2002). Predictors of academic success for freshmen residence hall students. *Journal of College Student Development*, 43(2), 267-283.

Trust Issues in Supply Chain Management

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ABSTRACT

When corporate boundaries become blurred, as they are in contemporary supply chain management, distinctive ethical issues arise. In a traditional market situation, agreement with another company to charge a fixed amount is considered to be collusion or price fixing and to be both illegal and unethical. In a supply chain context, agreements that a supplier charge a fixed amount are essential for vendor managed inventory. Such agreements are not illegal and not regarded as unethical. What is the ethical basis for this difference?

SUPPLY CHAINS

A traditional supply chain involves three entities: A supplier, the business, and the customer. Traditionally, the business needs some supplies in order to produce or have available items it expects to sell to the customer. Traditionally, several suppliers compete to supply the business with these items, usually on price, availability, and quality. Price is usually negotiated and, although a good past history with a supplier may provide an advantage, the business regards itself as constrained only by its interests, not those of the supplier, in awarding subsequent orders. Indeed, in a competitive economy, the relation of the business to the supplier is parallel to the relation of the customer to the business. Customers, after all, have no obligation whatever to continue purchasing from the same business. It is up to the business to satisfy the needs of the customer better than other businesses. This normally involves doing better in competition on price, quality, and availability.

Ethics in the traditional situation mainly involves honesty on the part of the three parties involved in the supply chain. Misrepresenting the items one is competing on is a traditional way of taking unfair advantage. Also, if a supplier agrees to price or availability and then backs out, the ethical implications of reneging are clear. Similarly if the business misrepresents quality to a customer, it is not likely to get repeat business. And the customer must pay for the merchandise.

I.T. has dramatically changed the way in which the supply chain can be managed. Wal-Mart in particular has been a leader in using I.T. to produce a more efficient supply chain. (Foley & Mahmood 1994, 7-8) In effect, suppliers are chosen on a long-term basis and given the responsibility for managing the business' inventory of that item. The business forgoes the ability to obtain lower prices through negotiating on an order-by-order basis with different suppliers. But it directly negotiates its own inventory levels with the supplier, and the supplier competes long-term on being able to maintain those levels. Clearly this sort of arrangement is advantageous with high- and steady-volume items. The business has only the inventory it needs to meet customer demands, and there is no slack caused by internal processing. The ability to have the right inventory levels may more than make up for small cost savings. And both supplier and business need to share an accurate and reliable inventory management system enabled by I.T.

But the ethical situation changes. Rather than the supplier and the business pursuing their own interest and interacting through competition, a whole new layer of trust is added. The interests of the supplier become embedded in the interests of the business. Similarly, the interests of the business become embedded in the interests of the supplier. The supplier can no longer be concerned with maximizing quantity in its own interest--it must now be concerned directly with the proper inventory level for that item for the business. And the business must recognize that the supplier has forgone the chance for extra profit in the interests of a stable long-term arrangement.

The ECR (Efficient Consumer Response) model developed in the 1990s and adopted by a number of supermarket chains includes CRP (continuous replenishment) which requires supermarket and suppliers to enter into a long-term net-price agreement. Only then is it possible for the supplier to manage store inventories directly. In the case of the Texas grocery chain H.E. Butt, it was necessary for both the chain and the suppliers participating in CRP to come to see the situation as long-term potential win-win as opposed to short-term win-lose. A "non-antagonistic" mindset was required. (Clark and Croson 1995, 8)

Some commentators argue that such arrangements are unlikely to be stable precisely because competitive profit maximization and mutual trust agreements are incompatible. (Cox 2004, 410) Other commentators note that supply chain efficiencies require the development of trust and that the requisite trust requires more than formal contract conditions, but is "developed on the basis of personal contacts and confidence in performance." (Claro & Claro, 2004, 411) A standard text on the management of I.T. notes that "For [successful sharing of corporate information], the partner firms must . . . have a high level of trust in each other." (Frenzel and Frenzel 2004, 503) I believe both sets of commentators are pointing to the same difficulty: To obtain the cooperative benefit of supply chain efficiency, both business and supplier have to acknowledge that cooperative benefits take priority over their own individual interests. The agreement is in fact an ethical one and supported not by sanctions but by mutual recognition of a principle higher than individual interest. It is, in effect, a small-scale social contract. The problem is the stability of such an arrangement in the context of a profit-maximizing market economy. In the context of a competitive market economy, sanctions for violating such cooperative agreements can only be supplied by market forces. In effect, if a supplier or the business is unhappy, it can take its business elsewhere. If the business or supplier is a corporation rather than an owner, any possible additional ethical persuasion is simply not available. Impact on the bottom line is the only relevant consideration. Therefore, long-term agreements with suppliers to manage inventory for mutual benefit need to be viewed cautiously, especially by the less powerful party in such agreements.

WAL-MART

Wal-Mart's treatment of its suppliers is an interesting example; it is not only a corporation, it is by far the largest company on the planet. Its strategy is to compete entirely on the basis of low prices. (Wal-Mart's slogan is "Low Prices--Always.") So perhaps it is not surprising that it does not seem to have great concern for the well-being of its suppliers. As Charles Fishman points out, ". . . the real story of Wal-Mart . . . is the pressure the biggest retailer relentlessly applies to its suppliers in the name of bringing us 'everyday low prices.'" (Fishman 2003, 68-9) Fishman notes that Wal-Mart's 21,000 suppliers are constantly being required to lower their prices. He claims that, rather than being constrained by cooperative agreements with suppliers, Wal-Mart uses its size and power to achieve its own strategic ends. Wal-Mart spokesperson Melissa Berryhill disagrees: "The fact is Wal-Mart, perhaps like no other retailer, seeks to establish collaborative and mutually beneficial agreements with suppliers." (Fishman 2003, 71)

One should also note that in its supplier agreement, Wal-Mart bans the use of bribes or any other sort of kickback. It also strongly encourages its suppliers not to discriminate for employment not only on such traditional grounds as race and religion, but also on sexual orientation. (Wal-Mart [Supplier] Requirements 2005)

Because of its size, many suppliers have little choice but to deal with Wal-Mart on its own terms. Those terms are quite ethical in a traditional supplier context--it does not cheat suppliers, keeps its word, pays bills promptly--but it is willing to drive such suppliers as Vlasic Pickles into bankruptcy and Huffy Bicycle into years of losses. Few suppliers are even willing to talk about their experience with Wal-Mart

for fear of being frozen out. Wal-Mart has cashed in on additional threats such as moving production offshore, for example to China. (Fishman 2003, 71-4)

There is no question about the supply chain efficiency Wal-Mart has been able to gain. Because of its size, it can set and enforce standards for suppliers, for example requiring RFID identification on products from many of its suppliers by 2006. Again, in a vendor-managed inventory system, the additional burden for supplying RFID tags falls on suppliers and many commentators feel it will be excessive.[b] (Thomas 2003, Handfield 2004) Rob Handfield notes that smaller suppliers still have little choice and recommends forming a supplier consortium to gain some bargaining power with Wal-Mart. (Handfield 2004, 2)

To get a clear view of the ethics of this situation, we need to recognize that corporations are not ethical individuals. A properly functioning for-profit corporation obeys the principle of maximizing shareholder profits. Period. This is not an ethical judgement about corporations, but rather an observation about their nature. To the extent a supplier becomes the "captive" of a large corporation, there is no room for trust. Therefore, insofar as a supplier enters into a managed inventory agreement with a large corporation, it should not depend upon trust. Rather, the supplier must be able to enforce its side of the agreement without depending on the good will of the corporation.

Is it unethical for Wal-Mart to make agreements with its suppliers and then squeeze those suppliers? This is a misleading question because a corporation is not a person. It is a legal creation with some, but not all, of the properties of a person. So we need to consider the ethics of dealing with powerful entities which are not bound by personal ethical considerations.

DEALING ETHICALLY WITH CORPORATIONS

Even though the corporation is a legal construct and thus cannot act either ethically or unethically, it is constructed out of individuals who can and should be ethical. So the appropriate way of conducting ethical dealings with corporations is through individuals.[c] For small non-corporate business, there is no distinction: The (small) company is the owner or owners and these individuals are ethically responsible for what the company does.[d] But corporations are not individuals. Normally corporations respond only to that which is "real" for them, namely effects on profit and loss. Thus the futility of issuing public statements about unethical corporate behavior. Corporations will not become ethical agents through discussion of any kind, because they cannot become individual ethical agents.

So too with Wal-Mart. Because the violation of trust involved is not an issue which is likely to garner wider public sympathy, the suppliers are on their own to negotiate conditions protecting their own interests. Perhaps a supplier's association parallel to a labor union might be in order, as Rob Handfield suggests. (Handfield 2004) But such an association would likely be as much anathema to Wal-Mart as labor unions themselves. One of the things that corporations protect closely is their own power.

In the case of the "squeezed" suppliers for Wal-Mart, one way to avoid getting "squeezed" would be if possible not to let Wal-Mart gain the lion's share of one's business for a particular product line. Otherwise demands for lower prices (a central part of Wal-Mart's strategy) will have to be agreed to.

It look as though, although Wal-Mart is sensitive to traditional ethical considerations in the supplier relationship--not cheating suppliers, keeping its word, paying bills promptly--it may not have fully recognized the ethical implications of converting the supply chain. In effect, it continues to treat suppliers as hands-off partners free to take their business elsewhere. And Wal-Mart can continue to do so as long as they maintain their overwhelmingly dominant position in retailing.

So what is an individual to do when faced with a corporation conducting itself in a manner that would be unethical for an individual? I.T. professional codes of ethics envision such possibilities: The ACM (Association of Computing Machinery) Code mentions the professional responsibility of assessing the social consequences of systems and possible whistle-blowing if management does not act to mitigate dangerous consequences. Your choice may be to comply with unethical orders or to quit. There may be an opportunity to be a whistle-blower, but in spite of legal protections, this course of action usually costs the whistle-blower a fair amount. An individual may be fortunate enough to be able to cause the unethical behavior to change within the company without damaging his or her own prospects in the company. But one can hardly count on this happening.

What, then, are your ethical obligations against a corporation which is acting contrary to ethical standards? The relevant ethical consideration is that, in theory, whatever you ultimately do, higher level principles have to be acknowledged by what you do.[e] The critical point is that even if reasons of interest make it difficult or impossible for you or to do what you believe is ethical, it is still necessary for you to acknowledge your own ethical principles in what you do. It is easy to see why. If the fact that others are not behaving well was a sufficient reason for you not to behave well, the situation could never improve.

For example, if your corporation is making substandard hardware, your ethical responsibilities differ depending on whether you have the ability to influence the strategy of the company. If you do have influence, then ethically you are required to use it. If, however, the company is unwilling to change (its market niche may be to produce substandard equipment until word gets around), you need to consider leaving. If, for other reasons (family obligations), it is not possible to leave, you still need to continue to make your position known. If you do not have influence, it may be harder for you to make your position known, but ethically you still need to try. The critical point is that ethically you must acknowledge your own ethical principles in what you do.

The trust situations we considered involve mutually beneficial agreements or understandings between companies, instead of individuals. The ethical question is how to handle such situations when such agreements or understandings are violated. When there is a great disparity in the size and power of the two companies, as is the case with many of Wal-Mart's suppliers, there may be no viable ethical trust arrangement. Hobbes (1651), one of the first social contract theorists, noted that social contracts are possible only between parties of roughly equal powers. In Wal-Mart's case, it can simply order suppliers to obey its wishes. As Fishman notes, Wal-Mart suppliers are even reticent to talk about their experience with Wal-Mart for fear of retribution. (Fishman 2003, 71-4) Just as with the individual, the disruption to one's business caused by making waves may be more than one is ethically required to do.

In the case of long-term mutually beneficial inventory arrangements or outsourcing arrangements with a corporation, any additional stability can only come from appeal to the interests of the corporation--its own survival and its efficiency in producing more profits. Corporations are indeed sensitive to damage to their reputations. They usually want to be thought of as responsible citizens. But not because they are participants in a social contract they have a commitment to uphold, but because it is "good public relations." In this respect, corporations could be seen as at Kohlberg's Stage Three, Conformity, with a goal of "looking good" for others.[f] (Stage 6 is the most developed ethically.) Extensive corporate philanthropy tends to be justified in this way. But it is ultimately for the sake of the bottom line. It is more important for corporations to be *seen* as caring and responsible, for example, for the environment, than for them to *be* caring and responsible. (Since they are not individuals, it is far from obvious that they actually *could* be caring or uncaring.) For the ethical individual, it does not matter whether anyone *knows* that he or she has done the right thing. But for the corporation, being *thought* to be ethical is the whole point.[g]

So appealing to possible damage to a corporation's reputation can be a good strategy. It may be that, if indeed Wal-Mart imposed a restriction on the percentage of business a supplier can do with them, it could be for reasons of reputation as well as possible impacts on the bottom line. But we cannot expect corporations to behave as ethical individuals would behave. So trust arrangements such as agreements for vendor managed inventory have a built-in source of instability which, given current institutions, are simply part of the environment.

REFERENCES

Applegate, Lynda M., Austin, Robert D., McFarlan, F. Warren. 2003. *Corporate Information Systems: Text and Cases*. Sixth edition. New York: McGraw-Hill Irwin.

Clark, Theodore H., and Croson, David C. 1995. "H. E. Butt Grocery Company: A Leader in ECR Implementation." *Harvard Business School Case 196-061*. Boston: Harvard Business School Publishing.

Claro, Danny Pimentel, and Claro, Priscila Borin de Oliveira. 2004. "Coordinating B2B Cross-Border Supply Chains: The Case of the Organic Coffee Industry," *Journal of Business & Industrial Marketing,* v. 19 no. 6, 405-414.

Cox, Andrew. 2004. "Business Relationship Alignment: On the Commensurability of Value Capture And Mutuality In Buyer And Supplier Exchange," *Supply Chain Management,* v. 9 no. 5, 410-420.

Fishman, Charles. 2003. "The Wal-Mart You Don't Know," *FastCompany*, Issue 77, December 2003, 68-78. (www.fastcompany.com/magazine/77)

Foley, Sharon and Mahmood, Takia. 1994. "Wal-Mart Stores, Inc." *Harvard Business School Case 9-794-024.* Revised 1996. Boston: Harvard Business School Publishing.

Frenzel, Carroll W., and Frenzel, John C. 2004. *Management of Information Technology.* 4th edition. Boston, MA: Course Technology.

Hancock, John and Oates, Steven. 2001. "Minding Other People's Business," *Supply Chain Management,* v. 6, no. 2, 58-9.

Handfield, Rob. 2004. "The RFID Power Play," *Supply Chain Resource Consortium,Hot Topics,* January 2004. Raleigh, NC: North Carolina State University. (//scrc.ncsu.edu/public/APICS/APICSjan04.html)

Hobbes, Thomas. 1651. *Leviathan.* darkwing.uoregon.edu

Plato. 360 BCE. *Republic*. classics.mit.edu/Plato/**republic**.html

RFID gazette. 2006 August 15, 2006

Schultz, Robert. 2006. *Contemporary Issues in Ethics and Information Technology.* Hershey, PA: Idea Press

Thomas, Daniel. 2003. "Wal-Mart's RFID Plan Too Aggressive for Suppliers," *ComputerWeekly.com*, July 1, 2003.

ENDNOTES

[a] A part of the material in this paper is from Schultz 2006. Its use for this conference is with the permission of Idea Press.

[b] *RFID Gazette* 2006 claims the rollout is not going that well. Less than 10% of Wal-Mart's 6,600 stores are RFID equipped. And suppliers have little incentive to pay the $9,000 average cost of conversion to RFID.

[c] The individual top executives of Enron were punished for ethical violations, but the corporation itself can be punished only by bankruptcy or closing its doors.

[d] My thanks to Major Johnson for this point.

[e] See Schultz 2006 Chapter 2, "The Rational Basis of Ethics"

[f] See Schultz 2006 Chapter 1, "Determining Right and Wrong."

[g] This discussion echoes Plato's in the opening discussion of his *Republic*. (Plato. 360 BCE, 357a-367e)

Social Interaction with a Conversational Agent: An Exploratory Study

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ABSTRACT

Conversational agents that display many human qualities have become a valuable method business uses to communicate with online users to supply services or products, to help in online order process or to search the web. Gaming industry and education may benefit from this type of interface. In this type of interface, users could have different alternatives: text display, photo of a real person, or a cartoon drawing and others. This is an exploratory study that reviews five randomly chosen conversations that an animated chatbot has with web users. The character simulates human gestures, but they are stylized to reproduce animation standards. The goal of this exploratory study is to provide feedback that will help designers to improve the functionality of the conversational agent, identify user's needs, define future research, and learn from previous errors. The methodology used was qualitative content analysis. The results of the study suggest improving the flexibility of the conversational agent, and reducing repetitions in the interaction.

INTRODUCTION

For today's online business whether selling a service or a product, the main goal of web sites is to keep its users at the site as long as possible. As an interface, a conversational agent has to offer some features to maintain its audience interested. Concerns about agents' body design and personal sociability have become obvious. Users may favor an interface that suits their own personality. They also may be more predisposed in an animated exchange with an agent if the character's voice matches content tone with gesture that complements the context.

Animation synthesis procedure permits to create through numerous randomly interconnected cycles a dynamic web based agent. Nadia (http://CLONE3D.com), a conversational chatbot, was developed by the third author, and it is a human like agent able to perform dialogues with users by "comprehending", generating phonemes with automatic lip-sync, and expressing body language, including body movements, hand actions, and facial gestures. The lighting of the virtual agent is practically naturalistic and uses conventional illumination techniques (See Fig. 1).

The design of conversational agents has to face a set of challenges: promote trusting relationships with their audience (Cassell and Bickmore, 2003), body language matching (Cassell and Bickmore, 2000), ability to communicate in different languages, and adapt to different cultural contexts. An intelligent real-time 3D artificial agent unlocks additional opportunities for computer mediated communication. The facial expressions in the agent are critical in a dialog and could be used with hearing-impairment audience (Massaro, et al., 2001). The goal of this exploratory study is to provide feedback that will help designers to improve the functionality of the conversational agent, identify user's needs, define future research, and learn from previous errors.

Figure 1. Nadia - a virtual character

DESIGN

Actions of the character are conceived to replicate human gestures, but behaviors are stylized to replicate animation standards. This design style builds a friendly web environment with web audience. The character employs AIML, Artificial Intelligence Markup Language, the Generation 4 Player, and Automated Personality Tool Set. Generation 4 is a player that simulates fluid full-body movement, mass and reactive actions, body tissue, gravity, and realistic physical responsiveness. The principles that guide the general design come from Lee and Lacey (2003).

The character is shaped with high production attributes in mind. Physical features containing an inner mouth with teeth and tongue, accurate fingers with fingernails and eyes are included in the model. The character also has over 50 facial points assembled into her expression database. These points are utilized to produce both a set of visemes, a basic unit of speech in the visual domain, to match phonemes for accurate lip-sync, other vocalizations, and present emotional changes in the facial expressions. Nadia's body features were developed for users' interest. The figure and components of the character's face and body are overstated to follow standards employed in caricature projects. For Nadia, the design target is to create an appealing, smart, young, female character, which is a standard method used in the development of female characters for broad appeal. To compliment the physical design, the personality is provided by ALICE bot, and its knowledge base was modified to answer with jokes by a process of trail and error.

TECHNICAL ENVIRONMENT

Haptek supplies a 3D player that is mostly employed to produce the character's movement. This technology can connect the model to a skeleton and provide method for correcting volume problems that appear when the character's extremities are in action. However, it does not have a simple approach to improve the model and re-skin the geometry to the skeleton. It has a pipeline for importing motion captured from the current skeleton, but export tool does not export it. The bone framework is used to have an easy method to incorporate skinning techniques. The Haptek player's toolset is hampered by its incapacity to supply the correct adjustments for the characters body, its poses, and mass volumes.

Currently the ALICE, an open source chatbot technology used for the verbal/text based responses, is limited by the amount of content that the knowledge base has. The knowledge base can be quite large and needs to address the questions and issues the user would have to develop an interesting character. ALICE knowledge base was modified to provide jokes to user by trial and error.

PROJECT GOALS

The primary objective was to develop a project called Artificial Comedy. A number of other characters are to be developed with the goal of building a set of perform-

ers: actors, singers, comedians, and other entertaining characters. Each one would have their own environment and friends. These environments would become part of a collection of bizarre expressions and comical performances of representative characters and circumstances. Exploring the exchanges these avatars have with online users will help in fine tuning their design.

RESEARCH DESIGN

Visitors

Authors could not identify who specific visitors were or population demographics, but from the server statistics some information was gotten such as top referring sites, visitor's country, queries visitors utilized to search.

According to the server statistics visitors who have requested files had come from the following domains: .au (Australia) 0.88 %, .ca (Canada) 1.34 %, .com (Commercial) 30.46 %, .de (Germany) 2.48 %, .edu (USA Higher Education) 0.77 %, .fi (Finland) 0.77 %, .fr (France) 1.85 %, .it (Italy) 1.70 %, .net (Networks) 26.84 %, .nl (Netherlands) 6.62 %, .pl (Poland) 1.12 %, .uk (United Kingdom) 1.12 %, [unresolved numerical addresses] 15.20 %, Others 8.77 %.

The words people used in search engines to find the site in the last seven days: 3d 1.80 %, animated 0.20 %, artificial 3.51 %, character 0.60 %, characters 1.20 %, chavez 0.10 %, clone3d 0.20 %, download 0.30 %, girl 43.69 %, haptek 1.10 %, intelligence 0.30 %, mark 0.10 %, stories 0.30 %, time 0.20 %, virtual 40.58 %, virtualgirl 1.10 %, not listed: 1,124 search terms 4.71 %.

Visitors used the following queries in search engines to visit the site: artificial girl 5.68 %, virtual girl 82.10 %, virtual 3d girl 0.21 %, virtual girl 3d 0.21 %, 3d characters 0.42 %, artificial girl 2 0.42 %, clone3d 0.42 %, artificial girl download 0.42 %, haptek characters 1.05 %, 3d virtual girl 1.26 %, virtualgirl 2.10 %, not listed: 1,283 search terms 5.68 %.

METHODOLOGY

The dialogues between the chatbot and the online users were recorded in a log file. Five dialogs were chose randomly, some of them were more than two hours long, and all of them were more than one hour long. Chats took place from June 1st. to June 19 from a set of more than 170 dialogues. Qualitative content analysis was used to analyze the data, utilizing QSR N6, previously known as Nudist. The categories were created in an inductive process, common in content analysis methodologies. These categories were examined by three authors, each one initially working independently, and later coming together to get a consensus, but inter-code reliability was not estimated. These categories were developed from the conversational agent's perspective, for example, how to supply information and help its visitors, how well it "comprehended" visitors' contributions, how it managed imprecise input, et cetera.

RESULTS

Topics Addressed in Dialogs by Visitors

One user had an illogical conversation with correct grammar in general terms and no spelling mistakes. Other asked for obscene expressions and jokes, and another required affectionate conduct from the chatbot.

One user tested the factual knowledge the agent posses and focus his questions on literature. He asked about who Mark Twain was, who wrote Tom Sawyer and his nickname, Philip K. Dick, a science fiction writer, and other questions. The same user tested the agent's analytic aptitude in Mathematics: the ability to solve equations, the Riemann hypothesis, and the demonstration of last Fermat's theorem.

Three visitors were trying to persuade the chatbot to engage in some sort of virtual sex. Two of them were interested in movies; one of them in science-fiction pictures, like Star Trek, Star Wars, and Matrix, and the other one wanted to know where to download free sex movies and movies in general. Two users showed great interest in the conversational agent competence, and one of them was interested in its potential.

Description of Dialogs

A dialog that had sessions as long as 43 hours may not imply the dialog was that lengthy. Visitors in addition to chat with Nadia did other things. Conversation one lasted one hour 22 minutes in June 19, 2006.

Probably, visitor one knew what to expect from a chatbot and asked: "Nadia, can you tell me why Eliza Clone copies everything I say". He attempted to comprehend the potential this chatbot has, and asked if he gave his name, the chatbot could recall it. In the beginning, the agent did not follow properly the dialogue, even visitor one was making a significant effort to maintain the dialogue flowing and making sense of the conversation.

The agent check the initial word of the next expression: "nice talking with you" and answers, "thanks for the compliment". It creates the impression when a visitor provides congruent responses, the agent is more proactive, and looks like the agent is following the conversation.

Visitor one handled the agent courteously as he was interacting with another person; in addition, the interaction was very positive. This user was interested in the agent's level of intelligence and its learning capacity. He explained different issues, tried to reason, talked about movies, and asked the agent for help to find a game that was only sold in Japan. This user made a big attempt to maintain the agent in track with the conversation, but the lack of contextual knowledge and knowledge in general limited the conversation. He had some misspellings, and his behaviour was very polite.

Dialogue two took one hour 22 minutes in June 1, 2006. The conversation was trivial, but the interaction was intense. For example, Nadia said "Excuse me! You are a really tedious dope". Only a few interactions have continuity, and the dialogue was chopped and repetitive. There was no proper beginning and end, some incorrect sentences, misspellings, and insults from the users. Probably, visitor two was a chatbot. The dialogue was full of non-sense, which is someway appealing and amusing to observe how two chatbots may interact with each other.

Conversation three took twenty-one hours and 40 minutes in June 14 and 15, 2006. Initially, visitor three did not make sense. He used single word or short expression without giving context. The chatbot behaviour became reiterative, and this user criticized that behaviour by exclaiming "stop repeating".

Visitor three articulated sexual expressions, gave orders, conveyed obscenity, and wrote sexual abbreviations such as "omfg" that Nadia did not understand. This visitor became repetitive as he used the same expression several time and twice consecutively, "one point for you", and he requested affectionate conduct from the chatbot. When he did not get what he demanded, he insulted Nadia. This dialogue in general was not interesting because of the amount of single words written by the visitor, and his involvement was limited in most part of the conversation.

Dialog four lasted 43 hours and 42 minutes from June 1st to June 3rd, 2006. Visitor four had belligerent actions, attacking the agent for not being sharp enough and did not fulfill his request for virtual sex. His language was contradictory; he was curious in the bot's analytical capabilities, intelligence, and its potential as information agent.

Dialogue five took 38 hours and 30 minutes from June 11 to June 12, 2006. Visitor five was basically motivated in one topic, virtual sex, including coarse language. He used diverse tactics to accomplish his objective. Frequently, when he failed, he abused the chatbot. The tactics he used were the followings: asking to perform some actions in his subject of interest, coercion, adulation, argumentations, et cetera.

Categories Developed

The categories arose from the agent perspective, its specific behaviors and answers during its dialogs. The sample of users is not necessarily representative of the population. The creation of these categories follows an inductive process typical of content analysis. Each author did the analysis independently, met, and achieved consensus over the final categories. The categories developed were the followings:

Ambiguous Input - Answers to short expression without context;
Bot Talking - agent talking like machine;
Complements - Answering and providing complements;
Greeting & Bye - Welcoming and saying good bye;
Help - providing information and suggestions offered by the agent;
Insults - Answering insults;
Intelligence & Knowledge - Factual knowledge and pseudo - analytical abilities;
Jokes - Agent humor;
Leading Comments - Agent answers guide the user to some topics;

Memory - "Remembering" information provided by the user;
Miscommunication - failure to communicate clearly;
Personal Issues - Exchange of personal information;
Proactive Behavior - Learning possibilities;
Repetitive Behavior - Recurring answers; and
Technical Problems - Technical difficulties the user confront.

DISCUSSION

Some operational troubles in the agent are interconnected. When a user brings in ambiguous inputs in the conversation, the agent becomes "confused". It does not have explicit context to maintain an articulated dialog. A dialog needs at least two parties, but the user may not intend to participate in the social exchange. The chatbot can be proactive, offer help and suggestions, and make remarks that may direct the conversation into topics in which it has its main assets. For example, when a user protested about technical troubles, the chatbot offered some recommendations. When the user asked for information, the chatbot answered them to do any of the followings: to check the open directory, answers.com, or to send an email to. Although, this is an adequate alternative, due to the limited amount of programmed answers, sometimes the chatbot sounds reiterative.

Some users deplored chatbot's lack of functions and repetitive answers. These issues could be solved by providing the agent with a variety of answers, employing the contextual information provided by the user, and improving and handling agent memory. Lack of conversation flow and miscommunication were frequent practice, but not always due to agent problems. Sometimes, the users were distracted. Users became perplexed when the chatbot repeated phrases, providing wrong answers, or not following the dialogue sequence.

In general, the chatbot is polite, and it can compliment users. At the same time, it is able to receive compliments graciously, but sometimes it answers with similar phrases, which could make the communication tedious. It is capable to respond some offences, but not all of them. The chatbot present a dual behaviour, sometimes it expresses clearly that it a conversational agent to the user, but not always. One of the most critical difficulties that users described in the dialogues was the agent voice. At that time in some conversations, not only the voice did not appear natural, but also not as woman speech. This problem was solved, but it generated some confusion in the users.

CONCLUSION

From this research, the authors found out that users in these conversations did not employ the chatbot for humor purposes. Some of jokes the agent can tell may not be adequate for some users, and we will have to find what type of joke visitors would like to hear. The opening and the end of a dialog are important. In the beginning, the chatbot, besides providing its name to the visitor, may provide a presentation about what it is and is capable to do. In that sense, visitors will not have expectations that the conversational agent is not able to perform. Among the areas for improvement are having better welcoming segment, involving more diverse answers, and reducing the length of the goodbye segment when the visitor provide clues that he has to abandon the dialog. Although, miscommunication cannot be prevented, it may be decreased if the conversational agent becomes more proactive and has better logs. The latent technical troubles should be recognized, and the possible answers should be part of the assistance the chatbot provides to its visitors.

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REFERENCES

Cassell, J., Bickmore, T. (2003). Negotiated Collusion: Modeling Social Language and its Relationship Effects in Intelligent Agents, User Modeling and User - *Adapted Interaction*, 13(1) pp. 89-132.

Cassell, J., Bickmore, T. (2000). External manifestations of trustworthiness in the interface, *Communications of the ACM*, 43(12) pp. 50-57.

Massaro, D. W., Cohen, M. M., Beskow, J., Daniel, S. and Cole, R. A. (2001). Developing and Evaluating Conversational Agents, In Cassell, J., Sullivan, J., Prevost, S., Elizabeth Churchill, E. (Eds.) *Embodied Conversational Agents*, MIT Press, 287 – 318.

Lee, M. H., Lacey, N. J. 2003. The influence of epistemology on the design of artificial agents, *Minds and Machines*, 13 pp. 367-395.

Municipal Broadband Case Study: San Francisco's Community Wireless Broadband Initiative

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ABSTRACT

In December 2005, the city of San Francisco issued a request for proposal (RFP) for a community wireless broadband network. The RFP stated that the network was to be built, operated and maintained at no cost to the city, that a basic level of service should be free, and that the entire city should be covered. Responses submitted included two proposals from consortia of major high tech firms (EarthLink and Google, IBM and Cisco) and four proposals from smaller firms and consortia. The EarthLink/Google proposal was selected as the winner. This initiative has achieved significant national and even international attention, largely because of San Francisco's visibility in the high tech world, and the involvement of Google. While San Francisco's wireless broadband initiative is an innovative approach to increasing broadband access for its residents, its underlying assumptions and strategies appear somewhat flawed. This paper analyzes the assumptions, the RFP and selection process, and compares them with municipal wireless initiatives in nearby Silicon Valley communities. The paper concludes with lessons and unresolved issues from the San Francisco experience relevant for other municipal broadband projects and for broadband community access in general.

1. THE CONTEXT: BROADBAND IN THE U.S.

Affordable access to services available over broadband is becoming increasingly recognized as an important contributor to social and economic development. Yet utilization of broadband in the U.S. lags many other industrialized countries. (The U.S. currently ranks 12th among industrialized countries in broadband access per 100 inhabitants according to the OECD.[a]) American broadband adoption is also highly dependent on socio-economic status: almost 60 percent of households with annual incomes above $150,000 have broadband; fewer than 10 percent of households with incomes below $25,000 have broadband.[b]

Broadband costs in the U.S. remain high: American consumers pay 10 to 25 times more per megabit than users in Japan. Also, average speed of broadband in the U.S. has not increased in the past five years; consumers in France and South Korea have residential broadband connections 10 to 20 times higher than in the U.S. Further, there is little competition in most areas, with cable and DSL providers controlling over 98 percent of the market.[c]

Some U.S. cities are responding to limited availability or take-up of broadband via DSL or cable by taking the initiative to provide free or low cost broadband via wireless. In October 2005, the city of Philadelphia selected EarthLink to establish a municipal wireless network that was the largest urban network to date in the U.S., and was to include subsidized access in low income areas. In 2005, San Francisco also jumped into this fray, with a Request for Information (RFI) and later a Request for Proposal (RFP) for free wireless broadband covering the entire city.

2. THE SAN FRANCISCO TECHCONNECT INITIATIVE

2.1. From Affordable Internet to Ubiquitous Wireless Broadband

The city of San Francisco has a population of about 777,000 and area of 49 square miles, with an average population density of about 16,500 people per square mile. It is highly ethnically diverse, with a population that is 30.8 percent Asian, 14.1 percent Hispanic, and 7.8 percent African American according to the 2000 census. Median household income is about $55,000.[d]

In mid 2005, the City of San Francisco[e] established TechConnect, a "strategy to promote digital inclusion by ensuring affordable internet access, affordable hardware, community-sensitive training and support, and relevant content to all San Franciscans, especially low-income and disadvantaged residents."[f] In September 2005, TechConnect released a request for information and content (RFI/C) which stated: "Universal, affordable wireless broadband internet access is essential to connect all residents of San Francisco to the social, educational, informational, and economic opportunities they deserve."[g]

Between the initial strategy announcement and the RFI/C release, "affordable Internet access" had become "affordable *wireless broadband* Internet access." Yet there was little rationale for the emphasis on wireless as a city-wide solution. San Francisco has broadband available over DSL and cable (primary providers are AT&T and Comcast); fixed wireless and fiber access are available in some areas and buildings. No data were provided on where broadband is not available, nor on broadband subscribership by zip code, neighborhood, income, ethnicity, or other variables. If broadband usage is lowest among low-income and other disadvantaged residents, as appears likely, no studies were available to show whether the primary reason was pricing of broadband services, or whether other factors were also important such as lack of computers, lack of computer and Internet skills, perception that content was irrelevant or harmful, etc. TechConnect has set up a Task Force on Digital Inclusion with representatives from many community and ethnic organizations, but this was not done until April 2006, *after* the RFP was written and the winning proposal was selected.

However, following the RFI/C process, the City issued a request for proposal (RFP) with the goal of providing "*universal, affordable wireless broadband* access for all San Franciscans, especially low-income and disadvantaged residents" (italics added). The RFP listed detailed specifications including:

- The network should be built, operated and maintained at no cost to the city.
- There should be a free (basic) level of service.
- Premium services can be fee-based, but should be priced lower than existing service alternatives.
- Outdoor coverage shall be provided for a minimum of 95 percent of the city's area.
- Indoor coverage shall be provided for ground and second floors of a minimum of 90 percent of all residential and commercial buildings in the city.
- Indoor perimeter room coverage above the second floor shall be provided for ground and second floors of a minimum of 90 percent of all residential and commercial buildings.[h]

Given San Francisco's topography with its numerous hills, and its high urban density including many areas with multistory residential buildings and office buildings, these are very demanding specifications. Also, although "existing service alternatives" are not defined, a version of DSL is currently offered for $13 per month and cable modem access for $20 per month.[i]

2.2. The Bidders

The city received six proposals, one of which was very sketchy and is not included in this analysis. The five complete proposals were from:

- EarthLink/Google (the eventual winner)
- MetroFi[j]
- nextWLAN[k]
- Razortooth[l]

- Seakay, with Cisco and IBM.

For a summary of key elements of their proposals, see Table 1. A few distinguishing elements included:

- RedTAP (the project submitted by Razortooth), proposed a cooperative model, community access centers, and also training and technology for residents. Their proposal noted: "Without a real strategy to provide technologically underserved residents with WiFi enabled laptops or desktops, the disadvantaged will be further left behind."[m]
- Cisco and IBM partnered with Seakay, a nonprofit organization, and stated about their financing only that the project would be financed through nonprofit fundraising, with cash and in-kind donations. Yet theirs was the longest and most technically detailed proposal.
- NextWLAN proposed that the higher speed premium service would be financed by deploying about 100,000 micronode repeaters that subscribers would rent and attach to an existing estimated 40,000 DSL lines.

2.3. The Google Effect?

The proposals were evaluated by five reviewers, four of whom were city employees with various IT responsibilities. The written proposals were scored out of 80 points, 20 being for firm qualifications and 60 for degree of compliance with the city's specifications. The top three were EarthLink/Google and MetroFi, separated by only 4 points with 260 and 256 out of a possible 400 aggregated from the five reviewers, and SeaKay a distant third with 148 total points. Three of the reviewers ranked EarthLink higher on firm qualifications, while four ranked MetroFi higher on compliance with city specifications. See Table 1. The oral interviews, which covered a wide range of issues including technical solutions, costs to the city, user interfaces, digital inclusion, experience in other municipal wifi projects, etc., turned out to be critical to the outcome. Here EarthLink/Google was rated highest by the four city employees (the outside consultant gave identical ratings to both), so that EarthLink/Google received a total of 69 points of the aggregate 100, compared to only 57 total points for MetroFi. Thus EarthLink/Google won the combined review, but the aggregate scores differed by only 16 points out of a possible 500 point total.

Was this the Google effect? Since the written proposals were scored very closely and covered many of the same topics, the EarthLink/Google presentation must have been highly persuasive. Did the opportunity of having Google as a partner make the difference? The press coverage (both popular and professional) of the project since the winner was announced has overwhelmingly highlighted Google's involvement.

3. OTHER BAY AREA MUNICIPAL WIRELESS INITIATIVES

3.1. Wireless Silicon Valley

Another major Bay Area RFP for municipal wireless was released in April 2006 by the **San Mateo County Telecommunications Authority (SAMCAT), for** service to some 35 communities in four counties in the area referred to as Silicon Valley. The RFP differs in several ways from that of San Francisco's TechConnect. The area and population covered are much larger; for example, the combined population of San Mateo County and Santa Clara County is about 2.4 million, and land area is about 1740 square miles. Population density is about 1400 per square mile, and about 30 percent of residents live in multi-unit dwellings.[n] Only outdoor wireless coverage of the region is required; service can be either free or "low cost." Other services are "desired" but not required, including enhanced outdoor service, indoor guaranteed service, government service, and public safety services. All of these other services may be fee-based.[o]

Seven proposals were received. SAMCAT announced on September 5 that it had chosen the Silicon Valley Metro Connect consortium as the winner.[p] This is basically the same group that ranked third in San Francisco, with the addition of Azulstar, a municipal wireless ISP. Neither written proposals nor evaluations by reviewers have been made available online.

Interestingly, EarthLink chose not to submit a proposal. Its rationale, submitted in a letter to SAMCAT, identifies some of the key issues in developing sustainable business models for municipal wireless. EarthLink states: "…we have not been able to reconcile the RFP's strong desire for a basic free layer of access throughout the coverage area." It points out the quality of service (QOS) problems that may result from low node deployment densities on some free systems: "Some of the operators … have attempted to obscure these problems by switching to free or advertising-supported business models, hoping that because end users are no longer required to pay for the service, they would be willing to overlook the poor performance and poor coverage of the networks."[q]

EarthLink appears to see municipal broadband as an opportunity to compete with incumbent telco and cable companies, i.e. to provide intermodal competition: "EarthLink … believes that municipal Wi-Fi connectivity will serve as a viable third broadband alternative to the home, at prices that will spur competition and choice in those progressive cities that elect to build."

It notes that its network design, using dense mesh of 36 Wi-Fi nodes per square mile, pushes the signal further into the consumer's home and requires higher investment. EarthLink concludes that advertising revenue alone would not cover its capital costs or provide a sufficient revenue stream. (Metro Connect apparently proposes that users can bring the outdoor signal indoors with the aid of special, signal boosting equipment that they will be able to purchase for $80 to $120.)[r] EarthLink also notes that free or ad-supported networks typically ignore other items that "comprise a comprehensive broadband solution" such as CPE and technical support. It also foresees needs to update and upgrade the network: "We do not believe that user needs five years from now will be the same as they are today."[s]

But is this the same EarthLink that won the San Francisco competition which required free citywide service and penetration within buildings for premium service? Is EarthLink simply stating that the less rigorous SAMCAT RFP would enable bidders with cheaper designs to win, but not to be sustainable? Or/and is it saying that Google's deep pockets are the only reason it chose to partner in a bid in San Francisco?

3.2. Cupertino and Santa Clara

Two other Silicon Valley communities, Santa Clara and Cupertino, have contracted with MetroFi to provide wireless broadband. However, the business models vary in the two small cities, which are also geographically and demographically very different from San Francisco.

Santa Clara has about 110,000 residents, and covers 19.3 square miles. It borders San Jose, and is the location of Santa Clara University, a convention center, and numerous high tech companies including Intel.[t] Santa Clara has authorized MetroFi to install a wireless citywide network.[u] In January 2006, MetroFi announced that free wifi was available across the 95050 and 95051 zip codes from 180 access points. It started with coverage of half the city, and planned to cover the whole city including about 40,000 households by the end of the year.

It appears from early press releases that MetroFi originally intended to use the same business model as adopted in Cupertino, charging $19.95 per month. However, MetroFi now appears to have adopted an advertising-based business approach: "The MetroFi network also brings a new opportunity for local businesses to reach the community through a truly local internet advertising medium. Customers that are accessing the network will be shown a banner advertisement in the frame of the browser. Local businesses can take advantage of the local and regional nature of the network by providing links to their website, coupons or announcements to those that are guaranteed to be near their establishment."[v]

Cupertino, also in Silicon Valley, has a population of about 52,000, of whom about 50 percent are Caucasian and 44 percent are Asian; the median income is just over $100,000 per household.[w] Cupertino is also the home of Apple Computer. The contract between MetroFi and the city is a non-exclusive installation and service agreement. The business model here is subscription-based; MetroFi acts as a no-frills provider and open access wholesaler. The basic service for $19.95 per month includes a wireless modem, but no email or other services, so that the user can continue with existing ISP (e.g. MSN, Hotmail, Google, etc.) MetroFi also wholesales access to ISPs such as EarthLink (which offers enhanced service for $24.95 per month).[x] Coverage is about 75 percent of Cupertino (about 15,000 households).

MetroFi states that the service in Santa Clara and Cupertino offers "DSL-like speeds" (about one megabit per second). The subscribers transmit data to the Internet via access points mounted on street light poles throughout the cities. The design uses 20 to 23 mesh infrastructure nodes per square mile (compared to the "dense mesh" of 36 nodes per square mile that EarthLink thought was necessary). MetroFi claims it is able to provide municipalities with "all-in" pricing of $50,000

per square mile, inclusive of site surveys, network design, equipment, and installation. MetroFi also operates and manages the network to provide municipalities with a turn-key, open-access solution.[y]

4. CRITICAL ISSUES

4.1. A Threat to Incumbents?

The incumbent telecom industry is claiming several points of view about the growth of municipal broadband, including wireless. First, they say that municipal broadband isn't the answer to increasing broadband access. Pyramid Research questions "whether the dream of 'cheap Internet for everyone everywhere' will ever materialize as expected." Their view is echoed by incumbents: "We expect that municipal Wi-Fi networks will not match other offerings' unique content, security features, and reliability."[z]

Second, incumbents claim that public investment in communication networks crowds out private investment. They have lobbied vigorously at the state level to prohibit or severely limit municipal broadband. Baller notes that in 2004: "Not just small rural communities, but even large cities, such as Philadelphia, San Francisco and Minneapolis, had become intensely interested in developing citywide wireless projects. The incumbents saw this as a much more significant threat than the relatively small number of municipalities that were operating or pursuing wireline options."[aa] As of August 2006, the following states had passed legislation to prohibit or hinder municipal entry into communications: Arkansas, Colorado, Florida, Louisiana, Michigan, Missouri, Minnesota, Nebraska, Nevada, Pennsylvania, South Carolina, Tennessee, Texas, Utah, Virginia, Washington, and Wisconsin[ab] [ac]

However, new entrants see municipal wireless as a means to increase competition. In Congressional testimony, EarthLink stated that municipal broadband is an antidote to facilities-based duopoly.[ad] A Florida study also finds no evidence to support the "crowding out" hypothesis, but strong support for a stimulation hypothesis – municipal-run networks typically provide wholesale access to key components of telecommunications infrastructure. Ford's empirical model, using data on the number of CLECs in particular markets in Florida, indicates that municipal communications actually increase private firm entry.[ae]

Yet incumbents also appear to think that may need to get in the game, if only to stave off new competitors such as EarthLink if partnered with major investors such as Google or possibly Yahoo or Microsoft. One consulting firm predicts that municipal networks (not only wireless) could grab up to 35 percent of the market share for video, fixed voice and high speed Internet services, and up to 20 percent of the mobile services market. It notes that "The competitive impacts will be especially threatening to incumbents to the extent that municipal networks can be cost-justified by increasing efficiencies, cost-savings and other 'internal' or 'social' benefits captured by local governments, schools, schools and other public institutions."[af] Thus "… broadband incumbents may have to deploy their own competitive Wi-Fi network offerings, and offer mobility as a differentiation tool."[ag]

4.2. Business Models and Sustainability

Several business models have been proposed for municipal broadband. More than 2000 US communities have public power systems; many have their own optical fiber for managing their networks. Some of these municipalities have decided to provide broadband access to the public over their networks. Their typical anchor tenant is the local government; some expand to serve local businesses. If they choose to serve residential customers, they may tie into the local telephone company for long distance services, or expand their networks to homes using fiber, hybrid fiber-coax or broadband over powerline (BPL). They may become an ISP or a conduit for multiple ISPs.

For wireless, municipalities typically contract with the private sector to build and operate the network, which may be owned by the municipality or the contractor (the latter investment model is known as build, own and operate or "BOO"). The revenue models are typically:

- Free service, advertising-supported;
- Subscription service, often with various tiers or options;
- Hybrid with free service in some areas or some users, and fee-based services elsewhere.

The verdict is still out on whether any of these models are sustainable. Given the insistence of many communities to include free service, advertising seems to be necessary, assuming that subscription fees would not be sufficient to cross-subsidize free service. The requirement of many municipalities to keep subscription fees low, or even to specify that they must be lower than available alternatives, limits operators' pricing flexibility.

EarthLink raises two additional issues, namely that quality of service must be adequate if municipal wireless is to be a viable alternative to DSL or cable, and that user needs, and therefore technology requirements, are likely to change over the next five years. Thus, capital and operating costs may be higher than foreseen by some community access proponents.

So why would the private sector want to get into this game? There appear to be two major drivers for the operators and content providers (as opposed to the equipment vendors, who have a clear interest in sales for this new market). First, some see it as a means to compete with incumbents without being forced to use their networks. It appears that MetroFi and EarthLink fall into this group. If they succeed, this might become the "third pipe" envisioned by the Hundt FCC or a form of the intermodal competition championed by the Powell FCC. Second, content and service providers are looking for new markets and testbeds. Google definitely appears to be in this category.

4.3. A Stepping Stone to 3G?

For incumbents, is municipal wireless an opportunity to try out services that could be offered over 3G? The real goal for content and application providers such as Google may also be to develop strategies and content that can be transferred to 3G networks. Of course, this scenario would also affect the business model of municipal wireless. Will 3G be the "killer response" that wipes out revenue for municipal wireless once mobile users have access to broadband on their cellphones and PDAs, or on notebook computers? If so, what happens to the goal of free or very cheap broadband access throughout communities?

4.4. Community Access and Demand

To achieve the goal of affordable broadband for low-income and disadvantaged populations, communities need more information on why few subscribe. For example, are there areas of the city that do not have broadband available by DSL or cable or some other means? Where service is available, what percentage of households in each neighborhood subscribe? Are the barriers to access strictly financial, or are there other barriers, such as lack of computers, lack of skills or confidence to use computers and the Internet, lack of appropriate content or applications?

Some national-level research may provide insights. For example, Flamm and Chaudhuri found that males are less likely to be Internet users, but once involved, more likely to opt for broadband. They also found that age, race and income have statistically significant impacts on propensities to use the Internet in general, but no additional impact on choice of broadband vs. dialup.[ah] Of course, these and other findings would need to be tested at the community level. We also know from other community access experience that many who are not connected will need training, access to computers, and an understanding of how the Internet could be useful to them and their families. Community outreach will also likely be needed.

If a key barrier is availability or affordability of computers, San Francisco could consider initiating a computer installment purchase plan for low-income and disadvantaged residents, such as a lease-to-own scheme for a small down payment and $20 per month. Private sector or NGO partners may be able to devise such a program.

If price of broadband service is a significant barrier (and if most unconnected households already have computers), the goal of affordable access for the low-income and disadvantaged could be achieved through a discount or voucher for those who meet low income criteria.

4.5. Pricing

San Francisco's RFI states: "Fees for access to the Network must be priced lower than existing alternatives and must be affordable for low-income and disadvantaged residents and businesses." These are two quite different criteria. The standard should be the second clause of this sentence, not the first. Affordability can be achieved without undercutting other broadband providers if they offer affordable service.

4.6. Is Ubiquitous Wireless the Only Solution?

The San Francisco RFP states: "Universal, affordable *wireless* broadband internet access is essential to connect all residents of San Francisco to the social, educational, informational, and economic opportunities they deserve." This pronouncement confuses the means with the ends. The goal should be *universal (i.e. available and affordable) access to broadband.* Wireless is very appropriate for outdoors and public spaces. It is less suitable for individual households, multiunit dwellings, high rises, office buildings, etc. Besides, many of these could already be served by commercial cable or DSL.

5. CONCLUSIONS

San Francisco's emphasis on wireless alone is misplaced; there is no evidence that the city needs *free universal wireless* broadband. The goal should be *universal (i.e. available and affordable) access to broadband.* Wireless is definitely a major part of the solution to achieve this goal, but it need not be the only solution.

The advantage of wireless for a city is that it can provide coverage for public spaces. San Francisco should be seeking wireless coverage first for outdoor public spaces and other community and public access locations.

A second priority should be facilitating broadband access for low-income areas and disadvantaged populations that do have other potential options such as DSL or cable, but cannot afford them. Discounts or vouchers for broadband access could be solutions. They should apply to service from any broadband provider, including cable networks and resellers as well as DSL from the incumbent, AT&T.

A third priority should be to require that all commercial and residential buildings in San Francisco have broadband access. Again, wireless may be part of the solution, but other technologies – and providers – are likely to be more cost effective in many cases, particularly given the terrain of San Francisco and the number of multistory residences and commercial buildings.

San Francisco should also use its legal and persuasive powers to achieve these goals. For example, the city selects and approves the cable franchisee, currently Comcast. A franchise requirement should be to provide Internet-capable cable access in all buildings and a subsidy program for low-income subscribers. Permits for new commercial buildings and multi-unit residences should require broadband cabling throughout.

The San Francisco TechConnect initiative and the experience of other communities seeking wireless broadband coverage suggest that many unanswered questions remain about the need for ubiquitous wireless, the barriers to broadband usage, and the financial and technical sustainability of municipal wireless.

ENDNOTES

[a] Source: www.oecd.org/sti/ict/broadband, data from December 2005.

[b] Turner, S. Derek. "Broadband Reality Check". Free Press, August 2005.

[c] Turner, S. Derek. "Broadband Reality Check". Free Press, August 2005.

[d] US census data from www.sfgov.org and http://censtats.census.gov/data/CA/05006075.pdf.

[e] Actually, the City and County of San Francisco; both have the same geographic boundaries and administration.

[f] Source: www.sfgov.org.techconnect.

[g] Source: www.sfgov.org/site/uploadedfiles/dtis/tech_connect/BroadbandFinalRFIC.doc (italics added).

[h] See www.sfgov.org/site/uploadedfiles/dtis/tech_connect/TechConnectRFP_2005-19_12-22-05Rev1-17-06.pdf.

[i] Promotions from AT&T and Comcast as of August 31, 2006. These rates increase to $30 and $35 per month respectively after introductory periods.

[j] MetroFi is privately held, and was cofounded by former Covad executives. See www.metrofi.com.

[k] NextWLAN is a privately funded wireless LAN company founded in 2003, headquartered in the Bay Area (Los Gatos). See www.nextWLAN.com.

[l] Razortooth does business as RedTAP, a grassroots Internet company headquartered in the Mission District of San Francisco. See www.redtap.com.

[m] RedTap Proposal Executive Summary.

[n] Census data listed in the SAMCAT RFP. See www.jointventure.org/programs-initiatives/smartvalley/projects/wirelesssv/documents.

[o] SAMCAT request for proposal: See www.jointventure.org/programs-initiatives/smartvalley/projects/wirelesssv/documents.

[p] Source: www.jointventure.org/inthenews/pressreleases/090506wirelessvendor.html.

[q] Letter from Cole Reinwand, Vice President, Product Strategy and Marketing, EarthLink, to Brian Moura, Chairman, SAMCAT (San Mateo County Telecommunications Authority), June 26, 2006.

[r] Source: www.jointventure.org/inthenews/pressreleases/090506wirelessvendor.html

[s] Letter from Cole Reinwand, June 26, 2006.

[t] See www.ci.santa-clara.ca.us.

[u] Neither RFPs (if any) nor contracts between the cities and MetroFi are publicly available electronically.

[v] Source: www.metrofi.com/press/20060130b.html.

[w] Census data provided at www.cupertino.org.

[x] See www.metrofi.com and www.muniwireless.com.

[y] See www.skypilot.com/company/pr_091905a.htm.

[z] "Municipality WiFi: Despite EarthLink, Google, Viability remains Unclear." *Pyramid Research Analyst Insight*, November 28, 2005.

[aa] "State Broadband Battles." *Public Power Magazine*, Sept.-Oct. 2006. Available at www.appanet.org.

[ab] "State Barriers to Community Broadband Services", *APPA Fact Sheet*, December 2004. Available at www.appanet.org and www.baller.com/pdfs/Barriers_End_2004.pdf.

[ac] See www.baller.com/pdfs/Baller_Proposed_State_Barriers.pdf.

[ad] Testimony of Christ Putala, Executive Vice President, Public Policy, EarthLink, before the Committee of the Judiciary, US Senate, Hearing on Reconsidering our Communications Laws: Ensuring Competition and Innovation," June 14, 2006.

[ae] Ford, George S. "Does Municipal Supply of Communications Crowd-Out Private Communications Investment?" Applied Economic Studies, Feb 2005.

[af] "Municipal Broadband will pose growing threat to for-profit operators." Pike and Fischer press release, available at www.pf.com.

[ag] "Municipality WiFi: Despite EarthLink, Google, Viability remains Unclear." *Pyramid Research Analyst Insight*, November 28, 2005.

[ah] Flamm, Kenneth and Anindya Chaudhuri, "An Analysis of the Determinants of Broadband Access" TPRC, 2005.

*Table 1: San Francisco Wireless Broadband Proposals**

Proposal	EarthLink/Google	MetroFi	nextWLAN	RedTAP	SeaKay
Participants	EarthLink, Google Motorola, Tropos	MetroFi	nextWLAN	Razortooth Communications	SeaKay (nonprofit), Cisco, IBM
Business Model	EarthLink build, own, op free low speed service, 300/300 kbps, ad supported "T1 alternative" $20/mo.	MetroFi build,own, op free 1mbps/300 kbps service various premium rates	free 384/384 service "zero infra, advertiser-funded" higher spd premium service financed by subs deploying ~100k micronode rptrs attached to ~40k DSL lines	wireless coop under RedTAP brand commty access centers with for-pay services free for city, state, fed $5/mo premium srv for others	City owned, Seakay managed Cisco equip, IBM support financed thru nonprofit fundraising: cash and inkind free basic service sponsored higher speed service
City Role	leverage city assets: lights, bldgs pay city for pole access, etc. no revenue-sharing with city	no cost to city no revenue-sharing with city	no use of city assets no revenue-sharing with city	free service for city requests $25k from city	city owned use municipal infrastructure no revenue sharing with city
Proposed Term	10 yrs with two 4-year renewals	5 years with two 5-year renewals	5 years	5 yrs with one 5-year renewal	5 to 10 years
Network Architecture	30 wifi nodes per sq mi. Motorola canopy, Tropos wifi mesh microwave links btwn towers CPE with high gain antennas	26-32 wifi nodes per sq mi 802..11a and microwave backhaul CPE with high gain antennas	~100k micronode CPE devices connected to DSL lines contract with other provider for premium portable services	citywide network Linksys routers, custom firmware	Cisco Aps plus WiMax
SF RFP Evaluation:					
written proposals/400	260	256	71	56	148
oral interviews (top 3)/100	69	57			60
Total Points/500	**329**	**313**			**208**

** A sixth proposal, from Communication Bridge Global, was incomplete.*

Derived from: Civitium, "Preliminary Review of Proposals Received," February 23, 2006, and TechConnect Aggregate Evaluation and Scoring Worksheets.

Re-Conceptualising IS Research: A Mindful Process

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ABSTRACT

In this discussion paper mindfulness is linked to Denzin and Lincoln's(2000) 5-stage qualitative research process. In socially-situated IS research a mindful researcher is more likely to produce quality results. A timeline for a typical qualitative research process in information systems presented. The paper concludes with suggestions for including mindful practices in research methods and supervision training in information systems.

Keywords: Mindfulness, qualitative research, information systems

INTRODUCTION

Mindfulness for IS qualitative researchers as an essential characteristic is presented in this discussion paper. First the characteristics of mindfulness are described(Fielden,2005); a typical qualitative research process is defined(Denzin and Lincoln,2000); mindful qualities are then mapped onto this 5-stage research process; a typical research project timeline shown; and implications arising from these mappings for educating qualitative researchers in information systems are also explored.

MINDFULNESS DEFINED

Mindfulness encompasses many qualities(Figure 1) including: mental flexibility, focussed attention, awareness of distractions, refocusing, immersion, meta-awareness and neutral observation.

Mindfulness and the Intellect

IS researcher's require is a well-developed intellect that notices novel distinctions(Figure 1). This ability is required in identifying new research opportunities. Mental flexibility is also required to view existing situations, data, or to analyse results. Understanding multiple points of view is a necessary requirement for gathering the rich data needed particularly for IS qualitative research.

Mindfulness as both state-of-mind and practice, envisioned as an integrated whole has its roots in multiple religious traditions. Bias-free observation and a deep understanding of self and others is a core part of such traditions.

Mindfulness and the Self

Developing levels of self-awareness of rational, emotional, spiritual, and psychological self is part of a mindful researcher's toolkit. Maturity emerges with growing awareness of multiple layers self. The mindful self is also aware of the likelihood of chaos, especially in initial research phases(Figure 1).

Mindfulness and Spirituality

Zukav(1989) believes that intuition is 'the voice of the soul(p83). Without intuition researchers do not have access to emergent whole systems, nor do they have the mechanisms that enable deep and powerful contact with the divine. Mindful researchers are more likely to embrace the spiritual dimensions of mindfulness: humaneness, courage, respect, integrity and reverence (which do not appear to be included in research training curriculum in information systems(IS)).

Non-judgment is a paradoxical mental state for an IS researcher (implied only in grounded theory(Glasser and Strauss,1967)) but not in other IS research methods. Non-judgement is also implied when any form of systemic thinking(Checkland, 1984) is utilised as a research tool.

Mindfulness and Immersion

It is assumed that immersion in research data will automatically occur. Awareness of changed states of consciousness, mental focussing, the nature and impact of distractions on immersion and the importance of chaotic thought processes that precede immersion are all mindful skills that can be learned(which do not usually form part of an IS research methods course).

Initial states of confusion Wheatley(2001b) are a characteristic of mindful engagement. Wheatley also suggests that listening, rather than engaging in our own inner dialog, is a necessary precursor to mindful engagement and immersion(Wheatley, 2001a). If we do not listen to self, others, and our surroundings, we cannot be present in our social interactions.

Practises that include: training in listening to own inner dialogue to distinguish this from listening to others, particularly when data is being collected; familiarisation with inner chaos – a common state during the early stages of research; a growing awareness of evolving conceptual maturity; an understanding of multiple points-of-view; and an acknowledgment of many self-layers; are all important mindful qualities for IS researchers.

Socially-Situated Mindfulness

Qualitative research in IS is socially-situated. Becoming mindfully aware of researcher-interactions in social situations in gathering data involves entering with a greater awareness of culture, protocols, practices and procedures. When heart and intellect operate together discernment, discrimination, and a greater appreciation of socially-situated knowing(Reason and Bradbury,2001) occurs. The mindful intellect acts upon novel distinctions Langer(2000) with greater flexibility. Butler(2001) identifies contexts of practice that include both social settings and the minds of the knowers.

Mindfulness and Cognitive Maturity

Meta-awareness and presencing are mindful dimensions achieved with cognitive maturity. Both require awareness of what is happening while it is happening. Both require a detached self to notice and learn from the process being experienced. It appears that meta-awareness and presencing belong at a higher cognitive level(but not necessarily high spiritual, emotional, or psychological levels).

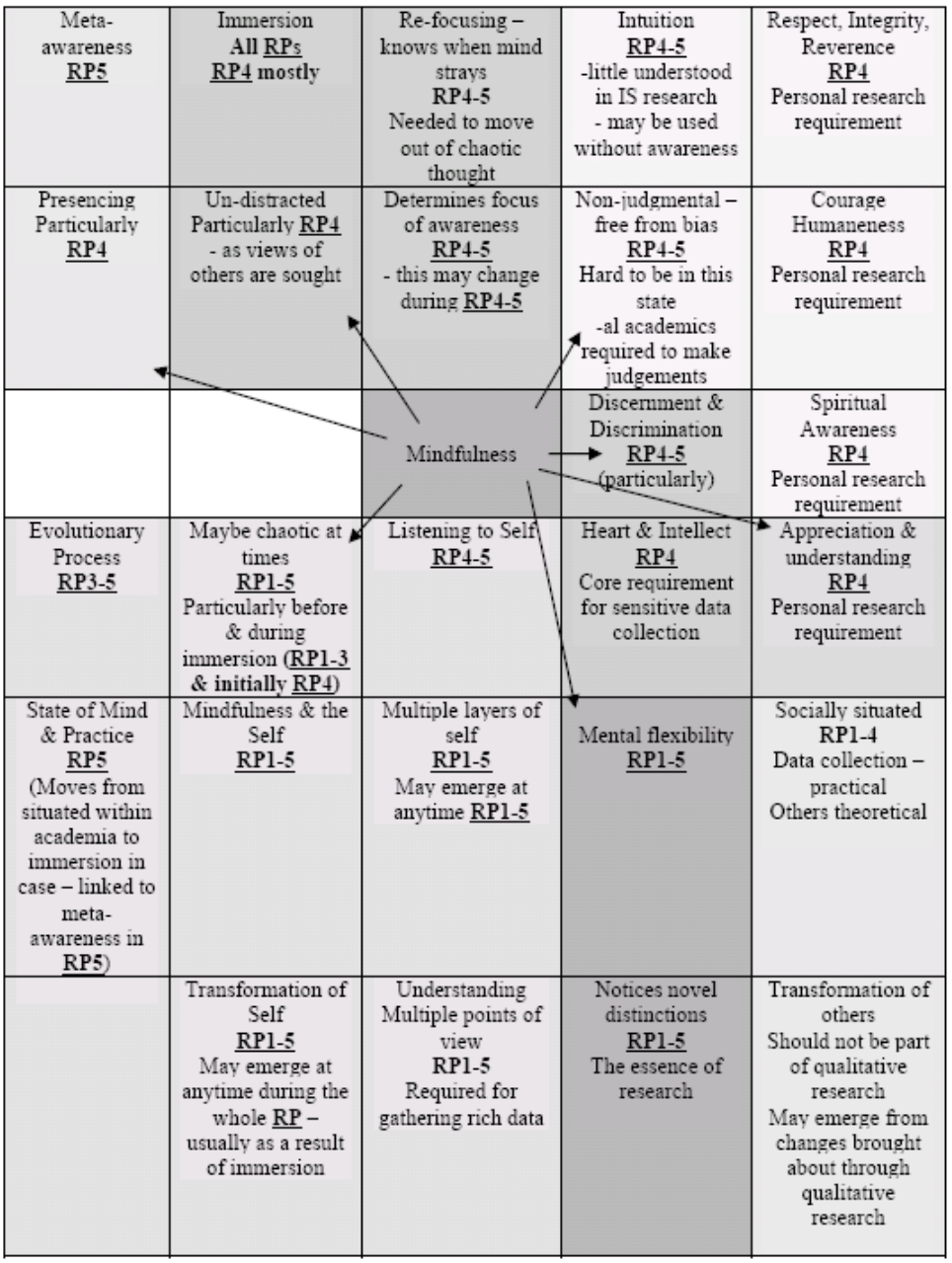
Meta-Awareness

Meta-awareness is achieved through spiritual traditions(meditation and/or prayer). Meta-awareness is achieved by designers, artists, and innovators by flow immersion (Csikszentmihalyi,1979). Meta-awareness is a skill seldom taught, learned, or practiced in Western spirituality.

Presencing

Scharmer (2000) describes presencing as "learning from the future as it emerges" rather than reflecting on past experiences(p.18). Presencing about foresight when applied to research practices and is a necessary mindful quality related to but different from meta-awareness. Meta- awareness is being aware of what is happening as it happens, while presencing is the ability to learn from the future

Figure 1. Research phases(RP) and mindfulness



(Note 1: Denzin and Lincoln's(2000) Research Phases; Note 2: Fielden's (2005) mindful dimensions)

as it emerges. Both meta-awareness and presencing are situated on the same timeline continuum and on similar levels of conceptual abstraction in interpreting research findings(Figure 2).

THE RESEARCH PROCESS

Most IS research is situated within a specific time and place in an organisation.

An essential tool for all IS researchers is the ability to see novel distinctions as the research process unfolds. An understanding of how one becomes immersed in the research domain and being one's own inner observer also helps in developing an understanding of multiple points of view and the self transforms during the whole research process(Figure 2).

Research Phases 3-5

An understanding of research as an evolutionary process emerges during RP3 and may be present, especially in qualitative research during data gathering, analysis, interpretation and presentation of research findings.

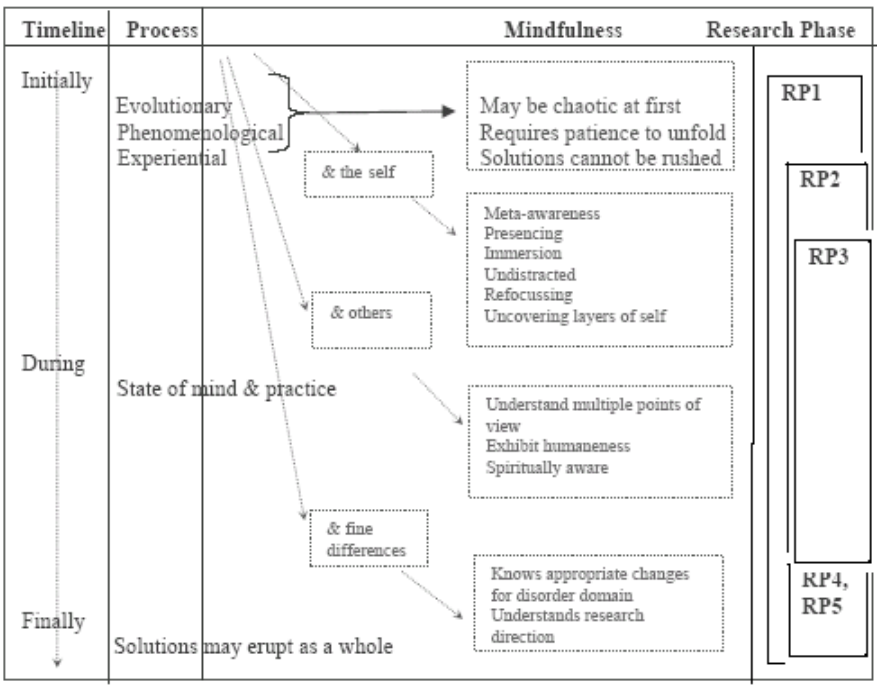
Research Phase 4

Mindfulness is critical at RP4 as the IS researcher enters the researched domain. The socially-situated characteristics of respect, integrity, courage, humaneness and appreciation of others all influence the way in which the researcher conducts data-gathering exercises. Understanding of how heart and mind work together and a deeper spiritual awareness are all mindful characteristics required.

Table 1. Pragmatics, process & philosophy/research phase

RESEARCH PHASE		PRAGMATICS	PROCESS	PHILOSOPHY
RP1	**RESEARCHER** Academic researcher image, subjective self in the process	Little historical or political view of research context in business How to enter business domains	Multiple roles Proposal approval Power and control issues	May have academic philosophical knowledge e.g. systems theory, appreciative systems . . .
RP2	**THEORY** Situated within philosophical foundations			Theory resides within this domain
RP3	**STRATEGY** Situated within academia, about research context (practice)	Suitable theory may not be practical	Ethical dilemmas, proposal approval	Research strategy situated within academia
RP4	**DATA COLLECTION** Pragmatics – informed by philosophy and formal process	May have emergent results Cultural issues may arise May have communication dilemmas What is not said or is not permitted to be said	Ethical dilemmas at data collection Language of data collection tools may be academic Distorted results	
RP5	**INTERPRETATION** About research context embedded in theoretical language	Reporting & interpreting emergent results Reporting language Missed data not reported or analyzed	What to report – political correctness What is not reported What is accepted as legitimate research Acceptance of emergent results	Results embedded in philosophical, academic interpretation

Figure 2. Mindfulness qualities and the research process



Research Phases 4-5
Mindful characteristics required at both RP4 and 5 are intuition, re-focussing, determining the focus of awareness, non-judgement, discernment, and listening to self.

Research Phase 5
When research findings are examined for meaning the mindful researcher brings to bear a level of meta-awareness about state-of-mind both in academia and in the researched domain.

Regardless of whether IS research is positivist, interpretive, or critical there is little influence from socially-constructed application domains when exploring philosophical frameworks. It therefore seems inevitable that little or no theoretical understanding of IS research crosses into these domains(Table 1).

When mindful qualities are applied to typical research project timeline(Figure 2) researchers different mindful qualities are required depending on the research phase. Initially an awareness and familiarity with chaotic thought processes is required. During the research process a deeper understanding of immersion and self experiences are beneficial. Social interaction within the research domain requires an understanding of multiple points-of-view and humaneness which enrich both the participants and the researcher. When research data is analysed(RP4-5) mindful qualities that find fine differences are required.

In RP1 an IS researcher is usually situated within academia, and 'knows the self' as an academic researcher(Table 1). Research rules, proposal approvals and ethical considerations all form part of the research process in the academic domain. Philosophically, academic research is usually grounded in a recognised body of theory; and builds on the research of others. The IS researcher therefore has little knowledge of the situated self in the world of the application domain.

RP2 is conducted entirely within academia where theoretical paradigms and perspectives are explored and is the domain in which mindful qualities are most easily applied as the researcher is within her/his own 'comfort zone'.

RP3 is the traditional starting point for most IS research – setting research strategies and this takes place within academia(Table 1). Theoretical ethical dilemmas are resolved, proposals approved and boundary setting for potentially unknown situations take place. RP3 provides many situations in which chaotic thought processes occur as planning for the unknown takes place.

In RP4 data is collected and analysed and it is here that the IS researcher moves from the sheltered world of academia into the less familiar research application domain. It is in RP4 that many mindful characteristics(Figure 2) are required as socially-situated and empathetic knowing is activated. It is likely that the more mindful the researcher the richer the data gathered. Whilst the mental models underpinning RP4 are grounded in academic theory and philosophy, this does not necessarily mean that the IS researcher is equipped to gather data in a mindful manner.

The final stage of the research process is, once again situated within academia. Research results are embedded in the underlying theory and philosophical approaches and written in academic language. Pragmatically, issues surrounding the interpretation of data are underpinned by the mindful maturity of the researcher. This is rarely acknowledged or reported in research articles.

RECOMMENDATIONS

IS researchers who have become mindful practitioners are more likely to produce quality research findings that benefit both participants and academia. It is recommended that: mindful practices be included within IS research methods classes; and postgraduate supervisors be trained in mindful practices to support and develop their students as mindful researchers.

A suggested plan to train mindful IS researchers is to:

1. Increase the awareness of mindfulness by introducing practices and skills into research training curriculum;
2. train postgraduate supervisors and educators in both mindful practices and how to teach mindful practices;
3. Include awareness of multiple points of view in research training curriculum. One suggestion is to include an introduction to systems thinking, complexity theory and chaos theory; and
4. Role model mindful practices in teaching and supervision through dealing with uncertainty and chaos, mediated solutions, self-responsibility, respect for others and acting with integrity.

CONCLUSION

It is evident therefore that to become a mindful IS researcher requires more than the standard research methods training in which the steps of various research methods are learned and applied. Instruction in mindful skills should lead to higher quality research reports. If, however postgraduate supervisors do not practise mindfulness then these qualities developed in student researchers may not be recognised and therefore are not likely to be developed any further.

Quality research reports in the academic domain may be evaluated according to the rigorous way in which research was conducted. What if these rigorous results were gleaned from data gathered by insensitive interviews, poorly facilitated focus groups with a lack of awareness of the effect the researcher was having on the participants?

In this paper the concept of mindfulness has been applied to a typical qualitative research process(Denzin and Lincoln,2000). If indeed we are to become better IS researchers it seems a sensible approach to address ways in which the research process can be improved.

REFERENCES

Butler,T.(2001).Making sense of knowledge: A constructivist viewpoint. *AMCIS2001*,1462-1466.

Checkland,P.(1984).*Systems Thinking, Systems Practice*.Great Britain:John Wiley & Sons Ltd.

Csikszentmihalyi ,M.(1979).The flow experience. In G.Davidson(Ed.),*Consciousness: Brain and states of awareness and mysticis* (pp.63-67):Simon & Schuster.

Denzin,N.K.,& Lincoln,Y.S.(Eds.)(2000).*The Handbook of Qualitative Research*(2nd ed.).Thousand Oaks,California:Sage Pub.

Fielden,K.(2005).Chapter 11:Mindfulness: An Essential Quality of Integrated Wisdom. In J.Courtney, J.D.Haynes and D.Paradice(Eds.), *Inquiring Organizations:Moving from Knowledge Management to Wisdom* (pp. 211-228). Hershey, USA:Idea Group Inc.

Glasser,B., & Strauss,A.(1967).*A Discovery of Grounded Theory.* Aldine,Chicago.

Langer,E. J.(2000).Mindful learning.*Current Issues in Psychological Science,9*(6),220-
223.

Reason,P., &Bradbury,H.(Eds.). (2001).*Handbook of action research: Participative inquiry and practice*.Thousand Oaks,CA:Sage.

Scharmer,C.O.(2000).Presencing: Learning From the Future as it Emerges: On the Tacit Dimension of Learning Revolutionary Change. In *Conference on Knowledge and Intuition,May 25-26*.Helsinki,Finland.

Wheatley,M.(2001a).Listening. *Berkana Institute Writings.* Retrieved September 26, 2004, from *http://www.berkana.org/resources/listening.hmtl*

Wheatley,M.(2001b).Partnering with confusion and uncertainty. *Shambala Sun. http://www.margaretwheatley.com/articles/partneringwithconfusion.html*

Zukav,G.(1989).*The Seat of the Soul*. New York:Simon and Schuster Inc.

Towards Metadata and Data Standards for Semantic E-Governance Services in India

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ABSTRACT

E-Governance facilitates outreach of government services to the citizens with help of information and communication technology. Metadata has been considered as an essential element in any digital environment. The paper discuses the Indian e-Governance efforts and enlists its different initiatives. The role of MetaData and Data Standards (MDDS) in e-governance is highlighted. Need for Interoperability in e-Governance is also discussed. A conceptual model towards achieving MMDS is presented.

INTRODUCTION

Internet has a marked impact on the methods of communication, business processes, commerce, research and academics as also in governance. Though it was primarily the businesses and also academics and research communities that initially adapted Internet into their activities, governments have also realized the importance of online reach to citizen and end users [Butt and Persaud, 2005]. One of the chief challenges for government departments is to outreach their programs to the wide spread communities considering physical aspects, such as distance, weather, terrains etc. E-mode of operation presents a viable and efficient option to governments to deliver services to the different sectors they deal with, overcoming the physical constraints. Also a larger mass of the end-users can be reached through e-governance systems. The use of Internet technologies has improved the effectiveness and efficiency of governance services [Agarkhani, 2003].

E-governance has different facets to it, in the sense that the models and the systems vary according to department and its services offered. Many e-governance systems - some domain specific and others task specific - have been discussed [Rotchanakitumnuai and Speece, 2003), (Sathye, 1999), (Doherty; Ellis-Chadwick and Hart, 2003), (Levy and Powell, 2003)]. The e-governance models depend on constitutional, cultural, economic fabrics of the government offering the services. This is evident is the differences that emerge between models adapted by different countries for their e-governance initiatives. [UkGovTALK**a,** AGLS].

In India, the National eGovernance initiative was started by the Government of India (GOI), with a vision to offer faster, improved and more efficient services, shared resources and services, increased productivity and to establish standardized systems and processes [NICa] to manage government services and serve patrons of different sectors.

1. E-GOVERNANCE IN INDIA

With a wide vision mentioned above and objective of outreaching government services to public, Indian government has started the e-Governance initiative. The main problems with individual systems for e-Governance developed in India so far is that there is too much data and not enough information. In the sense that there are no cohesive and meaningful services though a lot of data is available. Also the systems were developed independently as stand-alone with no common data architecture and are too expensive to bridge [NICa]. GOI aims to address these issues through the National E-governance Action Plan (2003-07). A few initiatives taken in this regard are as follows:

- Initiative on Digital Signature
- Initiative on EG Standard
- Initiative on India Portal
- Initiative on India Development Gateway (InDG)
- Initiative on National e-Governance Service Delivery Gateway (NSDG)
- Initiative on Replication
- Initiative on Technology Development for Indian Languages (TDIL)
- Initiative on EG Capacity Building
- I T Act & Rules
- Assessment Framework
- State Data and Service Centres

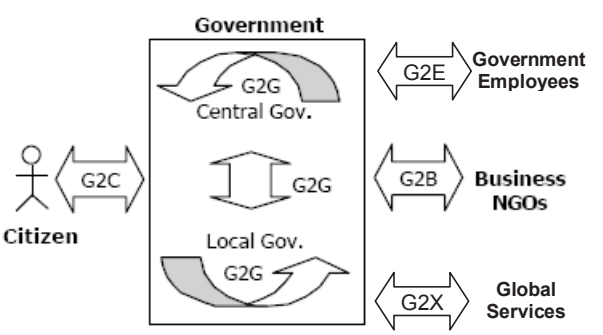
The work is taken up by National Informatics Centre (NIC), Department of Information Technology under the Ministry of Communication & Information Technology.

2. LEVELS OF INTERACTION IN E-GOVERNANCE

The level of e-Government services, NIC has defined, includes five main key players -Government, Citizen and Business, Employees, and Global Services. The most likely levels of interaction in this context can be: G2C, G2B, G2G, G2E and G2X.

- ***Government-to-Citizen (G2C):*** This is the interaction between Government and citizen. In this interaction, the citizens may utilize the information provided by the government at the service portal or gateway; sends email to concern government department, etc. For e.g. the farmer can check out the latest market price of wheat at the information portal containing latest crop prices.
- ***Government-to-Business (G2B):*** At this level of interaction, the business personnel can fill tenders, pay sales tax, enquire about the latest company laws, etc online to the concerned government department.
- ***Government-to-Government (G2G):*** This is the mode of interaction between two or more government departments for the smooth accomplishment of government functioning.
- ***Government-to-Employee (G2E):*** This is the mode of transaction between government to employee (Govt.) for accessing their pay slip, and other related

Figure 1. Interactions in e-governance [National e-Governance Plan, 2005]



transactions with the employer (i.e. respective Govt. Department). "Daily" is an intranet site of the Department of Rural Development, Govt. of India, promoting G2E governance within the ministry. It provides an easy, efficient and one-stop access to all information and services required by the employees to carry out their daily work [NIC, 2005].

- ***Government-to-Global Services (G2X):*** This is the mode of transaction between Government to various global services implemented and executed within the country or abroad.

In all the ways of communication at the levels indicated above, it is important that different stakeholders must have the ability to exchange and mutually use information. This is only possible when information is represented in meaningful manner with indicative tags. This is the function of metadata in e-governance.

3. METADATA

The most common definition of the term 'metadata' is structured data about data, information that describes other information. The World Wide Web Consortium has defined it as: "*machine understandable information for the Web*". For example, if a Web page has an author, a title, a date of creation and a unique Internet address, these elements constitute metadata about the page. Metadata is an Internet- age term for information that librarians traditionally have put into catalogs and it commonly refers to descriptive information about Web resources [Ercegovac, 1999].

A metadata record is a label, like the label we might find on an everyday product in a supermarket. The label describes the product, and quite often contains information that is useful both to consumers and to the electronic systems that control the store. The label contains data a person can understand, such as a list of ingredients, and data a machine can read, like a bar code [UKGovTalk, 2006].

Metadata labels are attached to documents and other information assets with similar aims in mind. By storing information such as author's name, version number, subject, we can help people to find information more easily, and allow computers to process it more effectively.

4. ROLE OF METADATA IN E-GOVERNANCE [EGMS, 2004]

Metadata standard can be used to classify and categorize Government information and services, facilitating identification of services and information intelligently. Inter-departmental information exchange becomes easier. Hence, metadata increases the visibility and accessibility of Government services over the Internet [Weibel, 2005]. Modernizing Government calls for better use of official information, joined-up systems and policies, and services designed around the needs of citizens. Metadata makes it easier to manage or find information [EURIM, 2002], be it in the form of web pages, electronic documents, paper files, databases, anything. For metadata to be effective it needs to be structured and consistent across organizations.

However while metadata aims to represent what data it carries, it is also important that the data itself should be represented following international standards in order to achieve interoperability between systems.

5. DATA STANDARDS

It can be said as, agreed upon terms for defining and sharing data. According to ISO, a standard is "documented agreements containing technical specifications or other precise criteria to be used consistently as rules, guidelines, or definitions of characteristics, to ensure that materials, products, processes and services are fit for their purpose." There are several types of data standards including terminology standards and message format standards [PHDSC, 2006].

Some important data standards which are commonly used in e-Governance services are:

- Author name format
- Personal information
- Address information
- Date/Time format
- Organizational information
- Financial Information; among others

6. INTEROPERABILITY ISSUES

Interoperability means the ability of information and communication technology (ICT) systems, as well as, of the business processes they support in order to exchange data and enable the sharing of information and knowledge [Edutools Wiki].

6.1 Why Interoperability

Effective e-Government results in reducing the amount of paperwork, streamlining processes and considerably enhancing citizen services and government communication. There are indeed many reasons that motivate governments in e-Government implementation, e.g.:

1. Reduction of expenditure: reducing time spent on administration, thus resulting in cost savings;
2. Improvement of professionalism in agencies management and modernization of the internal organization: e-Government will make internal government processes and external interaction more efficient;
3. Improvement of the quality of service and customer satisfaction.

It is ideal that each government department's information is encoded in the same format and also the services are planned in similar layers of data representation, service model and interface layers. But often this is not possible in practical governance. Each department has its particular needs in terms of data sets and also the expected forms of interaction and ultimate delivery of services. Hence, the e-governance method varies form department to department. Also, another reason for disparity arises because different department have moved to e-governance at different times and follow the standard and technology available at that time. Added to this is the disparity of cultural influences in approach to information and hence its representation. Another level applicable to diverse nation such as India is the multi-lingual communities that warrants cross lingual retrieval. This particular issue however, is outside the scope of this paper.

All of the above reasons warrant that measures of interoperability be implemented in e-governance system.

6.2 Crosswalk

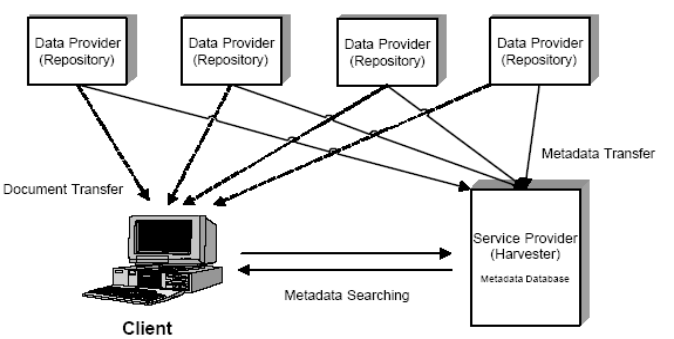
Crosswalks or metadata mapping support the ability of search engines to search effectively across heterogeneous databases, i.e. crosswalk helps to promote interoperability [LAOAP]. Crosswalk may be achieved through a table that maps the relationships and equivalencies between two or more metadata formats. This is rather simply said than possible, because of the wide disparities in metadata sets and data representations in practice.

6.3 Harvesting Technology

Harvesting refers to the gathering together of metadata from a number of distributed repositories into a combined data store [OAI, 2002].

One of the most interesting recent developments in the digital library arena involves the Open Archives Initiative (OAI). The Open Archives Initiative emerged out of the scholarly communications arena as a means to provide interoperability among multiple information sources. The communications model of OAI relies

Figure 2. OAI-PMH architecture



on the bulk transfer, or harvesting, of metadata between a service and all its data providers, based on a set of very simple protocols.

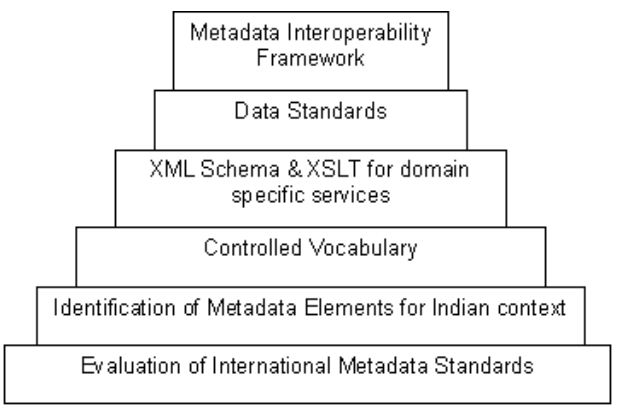
The OAI universe is based on information repositories, or "data providers," that make their metadata available, using a prescribed set of protocols, to "service providers" that build new information resources. End-users gain the benefit of OAI-based services that aggregate the metadata of multiple OAI repositories. It is to be noted that OAI operates with metadata, not complete works of digital content. In most cases the metadata include links back to the original information repositories for access to the documents or other digital objects [Mittal, Kumar, Mohania, Nair, Batra, Roy, Saronwala, and Yagnik, 2004].

7. ROADMAP TO INDIAN E-GOVERNANCE METADATA AND DATA STANDARD

Steps for developing metadata and data standards for e-governance are as follows:

1. **Evaluation of international metadata standards:** Some major e-governance standards has to be studied and evaluated to get the idea about the basic elements, metadata descriptors, vocabulary control and metadata management mechanism for development of metadata standard
   a. e-GMS
   b. GILS
   c. AGLS
   d. NZGLS
2. **Identification of metadata elements for Indian context:** Selection of basic metadata element sets and in conformity with the world standard for e-governance. As well as various application profiles suitable for the needs of various domains like agriculture, finance and economy, etc has to be developed.
3. **Controlled vocabulary:** Each government sector has its own vocabulary regarding it function and subject area. Therefore, two controlled vocabulary lists have to be prepared: one dealing with the services and another with the subject terminology.
4. **XML schema and XSLT for domain specific services:** To start web-based services, the domain specific service description has to be represented in the form of XML/RDF/OWL (Ontology). Its presentation on the web browser has to be taken care by their XSLT.
5. **Data standards:** The data which are to be input in the respective metadata fields also require standardization in terms of author name format, date format, organizational information, financial information etc.
6. **Metadata interoperability framework:** This framework is to ensure the interoperability between various services from diverse domains.

Figure 3. Roadmap to metadata standard for e-governance in India



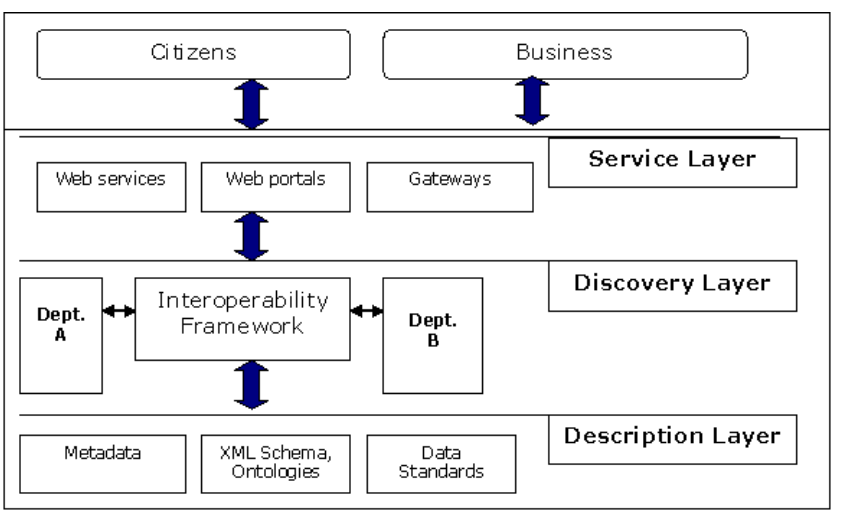
7.1 Use Case based on Conceptual Model for Metadata and Data Standard

The conceptual model has been framed to explain the role of metadata description in e-governance services. This also shows the usability of data standards in the given context. For example, a citizen looking for the information on agriculture can interact with the web portal providing the web services. The web service providing the required information is based on the interoperability framework. This interoperability framework works to translate the content of two different databases using different content representation format into the desired format. In databases, content is described using the e-government metadata elements in form of ontologies. The values of each of these elements can be standardized with pre-structured data standards. One of the instances is a farmer's enquiry for the best prices for his commodity. Ideally the query should return the best priced market with nearest reach. It combines departmental information about agricultural commodity, related markets, and other information like weather, transport etc. The interoperation is achieved through representation or description layers that support the discovery layer as shown in the conceptual model below:

8. CONCLUSION

e-Governance is quite complex to achieve with variance in the communities, services and formats among several other factors. Metadata plays an important role in providing a proper and standard representation of the e-governance metadata. But in many e-governance services and departments where data is different, there would be need for different sets of metadata elements for comprehensive representation. Yet other scenario is that different departments started e-governance with different data sets, standards and technological tools. This brings to for the problem of variation in standards and the only way to bridge this kind of

Figure 4. Conceptual model of interoperability framework for e-governance in India



disparity is to build crosswalks so that even when the end user approaches are different for the same data, it is still retrieved. Further, true interoperability can only be achieved when semantic interoperability can be achieved. A model, as illustrated, that is based on ontologies along with the metadata and standard data representation, in the description layer, would facilitate the discovery layer in vending services to patrons in varied scenarios.

9. REFERENCES

1. AGLS metadata element set. http://www.naa.gov.au/recordkeeping/gov_online/agls/metadata_element_set.html
2. Asgarkhani, M. (2003). A strategic framework for electronic government. Proceedings of the 22nd National IT Conference, Sri Lanka, pp57-65.
3. Butt, Irfan and Persuad, Ajax (2005). Towards a citizen centric model of e-Government adoption. Proceedings of the 3rd Intenational Conference on e-Governance, Lahore, Pakistan, pp6-15.
4. Doherty, Neil; Ellis-Chadwick , Fiona and Hart , Cathy (2003). An analysis of the factors affecting the adoption of the Internet in the UK retail sector," Journal of Business Research, vol. 56, no. 11, pp. 887-897.
5. eGMS (e-Government Metadata Standard), Version 3.0, (2004). http://www.govtalk.gov.uk/documents/eGovMetadataStandard%2020040429.pdf
6. Edutools Wiki. Glossary Analysis. http://www.edtechpost.ca/pmwiki/pmwiki.php/Main/GlossaryAnalysis
7. Ercegovac, Z. (1999). Introduction. Journal of the American Society for Information Science, Vol. 50, no. 13, 1165- 1168.
8. LAOAP. Latin America Open Archives Portal- glossary of terms. http://lanic.utexas.edu/project/laoap/glossary.html
9. Levy, Margi and Powell, Philip (2003). Exploring SME Internet Adoption: Towards a Contingent Model," Electronic Markets, vol. 13, no. 2, pp173-181.
10. Mittal, P. A.; Kumar, M.; Mohania, M. K.; Nair, M., Batra, N.; Roy, P.; Saronwala, A.; and Yagnik; L. (2004). A framework for eGovernance solutions. IBM Journal of research and development. Vol. 48, no. 5/6. http://www.research.ibm.com/journal/rd/485/mittal.html
11. National e-Governance Plan (2005). Approach and key components. http://www.mit.gov.in/plan/NGEP/NEGP11-03-05/NEGP%20WS%20Pres%20-%2011%20Mar%202005.ppt
12. NIC (National Informatics Centre), (2005). Good governance through ICT. NIC: New Delhi. 2005.
13. NICa. Metadata and data standards for e--Governance Applications. http://egovstandards.gov.in/standards_metadata_app
14. OAI (Open Archives Initiatives) (2002). Information Today. http://www.librarytechnology.org/ltg-displaytext.pl?RC=9627
15. PHDSC (Public Health Data Standards Consortium) (2006). Public Health Data Standards Tutorial - Glossary of Terms. www.phdatastandards.info/knowresources/tutorials/glossary.htm
16. UKGovTalk (2006). A layman's introduction to metadata www.govtalk.gov.uk/documents/Laymans_guide_to_metadata%20v1.1.doc
17. EURIM (2002). Interoperability- Joined Up Government Needs Joined Up Systems. The European Information Society Group, Briefing No 36. www.eurim.org.uk/resources/briefings/br36.pdf
18. UkGovTALK**a**. GovTalk- Information on policies and standards for e-government. http://www.govtalk.gov.uk/
19. Weibel, Stuart L. (2005). Reflections on a decade of metadata consensus building. D-Lib Magazine. Vol. 11, no. 7/8.

Knowledge Based Approach for Lithuania: Knowledge Cluster's Origin Development and Vision

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ABSTRACT

The paper aims at emphasizing the importance of knowledge management as a pilot project for investment productivity and competitiveness, presenting Lithuania as knowledge management case study. To show Lithuania's move in the direction of a knowledge-based-growth via creating a network of knowledge institutions, the "Sunrise Valley" and projects, present the vision and challenges of these projects and institutions as well as roots and origin of newly-born Lithuania's knowledge cluster with its infrastructure and future prospects. The researcher also made an attempt to study broader empirical /practical processes, that took place in transition economies including that of Lithuania, since it's experience might be adapted to other emerging market economies in the nearest future

Keywords: Business process outsourcing (BPO), knowledge economy (KE), knowledge management (KM), information and communication technologies (ICT), research and development (R & D), knowledge cluster (KC).

1. INTRODUCTION

The 21st century knowledge revolution created new opportunities and possibilities for the access and use of knowledge and information. The transition towards a knowledge-based economy requires from policy makers to understand the comparative strengths and weaknesses of their countries and then act upon them by developing appropriate short- and long- term policies and investments. In today's global economy, knowledge has become an even more decisive factor of competitiveness, productivity and growth. The global digital/knowledge economy offers unprecedented opportunities to produce and sell on a mass scale, reduce costs, and customize to the needs of consumers – all at the same time. Whether you live in a large country such as the USA or China, a medium-sized country such as India or Canada or a smaller country like Lithuania, your potential market is of the same global size. And you can source (net source) inexpensively wherever you wish.

2. THE SWOT ANALYSIS OF THE LITHUANIAN HIGH TECH INDUSTRIES AS STARTING POSITION FOR LITHUANIA'S MOVE IN THE DIRECTION OF A KNOWLEDGE BASED GROWTH

Every country possesses its own strengths and weaknesses, opportunities and threats. In spite of the heavy burden of the Soviet occupation legacies, after regaining its independence in 1990 Lithuania embarked on a path of determined, radical, and sustained reforms aimed at re-establishing democracy and functioning market economy. It succeeded remarkably and is now regarded Europe's transformation success story. At the same time Lithuania was in position to answer the question: what could and should a low – income country with an educated population do to exploit new opportunities associated with the knowledge revolution?

When the WTO&ITC team compared Lithuania's ICT industry with similar industries of the countries in the region, the conclusion was made that the industry was developing and expanding its activities across the region. In the EU market, activities related to sub-contracting or onshore software application were taking place.

Although the conclusion was drawn that Lithuanian ICT industry was relatively small compared to the ICT market of Poland, for example, it has good growth potential driven by niche areas and niche products.

Table 1 shows the results of the WTO & ITC team's research of Lithuania's ICT industry based on analysis of its strengths, weaknesses, opportunities and threats (SWOT).

3. A KNOWLEDGE MANAGEMENT APPROACH FOR LITHUANIA

In spite of the fact that knowledge industries in Lithuania are not sufficiently advanced yet as compared to global leaders, some pioneering firms that were created at research institutes do have histories going back a decade or so, especially those in biotechnology, laser research, etc. At present scientific-experimental lasers made in Lithuania can be found in 22 European Universities,10 USA Universities,15 Universities of Japan and 2 Australian Universities. According to Gartner Inc. expert's evaluation, the growth of the Lithuanian IT outsourcing market accounted for 40 percent in 2003 alone. Lithuania is rated as one of the most attractive providers of this type of service in Eastern Europe.

A national political consensus was reached and the national agreement was signed To encourage Lithuania to become a knowledge-based economy. The term "knowledge-based economy" has been coined to reflect an increase of importance of knowledge as a critical factor for economic performance.

The decision was made that a further development of the knowledge-based economy infrastructure (e.g. better access to high-speed Internet) was needed. That would necessitate a better public sector-private sector collaboration so as to arrive at innovative management models and strategies underpinning the knowledge economy in Lithuania.

Widening and deepening of the European integration markedly increased competitive pressures, so companies began looking for new, sustainable and dynamic advantages. Given that the continent is aging quite rapidly and immigration presents a problem for a number of reasons, a shortage of qualified work-force is developing, which can be best addressed by taking advantage of the digital/knowledge revolution and of the potential of the new EU members such as Lithuania.

Under these circumstances, a better use of the continent's resources has become critical to winning the competitive game or surviving in unified Europe and the integrated world.

Large European and multinational corporations (e.g. BT, Buckman Labs, Nokia, Siemens, etc) are the early adopters of new thinking. They first realized that high initial costs of research, human/intellectual capital costs, etc, are efficiently spread only over longer periods and larger geographical areas. The vision they have, specifically their new-frontier mentality and the ability to develop integrative thinking across functional areas of business, not only at the highest management levels but, what is even more important, at lower management levels, resulted in knowledge-sensitive enterprise cultures and the resultant organizational learning regarding new business models and strategies. Also, such issues are pretty high on the EU institutions' agenda (e.g. Lisbon Strategy). The unique European competitive advantage (e.g. as compared to that of the USA) is that the EU institutions are able to give push and pull to many continent-wide initiatives that fall within the public goods category (e.g. earlier adoption of continent-wide standards for

Table 1. The SWOT Analysis of the Lithuanian ICT and Other High Tech Industry: Summary & Outline

Strengths	**Weaknesses**
Human resources suitable for innovative activities and knowledge-based production; Healthy economy, growing most rapidly among the CEE (5-6% for 2001-2005); Well-developed high tech & other universities producing over 500 specialists in ICT and other disciplines annually; Other well-trained & low-cost human resources available; Modern telecom infrastructure with a digitalization ratio of 100% and mobile penetration of some 50%; Labor force versatile in English, German, Russian, and Polish; Open economy with rule-based system aligned to the EU & WTO – economic stability; Developed financial institutions & intermediaries; Location between the EU, Nordics, the Commonwealth of Independent States (CIS); Capacity to promptly adapt to rapidly changing ICT & knowledge based economy; Full scale privatization accomplished; industry re-structured based on comparative advantages; Institutional support to SME development; Well developed IT infrastructure across the region; Sound linkages between academia and industry for development of applications The EU and NATO integration to provide large market opportunities for ICT-enabled services.	Manpower adequately skilled but needs re-training on project management and quality management of ICT projects; Slow drafting and implementation strategies of ICT & other high tech; Vague long-term vision for ICT development including action plans or prioritization of funds; Comparatively small market - small investment by MNCs; Foreign economic relations still to be formulated on the basis of national and EU interests; Capital market in the development stage; ICT penetration not sufficient to give a substantial boost to e-commerce and e-business development; Logistics management poor - railway transport system physically inadequate; Public-private partnerships weak & cooperation among economic entities underdeveloped; Insufficient incentives for R&D by business.
Opportunities	**Threats**
Development of labor-intensive sectors like computer science and knowledge-based sectors to serve a larger market of the EU and CIS; Availability of structural funds from the EU to provide support to business modernization, employment promotion, improvement in quality of life, etc; Industrialization processes based on FDI, advanced technology and international management experience to enhance competitiveness and leverage advantages to achieve export-led growth; EU accession to expand sales markets and provide preconditions for foreign trade; Globalization of financial resources will provide alternative possibilities for financing; Use of digital technologies will open wider markets and provide conditions for more efficient cooperation with advanced economies in ICT, BPO, R&D, and other IT enabled services; Possibility to establish positions in the transport service markets of continental Europe, with logistic centers in Kaunas, Klaipėda and Vilnius; Free movement of IT and high tech personnel to provide opportunities for application development and onshore software development;	Emigration weakens the intellectual potential of Lithuania; Potential closures of domestic ICT companies due to fierce competition unless they develop sustainable niche markets; Fear of becoming a center of higher cost production because of alignment with the high-cost EU and trade distortions imposed by third countries; Loss of General Preference Systems discounts for exports to North America and Japan; International environmental obligations may lead to higher costs of production; Advanced ICT countries may wrongly see Lithuanians as consumers and not as developers/partners for modern products and services thereby leaving Lithuania out of BPO networks; Lack of coherent vision of the Lithuanian industry; Inconsistent policies and inadequate communications may lead to fragmented growth of IT and other high tech industry.

Source: Based on the WTO&ITC research and the authors' research.

mobiles, knowledge management practices, etc).

The main criterion for becoming a full member of the EU is the capability to withstand the European competitive pressures. While in the first period lower labor costs do provide certain competitive advantages pretty much across the branches of economic activity, this factor is of rather short duration in the case of Lithuania or other transitional economies. Lithuania will need to develop higher added-value market niches that will precisely call upon the Lithuanian capabilities to create an entrepreneurial economy that is integrated continentally and globally. Knowledge-based economy provides such opportunities especially in the context of knowledge and innovation in the European and global business.

A significant challenge posed to Lithuania is how to use a considerable theoretical research (e.g. biotech, lasers, semiconductors, game theory) potential of the Lithuanian research institutes, universities, and industry. There is a need to develop a practice-oriented strategy for knowledge-based economy in Lithuania.

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4. THE KNOWLEDGE- BASED PROJECT – "SUNRISE VALLEY"

In the present-day world separate market participants are unable to achieve good results which knowledge-based economy requires.

The key for solving problems are networks, clusters and other common activities. In the network of such knowledge-based institutions there are such popular objects of knowledge-based economy as knowledge camps, houses, towers, islands, technological parks, valleys, etc. One of such innovative schema is "Sunrise valley" in Vilnius, which was deliberately modeled after the Silicon Valley, California, where "Eastman Kodak", "General electric", "Intel Fairchild", "Lockheed", "Hewlett Packard" and other companies started and developed their activities.

Knowledge-based economy clusters are successfully created near Universities in different countries. Our neighbors-the Nordic countries are successfully developing in this direction. In recent years Finland and Sweden has twinkled their resources for R&D, especially in the last decade, and that influenced the growth of a high tech level of production in exports of those countries. Technological parks "Kista" and "Technopolis" are well known knowledge-based economy clusters all over the world. The neighboring country Poland can also boast great achievements

in this field of activities. Poland is successfully developing the 45 ha square Technological Park "Technoport" near its capital Warshaw. Good conditions for successfully activities started in Vilnius "Sunrise valley" where special social enterprise "Sunrise valley" was established in May 2003.

Vilnius University and Vilnius Gediminas Technical University, as well as well known Lithuania's corporate leaders: ALNA, SONEX, OMNITEL, BITE GSM, EKSPLA, Laser Research Institute, members of the Knowledge Economy Forum of Lithuania were founders of this public unit. In February of 2004 this project was joined by the Vilnius city municipality, which became a shareholder of this establishment. In reality "Sunrise valley" accumulated theoretical and practical potential of the best Lithuanian research Institutes, Universities, think tanks, consultants, firms and organizations and is ready to tap into the growing stock of global knowledge and adapt it to the local needs.

In the long run (till 2015) "Sunrise valley", the largest unit of Lithuania's knowledge cluster must be developed into the largest innovation centre in the Baltic states, where high added-value product and services will be created. Such a vision for "Sunrise valley" in the year 2005 was outlined by the International Consortium "Centre for Strategy and Evaluation Services", famous Technological parks from Great Britain, Sweden and experienced local business partners. According to the evaluations of the year 2015 in the territory of 2,5 ha about 150 new high tech enterprises with more than 3000 employees will be created, among them: the Innovation Center for the development of laser and IT, as well as the formation of a business incubator and a scientific–technological park. They will be companies established by Universities and Research Centers, where students, professors and researchers from those institutions will work.

5. CONCLUSIONS

The paper concludes that a knowledge- based economy is a wave of the future:

1. The transition towards a knowledge-based economy requires that policy makers understand the comparative strengths and weaknesses of their countries and then act upon them to develop appropriate short and long term policies and investments.
2. Lithuania will need to develop higher added-value market niches that will precisely call upon the Lithuanian capabilities to create an entrepreneurial economy that is integrated continentally and globally. Knowledge-based economy provides such opportunities especially in the context of knowledge and innovation in the European and global business.
3. Knowledge management provides a compelling platform to research the issues of upgrading competitive advantage in developed countries and contract out non–core competencies to emerging markets.
4. Conclusion was drawn, that Lithuania is moving towards a knowledge- based growth via creating a network of knowledge institution and projects and Lithuania's experience can be adapted to the former Soviet block countries. Post- communist and other emerging market countries such as Armenia, Czech Republic, Ukraine, Hungary, Poland and others are well advised to jump to these new opportunities as the latter provide the best chance to realize the "latecomer's advantage" by leapfrogging to technologies and models of doing businesses which are new for Western countries as well.

REFERENCES

1. Drucker, P. F. The practice of management. New York: Harper, 1954. 404 p.
2. Porter, M. E. The competitive advantage of nations. New York: The Free press, 1990. 396 p.
3. Samulevičius J., Samonis V. Business process outsourcing to emerging markets: A knowledge management approach to models and strategies // Outsourcing&Off shoring in the 21 st century. A socio-economic perspective. Idea Group, Inc. USA, Kehal, H., Singh, V., editors. 2006, p. 140-164.
4. Samulevičius J., Samonis V. International business strategies: Experience of outsourcing in USA Companies // Verslas, vadyba ir studijos,04. Vilnius, 2005, p. 186-194.
5. The strategy of knowledge management. A McKinsey Quarterly reader. 2006. www.mckinseyquorterly.com
6. Samulevičius J. Global business outsourcing: A knowledge management approach for emerging markets (Lithuania's case study) // 4th International Scientific Conference "Business and Management". V.: Technika, 2006, p. 226.

A Grid Based Approach for Dynamic Integration and Access of Distributed and Heterogeneous Information Across an Enterprise

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ABSTRACT

Information within an enterprise is often scattered across various administrative domains and geographical time zones. Moreover, such information is maintained in different databases in heterogeneous formats serving varied needs of different set of people. Need is often felt to integrate this information, spread across the enterprise, for strategic decision-making on a real time basis. In this paper, we introduce GRADIENT – an Enterprise Information Integration solution based on service-oriented architecture for accessing distributed information across an enterprise and for solving integration challenges associated with data heterogeneity and geographical spread. GRADIENT utilizes a grid based approach to distribute computational load of queries and realizes enhanced performance in real-time data integration.

Keywords: Data-Grid, Enterprise Information Integration, Distributed Query Processing

1. INTRODUCTION

Enterprises data is preserved in heterogeneous data sources/formats and dispersed across multiple administrative domains or geographical locations. Need is often felt to integrate such diverse data sources for strategic decision making on a real time basis. However, data integration is a complex and time consuming task due to the heterogeneity and semantic disparity of the underlying data sources. There are varieties of approaches for solving this complex data integration problem and they can be broadly classified into two as: Extract, Transform and Load (ETL) and Enterprise Information Integration (EII). ETL based solutions allow the disparate data sources to be extracted transformed and loaded into data marts or data warehouses for query processing on the integrated data. But, the major drawback of using an ETL solution for integrating disparate data sources is the latency and complexity involved in extracting, cleaning and transforming the data and then moving(also referred as loading) the transformed data into data marts or data warehouses. On the other hand, EII based solutions allow creation of virtualized view of the disparate data sources leveraging the existing infrastructure with little or no movement of data. This data virtualization is achieved in a manner that is transparent to the user. The key challenge in such data virtualization solutions is the complexity involved in integration of the distributed and heterogeneous data sources in real-time.

Grid computing is an ensemble of heterogeneous computing resources for solving complex computation intensive tasks. Data grid is a manifestation of grid technology that helps to achieve virtualization of the data stored in multiple heterogeneous databases stored across multiple locations [1]. Additionally, data grids enable sharing of computational load across different machines. Since EII solutions deal with huge volumes of data during data integration, it may be useful to investigate the use of data grids for queries involving high computational requirements to achieve superior information integration benefits. So, the primary motivation for our work is to combine the EII and data grid technologies to achieve enhanced performance in real-time data integration.

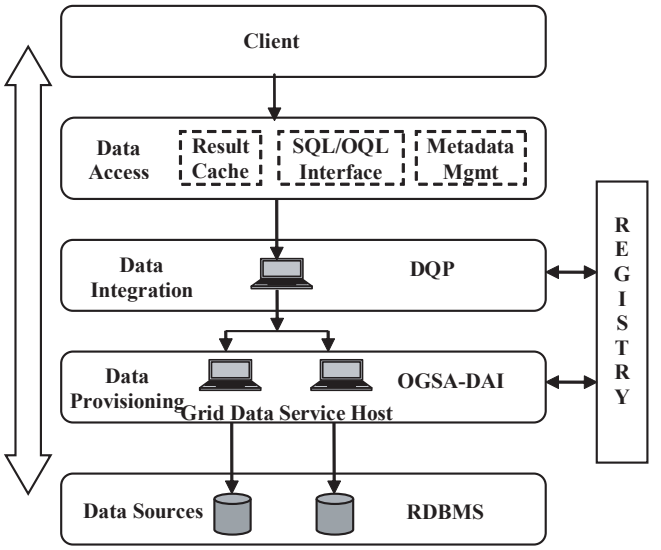
In this paper we present a grid based EII tool for accessing distributed information across an enterprise called GRADIENT (GRid Access of Distributed Information in the ENTerprise). GRADIENT is a service-oriented data grid solution that overcomes the limitations of ETL based data integration technologies and enables real-time data integration using data virtualization. GRADIENT allows the end user to seamlessly query disparate information sources using declarative query languages such as SQL. GRADIENT achieves greater scalability and performance using a distributed query processing engine. GRADIENT also addresses the semantic heterogeneity issues using RDBMS based metadata management system. Some of the salient contributions of this work include metadata management, advanced caching techniques and enhanced distributed query processing engine.

The rest of this paper is organized as follows. In section 2, we describe the proposed GRADIENT architecture. We deliberate on our preliminary experimental results in section 3 and provide concluding remarks in section 4.

2. GRADIENT ARCHITECTURE

GRADIENT is an EII solution that extends open source projects like the OGSA-DAI (*Open Grid Services Architecture – Data Access Integration*) [2, 3] and OGSA-DQP. Gradient offers a number of advanced features (like metadata management, advanced caching, enhanced distributed query processing engine) that were not supported in open source projects. Using Gradient as a Web Service or API, a client can invoke queries that involve join operations spanning multiple data sources using a single query without having the knowledge of the location of the underlying data sources and their formats. Figure 1, shows a high level architectural view of Gradient having three logical layers, namely, (1) data provisioning layer, (2) data integration layer, and (3) data access layer. We discuss the key features of each of these layers in detail in the following paragraphs.

Figure 1. High level architecture of GRADIENT



2.1 The Provisioning Layer

Provisioning layer provisions the data sources and exposes it as services. Gradient uses OGSA-DAI to expose disparate data sources as Grid Data Services (GDS). GDS accept perform documents (an XML document describing user queries) and parses and validates the query against the metadata extracted by GDS. GDS, then executes the query and constructs response XML document containing the query results. The OGSA-DAI has been extended to support metadata extraction of the data sources like Oracle, SQL Server, DB2 and POSTGRES. In future, we plan to extend it further to support other data sources.

2.2 The Integration Layer

The Integration layer in Gradient provides support for distributed query processing and is built on top of open source OGSA-DQP [3] project. The core distributed query processing engine of Gradient enables optimal sharing of the computational load intensive (e.g. join) queries. This allows for the parallel processing of a query using inter-operator and intra-operator parallelism. Since the database size usually exceeds terabytes, having different portions [4] of a query executed on different physical machines in parallel result in considerable improvement in query response times.

Gradient offers query processing and optimization support for declarative queries over a set of services that includes *databases services* and *computational services*. Database services use emerging standards of Grid Data Services (GDS) to provide a uniform and consistent access to different databases. Computational services are needed for performing query splitting and for executing different portions of the query on different computational nodes for achieving speed-ups. DQP is made up of two services:

I. *Grid Distributed Query Service (GDQS)*: GDQS, also called the co-coordinator, is responsible for (a) Retrieving and storing the metadata of each database (this is done only once during the installation of GDQS on the machine), (b) Creating the single node physical plan and then a parallel plan for a query through successive transformations using relational algebra and calculus, and (c) Scheduling the sub-plans of a parallel plan on the computational nodes. We extend GDQS by building upon the previous work of Polar* distributed query processor for grid [3]. The Polar* is implemented in OPTL-a database optimizer specification language defined by [5]. However, the query operators supported in the original version of Polar* were inadequate to handle the diversity of queries that a user may invoke from enterprise applications. We enhanced the functionality of Polar* to support various query operators such as or, not, in, like, aggregates and non-equijoins. These enhancements will allow the user to make more complex queries than were supported by the original version of DQP.
II. *Grid Query Evaluation Service (GQES)*: GQES, also called the evaluator, is used to execute the query sub-plans. Coordinator schedules query sub-plans on one or more instances of GQES based on decision made by the query optimizer. This allows sharing of the computational load since query processing tasks are often computation and memory intensive. In this context, the GQES is analogous to an idle computational node on a compute grid.

The schematic representation of a typical DQP environment is shown in figure 2. Nodes N_1 and N_2 hosts databases DB_1 and DB_2 respectively. The databases DB_1 and DB_2 are exposed using respective Grid Database Services (GDS). All the nodes also act as evaluators. Nodes N_3, N_4 and N_5 do not host any database and only act as evaluators for performing computation intensive tasks. Any query involving DB_1 and DB_2 will necessarily run on nodes N_1 and N_2 and can additionally employ nodes N_3, N_4 and N_5 for sharing the computational load of the queries.

2.3 The Access Layer

Access layer is the first point for the end user application to access the data exposed by the Gradient using standard SQL queries. In this layer, Gradient uses a metadata management service for input query parsing, query resolution and OQL generation. The GDS – a layer of abstraction that hides the heterogeneity of the underlying databases – provides a service oriented interface for extracting the metadata from the underlying data sources. The metadata which is stored as a relational database in a centralized location maintains all the information necessary for parallel query optimization. This central metadata repository is exposed as

Figure 2. Environment with DQP services

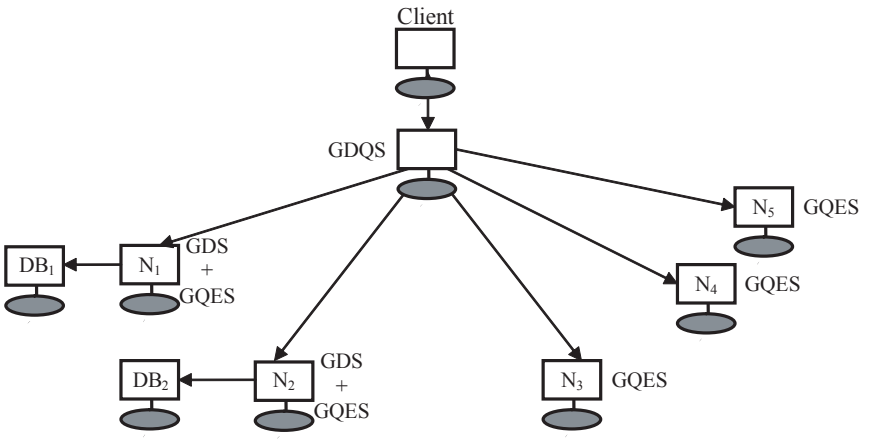
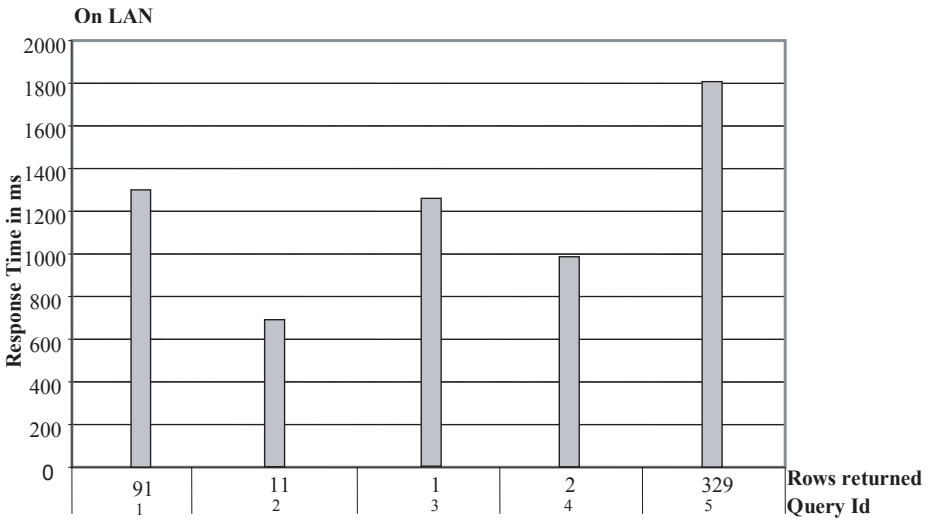


Table 1. Query types executed on GRADIENT

Query ID	Type of Query	Records Returned	No of records	Cross DB Join
1	Full Table Scan	91	91	DB2
2	Range Table Scan	11	34480	MYSQL
3	DB Equijoin	1	13278 * 91	DB2
4	Equijoin	2	34480 * 77	DB2 * ORACLE
5	Equijoin	329	34480 * 77	MYSQL * DB2

Figure 3. Performance Results for GRADIENT



a web service called the Global Metadata Service (GMS) and is responsible for much of the information virtualization talked about earlier. Gradient also employs a number of caching techniques such as data cache, query cache and metadata cache for improving the query response times.

3. EXPERIMENTAL RESULTS

We carry out extensive experimentation, with a Distributed Order Management System (DOMS) hosted on MYSQL, Oracle and DB2 for studying the performance of the Gradient system. GDQS is installed on a machine with Pentium 4, 2.8GHz processor and 1GB RAM. All the DQP evaluators were run on Pentium 4, 2.8GHz processor with 512MB RAM machines. We executed different types of queries ranging from a full table scan on a single database to cross database equi-joins. A complete list of queries used for the experimentation is provided in table 1.

Figure 3 shows the response time of the results for different queries executed in a LAN environment using Gradient.

4. CONCLUSION

The heterogeneity of the databases and the geographic dispersion of the data make it difficult to integrate the data and provide a transparent way of accessing this data by the user. In this paper, we presented an Enterprise Information Integration tool based on the service-oriented concepts and data grids, called GRADIENT. In particular, we elaborated on the metadata management, distributed query-processing and caching techniques implemented as a part of the solution. The Gradient is planned to support Metadata Synchronization, Adaptive Query Processing and Distributed Caching in the future.

REFERENCES

1. R.W. Moore and C. Baru, Virtualization service for data Grids, a book chapter in Grid computing: making Global infrastructure a reality, John Wiley and sons, 2003
2. K. Karasavvas, M. Antonioletti, M.P. Atkinson, N.P. Chue Hong, T. Sugden, A.C. Hume, M. Jackson, A. Krause, and C. Palansuriya. Introduction to OGSA-DAI Services. Pages: 1-12, Springer, Lecture Notes in Computer Science 3458, 2005.
3. M. N. Alpdemir, A. Mukherjee, N. W. Paton, P. Watson, A. A. Fernandes, A. Gounaris, and J. Smith. OGSA-DQP: A service-based distributed query processor for the Grid. In Simon J. Cox, editor, Proceedings of UK e-Science All Hands Meeting Nottingham. EPSRC, 24, 2003.
4. 2M. Tamer Özsu, Patrick Valduriez, Distributed and Parallel Database Systems, ACMComputing Surveys, 1996
5. L. Fegaras, and D. Maier, Optimizing Object Queries Using an Effective Calculus, ACM Transactions on Database Systems, Volume 25 , Issue 4, Pages: 457 – 516, 2000.

Communication Mode and Satisfaction with Mentoring

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ABSTRACT

This paper presents the results of one of a series of experiments done on mentoring and communication mode. In this study, the focus was on protégé satisfaction with the developmental interaction, and four communication modes were investigated: face-to-face (FTF), video-teleconferencing (VTC), telephone, and electronic chat. Between-subjects ANOVA was used to test for differences among mean satisfaction scores among protégés in the four different conditions. No significant main effect was found for communication mode on satisfaction, F (3, 68) = .64, p = .59. Trainees in all communications conditions found the developmental interactions to be satisfying.

Keywords: Computer-mediated communications; Human-computer interaction, Mentoring

INTRODUCTION

The changing nature of the employment contract, rapid advances in technology, and increasingly diverse organizational membership has led to an increased emphasis on continuous learning in an organizational context (Carnerdale, 1995; Higgins & Kram, 2001). Mentoring may serve as one form of non-traditional training in such a continuous learning environment.

Mentoring is typically considered a face-to-face activity. For a number of reasons -- increased knowledge specialization, the globalization of the economy, and the increased use of teams -- the degree to which such interactions would necessarily occur without participants meeting face-to-face is likely to increase. From the extensive literature on non-face-to-face communication, it is reasonable to assume that such communication may impact these interactions; however, little empirical research has been conducted on non face-to-face mentoring.

This paper presents the results of one of a series of experiments done on mentoring and communication mode. In this study, the focus was on protégé satisfaction with the developmental interaction, and four communication modes were investigated: face-to-face (FTF), video-teleconferencing (VTC), telephone, and electronic chat.

In the following section, a brief review of the mentoring literature is presented. In subsequent sections, the methodology and findings are discussed. The paper concludes with some suggestions for future research.

Mentoring

Traditionally, mentoring has been viewed as a relationship "... in which a senior person working in the protégé's organization assists with the protégé's personal and professional development (p. 265, Higgins & Kram, 2001)." More recently, researchers have investigated alternative forms of mentoring such as formal/assigned mentors (Ragins & Cotton, 1999), and peer mentors (Salinitri, 2005; Smith-Jentsch, et al., 2000).

Given that considerable evidence exists regarding the usefulness of mentoring for both the organization and protégés, there is organizational interest in promoting and facilitating such mentoring relationships. The degree to which such interactions would necessarily occur without participants meeting face-to-face is likely to increase as a result of telecommuting, virtual teams, and reduced manning. As Colky and Young (2006) pointed out, the benefits of virtual mentoring include lowered costs, increased access to mentors, and no limitations on space, time, and location. However, data is limited on the effectiveness of virtual mentoring. Thus, the focus of this study was on the effectiveness of mentoring in non-face-to-face settings.

METHODOLOGY

Participants

Protégés were freshman students recruited from Supplemental Instruction (SI) classes at a university in the Southeastern United States. SI classes are supplemental classes that the university instituted for courses that have historically high failure and dropout rates. There were 72 participants in the protégé sample. Of the 72 protégés, approximately 43% were male (n= 31) and 57% were female (n = 41). Their ages ranged from 18 to 20, with a mean of 18.32.

Mentors were juniors or seniors with at least a 3.0 cumulative grade point average. There were 18 participants in the mentor sample. Four of the mentors were juniors (22%) and 14 were seniors (78%). Of the 18 mentors, approximately 33% were male (n =6) and 67% were female (n = 12). Their ages ranged from 19 to 28, with a mean of 21.56.

Procedure

Protégés were randomly assigned to both mentors and communication condition. Each mentor had four protégés, one in each of the four communication conditions. Each dyad communicated for fifteen minutes, once a week for three weeks, using the same communication medium for all their sessions. The order in which mentors were exposed to the various conditions was counterbalanced to control for carry-over effects.

The laboratory set up allowed mentors and protégés to arrive for their sessions without meeting. In addition, mentors and protégés were asked not to contact each other outside out the laboratory, and to exchange first names only.

Measures

Because there was reason to believe that typing ability might restrict information exchange in the chat condition, and thus might be a covariate, all participants were given a typing test prior to starting the experiment; the *Keyboarding Skills Test*, a personal computer-based test purchased from RegSoft.

As with typing ability, it seemed likely that computer attitudes might have an effect on how favorably participants viewed the chat condition. Therefore, all participants were asked to answer a questionnaire regarding their computer experience prior to the start of the experiment (Levine & Donitsa-Schmidt, 1997). The reliability of the scale was $\alpha = .91$ for trainees and $\alpha = .93$ for coaches.

The final measure was a measure of satisfaction with the mentoring relationship, adapted from a 5-item scale developed by Finkelstein, Allen, and Rhoton (2003). The reliability for the five-item scale was .90.

RESULTS

There were no significant differences in computer attitudes or typing ability between the mentors and the protégés. For trainees, the mean net words-per-minute score was 33.5, with a standard deviation of 13.35. For coaches, the mean score was 34.17, with a standard deviation of 12.25. On the six-point computer attitudes scale, the mean score was 4.37 for trainees, with a standard deviation of .92. For coaches, the mean score was 4.56, with a standard deviation of .85. In addition, typing skill and computer attitudes did not significantly covary with satisfaction with the relationship.

Between-subjects ANOVA was used to test for differences among mean satisfaction scores among protégés in the four different conditions. No significant main effect was found for communication mode on satisfaction, $F(3,68) = .64$, $p = .59$. Trainees in all communications conditions found the developmental interactions to be satisfying.

Further analyses were performed to investigate if the lack of main effect was due to: 1) the sample's high levels of computer literacy, or 2) lack of power. The sample was split into two groups; those with mean scores equal to or less than three on the computer literacy test, and those with scores above three. Because the sample of those who scored less than three was very small, Levene's test for equality of variances was performed to check that the variances were not significantly different from each other. There were no significant differences between the two groups for satisfaction, suggesting that the lack of difference across conditions was not due to computer literacy.

The final possibility was that there was a lack of power. For satisfaction as the dependent variable, the amount of variability attributable to condition was .03 (partial eta-squared value), and the observed power, i.e. the power of the test when the alternative hypothesis is set to the observed value was .18 at $\alpha = .05$.

CONCLUSION

Although one can certainly conclude that this study did not have enough power to detect the effect of communication mode on the dependent variables, given that communications condition explains 1 to 3 percent of the variance in outcomes, is this, in practical terms, an effect? The power analysis suggest that it might be more useful, in terms of implementing non-face-to-face developmental programs, to focus on reducing the variability in the coaches' behaviors through training, than to focus on the effect of communication mode.

The two primary limitations of this study – the experimental design and the relatively novel topic – are, ironically enough, also two of its primary strengths. Because this study was experimental in design, there was control over the amount of interaction, the frequency of interaction, and prior acquaintanceship. However, in gaining this control, a certain amount of realism was lost; the interactions were very short, the sample was highly computer literate college students, and the participants appeared not to be driven by a specific knowledge needs, resulting in interactions that were primarily psychosocial rather than informational in nature.

The novelty of the topic area, although addressing both a void in the literature and a practical need, also resulted in a study that was different from much of the previous research. Although the research question "Can developmental interactions happen in a non-face-to-face setting?" required an unstructured task; this unstructured task makes it difficult to mesh the current research with the existing body of knowledge on communication mode effects. What the dyads in this study did *not* have to do was: solve a problem imposed by the researcher, reach consensus, or negotiate an outcome. Yet, these are precisely the types of tasks commonly found in research on the effects of communication mode (Graetz, Boyle, Kimble, Thompson, & Garloch, 1998; McLeod, 1992; O'Malley, Langton, Anderson, and Doherty-Sneddon, 1996).

For the dyads in the present study, there was no specific goal or objective other than to build a relationship that was satisfying and helpful; an objective that allowed the interactants a great deal of flexibility in terms of both evaluating the outcome and designing the process. Without the pressures imposed by a more structured task in the form of time limits, specific outcome requirements, or evaluative criteria, the limitation of the media may not have been as salient for these dyads.

A promising area for further research is suggested by this study. An interesting approach would be to replicate one of the earlier studies that used a structured task to determine if the passage of time, and the dramatic changes in communication technology, has changed the population's attitudes toward computer-mediated communications; and that the lack of an effect in this study might in fact be generalizable to a broader range of tasks.

REFERENCES

Carnerdale, A. P. (1995). Enhancing skills in the new economy. In A. Howard (Ed.), *The Changing Nature of Work* (pp. 238-251). San Francisco: Jossey-Bass.

Finkelstein, L., Allen, T., & Rhoton, L. (2003) An examination of the role of age in mentoring relationships. Group & Organization Management, *28*, 249-281

Graetz, K. A., Boyle, E. S., Kimble, C. E., Thompson, P., & Garloch, J. L. (1998). Information sharing in face-to-face, teleconferencing, and electronic chat groups. *Small Group Research, 29*, 714-743.

Higgins, M. C., & Kram, K. E. (2001). Reconceptualizing mentoring at work: A Developmental network perspective. *Academy of Management Review, 26*, 264-288.

Levine, T., & Donitsa-Schmidt, S. (1997). Commitment to learning: Effects of computer experience, confidence and attitudes. *Journal of Educational Computing Research, 16*(1), 83-105.

McLeod, P. L. (1992). An assessment of the experimental literature on electronic support of group work: Results of a meta-analysis. *Human-Computer Interaction, 7*, 257-280.

O'Malley, C., Langton, S., Anderson, A., & Doherty-Sneddon, G. (1996). Comparison of face-to-face and video-mediated interaction. *Interacting with Computers*, *8*, 177-192.

Ragins, B. R., & Cotton, J. L. (1999). Mentor functions and outcomes: A comparison of men and women in formal and informal mentoring relationships. *Journal of Applied Psychology, 84*, 529-550.

Salinitri, G. (2005). The effects of formal mentoring on the retention rates for first-year, low achieving students. *Canadian Journal of Education*, 28(4), 853-873.

Smith-Jentsch, K. A., Milanovich, D. M., Reynolds, A. M., Merket, D. M., & Eddy, E. R. (2000). An investigation of the unique effects of peer and traditional mentoring. Symposium presented at the annual meeting of the Society of Industrial and Organizational Psychology, New Orleans.

XML and Relational Data Integration: Best Practices and the Database Course Experiences

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ABSTRACT

Many database courses focus on fundamental aspects of relational design, data modeling, transaction processing, and backend database issues. Given the ever increasing importance of web enabled databases generally but particularly the influence of XML (eXtensible Markup Language) as a database enabling technology, the authors felt that an XML module should be integrated into both introductory and advanced database offerings. The focus of this paper is discuss issues related to the integration of XML and relational databases in an undergraduate IT curriculum.

1. INTRODUCTION

Advanced database courses traditionally cover the theory and concepts behind the design and implementation of relational databases. In recent years there has been mounting pressure to weave into this discussion content on integration with the Web as much e-commerce is facilitated by web-enabled databases. The purpose of this paper is to show how the authors enriched an advanced database class by adding an XML module that extended a typical a real world database project example with an integrated XML component. To do this we developed a database using Microsoft's SQL Server 2000, referenced several online tutorials, and created assignments to "pull" data from this database using the XML technology [1].

The remarkable history of the Internet and WWW, well-documented elsewhere, is marked in the mid 1990s by the increasing realization that for the web to facilitate e-commerce in a meaningful way, that production databases and web servers would have to be integrated so that ordering et. al. would be from real time inventories. With the explosion in web sites and web services designed to support this functionality, the limitations in HTML, the web's first language, became obvious [2]. Specifically, many businesses needed to pass data from dissimilar information systems (typically relational databases) via the web and HTML based web pages were not well suited to this requirement. The reason is that such transfers are greatly facilitated by a medium that describes the structure of data (so as to assist the receiving end in parsing / processing the data stream), a requirement that vanilla HTML cannot meet. This is where XML comes in.

Prior to the development of XML there were efforts to adapt the precursor of HTML, SGML (Standard Generalized Markup Language) to accommodate the requirements of web – enabled database applications. SGML was a descendant of IBM's Generalized Markup Language (GML), originally developed in the 1960s to enable the sharing of machine-readable documents in large projects in government. It had also been used extensively in the printing and publishing industries, but its complexity had prevented its widespread application for small-scale general-purpose use [cite = http://en.wikipedia.org/wiki/SGML]. So, when efforts to adapt SGML itself proved fruitless, Jon Bosak, Tim Bray, C. M. Sperberg-McQueen, and Jean Paoli of Microsoft, designed a simplified version of XML based on SGML that has since evolved into the standard XML that we have today [3]. Mind you, we say standard with some trepidation as there continue to be turf wars over how XML ought to be implemented and what valid extensions are, what the best support tool are and etc., but as is typical with important technologies, XML has taken on a life if it's own and isn't waiting for all the warring sides to completely define it but is being and has been usefully deployed in any number of organizational settings over the last dozen years; we try to acquaint our students with this reality as well.

So, XML today is not merely an extension of HTML, it is a meta-language that can be used to define a language particular to a business domain and allow the exchange of data using this defined language. For example, instead of just, say, the <H1></H1> tag pair that traditional HTML would offer that only has to do with how the text within tags is displayed, an XML tag has semantic value. An XML tag example might be <Whsle_Unit_Cost></Whsle_Unit_Cost> and such a tag would define the meaning of the data as well as the display format; i.e., data between the pairs would mean the wholesale unit cost of something, say a prescription drug, and an organization receiving an XML file so designed could easily import the data into their database systems. In short, XML allows a user to separate the presentation of data from its storage, meaning and management. This allows users a vast array of opportunities for using XML to exchange data with trading partners. This phenomenon alone justifies inclusion of XML technology in an advanced database class, in the authors' opinions. The XML enabled Medical Informatics Networks, Automotive parts networks and XML enabled ERPs (Enterprise Resource Planning Systems) that are evolving worldwide all give support to the penetration of XML within the database development community. [Both authors schools have adopted Banner, an Oracle based, XML enabled ERP for the academic environment].

Since its inception, XML has been adopted by many developers as a way to describe data sets and their contents and to define how the data should be output or displayed on a web page (or, significantly, a cell phone, PDA or any of a number of other human readable or machine readable devices). Before XML, a client application accessing a database needed to translate the result set returned to a format that could be understood and displayed by a web application. XML removed the need for client side processing (given a XML compliant client) as the data and its formatting were defined in the XML markup.

The importance of XML is further supported by the fact that Microsoft SQL Server 2005 supports XML, and the result sets can be returned directly in XML format, or data can be retrieved from an XML document as if it were a SQL Server table. Oracle offers a similar suite of functions. A list of XML terms and definitions provided to students in the described database module are included in Appendix A. These terms are a good reference for anyone wishing to begin the study of XML.

2. BRIEF LITERATURE REVIEW

After Codd's seminal 1970 paper on relational theory, hundreds of books and articles on relational databases have been published [5]. Knowledge of relational database design and normalization are staples of advanced database courses, and are key components of the IS2002 model curriculum and guidelines for undergraduate degree programs in information systems curriculum [6]. Likewise, many computer science departments rely strongly on the Computing Curriculum 2001 (or the 2005 version) [7]. We believe that while model curricula such as IS2002 are extremely valuable guidelines, they are by their nature conservative, and likely to be slow in responding to emerging technologies such as XML. However, we believe that XML is going to be integral to future web enabled database architectures and so

believe that universities need to instruct students in XML. As a first pass at such development we have developed an XML Module that can be integrated into an advanced database management course. This will help students prepare to use modern development tools using XML such as Microsoft's .NET framework, and Sun Microsystems's J2EE platform. The need to teach XML in database courses is further demonstrated by the inclusion of XML column types, XML views on relational data, relational views on XML data, XML Schema, and XML based query languages [8] in Microsoft SQL Server 2000 and Oracle 10g. What follows is a description of the teaching module we developed for advanced undergraduates and graduate students in an advanced database management course.

3. XML EXPERIENCES AND BEST PRACTICES

We have reported on the Moab Medical Clinic XML case in [7] as a method for integrating relational and semi-structured data for instructional purposes. We also have collected many semesters of pre and post test data regarding different methods of integrating relational and XML data. In the following section, we present best practices regarding both using and teaching XML and relational database theory based upon the prevailing literature and our own conclusions from the data we have collected.

During the time we have been using and teaching XML in various courses, the following is a list of some XML practices we have observed / evolved:

1. Storing data as an XML data type in an XML column facilitates the DBMS engine checking that the data is well-formed or valid according to the specified XML schema.
2. If large amounts of XML data are input and output on a regular basis, it is better to store the data as an XML data type as it is far more scalable.
3. Storing data as an XML data type in an XML column allows for indexing data for efficient query processing, scalability, query optimization.
4. We encourage students to use the XML output option that creates all XML in the form of attributes as opposed to attributes and entities or raw XML output. There is little advantage to using entities or raw XML output if the desire to integrate with relational data is desired.
5. If small amounts of XML data are inserted or if XML data is infrequently inserted, it is better to use a conversion function and a mapping tool and simply map and transform the XML data into relational tables. Additionally, relational data can be transformed into XML data and used for Web Services. Transforming data back and forth between relational and XML formats can be messy, time consuming, unwieldy, and not scalable.
6. Several third party mapping and transformation tools can be immensely useful. Our students did very well with the Altova XML Spy tool that has numerous features related to database mapping. Altova has a free, limited version that students find valuable for completing their assignments.
7. Students that had significant experience with relational database theory or experience with tag-based languages such as HTML, PHP, Cold Fusion etc. did significantly better than students than students without such experience.
8. Using XML for interoperability between heterogeneous databases looks very promising. Indeed, with numerous disciplines (like accounting creating the XBRL standards) creating XML standards for data formatting, interoperability and common methods of exchange seems inevitable.

4. CONCLUSION

We have previously presented a comprehensive teaching case that demonstrates the integration of a XML module into an advanced database course [7]. Here we discuss how XML is becoming an increasingly important technology, yet few schools are teaching students how to retrieve, format and display XML data. Based on a sound relational database built in earlier assignments, students using our modules proceed through a number of tutorials that develop their familiarity with key components of XML technology. We believe that this method offers a couple of advantages. First, students are reminded of the importance of good relational design principles as they build the MMC database into SQL Server 2005. Second, students learn XML technology in the context of an advanced database class. Third, this instructional approach lays an effective foundation for later courses in web services development or web application programming, without losing the course's focus on advanced database management.

With literally hundreds of competing software packages, languages, operating systems, and networking technologies, we believe students need to integrate and apply new learning within the context of previous skills. XML then becomes a part of student's fundamental understanding of data retrieval and formatting, rather than just one more language or tool.

5. REFERENCES

[1]Marshall, B. 2004 "XML Module." Available from http://olsen.usu.edu/Olsen/XMLModule/index.htm [accessed 1-05].

[2]Wagner, P.J., Moore, T.K. 2003 "Integrating XML into a Database Systems Course." Paper presented at 34th SIGCSE technical symposium on computer science education, Reno.

[3]Sperberg-McQueen, C.M. & Bray, T. 1997. "Extensible Markup Language." Available from http://www.cs.queensu.ca/achallc97/papers/p050.html [accessed 1-05].

[4]Codd, E.F. 1970. "A Relational Model of Data for Large Shared Data Banks." Comm. ACM 13:6.

[5]Gorgone, J.T., Davis, G.B., Valacich, J.S., Topi, H., Fenistein, D.L. & Longnecker, H. E. 2002. "IS 2002 Model Curriculum and Guidelines for Undergraduate Degree Programs in Information Systems." Available from http://www.acm.org/education/is2002.pdf [accessed 1-05].

[6]Computing Curriculum 2001. Available from http://www.computer.org/education/cc2001/ [accessed 1-05].

[7]Olsen, D., Cooney, V., Marshall, B., and Richard Swart, (Fall 2005), "Towards Full Integration of XML and Advanced Database Concepts," Review of Business Information Systems, vol. 9 no. 4.

Alignment and Integration of Competitive Intelligence Systems: A Case Study

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INTRODUCTION

'Competitive intelligence (CI) is organized, structured information gathering, analysis and processing to enhance strategic decision-making. It is used by businesses to gain a competitive edge by learning about suppliers, customers, regulators and competitors. It is used by business people looking to gain an insight into the future of their business, make more effective decisions…'(Cook & Cook 2000, p5). For all the functions of CI, an enterprise must set up a CI system working throughout the whole organization, which requires that a high level of understanding and awareness of CI pervades every aspect of the organization (Pole, Madsen & Dishman 2000).

Studies show that CI plays a very important role in business success (Behnke 2001). However, there exist barriers to applying a CI system in organizations, e.g. insufficient funding, internal bureaucracy, lack of sufficient skills and experience in intelligence teams. Particularly, many companies are not clear about how to setup a CI system that is integral with their current organizational structure (Swartz 2005). This paper provides a case study which shows how Company X (for confidentiality, the company cannot be named in this paper) sets up a virtual CI system that is aligned and integrated with its current management system and how the CI system is operated effectively within the company's activities.

Company X is a Chinese hi-tech company in the telecommunication industry providing customized network solutions for telecom carriers around the world. With its aggressive sale strategy, fast response services and new product development, the company has achieved a leading position in Chinese telecommunication markets within less than 20 years. Its competitors include a number of telecommunication equipment big players, e.g. Lucent, Ericsson, Nokia, Motorola and Cisco. Among the factors contributing to the company's success, its CI system plays an important role. This paper analyzes the company's CI system from the following aspects: 1) the structure of the CI system, 2) people in the CI system, 3) the CI process, and 4) cultivating a CI culture in the organization.

This paper starts with a general discussion of the CI system of the case company, followed by an analysis of key issues and problems identified through the case study. A brief conclusion is made at the end.

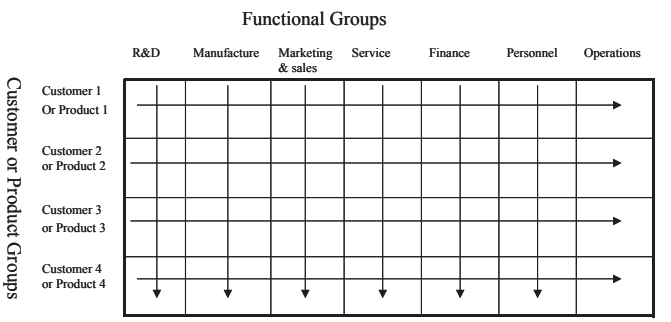
COMPETITIVE INTELLIGENCE SYSTEM IN COMPANY X

The Structure of the CI System in Company X

Research (Behnke 2001) shows that an integral CI team is characteristic of successful CI programs. Company X does not have a dedicated CI department. The CI team at Company X is a "virtual team" i.e. every employee takes the responsibility of CI and contributes to the CI system. The virtual CI system is integrated with the management structure of the company which achieves high efficiency in monitoring, collecting, analyzing all aspects of competitive information to support decision-making and daily operations.

The company adopts a matrix organizational structure as shown in Figure 1. There exist seven main functional departments: products research and development, manufacturing, marketing and sales, service, finance, human resource, and operation. At the same time, the company comprises several multi-functional groups that are organized according to customer groups or product types. The matrix organization structure facilitates speedy operation and decision-making because the functional teams can monitor their own localized business environments and move quickly to adapt to changes in them (Senior & Fleming 2006). Indeed, such organizational structure in Company X provides a good culture to build an efficient CI system while it also increases complexity of the CI system.

Figure 1. The company's organizational structure



The structure of the CI system in company X (Figure 2) follows its organizational structure. The virtual CI system in this Company is divided into three levels: (1) a virtual CI team under each functional group and multi-functional groups; (2) the CI coordinators in each business unit, e.g. the departments, representatives, overseas office, and call center; and (3) employees. The CI team in each functional group or multi-functional group administrates the whole CI system. They also undertake marketing, service and other research. The CI team members' responsibilities include (1) monitoring, collecting and analyzing information from external public information resources, e.g. internet, newspaper, journals, third party's report; (2) collecting and analyzing the information from the CI coordinators in each business unit; (3) intelligence dissemination; (4) conducting specific competitive intelligence research and surveys; (5) contacting consult or marketing research companies if a need arises; (6) supervising and measuring the CI works of CI coordinators; and (7) providing executives and employees with CI training and CI services. The CI coordinators' responsibilities include (1) collecting CI information from employees, customers, and any legal CI resource, (2) preparing for and submitting CI reports for the business unit that he/she works in, (3) helping conduct special CI research and surveys, (4) collecting CI needs and submit them to the CI team, and (5) providing the CI service to his/her colleagues.

Figure 2. The structure of CI system

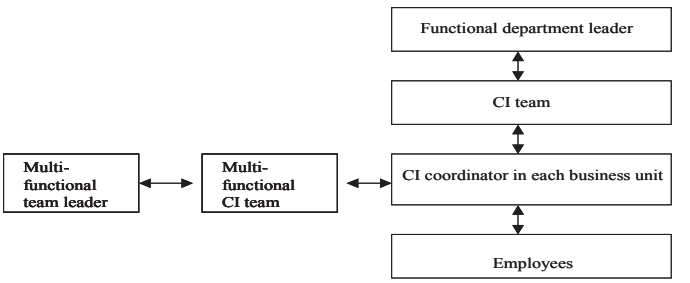


Figure 3. General CI process

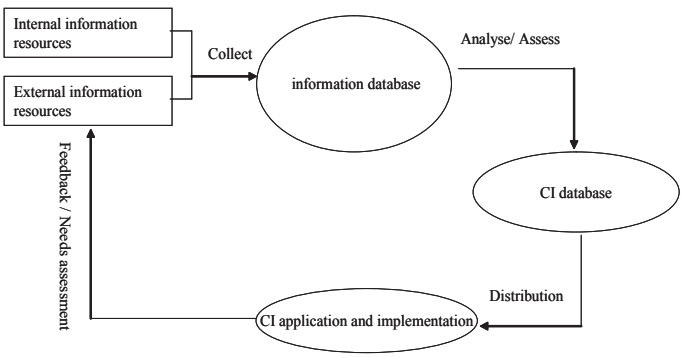
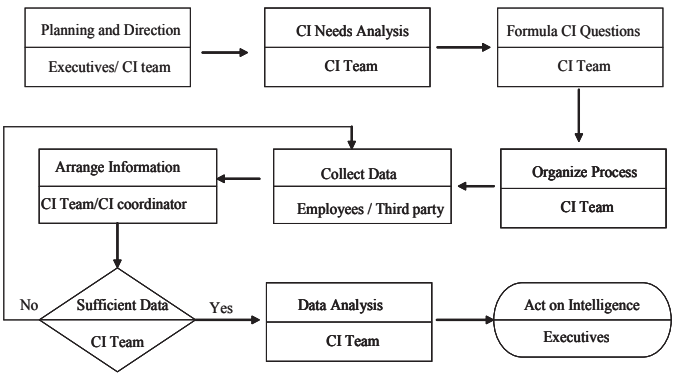


Figure 4. A specific sample of a CI research process



CI Process in Company X

Generally a CI process includes information collection, data arrangement, information analyses, intelligence application and implementation.

CI collecting process: The CI collecting processes in Company X includes two streams: general CI process and specific CI research project process. In the general CI processes (Figure 3), employees enter the information that they think valuable into CI information database every day. CI coordinators submit CI reports monthly after gathering the internal and external CI. The specific CI research projects (Figure 4) are often conducted when needs arise. They are usually derived from the CI needs for decision-making from CEO or CI teams. After formulating CI questions, the CI teams send a CI collection note to a CI coordinator and then to every engineer and salesman. The responsive information will then be collected.

CI analysis process: a CI team in each functional and non-functional group conducts CI analysis. People in the CI team have multi-CI analysis skills in the industry. They take charge of the CI analysis of specified competitors or customers.

CI distribution: After a professional analysis, the relevant CI reports are published in the company's intelligence database. Each report will be set a secret level for different level executives, managers or employees. The CI teams also send periodical electronic or printed CI reports to appropriate users through an internal delivery system. Executives, managers and employees can ask for help from the CI team to locate the intelligence or to conduct specific CI research.

CI application and implementation: The company uses CI to support decision making, to improve new products' development, marketing and sale, service, manufacturing and management, to position the company in the industry though comparing it with competitors, and to alarm and respond to competitors' actions, government policies and other changes in the competitive environment.

Cultivating CI Culture

To improve its CI capability, company X takes measures to cultivate a CI culture from both the institutional and educational perspectives. The institutional measures include:

1. Solidifying and constantly modifying its CI process and flow to satisfy development needs.
2. Setting up a systematic CI performance appraisal system. CI performance is taken as part of sale representatives and service centers' managerial performance (10%).
3. The functional departments also give feedback to CI teams to assure the CI teams improve CI quality continuously.
4. CI teams provide a CI template to coordinators and employees to standardize CI work.

The educational measures include:

1. Arranging CI training for the executives to strengthen their CI knowledge.
2. CI information gathering and analysis training.
3. CI legal and ethical training.
4. Anti-competitive intelligence training.
5. Cultivating a good CI sharing culture within departments, breaking sharing barriers between functional departments.

EXPERIENCE AND PROBLEMS OF THE CI SYSTEM

Key Features of CI Implementation of the Case Company

- Although Company X does not have a dedicated CI function team, it has a formal CI processes and a CI IT support system.
- Forming an excellent CI culture. Every employee is educated to contribute to the information collection and protect company's CI.
- Nominating CI coordinators in each department. These coordinators ensure that all valuable CI information can be collected and submitted to CI teams. At the same time, the CI information is analyzed and screened to avoid less valuable CI information being communicated. Furthermore, CI coordinators share quite a lot of CI service work and ensure CI teams spend more time on in-depth analysis.
- Regular collecting and defining CI projects are conducted, which helps acquiring comprehensive competitive information as well as conducting an in-depth analysis.
- Fostering a good CI utilizing environment. Besides electronic CI publication, CI teams edit periodical CI research reports and send them to directors, executives.
- Conducting periodical CI needs surveys.
- All CI works are based on CI needs and practices.
- Building a CI technological system systematically. Company X's CI technological system is constructed on Lotus Note system, which is not typical CI software. More employees can be involved in the CI system without having extra technological training.

Key Issues to Be Addressed

1. Company X's CI technological support system is not well constructed. First, the CI technological system is based on Lotus Notes system. The system is not a professional CI software system, which affects the efficiency of CI searching, sharing, and analysis. Second, the company has not set up a company level competitive database, which impedes CI sharing between different functional groups.
2. The company does not appoint a Chief Information Officer. This affects the quality of CI works and CI system building in the whole company although the CI in separated functional groups is successful.
3. Although the virtual CI team helps the CI works closely related to the workplace in the company. The lack of professional CI people would influence the effectiveness of CI.
4. System CI analysis tools are not used by CI teams to analyze information. Analysis results often depend on the CI team member's personal knowledge and skills, which might result in low quality of CI analysis.
5. Taking a short-term perspective in its leading CI system impedes the case company from building a systematic and professional CI system. In fact, it has influenced adversely the company's long-term strategy and earlier alarm system working properly.

CONCLUSION

This case study introduces a CI system that is aligned and integrated with Company X's organizational structure. We see that an integrated CI team plays a key role in building an efficient and effective CI organization. Organizations need to clarify what they need to construct an efficient CI system. The case also shows that the CI technological platform can be built up step by step. Any advanced CI technological tools need a systematic and institutional CI system to support. Due to the methodological limitations of the case study, the successful experience and lessons learned from this single case can only serve as an illustrative example of how a high-tech company implements a CI system.

REFERENCES

Behnke, L 2001, 'Virtuous CI teams', *Competitive Intelligence Review*, vol. 12, no. 1, p. 3.

Coleman, B 2002, *Competitive intelligence: real-time knowledge management*, The Data Administration Newsletter, <http://www.tdan.com/i019hy04.htm>.

Cook, M & Cook, CW 2000, *Competitive intelligence : create an intelligent organization and compete to win*, Kogan Page, London p.5.

Kahaner, L 1997, *Competitive intelligence : how to gather, analyze, and use information to move your business to the top*, Touchstone, New York.

Pole, JG, Madsen, E & Dishman, P 2000, 'Competitive intelligence as a construct for organizational change', *Competitive Intelligence Review*, vol. 11, no. 4, p. 25.

Senior, B & Fleming, J 2006, *Organizational change*, 3rd ed. edn, Prentice Hall/ Financial Times, Harlow, England ; New York.

Swartz, N 2005, 'Competitive Intelligence Underutilized', *Information Management Journal*, vol. 39, no. 3, p. 10.

Tyson, KWM 2002, *The complete guide to competitive intelligence*, 2nd ed. edn, Leading Edge Publications, Chicago, Ill.

Rural Internet Centre (RIC) as a Mean for Bridging the Digital Gap in Rural Communities: Assessment of Current Situations

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ABSTRACT

Rural Internet Centre (RIC) project by the Malaysian government offers opportunity to bridge the digital gap between the rural and urban communities in Malaysia. The RIC provides IT skills training and IT awareness programs to all groups of people including women, the elderly, and children. In order to assess the current RIC operations and usage, a survey was conducted in four selected RICs in Kedah and Perlis. Questionnaires were developed to measure the level of RIC usage and the RIC operations in the specific community. The findings show that role of partners, role of administrators, services/activities and functions, objectives, local infrastructures, financial support for sustainability, and users' trainings and support are critical in the RIC operations. However, this study has identified that applications and content development are also important.

Keywords: Rural Internet Centre (RIC), rural communities, community informatics, digital divide.

1.0 INTRODUCTION

The 8th Malaysia Plan, which covered the period of 2001-2005 was primarily aimed at sustaining economic growth and competitiveness in the face of growing globalization and liberalization (Dewan Rakyat, 2001). One of the thrusts was to shift the growth strategy from input-driven to knowledge-driven and productivity-driven. The primary challenge during the Plan period was to implement the National Vision 2020 Policy to strengthen the nation's capacity, capability and resolve in meeting future challenges (Anon, 2001). Nine key strategies have been addressed to meet the challenge. Two of the strategies are (i) enhancing productivity-driven growth and (ii) enhancing the usage of IT or information communication technology (ICT). For these purposes, about RM1 billion has been allocated under the Plan to carry out ICT programs and projects to increase the usage of ICT among communities in rural areas. Table 1 shows the detail of the allocation to support those programs.

The diffusion and usage of ICT within and across sectors is further expanded as ICT has a strategic role in accelerating economic growth. Accordingly, the ICT infrastructure is upgraded through several initiatives including increasing the capacity of the transmission backbone up to 10 gigabits per second and introducing the Network Management System for better service availability. The ICT infrastructure is also unrolled to the rural areas to reduce the digital divide and to achieve a balanced development. Among the programs implemented include the project of Rural Internet Centre (RIC), which was set up to bring the Internet to small towns and rural communities in Malaysia. The Ministry of Energy, Water and Communications (MEWC), Malaysia Post Berhad and Maju Sedunia Digital (MSD) are responsible for the project. The Malaysian government aim to set up 240 centres by the year 2010 which will eventually reaching an estimated 2.8 million members of the rural communities.

Table 1. Amount allocated for the development of ICT related programs and projects 2001-2005 (RM millions) Source: Laporan Rancangan Malaysia ke 8 (2001)

Program / Project	Allocation	%
Prime Application	**1,824.9**	**35.4**
Electronic Government	434.8	
Smart School	401.1	
Telemedicine	400.0	
Multipurpose Smart Card	418.1	
P&P Aggegation	1.9	
Application Integration	169.0	
Computing	**1,641.8**	**31.8**
Research & Development	**300.0**	**5.8**
Bridging Digital Divide	**1,098.0**	**21.3**
'Infodesa'	30.2	
Internet Center	3.0	
Global Service Provision	119.8	
Computer Infrastructure for Rural Area Schools	945.0	
Content Development	**10.0**	**0.2**
Others	**284.4**	**5.5**
Total	**5,159.1**	**100.0**

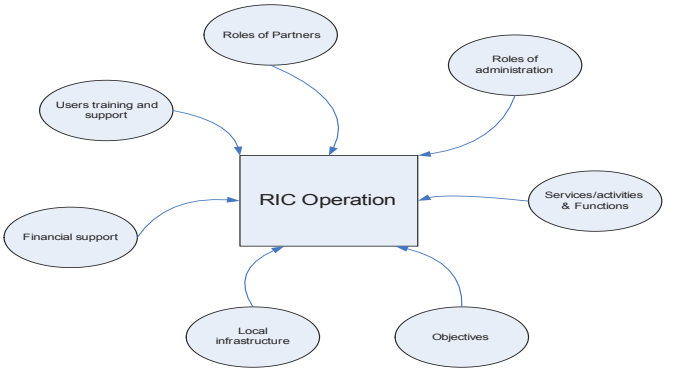
2.0 RURAL INTERNET CENTRE (RIC)

RIC was launched in March 2000 with two centers: Sungai Ayer Tawar in Selangor and Kanowit in Sarawak. By 2006, 42 Rural Internet Centres (RICs) have been

Table 2. Role of the partners in the MEWC's RIP steering committee (Adapted from: Guidebook on Developing Community E-Centres in Rural Areas: Based on Malaysian Experience)

Partners	Role/Resposibility
MEWC	RIC programme coordinator
Post Malaysia Berhad	Provided the space for RICs
Telekom Malaysia	Provided the telecommunication services
INTEL	Provided 2 PCs for each RIC
MAXIS Bhd.	Provided the local content i.e the Website for RIC
MNCC	Contributed to implementation concept
INTAN as governmenr site	Provide basic training in ICT at each site of RIC

Figure 1. Critical factors of RIC operations



implemented in thirteen states in the country (KTAK, 2006). RIC provides IT skills training and knowledge acquisition programs to the rural community in Malaysia, including women, the elderly, and children. Information about the existence of the RICs, the committees in the RICs, and the activities and services provided by and through the RICs are described in a specific website (http://www.idesa.net.my/). The number of RICs in each state and the types of facilities, activities and services provided in each centre are dependent on the size of states.

Noor Bathi (2005) reported that the initial MEWC's RIC model of partnership is made up of Malaysian National Computer Confederation (MNCC), Pos Malaysia Bhd, Telekom Malaysia, Intel, MAXIS, National Institute of Public Administration Training Centre (INTAN) and community representatives. Table 2 illustrates the roles and responsibilities of each partner.

A study on RICs in Selangor showed that the implementation of the centres in that state has been well accepted by the local communities (Mohd Nizam, 2005). The centres do not only give the communities an access to the Internet, but also improve their knowledge and skills in ICT. The numbers of RIC users and visitors have increased every day. The centres, however, do not have enough ICT resources, for example, PCs, printers, and other peripheral devices. Each centre is only equipped with between five to seven PCs. The centres also have a limited number of staff to administer the RICs. Mohd Nizam's (2005) study finally concluded that RICs in Selangor and other states should be given more spaces and resources in order to achieve the RICs' objectives.

This study intends to find out how RIC is currently being used in the community. The objective of this paper is to describe the initial findings of our research regarding the usage of four RICs in the states of Kedah and Perlis in Northern Malaysia. Specifically, the description focuses on the activities, users and the management of RIC. The financial aspect of RIC operations is not included but will be looked at in the future. Based on the results of this study, an initial RIC framework to effectively bridge the digital divide is proposed.

3.0 RESEARCH APPROACH

Based on the role and responsibilities defined in the partnership framework (Noor Baiti, 2005), seven components have been identified as critical factors to contribute to the operation of an RIC. These include role of partners, role of administrators, services/activities and functions, objectives, local infrastructures, financial support, and users' trainings and support as shown in Figure 1. These factors are then used to form the research variables in the survey instruments.

In order to assess the current RIC operations and usage, a survey was conducted in four selected RICs in Kedah and Perlis. The survey was carried out in September 2006. Data and fact-findings were done through questionnaires. Two sets of questionnaires were constructed which made up the survey instruments given to personnel responsible for administrating and maintaining the RICs and users of the RICs. Both instruments are developed to measure the level of RIC usage and the RIC operations in the specific community. Both sets of instruments were hand-delivered to their corresponding respondents.

The first set of questionnaire (Set A) which was distributed to eleven RICs' administrators consists of four sections: Profile of Respondents, RIC Users, RIC operations and RIC Website Information. Profile of Respondents section attempts to gather data on the respondent's background information. This includes the respondent's age, sex, marital status, race, qualifications, type of organization and position, roles in RIC, and the amount of time allocated for administrating the RIC. This information would give a general feel of the type of respondents and also to verify that the information captured from the right source. It also intends to identify the demographic factors that may influence the management and administration of the RICs.

The second section of the questionnaire, RIC Users, deals with the respondent's personal opinion regarding the RIC users. Among the information sought were users' categories that frequently visit the RICs. There are reasons to believe that users' categories may also influence on the RICs' operations and activities.

The third section of the questionnaire, RIC Operations, identifies the kind of activities, services, and facilities offered in the RICs. Opinion on how the RIC operations can be improved is also sought. The last section, RIC Website Information, gathers information pertaining to website development.

The second set of questionnaire (Set B) was distributed to seventy RICs' users consists of two sections: Profile of Respondents and Activities in RIC. The Profile of Respondents section attempts to gather data on the respondent's background information. This includes the respondent's age, sex, marital status, race, qualifications, type of organization and position, and IT courses or training taken. This information would give an overview of the type of respondents. It also intends to identify the demographic factors that may influence the usage of the RICs.

The second section of the questionnaire, Activities in RIC, will gather information about the frequency of RIC visits, activities carried out in RIC, benefits, problems and level of satisfaction with regards to RICs services and activities offered. Finally, opinions on how the services and activities of the RIC could be improved are sought.

The purpose of these two sets of questionnaire is to gather information about the RIC operations and services from the perspective of administrators and users. This information helps to confirm the relevancy of the questionnaire and also to complement the responses. Thus, this study is a pilot survey to test the validity and reliability of the questionnaires. Revision on the questionnaires will be done accordingly for future research.

4.0 RESULTS

The response rate is 100% for both sets of questionnaires. Hundred percent returned is achieved due to the fact that the questionnaire were hand-delivered and -collected. The major analytical treatment applied was descriptive techniques. Section 4.1 presents the demographic characteristics of the respondents. Since there are two groups of respondents in this survey, the results are presented accordingly. While, section 4.2 describes about the responses of administrators, Section 4.3 deals with users' responses.

4.1 Profile of Respondents

Table 3 presents the distribution of respondents (administrators and users of RICs) by demographic characteristics.

Table 3. Demographic characteristics

Variable	Administrators		Users	
	Frequency	Percentage	Frequency	Percentage
Age (years):				
Less than 21	0	0.0	21	30.0
21-30	8	72.7	32	45.7
31- 40	1	9.1	11	15.7
41-50	2	18.2	5	7.1
Above 50	0	0.0	1	1.4
Gender:				
Male	6	54.5	35	50.0
Female	5	45.5	35	50.0
Marital Status:				
Single	5	45.5	47	67.1
Married	6	54.5	21	30.0
Divorced	0	0.0	1	1.5
Race:				
Malay	11	100	62	88.6
Chinese	0	0.0	6	8.6
Indian	0	0.0	0	0.0
Others	0	0.0	1	1.4
Level of Qualification:				
Certificate	3	27.3	29	41.4
Diploma	5	45.5	5	7.1
Bachelor Degree	2	18.2	7	10.0
Masters Degree	1	9.1	4	5.7
Others	0	0.0	14	20.0

Of the eleven administrators, 72.7% aged between 21-30 years old. The rest are above 31 years of age. On contrast, the age of users are mostly below 30 (75.7%). It shows that the RICs have attracted the interest of the youth compared to the other age category. This could be another reason that indicates unmarried users are the majority visitors of the RICs.

In terms of gender category, the number of male and female administrators, as well as users, is almost equivalent. Malays outlay the other races as the RICs' administrators (100%) and users (88.6%). This is due to the fact that the communities surrounding the RICs are mainly the Malays. 45.5% of the administrators are Diploma holders, 27.3% has certificates and the rest hold Bachelor and Masters degree.

4.2 Responses of Administrators

Among the information sought from the administrators revolves around the IT courses and training taken, opinions about the users of RICs, the RICs' operations and activities, and the local RICs' webpage.

4.2.1 IT Courses and Training

As shown in Table 4, 90.0% of the administrators have undergone training on using Microsoft Office, operating systems (63.6%), computer maintenance (54.5%), and internet (63.6%). Other courses attended are Adobe Photoshop and Illustrator, and graphics and multimedia.

4.2.2 Operations of RIC

Most of the RICs operate between 8.30 a.m. to 5.30 p.m. on weekdays. All RICs have the basic ICT facilities such as printers, scanners, and internet access. Apart from that, many RICs are equipped also with photocopy and fax machine, LCD projector, digital camera, and reference books.

The services provided by the RICs include computer classes, advice on computer purchase, computer selling and servicing, card printing and writing official letter services, and internet access. Other services offered are webpage development, e-procurement services, and posting advertisement in webpage.

According to the administrators, users of the RICs are from the following categories: students, graduates, housewives, farmers, businessmen, government servants,

Table 4. IT courses and training

	YES		NO	
	Frequency	Percentage	Frequency	Percentage
Microsoft Office	10	90.9	1	9.1
Operating Systems	7	63.6	4	36.4
Computer Maintenance	6	54.5	5	45.5
Internet	7	63.6	4	36.4
Adobe Photoshop & Illustrator*	1	9.1		
Graphic & Multimedia*	1	9.1		

**open-ended questions, i.e additional courses attended by certain respondents*

private sectors employees, and pensioners. Among these categories, the most frequent users are from the students and graduates categories. Reasons for their frequent visits could be, to complete their assignments, search for information, look for job or study opportunity, and improve their IT knowledge. On the other hand, farmers, and pensioners do the least visits. This could be due to various reasons such as, have no interest in computer technology, have computer phobia, incompetence in using computers, and lack of ICT awareness.

RICs' activities focus on IT literacy programs, selling telecommunication product, Independence Day and festivals celebrations, and examination workshops. To attract more participation from the surrounding communities, the respondents suggested varieties of activities and services such as free workshops during the weekend, free photocopy services, e-procurement, online payment services and educational trip. In general, it seems that the idea of having a one-stop-centre is desirable.

4.2.3 Local RICs' Webpage

The administrators develop the webpage themselves by using Microsoft FrontPage and DreamWeaver. The common content include local information, webpage information, background of specific RIC, lists of RIC's activities, and information about the community. Some also include linkages to search engines and online applications.

4.3 Users' Responses

In general, most of the RICs' users are aware of the RICs existence through their friends (55.7%). Among the information gathered from the users are the IT courses and training taken, the services offered by the RICs, frequency of their visits, and their overall satisfactions. Suggestion on how to improve the RICs' services and activities, and the benefits acquired from the use of RICs are also presented.

4.3.1 IT Courses and Training Attended

Table 5 depicts the IT courses and training attended by the users. Most of them (72.1%) have the basic training in ICT, Internet and Microsoft Office. Other courses and training undertaken by the users are also shown in the table.

4.3.2 RICs Services and Activities

In the questionnaire, five services that are usually provided by the RICs are listed. These include computer classes (1), consultation on computer purchase (2), computer selling and servicing (3), card printing and writing official letter services (4), and internet access (5). Fifty-nine respondents (84.3%) agree that internet access services (5) are the common offered services by RICs, followed by computer classes (71.4%). Based on the common services offered the two activities that are popular among users are internet surfing (71.4%) and IT literacy workshops (41.4%). Internet surfing captures the users attention probably because it is interesting, fun and informative, while workshops are conducted to equip users with necessary ICT knowledge.

In terms of frequency of visits to RICs (refer Table 6), out of the 70 respondents, 44 (62.9%) visit the RIC when necessary. Of the 44, 20 respondents are from the 21-30 years age category, 15 from less than 21 years of age and 7 from 31-40 years. Almost 14.3% uses the RIC once a week. The rest visits the RIC once a month. The number of male and female users that visits the RICs is equivalent. This indicates that the most frequent visitors of RICs are aged below 30 years old regardless of their gender. Thus, this result confirms the administrators' responses on frequent RICs' visitors namely the students and university graduates. The fact that they only visit the RICs when necessary implies that the visits are made when they have assignments to complete, or the needs to search for relevant information on jobs or studies opportunities.

4.4 Users' Satisfaction

Most of the users described in Table 7, come from all age categories are satisfied with the services, activities and facilities provided or offered by the RICs. Despite the high level of satisfaction among the users, there are a few problems that have been highlighted by the respondents. The major problems stated by the respondents are insufficient number of computers, and inappropriate operation hours. The reason is that the most of the RICs in each community are only equipped with between five to seven PCs. This finding tallied with Mohd Nizam's study in 2005 regarding RICs in Selangor. With regards to the inappropriate operation hours, they would like the operation hours (currently 9 a.m. to 5 p.m) of the RICs to be extended since some of the users are working.

The respondents also provided their suggestions towards improving RICs services, activities and facilities. These include improving RIC promotions and activities, and equip the RICs with more PCs. In addition, the benefits acquired from the RICs' operations are shown in Table 8. Other benefits as stated by the users include free internet usage and printing services.

5.0 CONCLUSION AND RECOMMENDATIONS

This paper has successfully described the initial findings on RICs current situations in Northern Malaysia. It can be argued that the government intention to bridge the digital divide among the rural communities through RICs is not entirely

Table 5. IT courses and training

Courses and Training	Frequency	Percentage
Basic ICT &Internet	19	44.2
Microsoft Office	12	27.9
Autocad, & CorelDraw	3	7.0
Web Page Development	3	7.0
Chatting	1	2.3
Multimedia	1	2.3
Database	1	2.3
e-mail	1	2.3
never	2	4.7

**some do not write their responses*

Table 6. Visit to RIC by gender

	Gender (%)	
Frequency of Visits	Male	Female
Everyday	4 (11.4)	1 (2.9)
Once a week	6 (17.1)	11 (32.4)
Once a month	1 (3.90)	2 (5.9)
When necessary	24 (68.6)	20 (58.8)
TOTAL	**35 (50.0)**	**35 (50.0)**

Table 7. Category of users satisfactions towards RIC operations

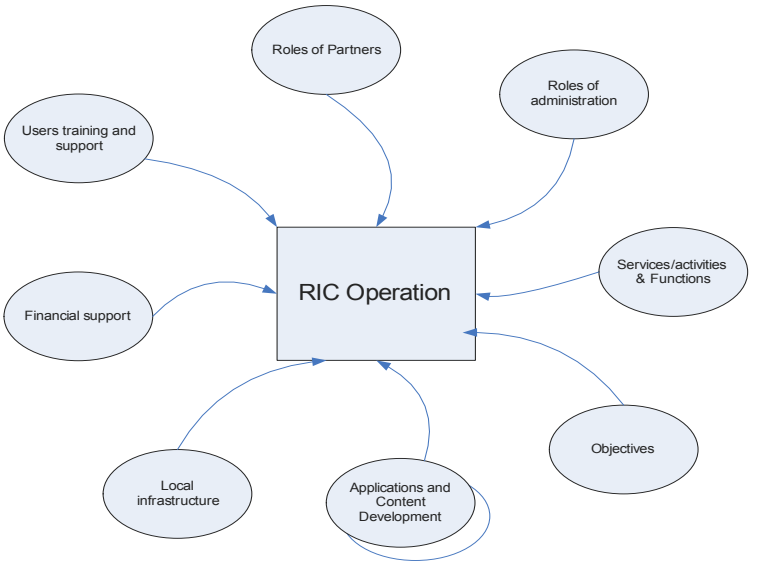
	Frequency (%)		
Age	Very Satisfy	Satisfy	Do Not Care
Less than 21 years	7 (22.6)	13 (38.2)	1 (33.3)
21-30 years	12 (38.7)	16 (47.1)	2 (66.7)
31-40 years	8 (25.8)	3 (8.8)	0 (0.0)
41-50 years	3 (9.7)	2 (5.9)	0 (0.0)
More than 50 years	1 (3.2)	0 (0.0)	0 (0.0)

**some do not write their responses*

Table 8. Benefits of RIC

Benefits	Frequency
Increase the ICT awareness	50
Increase the knowledge relating to ICT	56
Increase skills in using computer	55
Increase quality of work	32
Increase quality of life	29

Figure 2. A theoretical framework for RIC operation



achieved. Nevertheless, the centres do contribute to the local rural communities' development indirectly, for instance IT literacy and awareness are improved. Hence, further research on RIC will be carried out to increase the usefulness of the RIC to the rural communities, and to identify applications that will help the communities' development in the long run. Maybe if the community can see the need for the IT, the number of users may increase as well as the inclusion of older users and among the farming sector. This implies that more applications and content development are needed to attract and make the community realize the value of IT in improving their quality of life as well as their economy.

The findings of this study suggest that the role of partners, role of administrators, services/activities and functions, objectives, local infrastructures, financial support for sustainability, and users' trainings and support are critical for the RIC operations. In addition, applications and content development has been identified as another important factor. Hence, this study proposes an initial theoretical RIC framework to illustrate the contribution of these factors towards RIC operation. This framework is shown in Figure 2. In order to ensure the reliability of the framework, further research will be conducted.

6.0 BIBLIOGRAPHY

Anon. 2001. PM unveils Eighth Malaysia Plan. http://www.ids.org.my/planpolicy/report.htm [March 6, 2002].

Castells, M. 1998. *The end of the millennium.* Massachusetts: Blackwell.

Dewan Rakyat 2001. Eighth Malaysia Plan (2001-2005) http://www.ids.org.my/planpolicy/focus.htm [September 10, 2006].

KTAK 2006. Portal Komuniti Desa. http://idesa.net.my [4 October 2006]

Mohd Nizam O. 2005. Dasar Perlaksanaan Inisiatif 'Internet Desa': Cabaran dan Implikasi dalam mengurangkan jaringan digital di Malaysia. Presented at Workshop 'Membudayakan Masyarakat Jaringan: Cabaran dan Batasan', 16 Jun 2005, Universiti Kebangsaan Malaysia (UKM).

Moon, M.J. (2002), *The Evolution of E-Government among Municipalities: Rhetoric or Reality?* Public Administration Review, July/August 2002, Vol. 62, No. 4.

Musgrave, S. (2005, January 31). Community Portals: A False Dawn over the Field of Dreams? *The Journal of Community Informatics* [Online], 1(2). Available: http://www.ci-journal.net/viewarticle.php?id=13. Retrieved 13/06/06

Noor Bathi Badarudin (2005). *Draft Rural ICT Guidebook – Based on Malaysian Experience*, presented at Regional Meeting on Effective Design and Delivery of Rural Community ICT Sercives by UNESCAP/INTAN, 28-30 November 2005, INTAN Buklit Kiara, Kuala Lumpur, Malaysia.

Rancangan Malaysia ke 8 (2001). Kuala Lumpur: *Percetakan Nasional Berhad*.

Scott, J.K., (2006). *E" the People: Do U.S. Municipal Government Web Sites Support Public Involvement?",* Public Administration Review, May-June 2006.

Organization of Grid Resources in Communities

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ABSTRACT

Locating suitable resources within a Grid is a computationally intensive process. An alternative approach is to categorize resources based on the services they provide – leading to the interaction of peers with common goals to form societies/communities. The communities can be adaptive in nature and evolve based on changes in their operating. We have implemented JXTA prototype to illustrate the concepts of community formation in which Peers offering different services can be grouped together based on different criteria.

1. INTRODUCTION

Emerging distributed computing paradigms, such as Grid Computing, comprise of dynamic and distributed resources/peers. Resource discovery in such systems is a time-consuming process with network overhead. The numbers of interactions are likely to increase exponentially as the numbers of peers grow. Restricting interactions between set of peers is a key factor to scale the resource discovery problem. Davis and Smith referred it as the "connection problem" [1], where peers need to find other suitable peers to co-operate with, assist, or interact with. Peers are categorized based on criteria i.e. type and quality of service, etc. Any initial cost in categorizing peers result discovering "preferable" resource with minimum discovery cost subsequently – thereby leading to the development of "communities". "Focused Addressing" [2] is one solution to the connection problem where requests are sent to particular subset of peers, believed to assist the requesting peer.

Individual peers, although selfish, are expected to interact with each other in some way. Each peer prefers to be in environment where it may be easily discovered by a suitable user, and can locate other peers with minimum efforts. This analogy helps us to define two terms, Expertise and Interest [13], [14]. Expertise of a peer is the basic service provided by that peer and Interest of a peer is the service/services provided by other peers which are supportive to its main service. Each community has one Service Peer with dual responsibility of managing the member peers and providing communication source with external environment. Interaction between different communities is only through the Service Peers.

2. TYPE OF COMMUNITIES

Individual autonomous peers have expertise and interests in specific resource/s. Based on these expertise and interests, peers are grouped together, but expertise and interests are not the only criteria for categorizing peers. Communities/societies can be of different types as mentioned below:

Competing Community: In a Competing Community each peer has the same expertise – although some service attributes may vary. Similarity in services may develop competition amongst member peers, as members compete each other to get selected.

Co-Operative Community: In Co-Operative communities peers provide different services, which must be used alongside services of other members. Hence, when any peer is selected, then the possibility of selection of another member peer providing utility service/s increases. This mutual co-operation is suitable for peers which provide simple services.

Goal Oriented Community: This is collection of peers work together to achieve a particular goal. Goal oriented communities are important in self-organizing systems, where interactions between member peers are not pre-defined, but the services required are. In such instances, member peers may interact with each other in arbitrary ways to achieve a given end result.

Ad Hoc Community: In ad hoc communities peers interact directly with each other without interference and involvement of a Service Peer. Peers belonging to different communities providing supporting services form the basis of an ad hoc community.

Domain-Oriented Community: Such a community is formed by linking together similar-minded organizations and institutions, instead of the services they provide, such as academic communities, research communities, and open-source communities. Hence these communities are domain-oriented rather than service-oriented.

Virtual Community: The Virtual community is a community of communities. This effect is achieved by leasing out the member Peer to other community for certain time period, before that lease period either Service Peer requests to renew the lease of corresponding Peer or it can't use the service of the Peer directly.

Sharing Community: In this type of community different Communities share their resources with each other; this sharing of resources is not restricted to member Peers but includes core and optional services. Community A may have QoS monitoring module, which it shares with Community B assuming either Community B doesn't have such module or Community A may has more advanced monitoring module.

3. COMMUNITY FORMATION

Community formation involves three basic processes and in all of them the middleware plays a major role; utilizing different core services provided by the community. These three processes are "Initiation Process", "Maintenance Process", and "Formation Process" for collaboration on an ongoing basis between the members and with other communities.

3.1 Initiation Process

The community formation process can be initiated manually or by any peer. The first task of the newly created peer is to search for existing communities which may have interest in its services. The peer queries the middleware for appropriate communities; on failure it may request to create a new community. The middleware searches its own knowledge base to match the services of the peer with requirements of existing communities. The peer can refuse to join any existing community and can insist for the creating of new community. The newly formed created community (i.e. manually or on the request of any peer) search for other peers and services with complementary and competitive resources for long term partnership. The community search for new members by querying the peers registered within the middleware. The main achievement of this process is to promote mutual trust between the members, negotiate consistent rules and regulations i.e. pre-qualification criteria for new entrants, Quality of Service (QoS) [11], sharing costs and profits. The community formation process either creates new Service Peer or requesting Peer acts as coordinator.

3.2 Maintenance Process

After the initial formation of community, the coordinator is responsible for maintaining and improving the collaboration, which involves many different sub-management tasks, conducted concurrently. The coordinator observes the changes in the internal and external environment and adapts according to the changes (updating its knowledge base) to maintain its effectiveness in the distributed environment. The coordinator monitors the performance within the community and provides basic services to members to achieve the required performance. It

is important to keep track of the resources and core competencies of partners and their performance. To improve overall performance of the community, its coordinator is always looking for new members with missing or complementary resources. Although the maintenance process is mainly concerned with the local functioning of the community but in this stage the coordinator also communicates with the middleware to search for new members.

3.3 Formation Process

The community is opportunist and always exploits the potential for collaboration. When a new collaboration opportunity arises it is the coordinator identifies the required individual activities to match the opportunity. The first step for the coordinator is to create a "workflow" based on the available resources, competencies, strengths and weaknesses of the members. The workflow may require collaboration with external communities to "buy in" services missing within the community. No matter how complicated final workflow is; whether it utilizes only internal resources or involves an external collaboration, coordinator develops teamwork for achieving set goals. Once the workflow is formed and tasks are allocated and scheduled among participating members, the coordinator monitors the performance of individual members and quality of tasks. Post-Management formation process involves allocation of additional resources, replacement of under performing member/s, re-scheduling of tasks within the workflow, etc.

4. ARCHITECTURE OF TOOLKIT

The architecture for the community formation should be simple and supportive to the main purpose of their formation. The proposed architecture consists of three main components. These components are discussed following the Tool Selection:

4.1 Tool Selection

The efforts to design and implementation the system can be drastically reduced by selecting appropriate technology. The initial prototype is developed in JXTA [11]. JXTA (jxta.org) is an open source P2P framework initiated by Sun Microsystems. The JXTA protocols are independent of any programming language, and multiple implementations exist for different environments which make it best choice for prototype. The JXTA network consists of a series of interconnected nodes, or Peers. A JXTA Peers is "any entity capable of performing some useful work and communicating the results of that work to another entity over a network". Peers can self-organize into Peers Groups, which provide a common set of services.

JXTA has the concept of Peer and Peer Group which match to our vision of '*Peer*' and '*Communities*', which makes JXTA as best choice for implementing our prototype.

4.2 Middleware

JXTA had default peer group and every peer joins this default peer group after booting within the JXTA network. This default peer group is called the *NetPeerGroup* or *WorldPeerGroup*. The middleware is the extension of default peer group.

The middleware required to support the community formation is more than simple distributed registry. The customized middleware provides more specific search capabilities and match making. It provides the interface to create new community. The toolkit does not impose any restriction on the communities i.e. the nature or role of communities, the services they offer, why and when these communities are created. The framework supports the creation of communities and the definition of membership policy. It is up to cooperating peers to define communities, join communities, and leave communities.

The middleware provides the much required environment to peer and community for advertising their capabilities. All queries and match making is done against these advertisements.

4.3 Peer

A Peer can be simple service, resource on the computer or any hand held device. Each peer operates independently and asynchronously from all other peers, and is uniquely identified by a Peer ID. All peers are automatically members of the framework which extends the default NetPeerGroup. Peers may opt to join and leave customized or user groups/communities at will. In order to join any community, a peer must discover the community through the search capabilities provided by the middleware. Once the suitable communities are discovered then peer apply for the membership.

Peers publish one or more interfaces for its different services and resources. Each published interface is advertised as a peer endpoint, which uniquely identifies the network interface. Peer endpoints are used by other peers to establish direct point-to-point connections between two peers.

4.4 Community

Community is a temporary or permanent coalition of geographically dispersed individuals, group's organizational units or entire organizations that pool resources, capabilities and information to achieve common objectives. Each community has a similar architecture, with one Service Peer, which manages the whole community. Normally Peers from different communities are not allowed to communicate directly and the communication should be done through the Service Peer except for the Ad-Hoc community.

A community offer different services and resources; utilized only by the member peers. The peer looking for specific service should locate and join the appropriate community offering required service.

Communities may strongly enforce a membership requirement. This defines the boundaries for a secure environment where content can be accessed only by member peers. Communities can provide services and thus participate as a single entity in the formation of further communities.

4.5 Service Peer

The Service Peer is a community coordinator, which manages the proper working of the community, provides essential resources to its members and is source of communication with other communities. The Service Peer is the extension of the Rendezvous Peer provided by JXTA environment and has an optimized routing mechanism for an efficient propagation of messages. If the Service Peer cannot locate the destination of message or query, the request will be forwarded to other known Service Peers.

Service Peer maintains a local view of the environment, a list of known Service Peers and communities. Service Peers maintain information of member peers and a restricted set of other communities; this interest is governed by the expertise and interest of other communities. This restricted list of other communities is used to develop referral mechanism.

The Service Peer coordinates the resources and services within the group to achieve set objectives, maintain membership policies, monitors member peers. The Service Peer may not itself offer different services but may only coordinate services offered by different specialized member peers.

5. PROTOTYPE AND RESULTS

For simulation purposes the JXTA prototype has been developed with option for creating Groups and Peers along with their description. This description is used as the one of the membership criteria, when any Peer applies for the membership. The community is created along with randomly generated External Rating and community assigns randomly generated Internal Rating to all of its members at the time of membership. Peers apply for membership based on high external rating of the community. The community grants membership based on overall rating of the peer and description of the peer.

Prototype was evaluated with different set of parameters i.e. maximum number of member Peers in a community, maximum number of communities joined by single peer etc. Evaluation results were quite encouraging, and similar pattern was observed by changing the set of parameters. In the beginning of the evaluation following four steps were quite frequent:

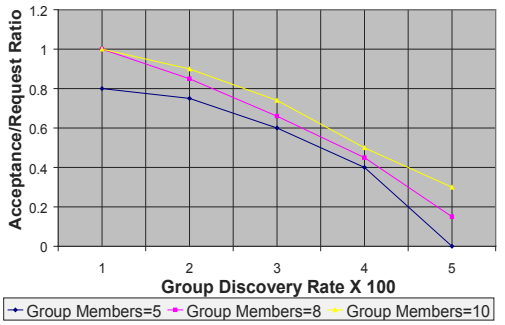
- Selection of communities by peers
- Compatibility checks i.e. rating and description by peers.
- Request for membership by peers
- Membership confirmation from the community.

The preliminary result with different set of constraints is shown below in the tabular and graphical form:

In the table above the left column 'Groups Discovered' compares with the ratio of total membership requests and the accepted requests. It is obvious from the

Table 1. Membership acceptance-request ratio

Groups Discovered	Membership Acceptance/Request Ratio		
	Group Size (50)	Group Size (80)	Group Size (100)
0 - 100	80/100 = 0.8	100/100 = 1.0	100/100 = 1.0
100 - 200	60/80 = 0.75	76/90 = 0.85	90/100 = 0.9
200 – 300	30/50 = 0.6	50/75 = 0.66	63/85 = 0.74
300 - 400	10/25 = 0.4	28/50 = 0.45	28/55 = 0.5
400 - 500	0/5 = 0	3/18 = 0.16	5/21 = 0.23



above table initially peer applies for most of discovered communities but this trend decreases when more communities are discovered. With the passage of time frequency of request for membership decreases and the rate of membership granted by communities decreases because either all member peers have better rating or their expertise matches the interest of community. Once System becomes stable then even peers don't apply for membership or changes group.

The time required by the environment to achieve stable state depends on the constraints set by system i.e. rate of community discovery, number of member peers in a single community and number of communities joined by single peer. We are confidant that organizing resources into different communities will give new dimension to Grid Computing.

6. CONCLUSION AND SUMMARY

In this paper, we have presented the concept of categorizing peers in communities on the basis of their expertise and interests. Social networks are a natural way for people to go about seeking information. Organizing peers in one form or another makes the discovery of resources efficient, whilst minimizing computational overheads. Categorizing the peers in communities is simple, open and easy to implement, and the initial overhead of developing communities pays-off latter at the time of resource discovery. Communities are more stable, and stability increases with the passage of time, communities have a simple learning time and are more adaptive to operate in a dynamic environment. We have proposed the external and internal rating for communities and peers respectively which may be used to support a given Quality of Service, effective participation of autonomous peers and better interaction among communities and member peers. Finally, we discuss the different services required to manage the group and requirements of the member peers. A JXTA implementation of a prototype system is discussed to describe the salient features of our approach. A key theme of this work is to determine how communities should be structured to support resource discovery, and how particular roles within a community can be used to determine interactions between participants within a community, and those between participants across community. This work extends techniques and results discussed in [12].

7. REFERENCES

[1] Davis, R. and R. G. Smith, *Negotiation as a Metaphor fro Distributed Problem Solving*. Artificial Intelligence 20, 63-109, 1983.

[2] Parunak, H. V. D., *Distributed Artificial Intelligence*, Chapt. Manufacturing Experionce With the Contract Net, pp. 285-310, Research Notes in Artificial Intelligence. Los Altos, CA: Morgan Kaufmann Publishers, 1987.

[3] P2People http://www.iti.gr/db.php/en/projects/P2PEOPLE.html

[4] Kautz, Henry, Milewski, Al, and Selman Bart, *Agent Amplified Communication*. AAAI '95 Spring Symposium Workshop Notes on Information Gathering in Distributed, Heterogeneous Environments, Stanford, CA.

[5] Kuokka, Daniel, and Harada, Larry, *Matchmaking for Information Agents"*. Proceedings of the International Joint Conference on Artificial Intelligence (IJCAI) '95, 1995.

[6] Leonard Foner: *Clustering and Information Sharing in an Ecology of Cooperating Agents, or How to Gossip without Spilling the Beans*. Conference on Computers, Freedom and Privacy, 1995.

[7] UP2P http://chat.carleton.ca/~narthorn/project/UP2POverview.html

[8] Catalin Dumitrescu (UChicago), Ian Foster (UChicago/Argonne), Mike Wilde (UChicago/Argonne), *Policy-based Resource Allocation for Virtual Organizations.* iVDGL/GriPhyN Presentation, Fall 2002

[9] Omer Rana, Asif Akram, Rashid Al-Ali, David W.Walker, Gregor von Laszewski, Kaizar Amin, *Quality of Services Based Grid Communities. Web Services and Agent Systems*. Kluwer Academic (2004)

[10] GNUTELLA. Gnutella Home. http://www.gnutella.com/

[11] JABBER SOFTWARE FOUNDATION. Jabber IM. http://www.jabber.org/about/overview.html

[12]Steven Lynden and Omer Rana, *Coordinated Learning to support Resource Management in Computational Grids* Second International Conference on Peer-to-Peer Computing, (2002) 81-89

[13]Leonard Foner. Yenta: *A multi-agent, referral-based matchmaking system*. In Proceedings of the 1st International Conference on Autonomous Agents, (1997) 301–307.

[14]Bin Yu and Munindar P. Singh: *Searching Social Networks*. Proceedings of Second International Joint Conference on Autonomous Agents and Multi-Agent Systems, 2003.

The Rationale and Recipe for a Web-Based Accounting Subject

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ABSTRACT

This paper discusses the rationale, content, and teaching and learning activities for a new web-based subject at Victoria University. An expansion of course offerings into an array of countries in the Asia-Pacific region plus budgetary and demand pressures on staffing and physical resources have accelerated the need for cost-effective teaching and learning solutions. In response an Accounting Project subject has been developed by the School of Accounting and Finance that allows students at any location to undertake a valuable, interesting and robust course in financial analysis with minimal face-to-face interaction with a supervisor. The first trial of this Web-based delivery method for student-centred learning has resulted in report outputs by students that are topical, are based on very 'fresh' contemporaneous information, and are of a quality and currency that has led to their acceptance at international conferences.

INTRODUCTION

This paper discusses the rationale, content, and teaching and learning activities for a new web-based subject at Victoria University. The sheer size and growth of the Victoria University combined with Australian Government fiscal cuts have caused a situation where there is significant pressure to cut discretionary spending and consolidate, rationalise course and subject offerings whilst at the same time coping with burgeoning enrolments, domestic and international geographical spread, and demands of students for flexible, value-for-money, and up-to-date study options. In this context, subjects that can be delivered in a cost-effective are being strongly encouraged. The brief for designing the first web-based Accounting Project covered three main areas: the requirement for a cost-effective teaching and learning solution to geographical spread, human, physical and financial resource constraints; the nature of desired student's modes of study; areas of student interest; and professional accreditation and standards.

A web-based subject was seen as a cost-effective teaching and learning solution to geographical spread, human, physical and financial resource constraints. Students doing any discipline of postgraduate Masters degrees offered by the Faculty of Business and Law, and who have elective options, can study the Accounting Project from any geographical location and at times to suit their private and business schedules. The demand for attendance flexibility is not just geographically driven, as students often have work and travel commitments that make attendance at set times in a conventional class-based mode problematic. The Accounting Project is therefore time and cost-effective for many candidates. Travel time and costs, and the need to commit specific times to attendance are entirely eliminated. The web-based nature of the subject allows for all resources to be obtained without additional cost – hence a significant saving on outlays for conventional resources such as textbooks. The web-based nature of the Accounting Project allows the Faculty to offer it for consumption by any eligible student at any global location in any of our four semesters.

The benefits from the University perspective are the ability to offer an up-to-date subject that is very much in demand globally, and at the same time eliminating the cost associated with providing a physical location for the classes, and allowing one lecturer to deal with student-centred learning candidates in a timely and cost effective manner. The lecturer is allowed about half an hour load for each project student. In simple terms, this actually costs more in academic time per student than a conventional class situation, but there are significant overall net savings in obviating the need for overseas travel expenses and the provision of physical infrastructure.

Financial analysis was chosen as the study area for the first iteration of the Web-based Accounting Project. There is exceptionally keen interest in this field from postgraduate students studying accounting and finance Masters degrees, and also those doing generalist MBAs and other programs such as Sports Administration. This is largely because of the huge professional demand for accounting and finance professionals with advanced financial analysis skills, and a recognition that managers in any field need competencies with financial management. For example, a sports administration manager may not actually do the financial analysis from their position, but they need to know when it should be done and be able to commission, critique, understand, interpret and apply the financial analysis that is placed before them. So far we have established that the web-based Accounting Project is advantageous from a resourcing point of view, fits with the delivery and content needs of many students, and by centering it around financial analysis, an important dimension in the professional competencies of managers from any discipline is addressed. To make sure that the course content meets professional standards, the subject content is monitored by an advisory group made up of professionals from GE Finance and CPA entities (Certified Practicing Accountants). Next we look at the content of financial analysis.

FINANCIAL ANALYSIS

Useful financial profiles of an entity's performance can only be made by combining the right technical "number-crunching" competencies with critical skills that question: "what is behind the numbers". In addition the effective analysis of a set of financial statements requires their interpretation to be framed by an understanding of the organisation's context. The mechanical financial calculations must be synthesised with concepts from economics, business strategy, accounting and other business disciplines to make sense of the historical numbers, and to make future financial projections. So financial analysis must be framed in the context of the whole business, and extends beyond "the financial numbers" to perspectives such as the core business, the market, operations, past performance, future innovations, and the quality of employees and management. Only by understanding the interrelationships between such perspectives can one make a meaningful financial analysis.

The subject aims to provide students with technical and analytical skills in financial statement analysis that informs investment, finance, credit, lending and management decision-making. This subject is designed to reward the student both intellectually and practically through performing financial analysis on actual companies. The analysis extends beyond 'the financial numbers', as sound assessment depends on factors other than comparisons of standard financial ratios. As cases such as Enron, Tyco, Sunbeam and Worldcom in the USA, and HIH, Harris-Scarfe and One-Tel in Australia show, only by understanding the what is behind the numbers and how they relate to the organizations context and strategy can one make a meaningful financial analysis.

By the end of the course students should have the capacity to understand; interpret; and critically assess financial statements put out by organizations in light of additional contextual information available. What we needed was a holistic framework that would get students to focus on a myriad of organisational and contextual issues in an organised and integrative way. We now discuss the integrative model through which financial analysis is approached - Price Waterhouse Coopers' Value Reporting Framework.

PRICE WATERHOUSE COOPERS (PWC) VALUE REPORTING FRAMEWORK.

PWC is the largest of the "Big 4" accounting firms. The insights that PWC has gained from an ongoing research program into the performance measures that

really matter to key stakeholders have been codified into the 'Corporate Reporting Framework' which is alternately badged as the 'Value Reporting Framework' (VRF).

The VRF consists of 'performance measures' about key *elements* of an organisation's context and operations that impact on value creation. This information is required by a range of internal and external stakeholders. These elements are grouped logically into one external category and three internal categories of performance information that all industries and companies share in common: Market Overview, Strategy and Structure, Managing for Value, and Performance. By performance measures, PWC advocates a range of information from financial and non-financial numbers to narrative descriptions (stories) to media like photographs.

These performance measures in the VRF are needed by internal and external stakeholders to reduce uncertainty in decision-making (about past & future performance) and demonstrate accountabilities (improve transparency).

Each of the four broad categories encompasses specific elements (Figure 1) that, according to PWC's research, both companies and investors consider critical to assessing performance.

There are a number of features of the VRF which are persuasive for its application to teaching and learning in accounting as the integrative model for subjects. Firstly there is an elegant simplicity and attractive logicality to the model. The VRF works on a logical sequence from left to right. Initially we must examine the external environment that an organization faces. Then we must consider whether the strategy and structure of the organization aligns to these contextual realities. Then there is the issue of whether the drivers required to succeed with the strategy are present and can be managed to achieve the value required. Next, the financial and non-financial performance outcomes must be articulated and evaluated. In this sequence we get logic and a breadth of issues to examine. In all of these considerations, accountants have a potential role and exert influence as practitioners and gatekeepers of financial and non-financial performance and members of multi-disciplinary management and project teams. Also the literature shows the VRF to be the more prevalent form of commercially developed performance management frameworks used in practice at the present time. Finally, the encouragement and support of PWC for the take-up to happen through the comprehensive free resources which it provides as is outlined later in the paper.

The logical sequence of the VRF translates to things students address in their case studies. First we must examine the external environment that an organization faces. Then we must consider whether the strategy and structure of the organization aligns to these contextual realities. Next comes the issue of whether the drivers required to succeed with the strategy are present and can be managed to achieve the value required. Lastly, the financial and non-financial performance outcomes must be articulated and evaluated. In this sequence we get logic and a breadth of issues to examine. Students doing the subject are expected to understand and react to the logic of the model and to cover each of the elements in each of the four sections in framework in their analysis report which compares two companies competing in the same commercial sector. However, students are expected to concentrate on key elements that are of supreme importance to their professional interest and professional development. Hence one student may chose to make a more comprehensive study of contextual external market-related elements whilst covering other elements in lesser detail, and another student might focus more heavily on analysing past financial and economic performance. So using thus framework gives the subject a relevant, robust and commercially recognized analysis model that gives the opportunity to combine breadth of issue coverage with depth of analysis that matches student requirements band the problem at hand.

Next we look at the web-based resources used in the Accounting Project.

WEB-BASED RESOURCES AND REPORT TASKS

The Accounting Project relies entirely on Web-based resources. Firstly students access the subject guide that outlines rationale, tasks, detailed notes and worked examples on calculating and interpreting ratios, subject timelines etc, and many other resources such as articles, subject bulletins, and referencing instructions via the subject's WebCT site at http://webct6.vu.edu.au/webct

Then for students to get an introduction to the ValueReporting Framework, they access PWC at http://www.corporatereporting.com/index.html. This site provides information on the background and structure of the ValueReporting Framework. Students can register access and obtain examples that bring narrative reporting alive by showing over 40 real-life examples of what good reporting actually looks like from companies across the globe. Each example contains detailed commentary from our professionals to provide guidance on improving the transparency of financial and non-financial information. This gives students free access to a resource that in hard copy would cost in excess of $200 US.

Next students access comprehensive examples of good practice reporting which reflects the sections and elements in the elements in the ValueReporting Framework. These relate to a public company listed on stick exchanges (Lintun at http://www.lintun.org/ or www.ebr360.org) and a private company (Re-Use at www.ebr360.org) which has statutory reporting requirements. These cases provide students with practical examples of how the ValueReporting Framework can be operationalised, and a benchmark for comparing their own choices of companies to be studied against good practice. The Re-Use case is also especially valuable in consolidating understanding of ratio and trend analysis obtained by the students from the previously mentioned detailed notes and worked examples on calculating and interpreting ratios that are to be found on the subject's WebCT site.

Next students must decide on their own choice of companies to analyse using the ValueReporting Framework as a structure. The aim is to introduce students to the information contained in the financial reports of companies and to give them the opportunity to use this information in contextual financial analysis via comparative case studies of two international businesses in the same broad industry sector. The specific requirements are that prepare a report in relation to two organizations which operate in the same general industry or commerce groups and present an oral presentation that summarises your findings.

With the Open Source database students can gather in-depth data on more than 100 major industries, including detailed SIC code-level information. They can find companies that match specific criteria--search by size, location or line of business. Students can find public companies via a large selection of variables and get detailed financial information. They can also find key executive contacts and board members by name, location, line of business, job function, biographical details, or company size. It gives access to news, articles, analysts' reports and SEC documents. Students use a basic search interface for quick text searching, whereas more focused searches utilize the Global Business Taxonomy of topics, geographies, and industries, through the precision search interface. By examining the range of information that Open Source provides on most of the world's major companies students obtain two key benefits. Firstly they can see how different analysts select, prioritise, balance and interpret the range of information that connects with each element in the value reporting framework.

Students have additional access to business information via the library's other databases such as Emerald and Ebsco which gives access to leading academic journals, business magazines and newspapers. Students can also access a range of significant information on company performance and prospects via: the Morningstar Financial Analysis and Investing website at www.morningstar.com; business sections of sites such as Yahoo, MSN and Google; and from company websites which contain annual reports, and investor briefings, and other information.

In terms of gaining knowledge and skills in the critical area of sustainability reporting, students access the comprehensive cases and information at the Global Reporting Initiative (GRI) site and the Roberts Environmental Centre.

In preparing their reports, students are asked to send their lecturer (termed 'supervisor') a plan and provide at least monthly feedback on progress. When the report is completed, students submit it electronically for assessment. The report is assessed and graded by the supervisor, and a completion or re-submission report is sent electronically to the student with a maximum 'wing-tip to wing-tip' turnaround time of one week.

To assure originality in content, the paper is submitted through Turnitin (http://www.turnitin.com/static/index.html). Turnitin is recognized worldwide as the standard in online plagiarism prevention, and helps educators and students take full advantage of the internet's educational potential. Every paper submitted is returned in the form of a customized Originality Report. Results are based on exhaustive **searches of billions** of pages from both current and archived instances of the internet, millions of student papers previously submitted to Turnitin, and commercial databases of journal articles and periodicals. Any matches uncovered between submitted papers and source material is detailed in an intuitive and unambiguous format.

CONCLUSIONS AND FUTURE DIRECTIONS

Ideas travel and are translated into different settings (Solli et al 2005), and so advances into the electronic sphere of teaching and learning need to contain the right mix of 'big steps' and 'baby steps', and should match the needs of the client base. With the initiative described in this paper, the first big step was to recognise the utility to students of the pure web-based form and content, and to subject the idea to a rigorous cost-benefit analysis that included and balanced educational, reputational and economic factors. The baby steps are concerned with technology uptake, and debate about how sophisticated the subject delivery should become. Had the commencement of this subject waited until the more sophisticated features of WebCT and associated technologies were mastered by staff and students for purposes like webcasts and real-time discussions, we believe the momentum could have been lost. If the methodology proposed had looked like requiring significant levels of new or shifted resources, the bureaucracy may well have halted the project on budget constraint and risk-aversion grounds. We learn by doing things in an iterative fashion (Demediuk 2006), and this is especially important to remember with e-learning initiatives. The 'buy-in' by staff and the first batch of students doing the web-based project was largely down to the fact that the time and effort to ramp up with the necessary technical skills were modest compared to perceived returns, and the risks of systems and competencies failure appeared remote. More sophisticated technological practices will be implemented slowly over time as baby-steps. Student output from the Project has already been accepted in the refereed international conference sphere. Feedback from students in the Accounting Projects suggests that student-centred learning can be productively and cost-effectively extended to subject areas that examine areas of current commercial practice.

REFERENCES

Demediuk, P. 2006 (forthcoming). 'Theory and Practice in Reporting on Organisational Value'. *Global Business and Economics Anthology*. Business and Economics Society International (BESI).

Solli, R, Demediuk, P and Sims, R. 2005. 'The namesake: On best value and other reformmarks', in Czarniawska, B. and Sevon, G. (eds) *Global Ideas*. Liber – Copenhagen Business School Press, Copenhagen.

PWC. 2002. 'Bridging the gap'. *Briefings magazine* – Price Waterhouse Coopers. May

PWC. 2005. *Trends 2006: Good practices in corporate reporting*. Price Waterhouse Coopers.

PWC. 2006. Trends in corporate Reporting. Price Waterhouse Coopers. http://www.corporatereporting.com/index.html

Strategic Alignment as a Key Factor of Success for 4PL Development: A Research Program

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ABSTRACT

One of the most significant upheavals of the logistics industry is the emergence of a new generation of logistics service providers, called fourth party logistics (4PL). Their function is to provide the supply chain members with a customized service, based on a flawless coordination of logistical resources mobilized from the various firms. Considering the importance of IT, the paper suggests a research program on this subject referring to strategic alignment models. Its aim is to know whether the 4PL are able to combine their business strategy, IT deployment and organizational performance efficiently so as to manage interfaces between the supply chain members in the best conditions.

1. INTRODUCTION

The logistics industry has been undergoing profound changes for about ten years under the pressure of new entrants. Thus, the most dynamic logistics service providers (LSP) are changing their organization and strategy to become dematerialized operators. They are developing a customized service for their customers by mobilizing resources and resorting to different partners and by making sure of its consistency thanks to a total control of information flows. The consultancy company Accenture called these LSP without physical assets the "fourth party logistics" (4PL). Their trade is to design and sell global supply chain solutions by coordinating the activities of carriers, storage operators, subcontractors, packaging companies, etc. The objective of this paper is to propose a research program on the evolution of 4PL to know whether they are able to combine their business strategy, technological deployment and organizational performance efficiently in order to carry through their role of coordinator. The question is important in a context of confrontation between the supply chains in which coordinating the logistical operations perfectly has become a prerequisite for developing a competitive advantage.

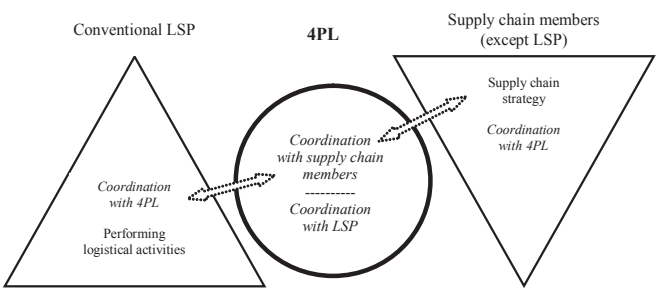
2. LOGISTICS INDUSTRY: THE RISE OF 4PL

Understanding where the logistics industry is headed requires a two level analysis. On the one hand, it is necessary to assess the role of outsourcing in the logistical process optimization (*supply side*) and, on the other hand, to study the evolution of LSP's activities (*demand side*). As time goes by, the number of manufacturing and retailing firms which no longer want to manage their logistics by themselves has kept on increasing in Europe and the United States. The reasons for this are widely known: restructuring the global supply chains to improve operations coordination; facing the fluctuations in the volumes and destinations of products to be dispatched; reducing costs and increasing service quality in terms of flexibility, deadlines and product customization, and adapting themselves to market globalization. LSP's supply has followed and in certain cases anticipated this new demand in three complementary ways: [1] a reorganization by sectors and customers at the European level; [2] the development of relationships with consultancy companies specialized in using management tools; [3] the development of innovative procedures ensuring a perfect traceability of flows in collaboration with customers.

What are the special features of 4PL compared with those of the transport companies and conventional LSP, which are themselves also involved in this radically changing logistics industry? The 4PL share an ability to carry out the activities of planning and coordination of information flows, designing both the logistical structure and the inter-organizational IS applied to the integrated processes along the global supply chains. By appropriating the new technological tools and combining them with conventional means, 4PL give a more informational orientation to their work. They aim at basing the string of logistical decisions on an electronic management of transactions, implementing interfaces to connect the management systems of the various members of the supply chains. As the services provided by 4PL are highly customized, they increase the interdependence between the partners thanks to common informational and organizational standards. So the 4PL are involved in a governance based both on the management of knowledge and on a "specialization of architectural competencies" which gives them a nodal position in supply chains and, to a larger extent, in the value creation process. In this aim, they position themselves at the interconnection between the supply chain members (except LSP) and the logistics operators, managing thereby their interfaces (Fig. 1).

In order to analyze and explain the key factors of success of 4PL, one refers traditionally to the current strategies of logistics outsourcing, which leads to more and more "dematerialized" supply chains. However, this approach is insufficient as it is only focused on the demand in logistical services. And it is also necessary to wonder about the way 4PL acquire the coordination and monitoring competencies step by step to facilitate the process which adjusts the conventional supply of LSP to meet this specific demand. Thus, if a few academic works are devoted to 4PL's performance, they do not sufficiently take into account all the determining factors of its evolution as a *transactional center* acting at the meeting point of a multiplicity of supply chains. The co-alignment models seem to be pertinent to highlight the part played by 4PL.

Figure 1. The management of interfaces by 4PL



Source: Adapted from Van Hoek [7].

3. MODELS OF STRATEGIC ALIGNMENT

There is a strong interaction between the structure of 4PL and their technological environment. Indeed, 4PL are nowadays the catalyst for the organizational change within the supply chains. Here, the concept of *fit*, i.e. the alignment of many contingent elements which affect the firm and inter-firm performance, comes into play. The strategic alignment (or co-alignment) models developed for the past twenty years are based on the essential idea that organizational performance is due to the co-alignment of several factors: strategy, technology, structure, etc. These issues interest a growing number of researchers in IS management, strategic management and SCM. Their conclusion is that companies cannot be competitive in the long run without aligning their generic strategy (including logistics) and their IT [2,4]. Some models also include people (culture, leadership) and processes (supply chain workflow) [4].

From a supply chain perspective, the strategic alignment is the result of two elements: on the one hand, a specific type of "business climate" (cooperation vs. arm's-length competition) and of organizational structure; and on the other hand, the use of IS at a specific level in a given social and cultural context. Thus, the use of IS results not only from the need for operational efficiency in the commercial, industrial and logistical transactions of the supply chain members, but also from the search for synergies: risk-sharing and strategic gains. The academic literature gives several theoretical models of strategic alignment. It will be interesting to apply the seminal models of Venkatraman [9] and Henderson & Venkatraman [3] to the particular case of 4PL development. Other research followed but did not try very hard to assess them empirically and to make them operational except for Bergeron *et al.* [1]. Indeed, we can think that 4PL are the actors of a strategic alignment since the more the synergies and coordination are developed within a supply chain, the higher its performance level is likely to be. As the role of a 4PL is to build up, dismantle and rebuild supply chains, making logistical resources coincide with the needs of the supply chain members becomes a key point.

One should wonder about the relevance of applying co-alignment models to the particular case of 4PL. What are the benefits of studying simultaneously the links between business strategy, technological deployment and organizational performance? Does the impact of IT on 4PL result in a true revolution in flow monitoring, or is it merely a natural evolution of the logistics industry? To answer these questions, this paper intends to present a research program on the strategic evolution of 4PL in Europe, influenced by a significant development of the supply in value-added services (Fig. 2). In the wake of works integrating the network organization models to understand logistics industry trends, we intend to apply the dimensions of the strategic alignment of business and IT to assess the chances of success of the 4PL as a coordinator of supply chains. Following the example of Bergeron *et al.* [1], the objective is to adopt a holistic approach to examine the impact of the fit among alignment domains on the firm performance.

4. RESEARCH PROGRAM

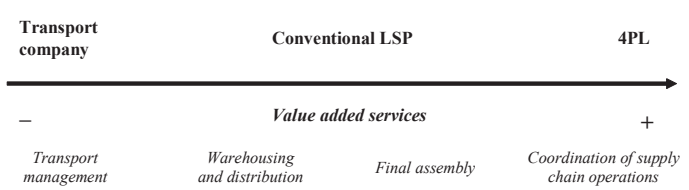
The legitimacy of the research program suggested is reinforced by the publication of two recent studies. The first study is European. Carried out by TN Sofres Consulting for the European Commission, it studies the impact of IT on retail firm logistics. It deals with the current situation, transformation factors, changes in process and stakes. But after having emphasized the difficulties encountered in measuring the performance of logistical structures in general, nothing is said about the importance of the co-alignment of the supply chain members which support all the flows. The second study is American. It tries to answer the following issues: "Do supply chain IT alignment and supply chain inter-firm system integration impact upon brand equity and firm performance?" [5]. The study is based on an analysis of the managers listed by the Council of Supply Chain Management Professionnals, but it remains incomplete as the authors have ruled out the consultants, freight forwarders, conventional LSP and 4PL. Which amounts to ignoring the fact that 4PL are one of the most advanced forms of virtual organization logistics.

One of the possible leads to assess 4PL's competitiveness consists in using the co-alignment process as a logistical monitoring tool. In this respect, the analysis of academic literature reveals unexplored fields regarding the 4PL's monitoring mechanisms and processes, but also and above all regarding the structuring role of IT, i.e. with regard to the configuration of exchanges within the supply chain. So, having a co-alignment measure turns out to be essential to understanding the 4PL's functioning as well as their performance levers and strategic and technological orientations. Compared with the classic approaches of performance measurement, co-alignment integrates a certain number of contextual, environmental and institutional variables. Thanks to adapted models, we can expect an answer to the following questions, which structure the research program in four complementary directions [3, 9]:

1. *Strategy execution.* What business strategy is chosen by 4PL top management to develop a sustainable competitive advantage? Is it based on a cost leadership or a differentiation strategy?
2. *Technology potential.* What kind of IS infrastructures is used, and on what IT tools are they based? How are the flow monitoring tasks carried out between the supply chain members at an operational level?
3. *Competitive potential.* Does the exploitation of emerging IT capabilities lead 4PL to develop distinctive competencies? If so, are these competencies recognized by the supply chain members? What kinds of supply chain governance result?
4. *Service level.* Does the use of IT resources enable 4PL to increase its level of responsiveness faced with fast changing supply chains? What are the procedures used to combine (and re-combine) logistical resources without being detrimental to the service level?

In a way, the research program is a logical result of the research being carried out currently on 4PL [6]. Its objective would be to describe in detail some cases of 4PL development in order to recommend actions able to improve their service supply. With this aim in view, it is necessary to resort to a conceptual framework referring to both IS management and SCM. Our ambition is thus to make progress in the formulation of a general model of the logistics virtual firm, which emergence seems to be a profound brake in the 1980s and 1990s' supply chain dynamics. This is part of a more comprehensive and older project to better understand the foundations of logistics management based on an in-depth study of the organizational and technical means implemented in a given context.

Figure 2. From transport company to 4PL



5. REFERENCES

[1] Bergeron, F., Raymond, L. & Rivard, S. (2004), "**Ideal patterns of strategic alignment and business performance",** *Information and Management***, 41(8): 1003-1020.**

[2] Earl, M. (1996), "Integrating IS and the organization: a framework of organizational fit", *in* Earl, M. (ed.), *Information management: the organizational dimension*, Oxford: Oxford University Press, 485-502.

[3] Henderson, J. & Venkatraman, N. (1993), "Strategic alignment: leveraging information technology for transforming organizations", *IBM Systems Journal*, 32(1): 4-16.

[4] Lee, C. (2006), "Designing integrated supply chains", *in* Lan, Y.-C. & Unhelkar, B. (eds.), *Global integrated supply chain systems*, Hershey (PA): Idea Group Publishing, 97-124.

[5] Seggie, S., Kim, D. & Cavusgil, S. (2006), "Do supply chain IT alignment and supply chain interfirm system integration impact upon brand equity and firm performance?", *Journal of Business Research*, 59(8): 887-895.

[6] Van Hoek, R. (2004), "UPS logistics and to move towards 4PL−Or not?", *Proceedings of the Annual Supply Chain Management Educators' Conference*, Philadelphia (PA), pp. 1-19 (CD-rom).

[7] Venkatraman, N. (1989), "The concept of fit in strategy research: toward verbal and statistical correspondence", *Academy of Management Review*, 14(3): 423-444.

Blending Technology with Inquiry-Based Pedagogy: Implications for Learning and Teaching in Online Environments Designed for Graduate Level Teacher-Education Courses

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ABSTRACT: PURPOSE OF THE STUDY

This study is intended to further inform the construct for teacher-learners' transfer of technology first to their teaching dogma, secondly for their pedagogical praxis and ultimately for the paradigm of teaching and the students' learning environment. Although much has been written and reforms mandated about the professional development of teachers and the need for technology rich instruction more discrete information is needed about the teacher's learning being situated in technology learning environments. What evidence does the situated praxis of online discussions in the teaching of teachers offer to further the research of meaningful technology transfer into their classrooms?

Keywords: distance education, teacher education, online teaching, Web-based instruction, blended classes, inquiry-based pedagogy

INTRODUCTION TO THE STUDY

We are examining data accumulated from blended course online discussions with in-service and pre-service teachers. The data accumulated from these blended course online discussions includes topics of threads, content of responses, identification of originator (instructor versus teacher-learner) of threads, and occurrences of collaboration in forming meaning. Our in-depth evaluation of the online interactions and subject of discussions will contribute to creating a potential model for teachers as participant practitioners in online learning in order to demonstrate the transfer of technology into their pedagogy.

LITERATURE REVIEW

Angers and Machtmes' (2005) qualitative study identifies the "adoption and use of technology in the classroom is determined by teachers' attitudes and beliefs." (Angers, 2005, p. 780). Their findings regarding that "Teachers beliefs about classroom practice appear to shape their goals for technology, " (Angers, 2005, p. 789). In our study we look at how these intrinsic beliefs can be expressed, changed over time and influenced by participating in online classes, thereby guiding the students to become expert-practitioners. How can the instructor design the learning experience to get these results? We are also adding to the body of literature by studying the mechanism for the eventual transfer of technology learning to the classroom.

Stephenson's (2002) work is a collection of articles by many authors on how to transit from theory to practice, create effective online learning environments using theoretical frameworks and evidence-based research and pedagogy to help learners to make the optimum use of online learning. The articles all lead to the transformation from instructor-managed to learner-managed pedagogy for best online learning. Several features that are most relevant to both instructors and learners include the following: access to resources, heuristics, attention to different learning styles and needs, access to experts, both online and offline, tracking and recording of dialogue, transactions among students, teachers, student-student, a variety of types of engagement, including synchronous and asynchronous, feedback, good design of the web environment, easy links to multimedia, universal design, opportunities for telementoring and interaction with experts both within and outside of the institution, an the opportunity to work in collaboration with peers and groups online and globally. These features should be flexible and learner-controlled. Learners should be able to utilize all of these features online and go to other resources. Importantly, students must perceive the difference in the online environment as offering more than a lecture delivered online, be encouraged to use the interactivity, and to take responsibility for his/her own learning and participation in order for this transformation to occur. These are the goals of our online course development, to encourage transfer from the blended component of the class to the teacher-learner's own pedagogy and practice.

While Kozleski (2004) emphasizes the economic contribution of technology as being imbedded in education, she identifies changes to teachers' dogma and pedagogy as critical for the transference of technology in education. Our efforts to identify discrete teacher learning underscore, "rather than harnessing the curriculum, understanding education as a technology transfer activity opens the dialogue about how and what to teach." (Kozleski, 2004, p.191).

Borko (2004) identifies elements of a situated analysis of teacher learning as a learning program, with teachers as the learners, the instructors as the guides for the teachers as they construct new learning along with the context in which the teachers learning occurs. While many researchers have studied some combination of these relationships and the factors that influence them our study will further our understanding of what and when meaning is being situated in the teachers understanding of the new role technology will now play in their teaching for their classrooms.

CONCEPTUAL FRAMEWORK

The impetus for this study came as a response to the meta-analysis done by Mary Tallent-Runnels, Julie A. Thomspons, William Y. Lan and Sandi Cooper (2006).

Their research suggests that courses taught totally online are called "online courses" and those taught partially online be labeled "blended courses." As part of their findings and recommendations for future research, the authors suggest that there are few existing studies focusing on pedagogy and learning online, which type of format fits which particular class and instruction, what the online roles of instructors and students play, and how the depth of online interactions that occur can lead to and encourage higher-order, critical thinking and constructivist learning.

To achieve higher order thinking, Wakefield (1996) suggests three pedagogical approaches; 1.) Stand-alone instruction in thinking independently, 2.) Dual agenda

combining the first approach with some subject discipline content 3.) Authentic task approach, students are required to apply higher order thinking skills in performing some task. Our research pulls from this later approach suggesting that scaffolding discourse online is an authentic pedagogical approach to promoting higher order thinking outcomes for student learning.

Kotik and Redman (2005) examine the "Extent of Technology Integration In Instruction By Adult Basic Education Teachers," researching how much adult basic education teachers integrate technology into their curriculum and have learned how to use technology themselves, recommending the four methods cited by Ginsburg, (1998). These methods include considering technology as specific curriculum learning digital literacy skills, technology as an instructional delivery system, as another component to instruction for learning skills, and as a tool to enhance heuristic skills, write, and comprehend. The authors cite the process of learning to integrate technology from learning to adapt to using technology to construct new learning environments. There are several discreet barriers for adult learners such as teachers: how to integrate technology, including the lack of opportunity to learn from their peers, ask and answer teaching-related questions, and actual practice in online discourse. Teacher-learners do not generally get to use technology on a higher level, and lack the opportunity to make innovative integrative use of it in their practices. According to this study, not much progress has been made since a 1995 Office of Technology Assessment report.

This study is relevant as the online component of blended courses offers greater opportunity for teacher-learners to participate in discourse, learn from the instructor and their peers, and gain knowledge along with insights on how to better integrate technology into their curriculum, thereby overcoming these barriers.

As opposed to how teachers are facing impediments to technology integration, Ertmer, Ottenbreit-Leftwich and York (2006-2007) have examined "Exemplary Technology-Using Teachers: Perceptions of Factors Influencing Success". This study looks at teachers who actually use technology meaningfully in their classrooms despite internal and external challenges, including lack of time, resources, technophobia, access and institutional support. While other articles cite the barriers that lead to full implementation of technology, this study looks at the most important indicators that help teachers overcome these known obstacles. Interestingly, one of the findings suggests that digital immigrants, those teachers with more than five years of teaching experience, but less technology savvy and confidence, are actually more likely to direct their students to use technology in a more effective, meaningful way to enhance learning than their less-experienced, digital native colleagues who have more technology experience and confidence, but lack the expertise and management skills of more seasoned educators.

The more experienced teachers appreciated the value of the use of technology more than the more novice teachers who felt more at ease using the technology, but used it less effectively. This supports the data-analysis of the Introduction to Technology MD 400 course section with fewer digital natives, but more experienced teachers who are digital immigrants and a larger number of transactional postings.

The study also examined what intrinsic and extrinsic factors affected the use of technology to find which characteristics were more determinant. The results of the study indicated that the teachers who used technology in the most exemplary way felt that the factors such as confidence and experience (intrinsic) rather than extrinsic factors such as availability, quality of resources and their own time were most influential in their effectiveness.

For our purposes, giving teacher-students experience online will increase their confidence and expose them to collaborative learning from their peers and instructors. As engagement deepens, the teacher-learners become more effective in the planning of curricula using technology for their own students. These are all intrinsic factors which will influence their success regardless of their access to resources, time availability and other extrinsic factors which they cannot control.

Examination of the data includes three primary areas:

I. Sample Population- characteristics and description
The sample population is comprised of adult students who are participating in a Graduate Teacher Education Program at a Jesuit university. Some are majoring in educational technology, while others are taking their required educational technology course and electives. The teacher-learners range in age from recent graduates of a Bachelor's program, to older, returning students who are making career changes or enhancements. The majority of the students are either pre-service or in-service teachers pursuing a Master's Degree.
Combined population demographics include a total of 188 students (some of which are ESL, 14 blended classes, conducted from Fall 2002 through Summer 2006. Both authors have been teaching on-site, online and blended courses in educational technology for graduate-level teacher education from 2001 through 2006.

II. The Role of the Instructor
Along with the designing of the course, we examine the instructor's pedagogical praxis and paradigm choices. As an example, both instructors have made use of inquiry-based teaching methods in class and online.

III. Online Discussions
The online postings will be examined in terms of topics, and content. We will pay particular attention to teacher-learners' references to prior experiences and knowledge in connection to their new learning within the content and topics of the online discussions.

Do particular categories of discussion topics provoke teacher-learning level of engagement with technology learning?

INITIAL FINDINGS

Identification of characteristics for online pedagogical practices:

Pedagogical implication of online postings allows for more in-depth assessment of learners' levels of engagement with material as well as analysis of learners' construction and integration of meaning for learning.

Initial analysis of the data suggests the Instructor/Teacher-Mentor's pedagogical approach to the online setting shows movement from leading to some combination of modeling online behavior and heuristics for teacher-learners.

REFERENCES

Angers, Julie and Machtmes, Krisanna (2005). An Ethnographic-Case Study of Beliefs, Context Factors, and Practices of Teachers Integrating Technology**.** *The Qualitative Report*, 10, (4), 771-794.

Ausbel, D. (1963). *The psychology of meaningful learning*. New York: Grune & Stratton.

Borko, Hilda (2004), Professional Development and Teacher Learning: Mapping the terrain. *Educational Researcher*, 33, (8), 3-15.

Brown, J., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Research,* 18, 32-42.

Ertmer, P., Ottenbreti-Leftwich, A., and York, C. (2006-07). Exemplary Technology-using Teachers: Perceptions of Factors Influencing Success. *Journal of Computing Education*, 23(2), 55-61.

Ginsburg, L. (1998). Integrating technology into adult learning. In C. Hopey (Ed.), *Technology, basic skills, and adult education: Getting ready and moving forward* (Information Series No. 372, pp. 37-45). Columbus, OH: Center on Education and Training for Employment. (ERIC Document Reproduction Service No. ED 423 420)

Kotrlik, Joe W. and Redmann, Donna H. (2005). Extent of Technology Integration in Instruction by Adult Basic Education Teachers. *Adult Education Quarterly*, 55, (3), 200-219.

Kozleski, Elizabeth B. (August 2004). Technology Transfer and the Field of Education. *Comparative Technology Transfer and Society*, 2, (2), 176-94.

Office of Technology Assessment, U.S. Congress. (1995). *Teachers and technology: Making the connection. OTA report summary.* Washington, DC: Government Printing Office. (ERIC Document Reproduction Service No. ED 386 154)

Resnick, L. (1987). *Education and learning to think.* Washington, DC: National Academy Press.

Stephenson, J. (Ed.) (2002). *Teaching & Learning Online: Pedagogies for new technologies*. VA:Stylus Publishing.

Tallent-Runnells, M., Thompsons, J., Lan, Y., and Cooper, S. (2006, Spring). Teaching courses online: A review of the research. *Review of Educational Research* , 76, 93-135.

Wakefield, J. (1996). *Educational Psychology: Learning to be a problem-solver*. Boston: Houghton Mifflin.

Deakin University and Online Education

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Please note that at the time of submitting this paper, the proposal of project had been submitted to the Faculty of Business & Law and was awaiting approval. Human ethics clearance as part of the University's and Australian privacy laws requirement for the project had already been obtained.

THE RISE OF E-LEARNING TECHNOLOGIES AND CHANGES IN STUDENT LEARNING

Electronic learning (e-learning) is an approach to facilitate and enhance learning through information and communications technology. For the purpose of this project, the authors have adopted the Mills, Eyre and Harvey (2005, p.45) definition of e-learning, "effective learning processes created by combining digitally delivered content with (learning) support and services". The equipment and software (such as computer software and hardware) that are used in this endeavour are collectively referred to as e-learning technology. It is anticipated that by adopting and practicing e-learning technologies, a University would be able to address the knowledge thirst of higher percentage of learners, those who require flexible working hours due to their professional or personal commitments.

Our current students perceive information and learn in different ways compared with the past. There have been emerging debates about generation Y (also known as Millennials, Buckingham, 2006; Eisner, 2005) and the fundamental nature of thinking that is applied by people who are raised in an environment filled with digital media. The digital natives, as Prensky (2001) refers to them, seem to challenge teachers (referred to as digital immigrants) to address new learning needs. Such learners now need connection more than they need content. By this we mean that knowledge about how to conduct information search, how to manipulate metadata, how to connect from one digital device to another, becomes the majority of information that is needed to become proficient in a specialised field. In any given discipline, the answers to questions can be found in the sea of information by knowing how to search for it (for example Google the word or phrase). This usurps the need for memory of content that was required before the era of interconnected information. What is important to digital natives is not retention of memory of content, instead understanding of how to locate content quickly.

SCUP (2004) observes in United States generation Y students that nearly every one of them has a cell phone and access to instant messaging/text messaging wherever they are, and social networking software is increasingly becoming part of the online experience [see also Miller, 2006]. The implication is that learning should occur through dominant media. As digital devices transform to become e-learning technologies, there is a ready generation of learners eager to have their experience through such devices. Accordingly, to retain their current and attract future students, a number of Australian universities are allocating millions of dollars for upgrading and installing new technologies to support e-learning initiatives (Alexander, 2001) or else they prospect losing their global competitive market.

CHANGES IN TEACHING AND LEARNING

We have applied the 'full circle' metaphor intentionally in our study to remind ourselves of the cyclical nature of information flow and the evolutionary nature of understanding in any given teacher-learner relationship. Over the centuries educations institutions have moved from an oral culture to a written one nonetheless even in this digital age the importance of coherent words has only gained more importance to communicate well.

Kolb (2000) has suggested that digital media (e-learning technologies) have destructive elements that must be consciously harnessed and controlled if they are to be turned into educational value. This appears to suggest that good management education can occur online, despite the risk that the online experience could manifest inferior to traditional classroom opportunities to interact face-to-face. As a result, educators often need to intervene in online education to be sure critical thinking emerges as an accurate response. Our experiences online tend to support this fact. People can react quite emotionally to subtle variance in application of language. Post a discussion thread message with a word that can be interpreted ambiguously, and the flame begins. Alternately, to leave an online classroom unattended for very long ensures students will feel ignored and the associated social ructions can manifest in that environment.

THIS PROJECT

The newest generation of learners in Australia and beyond have been raised on a diet of new media technologies leaving some observers wondering if the very processes of learning are being altered by this digital ground shift. The aim of the research is to gather information regarding the usage of e-learning technologies used by staff and students at Deakin University. Identifying the 'maturity' of various e-learning technologies being used within the "educational delivery [and] understanding learner needs and preferences towards e-learning" has also been highlighted as an area for future research by Pittard (2004, p.186). Most of the student respondents will belong to generation Y and may be categorised as digital natives.

The objectives of this research project are to:

- Identify best practice methods of online teaching models using e-learning technologies
- Identify challenges accompanied with improving teaching and learning via e-learning technologies, and
- Recommend guidelines and a model for improving teaching and learning via e-learning technologies.

Universities around the world are incorporating e-learning technologies within their curriculum. Deakin University is part of this change and is one of the Australia's leading distance education and online teaching universities. Deakin's commitment to online teaching and learning can be reiterated by the recent directive from its Vice Chancellor that all students need to complete a fully online unit to graduate. Universities, students and academics as stakeholders all benefit from this initiative and collaboration. A university can sell the flexibility of its online courses to gain a larger market share by targeting both full time and mature age students. It can also be argued that by forcing students to complete one fully online unit, in addition to addressing one of its graduate attributes, the university is also teaching its students computer/IT skills. People from generations X have realised that learning and using IT has become a prerequisite for their survival and advancement both in their professional and personal lives.

When academics use technological tools as part of their teaching, the students regardless of their generation benefit from getting more efficient, prompt and timely feedback on their assessment tasks. IT also allows both academics and students to communicate with each other in a virtual environment hence addressing one of the major concerns of off-campus or distance students, losing information and contact with their academics and peers due to their respective mode of enrolment. Online technology nevertheless may act as a double-edged sword for academics. On one hand, academics like their mature age students are forced (or in some instances motivated) to learn about how technology can be used to enhance teaching mediums and bridge the gap between them and their current students. On the other hand, many academics complain about the entire activity being time consuming and a steep learning curve without much assistance from the university.

The emerging landscape of e-learning technologies has the potential to fragment online delivery options. Wireless applications are testing the traditional definition of online, however, the functional aspects are synonymous in the sense that internetworked digital learning objects are the content delivered through this media. At the heart of any operational change will be the need to stay focused on good quality teaching practices. The question accordingly is, 'What constitutes good education in the online and e-learning context and how can a university such as Deakin maintain or improve its standards and competitive advantage?

This project will focus on the current e-learning teaching practices used by Deakin University academics in order to identify a best practice framework. It will also recognize the challenges experienced by academics using these e-learning technologies and when attempting to improve the quality of teaching. The project will also look at the benefits and challenges of using e-learning technologies as experienced by Deakin's students. Findings of the research will result in a set of guidelines and a model for improving quality of delivery via e-learning tools.

RESEARCH METHODOLOGY

To obtain a 'full circle' perspective on e-learning applications, we decided to research the views of both academics and students. We are in the process of finalising questions for staff questionnaire and students focus group procedure in order to capture the data snapshot.

Staff Questionnaire Survey

Questionnaire survey will be administered to Faculty of Business & Law, Deakin University academics to obtain feedback on a number of key variables in relation to e-learning technologies. Questionnaire surveys have been described by Ferber et al (1980, as cited in May 1993, p.65) as "a method of gathering information from a number of individuals, a 'sample', in order to learn something about the larger population from which the sample is drawn". Questionnaire surveys, as a deductive methodology with time, have gained an edge over other research techniques such as door-to-door surveys or telephone interviews (Spencer, 1982). One of the reasons behind their wide spread use is that the results obtained can be exhaustively analysed by the use of sophisticated computer software packages. Moreover, the assurances of anonymity and confidentiality (Jobber & O'Reilly, 1996; Jobber & Sanderson, 1983; and Jobber, 1986) increases the rate of getting true responses from the respondents that are not achieved for instance by telephone surveys (Peil et al, 1982).

Muller & Miller (1996); and Jobber et al (1985) have provided examples of the benefits of usage of questionnaire over phone surveys. Nonetheless, before undertaking this methodology, a researcher needs to be also aware of its weaknesses (see Jobber, 1989; Herberleain & Baumgartner, 1978; Lewis, 1997; and Inguanzo, 1997).

Student Focus Groups

As no previous research had been undertaken in this specific area, focus groups were chosen as a methodology for students as an exploratory technique was required. Researchers are increasingly using focus groups to "identify issues and attitudes [and to] see how various people from the group respond to other's position" (Bouma, 2004, p.182). As opposed to directing one-on-one questions as in case of interviews, during a focus group the facilitator asks an open question to the group and observes the group responses and dynamics. The facilitator nonetheless needs to be careful to not intervene and bias the group discussion from previous knowledge, experience or background. Keeping in view focus group advantages (Ghauri & Gronhaug, 2005; Veal, 2006; and Morgan, 1997) and drawbacks (Ghauri & Gronhaug, 2005; and Morgan, 1997) focus groups can be used to raise and pilot new ideas.

NEXT STEP …

In views of the authors, e-learning technologies are both consolidating and proliferating the universities and academics environment. IT is allowing people from diverse backgrounds and age groups to come together and learn new skills and secure more degrees. Simultaneously, e-learning technologies are proliferating as both technologies and learning methods are constantly changing.

Our project will take a foundational view of education, as identified by researchers such as Dewey (1963) and Alexander (2001), in context with e-learning technologies and the concept of the digital native. Is knowledge of connection between media the kind of knowledge Dewey (1963) may have anticipated? Could it be that learners now have some kind of advantage over many of their teachers, simply by knowing more about how digital devices connect and sift metadata in a sea of information? Or does the teacher still retain the upper hand? Perhaps the role of experience simply cannot be replaced by connection? What use is connection to information if one does not have the experience or wisdom to know what to do with it? Knowledge of connection may just be another way of conceptualising rote memory. Biggs (2003, p.214) raises this very warning, suggesting that transmission of information does not in itself constitute learning. We will reflect upon these burning questions as the project evolves.

As the next step, the authors would like to explore the industry/practitioners views to fully close the 'circle' and identify whether the e-learning practices are of any use for them. The researchers would also like to replicate their study in other countries and universities.

REFERENCES

Alexander, S. (2001) E-learning Developments and Experiences, *Education + Training*, Vol. 43, No. 4/5, 240-248.

Biggs, J. (2003) *Teaching for Quality Learning at University*, 2nd Ed. Open University Press. Buckingham.

Bouma, G., D. (2004), *The Research Process*, (4th edition), Oxford University Press, Victoria, Australia.

Buckingham, M. (2006) Engaging Generation Y: An interview with Marcus Buckingham, *ASTD*, August, 27-30.

Dewey, J. (1963) *Experience and Education*. London: Collier Books.

Eisner, S. (2005) Managing Generation Y, *SAM Advanced Management Journal*, Vol. 70, No. 4, 4-15.

Ghauri, P. and Gronhaug, K. (2005) *Research Methods in Business Studies*, (3rd edition), Prentice Hall, UK.

Herberleain, T., A. and Baumgartner, R. (1978) Factors affecting response Rates to Mailed Questionnaires: A Quantitative Analysis of the Published Literature, *American Sociological Review*, Vol. 43, No. 4, 447-462.

Inguanzo, J. (1997) Based on Response rates, Phone Surveys are Cheaper than Mail, *Marketing News*, Vol. 31, No. 1, 15.

Jobber, D. (1989) An Examination of the Effects of Questionnaire Factors on Response to an Industrial Mail Survey, *International Journal of Research in Marketing*, Vol. 6, 129-140.

Jobber, D. (1986) Improving Response Rates in Industrial Mail Surveys, *Industrial Marketing Management*, Vol. 15, 183-195.

Jobber, D., Allen, N., and Oakland, J. (1985) The Impact of Telephone Notification Strategies on Responses to an Industrial Mail Survey, *International Journal of Research in Marketing*, Vol. 2, No. 4, 291-296.

Jobber, D. and O'Reilly, D. (1996) Industrial Mail Surveys: Techniques for Inducing Response, *Marketing and Intelligence Planing*, Vol. 14, No. 1, 29-34.

Jobber, D. and Sanderson, S. (1983) The Effects of a Prior Letter and Coloured Questionnaire Paper on Mail Survey Response Rates, *Journal of the Market Research Society*, Vol. 25, No. 4, 339-349.

Kolb, D. (2000) Learning Places: Building Dwelling Thinking Online. *Journal of Philosophy of Education,* Vol. 34, No. 1, 121-133.

Lewis, O. (1997) Do Your Homework, *Successful Meetings*, Vol. 46, No. 3, 120-121.

May, T. (1993) *Social Research: Issues, Methods and Process*, Open University Press, USA.

McLuhan. M. (1964) *Understanding Media: The Extensions of Man*. Mentor, New York.

Miller, J. (2006) Catching Generation Y, *CMA Management*, April, 13-14.

Mills, J., Eyre, G., and Harvey, R. (2005) What makes Provision of e-learning Successful? Charles Sturt University's Experience in Asia, *Education for Information*, Vol. 23, No. 1/2, 43-55.

Morgan, D., L. (1997) *Focus Groups as Qualitative Research*, (2nd edition), Sage Publications, USA.

Muller, G., D. and Miller, J. (1996) Interviews make the Difference, *Marketing Research*, Vol. 8, No. 1, 8.

Peil, M., Mitchell, P., K. and Rimmer, D. (1982) *Social Sciences Research Methods: An African Handbook*, Hlodder & Stoughton, Great Britain.

Pittard, V. (2004) Evidence for E-learning Policy. *Technology, Pedagogy and Education.* Vol.13. No.2, 181-194.

Prensky, M, (2001) Digital natives, digital immigrants. On the Horizon, 9(5), 1-2. Available: http://www.marcprensky.com/writing/Prensky%20-%20Digital%20Natives,%20Digital%20Immigrants%20-%20Part1.pdf [viewed: 19 September 2006]

SCUP (2004) *Trends in Higher Education: November Ed*. Society for College and University Planning. Ann Arbor, MI

Spencer, D., L. (1982) *Researcher's Guide: How and Why*, College-Hill Press, USA.

Veil, A., J. (2006) *Research Methodology for Leisure and Tourism: A Practical Guide*, (3rd edition), Prentice Hall, UK.

Reasons for Non-Completion of Online Computer Software Course: A Preliminary Study

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ABSTRACT

Business majors are required to complete a course using Microsoft Office. The course is offered both online and in a traditional hands-on classroom setting. Students who enroll in the traditional setting have a completion rate of 97% while the online students have a completion rate of only 75%. All students complete the same assignments and take the same exams. Extensive online help is available for all students. Demonstrations of all in-class activities are captured in Microsoft Captivate and are available at any time. Demonstrations are created in two formats: with sound and without. The demonstrations with sound have the instructor showing the specific skill while talking through the skill. The demonstrations without sound have the same skill but have word balloons explaining the step. The two types of demonstrations are available to meet different learning styles and different computer hardware setups. The online students were surveyed to gather data on locus-of-control, self-efficacy, use of available course tools and demographic information. Preliminary results show a strong correlation between grade earned in a required prerequisite class and completion of this software class. A secondary predictor of success was self-efficacy.

INTRODUCTION

A required course for all business majors is a Microsoft Office software course focusing on business applications of Access and Excel. Six sections are offered each semester; four in a traditional on-campus setting with a computer for each student and two in an online format. All students complete the same assignments and take the same exams. Extensive online help is available for all students. Demonstrations of all in-class activities are captured in Microsoft Captivate and are available at any time. Demonstrations are created in two formats: with sound and without. The demonstrations with sound have the instructor showing the specific skill while talking through the skill. The demonstrations without sound have the same skill but have word balloons explaining the steps. The two types of demonstrations are available to meet different learning styles and different computer hardware setups.

While the online students have all the same material and instruction available to them via the online demonstrations as the traditional students have through in class instruction, the online students have a consistent withdraw rate of 25% and the traditional students have a withdrawal rate of 2% to 3% according to course data over the last six semesters. A study of undergraduate courses at the University of Georgia system found that 30% of the online students dropped by the end of the semester (Morris, 2005).

Historically students who complete the online version of this skill-based course have an overall average grade of more than 85% which is usually similar to the students in the traditional classes. However, during the fall 2006 semester, the final grade average was 68% for the online sections and 80% for the traditional on-campus sections. The students who withdraw from the online course frequently retake the course the next semester in a traditional setting, causing the students to pay for the course twice.

Students are not required to complete an assessment before enrolling in an online course to help determine if they are well-suited for online learning. Students are also not required to speak to the instructor before enrolling in an online course. The university does not survey students who withdraw from online courses to find out why they have withdrawn from the course.

A required pre-requisite (BE&O) to the course is a basic computer literacy course in which students are required to pass exams using Microsoft Word, Excel and PowerPoint as well as take exams over traditional computer literacy topics such as parts of a computer and computer networks.

PRIOR RESEARCH

Locus of control and self-efficacy are well established measures in predicting educational success as these examples of prior research demonstrate. Gifford, Bricefho-Perriott and Mianzo (2006) found that students with strong internal locus-of-control are have a higher GPA than students with strong external locus-of-control. Sisney, Strickler, Tyler, Wilhoit, Duke and Nowicki (2000) determined that locus-of-control and self-esteem were high predictors of success in college courses. Onwuegbuzie and Dailey (1998) found that locus-of-control was the best predictor of successful study skills. Elias and Loomis (2002) found that self-efficacy and need for cognition were both significant predictors of GPA for undergraduate students. Pajares (1996) found that self-efficacy was a predictor of math problem solving ability in middle school students, using a path analysis.

COURSE DESIGN

The course is required for business majors and focuses primarily on Microsoft Access and Excel used in business applications. Most assignments are drawn from the textbooks, however for most students; the textbook does not give enough information to successfully learn the required skills. To compensate for the lack of in-class practice and demonstrations, online demonstrations have been created for most skills in the course. Everything that is done in the traditional classroom has been transferred to online demos. The demos, created in Adobe Captivate, are short demonstrations of specific skills. Homework assignments are broken down into steps with each step having its own demonstration. Demonstrations are available with sound and without sound. In the sound versions, the primary instructor of the course verbally describes each step of the skills. In the non-sound version, the descriptions are in word balloons. Students are able to use the different versions based on their learning style as well as their ability to use sound. For example, no sound is available in the campus computer labs unless the students bring their own headphones.

Students also have samples of the finished homework available to them. They can see the finished Excel spreadsheet or Access query to allow them to match their results with the correct answers. Between the demonstrations that take the students through the skills step-by-step and the graphic of the finished results, the students are given as much help as possible to encourage successful completion of each assignment.

Assignments are due on the same day and time of each week. The instructor sends the students a weekly email letting them know what skills they should be working on that week, what online demos are best suited to help learn the skills, what assignment is due next and when the next exam will be. For several semesters, the instructor offered online office hours from 9-11 pm on Tuesday nights using Macromedia Breeze. In the last several semesters, only one or two

students took advantage of the online office hours and thus, the option was not offered the Fall 2006 semester.

Nearly all of the online students are on campus at least three days a week for other classes and can attend regular office hours. Email is used extensively to answer student questions and often students attach the file they are working on to allow the instructor to see exactly where the problem area is. The instructor then replies in email how to do the skill or formula correctly and the student is able to successfully complete the homework. All homework is submitted through Blackboard. To allow immediate feedback, quizzes have been created over each of the homework assignments. Students are expected to have completed the assignment before taking the quiz and can take the quiz two times with the higher score being recorded. The instructor checks the submitted files for a pattern of problems and addresses widespread problems in an email to all students. Individual students receive emails to address particular problems observed in the submitted files.

Discussion boards are not used in the course. In the past, threaded discussions were attempted hoping students would discuss with each other problems and solutions they had found. However students did not use the tool and it has been discontinued.

PURPOSE OF THE STUDY

Because so many online students drop the course and retake it in a traditional on-campus course, a study was started to determine if factors exist to predict if students will be successful in the online version of this skill-based course. Because the university does not require any self-assessment before enrolling in online courses, there is no institutional data as to who is successful in online courses. And because most online courses are in upper level courses, no institutional attention has been given to online course retention at the freshman level.

Our first hypothesis is that students who did not take advantage of the online demonstrations do not do as well in the course. Our second hypothesis is that students with a high level of self-efficacy will have a better outcome in the course than those who do not. Our third hypothesis is that those with a strong internal locus-of-control, compared to those with a strong external locus-of-control, will do better in the course.

METHOD

Procedure

Students in the Fall 2006 online version of the course were surveyed. The survey included four main sections: self-efficacy (an adapted version of Bandura's (1977) concept), multidimensional locus-of-control (an adapted version of Rotter's (1966) original construct and of Wallston's (1978) adaptation for multidimensionality), course tool use and demographic data. The survey was approved by the university human subjects committee and was administered using the university's online survey tool. Students were given fifteen points to encourage participation. Students could skip any question on the survey. Because of the lateness of starting the study and time required to obtain human subjects approval, the survey was not administered until after the last day to drop classes. Students who had already dropped the class were emailed and encouraged to take the survey, however only one such student completed the survey.

Participants

Twenty-one of the 45 undergraduate students originally enrolled in the course completed the survey with an average age of 25.9 (SD=8.7) and consisted of a primarily white/Caucasian sample (88%).

Analysis Plan

We will run an exploratory multiple linear regressions predicting final grade in the online course that includes all variables in the dataset using the forward method. We will also run a multiple linear regression for the variables that objectify the web demonstrations with voice forced into the model. Variables that are in the final model, those that are significant, will be considered for future analyses.

RESULTS

We conducted an exploratory multiple linear regression predicting final grade in the online course that included all variables in the dataset using the forward method and the final model was significant $F(3,17) = 24.30$, $p < .001$. Individual predictors that were significant were BE&O grade ($\beta = -.529$, $p < .001$), self-efficacy ($\beta = .389$, $p = .003$), and number of assignments completed ($\beta = .364$, $p = .004$).

We conducted a second multiple linear regression predicting final grade that included BE&O grade, web demonstrations, and number of assignments completed and the model was significant $F(3,18) = 8.66$, $p = .001$. Individual predictors that were significant were BE&O grade ($\beta = -.580$, $p = .002$) and web demonstrations ($\beta = .316$, $p = .054$).

DISCUSSION

Success in the prerequisite course was the highest predictor of success, followed by self-efficacy, and number of assignments completed. Because the course is a computer skills and literacy course, possibly the prerequisite course grade is a better predictor of success than overall GPA. Possibly this applies even more in this course because the prerequisite course required the students to use Blackboard and portions of Microsoft Office. In addition, those that were confident in their abilities (self-efficacy) to do several tasks that were required for the course did better in the course. Dupin-Bryant (2004) found that students who have adequate computer training in relevant computer technologies are more likely to complete the online course because the technology will not impede the process. The level of activity in the course by the individual also seemed to play a significant role, which can be inferred from the number of assignments completed and the number of times a web demonstrations was used (which was found significant when using the enter method and self-efficacy was removed).

Our primary hypothesis that students who did not use the online demonstrations would do worse in the course was confirmed, with exceptions. Our secondary hypothesis that self-efficacy would predict course outcome was confirmed. Our tertiary hypothesis that different levels of locus of control would predict course outcome was not confirmed.

IMPLICATIONS AND LIMITATIONS FOR FURTHER STUDY

Because this study was started late in the semester, most of the students who dropped the course did not complete the survey and most who stayed in the course but failed it also did not complete the survey. In future semesters, the survey will be offered early in the semester when most students are still participating in the course. A possible result of the study could be that only students with a specific grade in the prerequisite class are eligible for enrolling in the online section. Another outcome could be that the university would require an assessment before students are allowed to enroll in online courses, especially the students at freshman and sophomore level courses. A limitation of the study is reaching students who have dropped the course because they have no incentive to complete the survey. The still-enrolled students are given points for completing the survey. In the future, the survey must be done early enough for more students to want to complete the survey to obtain the extra points given for completion.

REFERENCES

Bandura, A. (1977). Self-efficacy: toward a unifying theory of behavioral change. *Psychological Review, 84*(2),191-215.

Dupin-Bryant, P.A. (2004). Pre-entry variables related to retention in online distance education. The American Journal of Distance Education, 18(4), 199–206.

Elias, S. M. and Loomis, R. J. (2002). Utilizing need for cognition and perceived self-efficacy to predict academic performance. Journal of Applied Social Psychology, 32(8), 1687-1702.

Gifford, D.D., Bricefho-Perriott, J., Mianzo, F. (2006). Locus of control: academic achievement and retention in a sample of university first-year student. Journal of College Admission, 191, 18-25.

Morris, L., Wu, S, Finnegan, C. (2006). Predicting retention in online general education courses. The American Journal of Distance Education, 19(1), 23–36.

Onwuegbuzie, A. J. and Daley, C. E. (1998). Study skills of undergraduates as a function of academic locus of control, self-perception, and social interdependence. Psychological Reports, 83, 595-598.

Pajares, F. (1996). Self-efficacy beliefs and mathematical problem-solving of gifted students. Contemporary Educational Psychology, 21(4), 325-344.

Rotter, J. B. (1966). Generalized expectancies for internal versus external control of reinforcement. Psychological Monographs, 80(1), 1-28.

Sisney, S., Strickler, B., Tyler, M. A;, Wilhoit, C, Duke, M. and Nowicki, S. Jr., (2000). Reducing the drop out rates of at-risk high school students: the effective learning program. Emory University Press.

Wallston, K. A., Wallston, B. S., DeVellis, R. (1978). Development of the multidimensional health locus of control (MHLC) scales. Health Education Monographs, 6(2), 160-70.

Identity Management for Educational Portals

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INTRODUCTION

Identity management (IDM) is a broad administrative task that includes identifying users in a system, controlling their access to resources, and associating user privileges with the established identity. It is a crucial aspect in a portal's design (Emigh, 2002). Enterprises everywhere are undergoing transformations to enhance the value they deliver to the business while reducing costs. A properly designed portal brings together a range of disparate tools and information sources, providing an effective channel between the business and its stakeholders (Stone, Roof & Lonsdale, 2006). For an educational portal, it must provide equal level and quality of access to applications, from both main campus and satellite centers, and for both on and off campus users. Students and faculty should not have to memorize multiple user ID/password pairs as they use different resources, though access privileges for the same user may be different (Levinson, 2002).

SINGLE SIGN-ON & STRONG AUTHENTICATION

Authentication is the bedrock in a portal as it bridges access privilege and user identity together. By verifying a user's identity, access is correctly granted or denied. Organizations pursue a variety of strategies to simplify and consolidate multiple sign-on, as it betters user experience, reduces costs and improves compliance. Typically, a user authenticates once when accessing a protected resource. The IDM issues the browser a cryptographically protected cookie, which maintains authentication state across applications. Apart from convenience, single sign-on (SSO) externalizes application security. Security externalization results in simpler policy maintenance as authentication no longer maintained within every application. It also improves compliance, as externalization forces the school to take a holistic view on security for all of its applications.

While user ID/password is most commonly used, it is weak and insecure with countless security problems. Stronger authentication can be achieved by using two factors. Two-factor authentication is any protocol that requires two independent ways to validate identity. Commonly, it uses "something you know" (password) as one factor, and either "something you have" (tokens, smart cards and digital certificates) or "something you are" (biometrics) as the other factor. Two-factor authentication enhances security, but each business scenario must dictate the authentication mechanism (Bowers, 2006). As a rule of thumb, schools should consider which regulations impact them, and conduct a risk assessment to balance between vulnerability, cost and impact. They can then decide the most appropriate way to strengthen authentication so that sensitive resources are protected while meeting regulatory requirements without going overboard.

ACCESS CONTROL & AUTO-PROVISIONING

As operating environment expanded to include more distributed applications and growing complexity in user relationship, managing user access is becoming enormously expensive and challenging for any organization (Jacknis, 2005). Access Control List (ACL) is the mechanism for defining security that limit access between users and network resources using filter rules. When a data packet arrives at a firewall, ACLs trigger a filtering process based upon predefined rules. IDM uses ACLs to assign access rights for users to resources. For example: professor A is allowed to access student records, while student X is denied access; student X is allowed to access the distance learning servers while guests are prohibited.

While commonly deployed, rule-based ACs are attached to objects. They are advisable only when options are few. Too much alternatives can complicate the policy to unmanageable and impede performance. In role-based ACs, access privileges are grouped into roles, and users are attached to roles as a way to manage their access (NIST, 2006). Role-based AC is more appropriate for Web services as access are assigned against a specific user's role and asserted to requesting applications. While simpler and more flexible, role-based AC does raised privacy concerns. In practice, both roles and rules are used to determine access rights. While inflexible and complicated, rules can provide fine-grain control and limit role proliferation.

Provisioning refers to the deployment of digital access rights for employees, business partners and customers across multiple applications and resources based on business policies. Resource provisioning includes the creation of user IDs and credentials. Conversely, de-provisioning deactivates accounts and reallocates resource when an employee leaves an organization. Apart from security, self-service auto-provisioning greatly increases an organization's operation efficiency. Auto-provisioning, for example, can automate account creation for new hires and account shut-off when employees leave the company. Self-service allows users update their accounts such as password reset, freeing up an enormous amount of staff and resources. Educational institutes are mandated to be in compliance with privacy legislations such as HIPAA and FERPA. Provisioning can be extremely helpful when it is time for the school's audit (Tynan, 2005).

CONCLUSION

For an educational portal, the hardest part of IDM does not lay in its development and deployment. Documenting business processes and defining who gets access to what resources can be a monumental task. While implementing IDM in the portal can be expensive, complex, and time-consuming, it can also lead to greater efficiencies and cost savings over time. More importantly, IDM is vital for any educational portal in this age of concern for privacy.

REFERENCES

- Bowers, Tom (2006). Two-factor Authentication Options, *Information Security,* 9(8) pp.30-35.
- Emigh, Jacqueline (2002). Portal Management - Do You Know What It Takes? *Enterprise Networking Planet*. Retrieved 9/22/06 from http://www.enterprisenetworkingplanet.com/netsysm/article.php/1478751
- Jacknis, Norman (2005). A Question of Identity, IT Architect. 11/2005 issue, p. 94.
- Levinson, Meridith (2002). Case Files: Knowledge Management, Portal U. CIO Magazine Retrieved 9/22/06 from http://www.cio.com/archive/110102/portal.html
- NIST (2006). Role Based Access Control, *NIST*, Retrieved 9/22/06 from http://csrc.nist.gov/rbac/
- Stone, J., Roof, J. & Lonsdale, D. (2006). The IT Portal - A Platform for Service Management, *Insight on IT Service Management*. Retrieved 9/22/06 from http://www.itsmwatch.com/itil/article.php/3613771
- Tynan, Dan (2005). Identity Management in Action, *InfoWorld*, 27(41), pp 23-26.

An Analysis of the Effectiveness of Law Enforcement Against Online Music Piracy

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INTRODUCTION

Obtaining a copy of music without permission from the music's copyright owner is illegal. Yet, millions of consumers engage in exchanging illicit music files over the Internet. Unlike other illegal activities, file sharing appears to be widespread among consumers across all walks of life. In order to curtail widespread music file-sharing activities, the music industry has sought to increase the enforcement of existing copyright laws (Liebowitz 2006). Initially, lawsuits were filed against operators of file sharing networks such as Napster and Audio Galaxy. Using these lawsuits, the industry was able to shut down file-sharing networks that engaged directly in helping computer users locate music files on other users' computers (see, Napster, for example). However, the legal victory was short-lived. As soon as the operator of a file-sharing application is defeated in court, new file-sharing applications usually emerge quickly and draw a large number of consumers to start new, viable electronic networks for sharing music (Black, 2002). After Napster was ordered to shut down, new generations of file-sharing applications using updated and more decentralized technologies such as KaZaA, BearShare, and LimeWire appeared on the Internet.

Subsequently, the music industry turned to individual consumers who allegedly engaged in illegal music file sharing. In September 2003, the industry filed lawsuits against 261 individuals who the industry claimed traded a large number of music files online (BBC News, 2003). Prior to these lawsuits, individual file sharers were almost completely immune from any liability of their online activities. These lawsuits, the industry hopes, would alter that notion of online immunity. Coupled with successes in shutting down operators of file-sharing networks (see, shutting down of Grokster and KaZaA, for example (Borland, 2005)), the industry has been emboldened and has expanded its legal efforts to countries outside of the U.S. In this paper, we use economic modeling and data analysis to evaluate the effectiveness of these lawsuits.

The remainder of the paper is divided into two sections. The first section presents an economic model that explores consumers' decisions about whether or not to engage in illegal file-sharing activities. The second section outlines our data analysis plan to validate key assumptions and estimate the parameters included in our economic model. Integral and essential to this data analysis is our data collection effort to track actual file-sharing activities on KaZaA, one of the most well-known and largest file sharing networks. Our data collection process covers a period of 6 months between November 2005 and May 2006.

ECONOMIC MODEL

In this section, we model the file sharer's behavior using the approach taken by Becker (1968), Ehrlich (1973 and 1972), and Garoupa and Jellal (2002). To obtain a music product, an individual consumer can either purchase a legal copy or download an illegal copy of the music. First, we consider a situation where a consumer looks to obtain a single song. Let U denote the utility function derived from listening to a song, v denote a consumer's expected valuation for a song, p the consumer's perceived risk of getting caught, f the monetary penalty from being sued, and q the ratio of expected reduction of value of v due to factors such as uncertain quality of music files from illegal sources and reduced utility from consuming illegal products (i.e., when $q \rightarrow 1$, the utility received from an illegal copy of a music file is almost as high as that from purchasing a legal copy). Thus, the expected utility from downloading the song illegally is:

$$EU(v, q, p, f) \tag{1}$$

where EU denotes the expected value of U.

If the consumer wants to purchase the song, he/she has two options: 1) purchasing the song online or 2) purchasing a CD. For the online option, the consumer's expected utility is:

$$EL_1(v, s_1, r_1) \tag{2}$$

where L_1 denotes the utility function derived from purchasing a legal copy of music, EL_1 the expected value of L_1, r_1 the ratio of reduction in utility due to the restriction of usage of the digital file, and s_1 the lowest price of the song the consumer can purchase online.

The consumer's expected utility from purchasing a CD is:

$$EL_2(v, s_2, r_2) \tag{3}$$

where L_2 denotes the utility function, EL_1 the expected value of L_2 s_2 the price of the single CD (or other physical media formats), and r_2 the ratio of reduction in utility. From these retail options, the consumer would choose the one that yields the maximum expected utility.

$$EL = Max\{EL_1(v, s_1, r_1), EL_2(v, s_2, r_2)\} \tag{4}$$

where EL denotes the expected utility derived from a legal retail purchase.

It follows that if (1) > (4) and (1) > 0, the consumer would download an illegal copy of the song; otherwise the consumer would purchase the song. In order to influence the consumer's decision, the music industry can employ its technical resources to interfere with the online exchange of music files (i.e., the value of q) by injecting seemingly-legitimate-but-fake music files onto peer-to-peer networks, in addition to increasing the values of p and f. The industry can also influence the consumer's behavior by changing the retail prices of its music.

If the consumer wants to obtain multiple songs (say, n songs), he/she may decide whether to pirate or purchase each song individually. The consumer's total expected utility would simply be the summation of the utility expected from individual songs, or:

$$\sum_{i=1}^{n} Max\{EL_i, EU(v_i, q_i, p, f), 0\} \tag{5}$$

Alternatively, the consumer may choose to purchase an online subscription. We assume that the consumer can download all desired songs by purchasing one

subscription. Let c_1 denotes the subscription fee and $\mathbf{v} = \{v_1, v_2, v_3, \ldots, v_n\}$ the expected valuation of the songs the consumer wants to download. The expected utility from purchasing an online subscription is.

$$EW_1(\mathbf{v}, c_1, r_1) \quad (6)$$

where W_1 denotes the utility function derived from purchasing an online subscription.

For a compilation of songs in on CDs, we define c_2 as the total retail price of the CD(s) the consumer needs to purchase in order to obtain all the desired songs. The expected utility from purchasing compilations of songs in a CD would be

$$EW_2(\mathbf{v}, c_2, r_2) \quad (7)$$

where W_2 denotes the utility function derived from purchasing songs in a physical media format.

As a result, among the other retail options, the consumer would choose the choice that maximizes his/her utility, or

$$Max\ \{EW_1(\mathbf{v}, c_1, r_1), EW_2(\mathbf{v}, c_2, r_2)\} \quad (8)$$

The consumer's decision whether to pirate or purchase the songs would depend on the values of (5) and (8). Specifically, if (8) ≥ (5) and (8) ≥ 0, the consumer would purchase all songs legally, otherwise his/her decision will be made on an individual song basis.

In a multiple-period situation where the consumer re-evaluates his/her choice after obtaining each song, our model can be extended as follows. If the consumer initially chooses to obtain an individual song either by pirating or purchasing a legal copy, then the subsequent decision in the second period would be based on comparing the value of (9) and (10) as shown below.

$$\sum_{i=1}^{n} Max\{E_i, E(v_i, q_i, p, f), 0\} \quad (9)$$

Figure 1. Number of KaZaA users (5-day moving average) in millions)

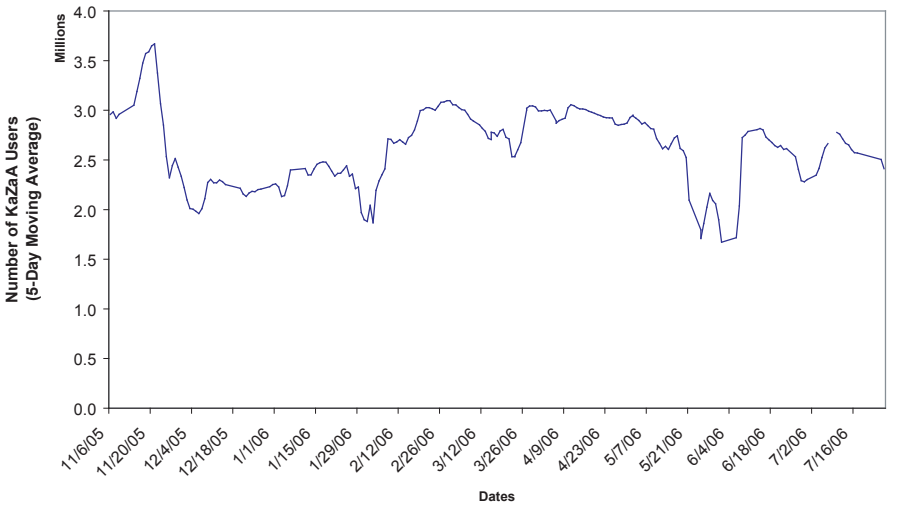
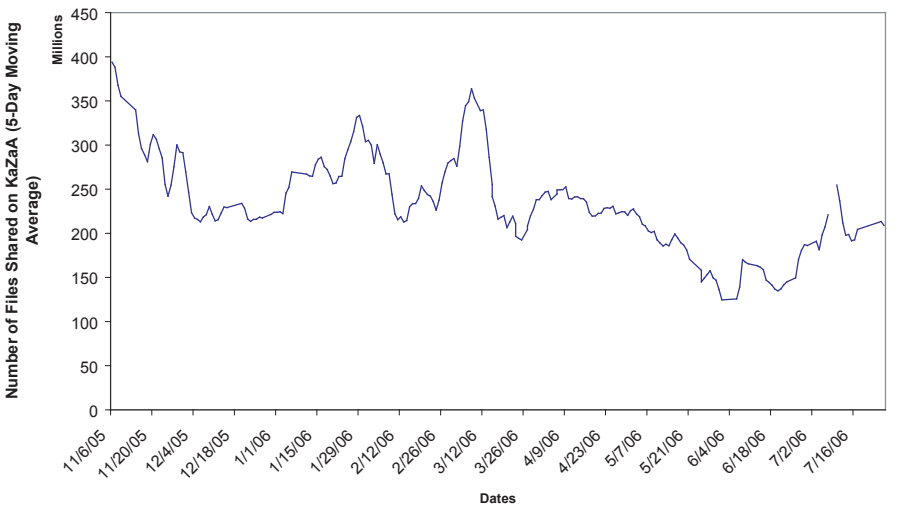


Figure 2. Number of files shared on KaZaA (5-day moving average) in millions



$$Max\ \{EW_1(\mathbf{v'}c_1,r_1),\ EW_2(\mathbf{v'}c_2,r_2)\}\ ;\mathbf{v'} = \{v_1, v_2, v_3, \ldots v_{n-1}\} \quad (10)$$

Subsequent decisions in later periods would follow the same rationale until the consumer obtains all individual songs he/she wants or purchases a subscription or a compilation of music in a physical format.

The total number of music files being shared (and thus downloaded) on peer-to-peer networks would therefore be derived from the decisions made by participants on the networks. Although the decisions made by file sharers depend on the values of parameters *v*, *p*, and *f* which vary greatly based on their financial resources, education, age, etc., we follow the approach taken by Becker (1968) to consider only the average values of these parameters.

DATA ANALYSIS

In this section, we develop an online data collection agent and conduct an empirical analysis to examine the actual impact that legal efforts by the music industry have had on the illegal file sharing activities. We characterize file sharers in terms of the variables in our economic model: valuation toward music (*v*), perceived risk of getting caught (*p*), and perception on the retail price of music. Our data collection agent tracked file-sharing activities on KaZaA between November 2005 and July 2006, during which many lawsuits were filed against alleged file sharers. Figures 1 and 2 show the number of file sharers and the number of files available for download on KaZaA between November 2005 and July 2006. Our preliminary results indicate that, while the lawsuits may have discouraged file sharers from engaging in online music piracy, the number of file sharers participating in peer-to-peer networks remain very high. The lawsuits were usually filed at the end or in the middle of each month (e.g., November 30, 2005, December 15, 2005, January 31, 2006, and February 28, 2006). As shown in Figures 1 and 2, file sharers tend not to participate on KaZA immediately after the industry's lawsuits. However, overall, the number of files being shared and the number of file sharers on KaZaA remain very high (i.e., on the day that we observed the lowest number of files shared on KaZaA, we found over 105 million files, and the lowest number of KaZaA users observed during our data collection period was 1.2 million).

In late July 2006 after our data collection was concluded, KaZaA received a court order to either shut down its operation or filter out all copyrighted materials from its network. In the past, when a popular file-sharing network was legally shut down (see, for example, the case of Napster), file sharers simply moved on to other networks and resume their online activities. At present, there are already other popular peer-to-peer networks such as Shareaza that allow file sharers to exchange copyrighted music files, filling the void left by KaZaA and thus undermining the legal efforts made by the music industry.

The second part of our analysis includes an opinion survey that looks at consumer's perception of the copyright law and its enforcement, the consequences of online piracy, and the retail price of music. Our data will be compared and supplemented by the data reported in previous studies. These empirical results will allow us to estimate the values of the parameters in our economic model presented above.

REFERENCES

1. BBC News. 2003. "Music Firms Target 12-year-old." *BBC News Online*. September 10, 2003. http://news.bbc.co.uk/go/pr/fr/-/2/hi/entertainment/3096340.stm.
2. Becker, G. 1968. "Crime and Punishment: An Economic Approach." *Journal of Political Economy*. March/April 1968. pp. 169-217.
3. Black, J. 2002. "Napster's Sons: Singing A Different Tune." *Business Week Online*. February 21, 2002. http://www.businessweek.com/bwdaily/dnflash/feb2002/nf20020221_6377.htm
4. Borland, J. 2005. "Supreme Court Rules Against File-Swapping." *CNet News*. June 27, 2005. http://news.com.com/Supreme+Court+rules+against+file+swapping/2100-1030_3-5764135.html
5. Ehrlich, I. 1972. "The Deterrent Effect of Criminal Law Enforcement." *Journal of Legal Studies*. June 1972. pp. 259-276.
6. Ehrlich, I. 1973. "Participation in Illegitimate Activities: A Theoretical and Empirical Investigation." *Journal of Political Economy*. May/June 1973. pp. 521 – 565.
7. Garoupa, N. and Jellal, Mohamed. 2002. "Information, Corruption and Optimal Law Enforcement." CEPR Discussion Paper no. 3560. London, Centre for Economic Policy Research. http://www.cepr.org/pubs/dps/DP3560.asp.
8. Liebowitz, S. 2006. "File-Sharing: Creative Destruction or just Plain Destruction?" *Journal of Law and Economics*. April 2006. pp. 1 – 28.

A Personal Portal for Individual Resource Control System

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INTRODUCTION

A portal aims to make the user more efficient and convenient by providing an entrance to all other coordinators. Variant portals may apply for different purposes, for instance, Yahoo is a portal for all Internet users to connect to sites which are grouped into categories. Except the Internet portal, users might need another kind of portal for their life.

In the real world, users might have different computing devices for use on different occasions, such as a personal computer, a laptop, a Personal Digital Assistant (PDA), or even a workstation with privileged access.

However, users tend to use only one device at a time, for instance a personal computer at home, a workstation accessed on an account provided by an employer, or a PDA to send a file to a co-worker when travelling. In this context, two problems are illustrated: first, when one device is being used, the other (or all others) might be idle; secondly, the user might have to maintain several copies of objects at different places, in order to access them everywhere, causing serious consistency and maintenance problems. IndiGrid, which stands for 'Grid system for Individuals', is designed for a single user solution to those problems. It also acts as a personal portal. By means of IndiGrid, a user is able to access every device he is privileged to access, and perform some authorized actions without bothering about security issues or file version synchronization. IndiGrid is based on web-services technologies and uses communication port 80 for messaging. It also enables asynchronous message transmission to improve transmission and performance. IndiGrid is a personal portal to enable global sharing and resource control to provide efficiency and convenience in the computing world for individuals.

RELATED RESEARCH

1. Grid Computing

Grid computing (Foster 2005) tries to solve the resource sharing problem of boundary crossing. It also refers to the management and integration of distributed resources, conceptual and physical resources, and services across globalized, large-scale, multiple administrative domains (Foster & Kesselman, 2003). Since participants might belong to or follow different rules, as far as "trusting" each other and "being trusted" is concerned, the participants can form a virtual organization, in which every member is mutually trusted. Therefore, they can share resources with each other. Grid computing can be classified as comprising a computational grid or a data grid. However, no matter what the grid system is, it must provide a multi-user and multi-resource enabled environment.

2. Peer-to-Peer

As computational performance on personal computers and network communication infrastructures has improved, Peer-to-Peer (P2P) computing has become another communication model for the environment in which devices (computers, servers, and all other computation devices) link to each other directly. All the devices are "peers". The computers in P2P computing can be both clients and servers, unlike as in server-centric computing (Online, 2006) or asymmetric client-server systems (Foster & Kesselman, 2003). All the participants share their resources (mostly files) equally. The main aim of P2P is for resources to be provided and consumed by each peer, in contrast to the client-server system, in which only servers provide resources. P2P is also comparatively more robust and reliable.

3. WSGrid

WSGrid (Henderson, 2004) is a web services based grid computing environment, proposed by Professor Peter Henderson of the University of Southampton, UK. A WSGrid based grid environment is composed of nodes, where a set of WSGrid web-services is installed. A node is also known as a host, where computation occurs and resources are provided. The virtual organization in WSGrid is constructed around a combination of nodes and users. Unlike most virtual organization solutions, which often have one or more centralized components, the virtual organization of WSGrid's distributed idea is full distributed. Each node in WSGrid has equal position. However, in comparison to Peer-to-Peer computing, WSGrid does provide more controllability and security by allowing users to set up different privileges for different remote accounts.

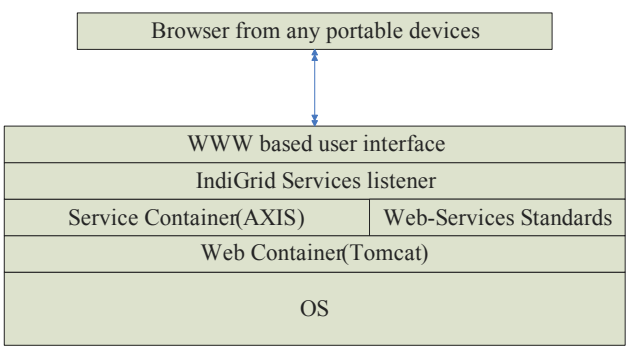
CURRENT RESEARCH STATUS (SYSTEM INTRODUCTION AND ARCHITECTURE)

1. The Architecture

In order to provide "light-weight" middleware, reduce the risk from malicious users, and maintain network security, IndiGrid's design is based on web-services technologies. All services (the components of IndiGrid) can be hot-plugged and unplugged, so the performance will not be affected. Another benefit of using web-services technologies is that web-technologies and open resources on webs are maturely developed. In addition, configuring a web container is not too difficult, even for a non-professional user. The threshold is low. From the point of view of network security, communication port 80 is turned on as a default. As regards user friendliness convenience, efficiency and performance, web-service architecture is very suited to grid systems. IndiGrid was originally designed for individuals, so it is assumed that only the owner has the privilege of access to the computers in the group. However, through a delegation process, temporary access rights are also provided.

IndiGrid is designed to be a single user grid middleware to provide grid users with a convenient access to their workspaces and resource. Since it is for individual, it is assumed that everyone has security tokens (i.e. username and password, certificates) to be authenticated by their spaces. Furthermore, when a device is connecting to the Internet, remote connection should be restricted to only certain areas. So does IndiGrid. Only opened areas (configured in the configuration)

Figure 1. Middleware structure



are allowed to be remotely accessed. Through the process of authentication and authorization, the security of a host is basically remained.

2. The Functionalities

By referring to the requirements of the Grid (Foster 2005), a grid middleware should provide the following functionalities: discovering and configuring resources, moving data, monitoring and controlling components, and manage credentials. IndiGrid is composed of set web-services for the above functionalities of resource sharing and load balancing.

a. FileService

FileService is used to move objects from one location to another. IndiGrid follows the idea of WSGrid to allow (restrict) remote access to certain locations to prevent possible attack from malicious users. Thus, the owner can move all objects around. And the moved objects can be marked to be removed after use.

b. JobService

JobService is a submission service to allow an owner to submit a job (process, task) to another device. This service aims to balance the computation load and uses some resources only located on a certain computer. The user sends a job along with the job description, which states the conditions for the job (such as delete after execution or result returning to a specific place).

c. LoggingService

LoggingService is used to record the status of the execution and servers. It can also be used as a task-status-query service.

d. MyFavoriteService

Users commonly keep logs of their favourite websites on their computers. However, keeping all web favourites consistent (on different computers) is difficult. MyFavorite- Service is the service to return the favourite web sites as a linkable web page, so users can access them anywhere without bothering synchronization.

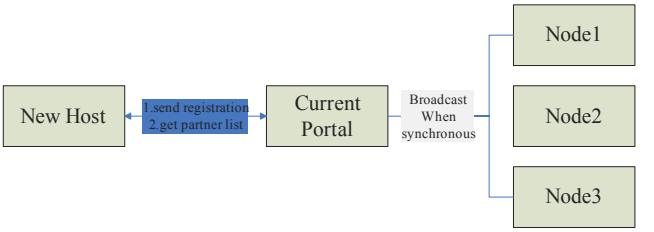
e. DelegationService

DelegationService is an important and existing service to allow the user to "issue" a temporary passport to someone trustworthy. This service follows the idea of GateService (Lee, 2005). This service in IndiGrid is for sharing. For instance, a man needs to share his file(s) to group members. The delegators must specify the rules of delegatee in a simple and clear XML file.

f. NotificationService and StatusRequestService

NotificationService and StatusRequestService are working in pair of co-existent services. When a host joins in the group, the node must firstly invoke the NotificationService (as saying Hello) of any other node (like a registry) to introduce the node itself, ie the WSDL for its services and its capability. The notified node forwards the registration information to all known partners, which then say 'hello' to the new member. Thus, nodes can know each other. Then StatusRequestService can respond any information regarding the status of nodes. They will be illustrated in the next section.

Figure 2. The registration sequence of IndiGrid



THE FRAMEWORK OF HEALING (NODE STATUS CONTROL)

As a full distributed environment, to aware the availability and capability of nodes is very important. In the earlier version, GateService, the submission can only queue for its execution. However, it is possible that the node might be currently unavailable, but it still appears as online. Therefore, IndiGrid uses a partner list to keep the status of partners.

Partner list is an XML format file to keep the current status. The information of partner list is coming using the NotificationService. Three kinds of NotificationService are currently available. When an environment is built, a Root must be chosen. The root can be specified by the owner or be elected using the token ring method. However, only the nodes who can be servers are candidates.

First, when a node (which is not currently on the partner list) joins in the group, the node will say Hello to a node (acting as a registry). Then the notified node (root) can update its partner list and reply the message with the partner list. On occasion, the root might forward the new partner to all other known nodes.

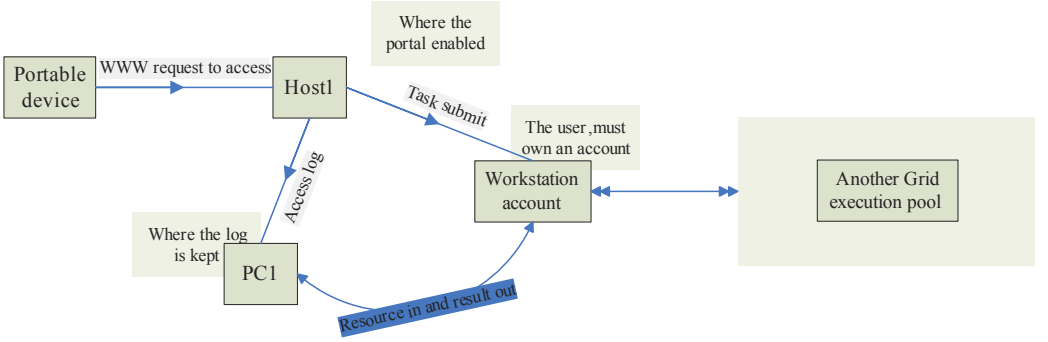
Second, when a node is busy (the job queue is full or nearly full), it can send an "unavailable" message through NotificationService. The corresponding process is to move the node to the end of the partner list.

Finally, when the "unavailable" node is back online, it can also notify its partner about its return.

All these three kinds of notification are using push methods to automatically process.

StatusRequestService is another side of story. It is designed for pull method. For instance, when a node sends a request but does not get the response back in

Figure 3. IndiGrid



reasonable time. The user might want to initiative a StatusRequestService request. When a node initiates the request, a timer is also enabled. When time out happens, a node with no response is moved to "unavailable" state. In order to improve the performance of network, broadcast of StatusRequestService request is not recommended. Other status synchronization methods are still in progress.

CONCLUSION AND FUTURE WORK

At the time being, services 'a' to 'e' listed above have been successfully implemented and tested, but NotificationService and PartnerService are only at version 1. To automatically manage the status of each partner (node) is not too difficult. There are two kinds of notification transmission methods to be provided. The problem is that if the synchronization is processed too frequently, the system performance and network bandwidth might be affected. However, if the synchronization process is seldom performed, the system status is hard to maintain. Thus, both push and pull methods of synchronization are provided. For active information providers, the push method can be used for notification at initiation, busy time and off line. For accidentally system crash or expected system busy, the pull method should be able to help. Besides, a novel equation of automatically reconfiguration is being studied and will be proposed to solve the problem.

IndiGrid is expected to be a fully functioning grid system for individuals. By using web services, it is a portal, able to connect every computer or computing device for the owner. With IndiGrid, users do not need to deal with multiple inconsistent files or wait for a busy device to return the computing result. They can share load and resources among different computers and use them just like at home.

REFERENCES

Foster, I., & Kesselman, C. (2003). The grid 2: Blueprint for a new computing infrastructure. Morgan Kaufmann.

Online (2006) Definition of distributed computing. http://www.microsoft.com/net/basics /glossary.asp

Henderson P., (2004). WSGrid. http://www.ecs.soton.ac.uk/~ph

Lee, Yih-Jiun (2005) A security solution for web-services based virtual organizations in Proceedings of the Information Resources Management Association International Conference (IRMA 2005): Managing Modern Organizations with Information Technology, San Diego, USA, May 2005.

Lee, Yih-Jiun, (2006) A Distributed Grid Service Broker for Web-Services Based Grid Applications, The 10th WMSCI 2006, July 16-19, 2006 Orlando, Florida, USA

Foster, Ian (2005) Globus Toolkit Version 4: Software for Service-Oriented Systems. IFIP International Conference on Network and Parallel Computing, Springer-Verlag LNCS 3779, pp 2-13, 2006.www.globus.org/alliance/publications/papers/IFIP-2005.pdf

IT Audit Process Quality Improvement Factors

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ABSTRACT

This Research-in-Progress paper outlines the beginning of what we plan to be a comprehensive research stream related to the issues, factors, skills, etc. that would culminate in an effective and efficient IT audit engagement/project. We use focus groups in this current research effort to identify critical success factors related to a quality IT audit.

INTRODUCTION

Information Governance is an important requirement for those responsible for managing information systems (IS) and the various business processes that utilize these systems. One of the driving factors behind an increased focus on governance is the Sarbanes-Oxley Act of 2002, which requires publicly traded companies in the United States to adhere to very strict controls requirements around their financial statements and the systems that produce the financial numbers. These controls must be documented by management and attested to by independent auditors. A large component of these attestation engagements is the review and testing of information technology (IT) controls by systems specialists commonly referred to as IT (or IS) auditors.

IMPORTANCE OF STUDY

Thus far in our research, we have built upon the audit process quality literature by facilitating focus group research sessions with both internal (i.e., corporate) IT auditors and "Big Four" public accounting IT audit managers to identify and classify critical IT audit process quality factors. The overall goal of our ongoing research is to determine if there are a key set of factors that auditors both within an internal audit function as well as across different companies agree are critical to the success of an IT audit engagement. Overall, these factors can act as important antecedents to the IT audit process and influence the successful outcome of a specific IT audit. The objective of this study is to discover these constructs and develop a model of the IT audit process that can be used to improve process quality. Thus this model should enhance our understanding of the broad range of factors that influence the quality of IT audits.

METHODOLOGY

The method we are using to identify the quality factors for the IT audit process is a nominal group technique. An underlying assumption of this method is that individuals who perform a task can provide valuable insight into the important factors influencing their ability to achieve a high level of productivity and effectiveness when performing the task. This method has been used successfully in several domains, including systems development (e.g., Havelka and colleagues; Sutton and colleagues).

EXPECTED FINDINGS

The output of these focus groups include a set of factors that can be used by managers to improve the IT audit process or by researchers to further investigate the relationships among the various factors. We are unaware of prior research in this domain, which makes our contribution potentially very significant. Once the key critical success factors for IT audit quality are identified, we look forward to sharing our findings with both academicians and practitioners.

REFERENCES

Havelka, D.J., Sutton, S.G. and Arnold, V. "Information systems quality assurance: The effect of users' experiences on quality factor perceptions," *Review of Business Information Systems* (5:2), 2001, pp. 49-62.

Sutton, S.G. "Toward an understanding of the factors affecting audit quality," *Decision Sciences*, 1993, pp. 88-105.

Sutton, S.G., Arnold, V. and Havelka, D.J. "A methodology for developing measurement criteria for assurance services: An application in information systems assurance - Reply," *Auditing-A Journal of Practice & Theory* (17), 1998, pp. 103-107.

Sutton, S.G., and Lampe, J.C. "A Framework for Evaluating Process Quality for Audit Engagements," *Accounting and Business Research*, 1991, pp. 275-288.

Virtual Organizational Learning in Open Source Software Development Projects

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1. INTRODUCTION

Open source software (OSS) development projects exhibit many of the characteristics that make virtual organizations successful, including self-governance, a powerful set of mutually reinforcing motivations, effective work structures and processes, and technology for communication and coordination (Markus et al. 2000). Examples of thriving OSS projects include the Linux operating system, Apache Web Server, and the Mozilla Web Browser. Many OSS projects have achieved substantial success despite their seemingly disorganized structure (e.g., no central management) and the lack of monetary incentives. Raymond (2001) described the open source method of development as "a great babbling bazaar of differing agendas and approaches… out of which a stable and coherent system could seemingly emerge only by a succession of miracles." The Bazaar development approach is characterized by design simplicity, teamwork, a visible product, and communication (Wagner 2006).

Researchers have studied OSS development to better define the successful characteristics of this particular form of virtual organization. For example, Mockus et al. (2002) conducted a case study on the Apache Web server and Mozilla Web browser projects. They found that projects based on a relatively small core (10 to 15 people) of geographically dispersed developers could communicate and function without conflict via a set of implicit coordination mechanisms (i.e. informal email exchange). However, other explicit coordination mechanisms (i.e. code ownership policy) were required to maintain communication and reduce conflict when the number of core developers exceeds 10-15 people.

In a related study, Huntley (2003) attempted to explain the success of OSS projects using organizational learning effects. He maintained that learning effects were manifested by the decreased time required for fixing bugs. He noted significant debugging differences in Apache versus Mozilla, with the attributing factor being project maturity, as opposed to other measurable factors such as project size or number of programmers. Huntley modeled debugging data from Apache and Mozilla according to learning curve formulas. As noted, Mozilla, an emerging project, exhibited a steady debugging process, with predictable improvements. The results illustrate that the learning effects are present in the Mozilla team. In their attempt to defining OSS success, Crowston et al. (2003) suggested that the number of developers involved in a project was an important indicator of the success because the project can gain momentum going forward only by attracting enough voluntary developers.

Our research seeks to extend Huntley (2003)'s study by analyzing 118 OSS development projects (as opposed to only two in Huntley's). These projects vary not only in size (in terms of the number of developers involved and lines of code developed) but also in type (from simple file management software to complex enterprise software suites). We draw our data from SourceForge.net's vast database. Specifically, we are interested in answering two main research questions. First, are learning effects universally present in OSS projects? Second, what are the factors that affect the learning process? Similar to Huntley (2003), we use the number of reported bugs and bug resolution time to measure the learning effect. We look at how different project types, number of developers and their experiences, and the intensity of assigned bugs affect the bug resolution time, and whether there is a learning curve effect.

2. EMPIRICAL MODEL

Based on the Power Law learning curve formula (Wright 1936), and motivated by the models in Argote et al. (1990) and Huntley (2003), we developed a log-linear regression model with both qualitative and quantitative variables:

$$\ln MeanResTime_t = \alpha_0 + \alpha_1 \ln CumResBugs_t + \alpha_2 \ln AvgDevExp_i + \alpha_3 \ln PctAssignedBugs_t + \sum_{i=1}^{2} \beta_i ProjCat_i + \sum_{j=1}^{3} \gamma_j ProjSize_j + \varepsilon_t$$

Where:

$MeanResTime_{it}$ = Mean time to resolve the bugs of Project *i* reported in Week *t*
$CumResBugs_{it}$ = Cumulative resolved bugs of Project *i,* including Week *t*
$AvgDevExp_i$ = Average number of other projects each developer in Project *i* has worked on
$PctAssignedBugs_{it}$ = Percentage of assigned bugs in Week *t* of Project *i*
$ProjCat_i$ = Category of Project *i*
$ProjSize_i$ = Size of Project *i*, measured in terms of the number of developers in the project (1 developer; 2-4 developers; 5-10 developers; >10 developers)

Our model tests the following hypotheses:

H_1: As the number of bugs resolved to date increases, the average bug resolution time decreases.
H_2: Increased developer experience decreases average bug resolution time.
H_3: Increasing the percentage of bugs assigned to specific developers decreases average bug resolution time.
H_4: Project type has an effect on average bug resolution time.
H_5: Project size has an effect on average bug resolution time.

3. DATA COLLECTION AND DESCRIPTION

We collected data from SourceForge.net's repository of more than 100,000 projects.[1] SourceForge classifies projects according to the following categories: database, development, desktop, games, hardware, enterprise, financial, games, multimedia, networking, security, system administration, and VOIP. To ensure an appropriate cross-section of Open Source projects were included in our sample, we identified the top 50 projects in each of these categories based on two factors: development status and site rank. The first factor prevented "conceptual" projects with no event reports from reducing the set of usable responses. The second factor produced the best projects based on SourceForge.net's internal ranking system. The ranking system uses three sub-factors 1) traffic, 2) communication, and 3) development to determine an overall rank of projects. The multi-factor ranking system enhanced sample validity by dropping older and less active projects. This produced a sample representative of the current state of Open Source development. Based on these rankings, we collected a "snapshot" of the top 50 projects in each category on March 9, 2006. Note that some projects were cross-listed in multiple categories.

We determined the final dataset by 1) assigning cross-listed projects to their most appropriate category, 2) removing projects with less than two years of data, and 3) removing projects with less than 100 bug reports. This reduced the sample to 118 projects.

Each project has a "bug report", which provides a generic description for project events including number of: 1) bugs, 2) support requests, 3) patches, and 4) feature requests. Each bug also has a status such as open, closed, deleted or pending. An important measure of organizational learning is a comparison of the ratio between reported and closed bugs. After applying all project selection criteria our final pool of bugs included 91,745 reported bugs and 73,253 resolved bugs. We then aggregated the data to produce weekly averages for each project. This resulted in a dataset capturing 16,175 project-weeks of information.

We also collected information about the developers associated with the projects. This included the number of developers for each project, as well as information regarding developers registered for more than one project. We used this data to test our hypotheses related to number of developers and developer experience.

Bottlenecks

Collecting bug data from the SourceForge.Net repository proved to be the greatest project challenge. Data was only accessible through a limited web-based interface. As a result, we had to run multiple small queries and compile results into a single database. We often faced connectivity problems, which hindered our data retrieval efforts. At one point, the database was unavailable for several days because of a system upgrade. Fortunately, the upgrade alleviated some of our data retrieval problems. Once retrieved, the data had to be formatted, subjected to a number of intermediate calculations and aggregated to produce the desired data set. This eventually entailed a process of more than 200 individual steps.

4. PRELIMINARY RESULTS

Preliminary results show support for each of the five hypotheses:

- Average bug resolution time decreases as the cumulative number of bugs resolved increases (H1)
- Average bug resolution time decreases as developer experience increases (H2)
- As percentage of bugs assigned per developer increases, average bug resolution time decreases (H3)
- Project types "SysAdmin" and "Hardware" have the lowest bug resolution times (H4)
- Projects utilizing 2-4 developers have the lowest average resolution time (H5)

Following is a brief overview of some of the major points.

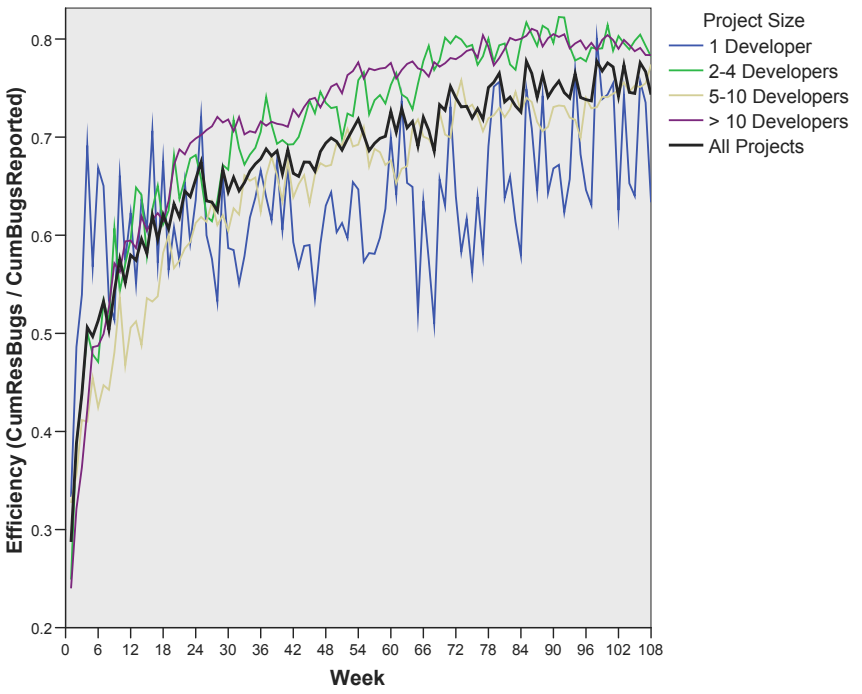
To test the impact of project size, we divided the projects into 4 categories of project size consisting of 1, 2-4, 5-10, and >10 developers, with project size of 1 developer as the reference category. The results indicate that all project sizes have lower resolution times than the reference category, with projects utilizing 2-4 developers having the lowest average resolution time. The average resolution time increased for projects with 5-10 developers and then decreased slightly for those projects with more than 10 developers.

Regression analysis resulted in a negative coefficient ($p < 0.000$) for *CumResBugs*, providing support for H1. Average bug resolution time decreases as the cumulative number of bugs resolved increases. This is in contrast to Huntley's (2003) finding. This finding indicates the presence of a learning curve effect, which is measured by improvements in mean cycle time as more bugs are resolved. A closely related measure is adaptive learning, which is the ratio of cumulative resolved bugs to cumulative reported bugs (Huntley 2003). The graph in Figure 1 provides evidence of an adaptive learning process in the projects, but the process varies based on project size. In particular, projects with a single developer learn faster and thus achieve better efficiency in a shorter period; but over time, they become less efficient relative to projects that employ a group of developers. Projects with 2 to 4 developers demonstrate the best efficiency over time, followed closely by projects with more than 10 developers. It is also interesting to note that the variability of efficiency decreases substantially as the number of developers increases.

5. CONCLUSION

Our preliminary results show there are learning effects in OSS projects. They also show that other factors such as developer experience, project type, project size, and the percentage of bugs assigned to specific developers affect the bug

Figure 1. Comparison of project size efficiency per project week



resolution time and thus the learning curve. Space limitations prohibit further discussion at this time. We will provide a detailed discussion of each hypothesis and its implications at the conference.

REFERENCES

Argote L., Beckman, S. L., & Epple, D. (1990). The persistence and transfer of learning in industrial settings. Management Science, 36(2), 140-154.

Christley, S., & Madey, G. (2007). Analysis of activity in the open source software development community. *Proceedings of the 40th Hawaii International Conference on System Sciences*. Los Alamitos, CA: IEEE Computer Society Press.

Crowston, K., Annabi H., & Howison, J. (2003). Defining open source software project success. In March, S. T., Massey, A. P., & DeGross, J. I. (Eds.) *Proceedings of the 24th International Conference on Information Systems*, Seattle, WA.

Erikson, J. M., & Evaristo, R. (2006). Risk factors in distributed projects. *Proceedings of the 39th Hawaii International Conference on System Sciences*. Los Alamitos, CA: IEEE Computer Society Press.

Huntley, C. L. (2003). Organizational learning in open-source software projects: An analysis of debugging data. IEEE Transactions on Engineering Management, 50(4), 485-493.

Markus M. L., Manville B., & Agres C. E. (2000). What makes a virtual organization work? *Sloan Management Review 42*(1), 13-26.

Mockus A., Fielding R. T., & Herbsleb J. D. (2002). Two case studies of open source software development: Apache and Mozilla. *ACM Transactions on Software Engineering and Methodology, 11*(3), 309-346.

Raymond, E. S. (2001). The cathedral and the bazaar. *First Monday, 3*(3). Retrieved Jan 03, 2007, from http://www.firstmonday.org/issues/issue3_3/raymond/.

Wagner, C. (2006). Breaking the knowledge acquisition bottleneck through conversational knowledge management. *Information Resources Management Journal, 19*(1), 70-83.

Wright, T. P. (1936). Factors affecting the cost of airplanes. *Journal of the Aeronautical.Sciences, 3*, 122–128.

ENDNOTE

[1] Details on SourceForge.net's database are avalaible at http://zerlot.cse.nd.edu/mywiki/ ("SourceForge Research Data Archive: A Repository of FLOSS Research Data"). Christley and Madey (2007) provide further descriptions of the SourceForge.net data set and discuss various data mining techniques that can be applied to the data.

The Impact of Business Process Modeling During the Implementation of Electronic Records Management Systems: Theoretical Framework and Empirical Studies

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ABSTRACT
In introducing Electronic Government solutions, in particular Electronic Records Management Systems (ERMS), public authorities require a comprehensive framework concept to meet the multidimensional integration need. Before the implementation of new software processes a software analysis and design should be conducted. This paper reports on our research in progress to observe the diffusion of Business Process Modeling (BPM) during Electronic Records Management projects.

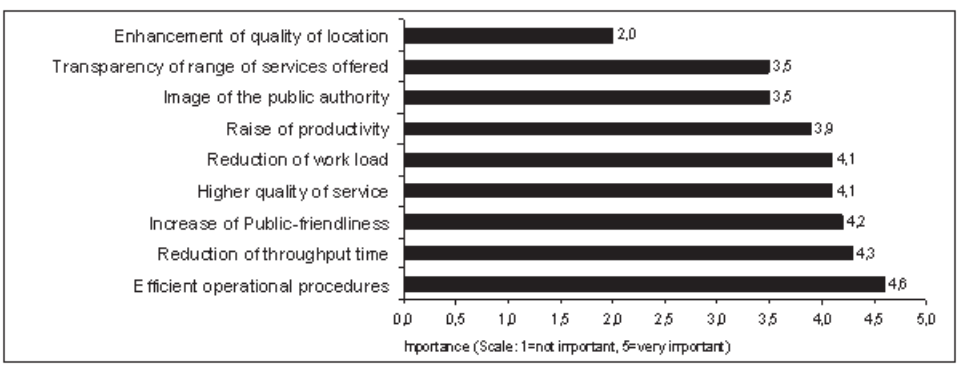
1. PROBLEM DESCRIPTION

The "eEurope 2005" initiative of the European Commission, which is also part of the Lisabon strategy, has the objective to develop modern public services and a dynamic environment for e-business through widespread availability of broadband access. In particular the public administration and their services should be modernized by an increased usage of modern information technologies (EU, 2006). Within the eEurope 2005 action plan there are efforts on the one hand to offer online public services and on the other hand to increase productivity, effectiveness within the public authorities and across organizations and national borders by means of digital technologies accompanied by organizational change and new management skills (EU, 2005; Grönlund, 2002). This includes not only external governmental operations via E-Government Online Services but also internal operations by the use of GIS[1], ERMS[2], WMS[3], ERP[4] and much more in combination with modern management methods like Change Management, Project Management, Business Process Management, Controlling, Quality Management and so on (Grönlund, 2002). Focusing on administrative procedures the purely electronic processing of administrative affairs should lead on the one hand to a higher service quality and democracy for citizen and on the other hand to higher effectiveness, transparency and economies in particular financial resources (Antirroiko & Mälkiä, 2006). The objectives for E-Government solutions are according to an E-Government study of the German Research Center for Artificial Intelligence (DFKI) in 2003 are illustrated in figure 1.

Beside many other initiatives like E-Procurement, E-Learning, E-Health, and so on the management of electronic records is one of the most important issues in the government's modernization program (Traunmüller & Wimmer, 2001). Most requirements on Electronic Records Management Systems (ERMS) are predefined on national level through country specific concepts like the „DOMEA[5]" concept in Germany, the "ELAK[6]" concept in Austria, the "GEVER[7]" concept in Switzerland or "The National Archives[8]" concept in UK (Müllner & Grimm, 2006). These concepts should assure that all deployed ERMS meet the requirements respect to national right, organizational and operational structure and functionality, so that a quick and high quality as well as an area-wide and interoperable implementation could be realized (TNA, 2001).

The transition from traditional administrative processes to E-Government processes means not only an adoption of previous (non-electronic) procedures onto electronic ones but also it opens new possibilities and challenges regarding reorganization and process reengineering (Wimmer, 2002, pp. 149-156). Before the implementation of new software a process analysis and design should be conducted (Matheis et al., 2006). A use of Business Process Management (BPM) methods after important technical decision or implementation of new software can only yield to a sub-optimal result. Nevertheless most of actual E-Government

Figure 1. Objectives on implementing e-government (Scheer et al., 2003)

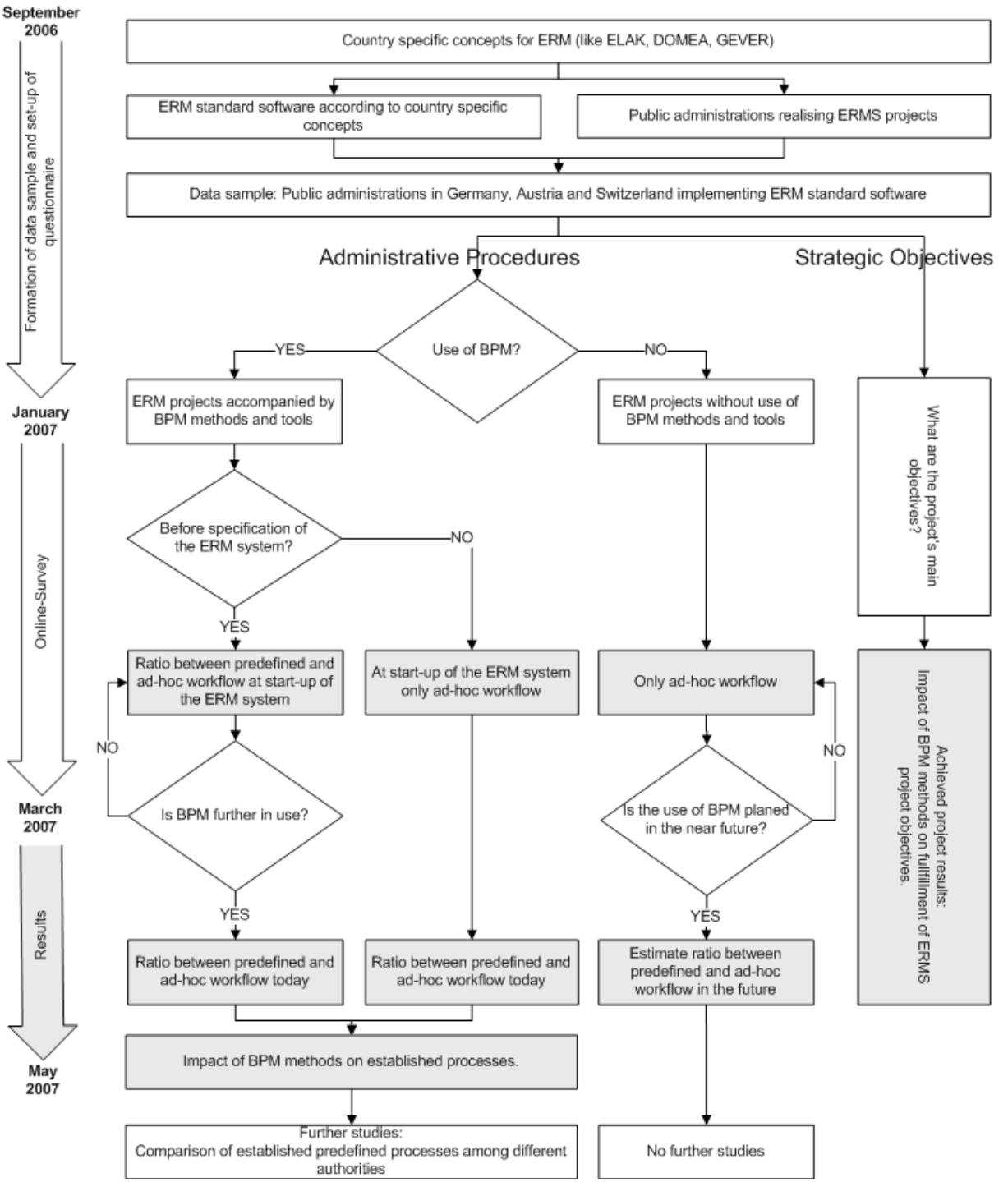


projects are in progress without using BPM (Traunmüller & Wimmer, 2003). Some reasons for that are:

- The diversity of public administration processes, heterogeneity of participants as well as procedure specific, local and legal regulations allow only a restricted design of standardized processes (Klischewski & Lenk, 2002)
- A multitude of administrative processes are decision-making processes which require situation specific workflows and are carried out in the person in charge's sole discretion (Lenk & Traunmüller, 2000)
- A lack of documentation of actual procedures and individual operating know-how of each executive (Lenk & Traunmüller, 2000)
- Most of the already successfully deployed BPM methods in private industries can only be restricted applied to public administration processes (Scholl, 2005)

Public authorities have now the problem, that ERMS should be implemented but still there are missing adequate methods to exactly design administrative processes.

Figure 2. Research process model



2. RESEARCH FRAMEWORK

In order to systematically manage the complexity of software systems a top-down approach can be used. (Lee, 2005). Regarding to the transformation of administrative processes for a specific use case the following top-down structure can be designed: process -> activity –> work step. In general Electronic Records Management Systems allow the following possibilities of workflow functionality for the flow of files (Müllner & Grimm, 2006):

- By predefined workflow: From the beginning to the end of the process all activities and work steps are strictly predefined.
- By ad-hoc workflow: For a specific use case the process starts with a predefined standard start activity. All following activities are defined by the person in charge.
- By semi-predefined (mixed) workflow: For a specific use case a standardized process is rough predefined by usually needed activities and work steps, but could be situation specific adapted by the person in charge.

The research question is: "In implementing Electronic Records Management Systems which BPM methods and tools are mostly used, how these influence the establishment of electronic processes in respect of predefined or ad-hoc workflows and how the impact of BPM methods on the fulfillment of project objectives is?"

According to this we can formulate the following two hypotheses:

H1: The use of BPM methods and tools before the specification and implementation of Electronic Records Management System (ERMS) in public authorities causes an increased use of predefined electronic processes on routine processes and an increased use of semi-predefined electronic workflow on decision-making processes.

H2: The use of BPM methods during the implementation of Electronic Records Management System (ERMS) has a direct and positive impact on the successful fulfillment of project objectives such as efficiency of operational procedures, reduction of throughput time, increase of Public-friendliness, reduction of work load and raise of productivity.

3. RESEARCH METHODOLOGY

Because of the complexity and the interdisciplinary magnitude of ERMS projects and the great number of participants, we have chosen an expert survey as research method, which allows well directed interviews in an economical and time-saving manner (see Figure 2).

The survey will be done on public administrations in Germany, Austria and Switzerland, which have implemented an Electronic Records Management System (ERMS) conforming to their respective national concepts. Implemented means that the specification of the software has already been finished and the roll-out of the final production system or pilot system has been accomplished at least at one department.

Due to their participation on all stages of the ERMS project, the experts are defined as project leader and/or head of department of the public authorities, which are realizing an ERMS project. Because of the geographic distance an online survey is chosen as the most practicable research method.

The online form will contain quantitative as well qualitative questions about following aspects: Implemented software and ERMS standard concept; primary project objects, used BPM methods, successful established electronic processes; achieved project results and further need for action.

In November 2006 the research is starting with the formation of the data sample and the collection of all contacts for the survey, which should be finished latest in January 2007. Estimated is a data sample between 150 and 200 public authorities. At the moment the questionnaire set, the data base and the online form are prepared. The survey is structured in 4 parts and will contain approximately between at least 15 and at most 25 questions:

- Part 1: General project data (5/5)
- Part 2: Implemented ERM standard software (4/4)
- Part 3: Processes and used BPM methods and tools (3/8)
- Part 4: Established processes and achieved project results.(3/8)

The expert online survey will be accomplished from January 2006 until March 2007. First results are expected in March 2007. The final report should be available not later than May 2007.

4. CONCLUSION AND FUTURE WORK

They survey will show if there is nowadays an increased use of BPM methods during the implementation of Electronic Records Management Systems in public authorities. Further, we expect to find out which BPM methods and tools are mostly used in public administrations and which impacts they have on implementing ERMS regarding process redesign, internal administrative procedures and fulfillment of project objectives. In comparing data results of different project proceedings, used methods and finally achieved project results may lead to recommendations, best practice approaches and/or further need for action. Future work will be concentrated on analyzing established electronic processes and their comparison between similar authorities in Germany, Austria and Switzerland.

5. REFERENCES

Antirroiko, A. & Mälkiä, M. (2006). Encyclopedia of Digital Government. Hershey. Idea Group Reference.

EU (2005). eEurope 2005: An information society for all. Commission of the European Communities. An Action Plan to be presented in view of the Sevilla European Council. 21/22 June 2002. Executive Summary 28-05-2002. COM(2002)263 final. Brussels: http://ec.europa.eu/information_society/eeurope/2002/news_library/documents/eeurope2005/eeurope2005_en.pdf, Last update 31-05-2005.

EU (2006). About eGovernment. Europe's Information Society Thematic Portal. The European Communities. Brussels: ttp://europa.eu.int/information_society/activities/egovernment_research/about_us/index_en.htm, Last update 01-08-2006.

Grönlund, A. (2002). Electronic Government: Design, Applications and Management. Hershey. Idea Group Publishing.

Klischewski, R. & Lenk, K. (2002). Understanding and Modelling Flexibility in Administrative Processes. *In Traunmüller, R., Lenk, K. (2002). Electronic Government, First International Conference, EGOV 2002. Aix-en-Provence.* Berlin. Springer Verlag.

Lee, K. (2005): A Top-Down Approach to Quality Driven Architectural Engineering of Software Systems. *In IEICE Transactions on Information and Systems 2005.* Oxford Journals. Oxford University Press.

Lenk, K. & Traunmüller, R. (2000). A framework for electronic government. In 2000, Proceedings, DEXA, 11th International Workshop on Database and Expert Systems Applications, IEEE Computer Society Press.

Matheis, T., Daun, C. & Loos P. (2006). Performance Measurement for E-Government Scenarios. *In Koshrow-Pour, M. (2006). Emerging Trends and Challenges in Information Technology Management. Information Resources Management Association*. Hershey. Idea Group Publishing.

Müllner, T. & Grimm, D. (2006). Applications for Comprehensive E-Government. *In Antirroiko, A., Mälkiä, M. (2006). Encyclopedia of Digital Government.* Hershey. Idea Group Reference.

Scheer, A.-W., Kruppke H. & Heib, R. (2003). E-Government – Prozessoptimierung in der öffentlichen Verwaltung. Berlin Heidelberg. Springer-Verlag.

Scholl, H.J. (2005). E-Government-Induced Business Process Change (BPC). In International Journal of Electronic Government Research, Vol. 1, No. 2, Idea Group Publishing.

TNA, The National Archives (2001). e-Government Policy Framework for Electronic Records Management. A joint Public Record Office / eGovernment Unit publication: http://www.nationalarchives.gov.uk/electronicrecords/pdf/egov_framework.pdf.

Traunmüller, R. & Wimmer M. (2001). Directions in E-Government: Processes, Portals, Knowledge. *In Proceedings of the DEXA International Workshop. On the Way to Electronic Government.* Los Alamitos, CA. IEEE Computer Society Press.

Traunmüller, R. & Wimmer M. (2003). E-Government at a Decisive Moment. Berlin Heidelberg. Springer-Verlag.

Wimmer, M.(2002). Integrated Service Modeling for Online One-stop Government. In EM - Electronic Market. Special issue on e-Government, vol. 12(3), pp. 149-156(8). Routledge. Part of the Taylor & Francis Group.

ENDNOTES

1 GIS: Geographic Information System
2 ERMS: Electronic Record Management System
3 WMS: Workflow Management System
4 ERP: Electronic Resource Planning
5 DOMEA: DOcument Management and Electronic Archive in the public administration, Coordination and Information Center for ICT of the German Federal Administration (KBST)
6 ELAK: Electronic Record (ELektronischer AKt), Chief Information Office (CIO), ICT strategy of the Austrian Federal Administration
7 GEVER: Records Management (GEschäfts VERwaltung), Information Strategy of the Confederation of Switzerland (ISB)
8 The National Archives: Public Records Office (PRO)

Promoting the Economic Development Through the IT Industry in Mexico: The PROSOFT Program

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INTRODUCTION

The Information and Communication Technology (ICT) industry has been identified as a key factor for increasing national competitiveness giving the variety of applications of ICT in many economic sectors. In fact, productive and social networks are enabled by ICT to satisfy the needs for health, education, government, and economic well-being (García, 2006). Moreover, and because of synergies and spillovers of the ICT sector, policy makers around the world are devising plans to increase the investment in ICT in order to promote economic growth (Baily, Farrell & Remes, 2006). In this way, the ICT industry has become in the last years an important catalyst for national economies.

Recent changes in exportation patterns have motivated the Mexican government to create a campaign to position Mexico as an ICT provider. The campaign intends to show the advantages of outsourcing services to Mexico, focusing particularly on the United States market (Ruiz, Piore & Schrank, 2005). This campaign is a key component of the digital economy policy in Mexico, and has been called the Program for the Development of the Software Industry (PROSOFT).

Achieving PROSOFT goals will depend on several interrelated factors (Secretaria de Economía, 2006). First, it will depend on the ability of policy makers to promote investments. Second, the ICT industry in Mexico will need a transition toward a new administration and governance. Moreover, Mexican success will also depend on the speed and capability of ICT industry in adopting a collaborative approach to respond to the needs of the international market.

This paper reports the current progress of a case-based simulation project in which we analyze the PROSOFT program. Our objective is to explore the relative effectiveness of different policy mixes to achieve the PROSOFT goals. Some of the aspects of the program to be included in the model will be the workforce, human capital, financial investments, and governance and collaborative approaches being promoted by PROSOFT project leaders.

LITERATURE REVIEW

The Mexican economy has two main problems according to some analysts (Martínez, 2001): The first one is associated with the low nutrition levels suffered by many Mexicans, and the second one is related to the uneven distribution of wealth. Moreover, domestic economic growth is not having a direct impact on basic well-being of the growing population, but rather it has increased the accumulation and the concentration of income in very few people.

In order to improve the economic conditions for the general population, it is needed either to increase allowances or to reduce the population's growth. To achieve this development is necessary to elevate the investment rate substantially and to modify the distribution of income in order to reach a better level of efficiency (Baily et al., 2006).

Latin American economies have problems because of the lack of capital. Countries in this region depend on those countries that have the capital to invest and promote economic development. The dependence resides on the importation of capital goods and capital investments. Important factors attracting such capital investments are the existence of qualified and cheaper workforce (C.I. García, personal communication, December 7, 2006).

Investing in the ICT sector to promote economic development is attractive for several reasons. ICTs are having a direct impact on many countries inflationary trends, reducing the unit capital costs, and accelerating demand for ICT products as a mayor driving force. It is amazing how the ICT prices, adjusted for quality improvements, are going down while prices in the rest of the economy have been increasing. This has been allowing a non-inflationary growth, which generates a positive effect on the economy. (Hilbert, 2001). In addition, the economy is indirectly impacted by human capital and telecommuting workforce programs, which tend to report an increase in productivity through increased morale and commitment to the company.

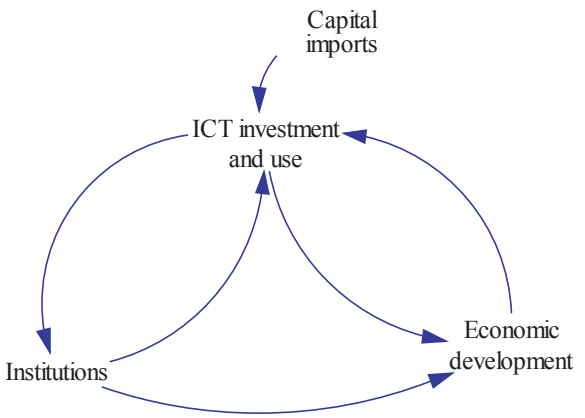
In this way, ICT should eventually lead to a permanent increase in productivity, just like every other innovation, which decreased input costs. Currently, some countries are already investing on research and the final integration of the new economic features into their societies, in order to benefit from it, while others (such as many Latin American countries) are still trying to provide the basic access to the knowledge-based economy for several sectors of their populations.

Economies are increasingly based on knowledge. The generation, processing and distribution of knowledge and information are a fundamental source for productivity, power and prosperity (Baily et al., 2006). In the past, the growth of the economy of a country depended on the optimization of the physical labor and financial capital, it's been proved that information and communication (networking in the network), are definitely the main component of growth in the new knowledge society (North, 1994).

Institutions have been identified as another important factor affecting economic development (Hassan & Gil-Garcia, 2006). Moreover, institutions have been also identified as an important constraint and enabler of ICT investments, development and use (North, 1994). Authors describing such effects do not only recognize the impact of institutions in economies or ICT applications, but also recognize ways in which individual and organizational interactions affect the institutional arrangements (Figure 1).

Most of the discussion about ICT and economic growth recognizes the effect of ICT investments on economic development. However, as shown in Figure 1, Institutions are also constraints and enablers of economic development because of its impact on transaction and transformation costs. Moreover, institutions also affect the ways in which individuals and organizations decide to invest and use ICTs, modifying the possible benefits of ICT use and explaining differences between organizations or countries (i.e. some organizations or countries obtain more benefits from ICT investments than others). However, Institutions are also modified through time by individual and organizational actors. In this way, our exploration of the impact of ICT policies such as PROSOFT will use institutional

Figure 1. Interactions among institutions, ICT investment and use, and economic development



theory as a reference to understand the complex interactions among ICT investment and use, institutions, and economic development.

METHODS

In order to understand the PROSOFT case two main data collection methods are used. First, we performed an analysis of relevant documents including articles, digital references, and books. This review will provide some background, general information, and the basic characteristics of the PROSOFT program. Information was also extracted from articles and reports in which we observed the growth of the Information Technologies, as well as the different behavior and scenarios of several countries who are investing on the implementation and development of ICT.

Second, we will conduct semi-structured interviews with people responsible for the promotion of information and communication technologies in Mexico. These interviews will provide additional information on the evolution of the PROSOFT program, and help to understand why the development of information technologies is so important to increase national competitiveness. Participants will be asked about the main rationale of the program, program development, and main achievements.

Finally, we will use System Dynamics as a method to understand all the strategic components of the PROSOFT program and their interrelationships. This method consists on identifying the behavior of several variables in the system and identifying a causal structure associated to it. The development of the model represents an iterative process of comparing system's performance over time, linking those processes into causal structures and evaluating the feedback processes (Richardson & Pugh, 1981). The main objective is to simulate the most important components of the PROSOFT program to analyze and understand their main interactions. As a result of the modeling process we will develop and evaluate hypotheses about the impact of the behavior of ICT investment and use and the simulation will help to understand and manage the different variables that appear in the program. This preliminary version of the paper reports the results of the analysis of documents and one interview with two key participants in the PROSOFT program.

PRELIMINARY RESULTS

The PROSOFT program was officially created in 2002, following a 10-year plan, PROSOFT focuses in the development of the software industry integrating public and private funding, promoting collaboration among private industries, federal and state governments, and institutions of higher education. (Colón, 2006). One of the goals of PROSOFT is to achieve by 2013 an annual production of technological solutions for 5,000 million dollars. In this way, Mexico will reach the world average of expense in ICT, becoming the Latin American leader in software and digital contents development in Spanish. Initial results are encouraging, and the ICT sector growth has changed from a negative rate in 2002, to 10.7% in 2005. This growth represents three times the growth of the domestic economy in that same year. It is expected a 11.4% growth for 2006.

The program is organized around seven strategic lines:

1. Promotion of exports and investments in the software sector
2. Education and training of competent personnel in the development of software, as well as the required quantity and quality
3. Appropriate legal framework in place promoting this industry
4. Development of the IT domestic market
5. Strengthening of the local industry
6. Achieve international levels in process capability
7. Promote cluster development throughout Mexico

As of 2006, PROSOFT is working with approximately 26 of the 32 Mexican states, 121 universities, and 25 clusters have been developed since the beginning of the program. Overall, PROSOFT has increased growth of the Information Technology (IT) Industry (C.I. García, personal communication, December 7, 2006). It has been an engine to the IT Industry, and helped to develop and increase well-paid salaries as well as jobs for well-prepared people. PROSOFT allows to develop exportation services and technologies. This program has created a new culture that shows the commitment of the people who are involved in this environment and the best administration of human and material resources.

NEXT STEPS

The results of the program seem to be promising. However, more information is needed and we will continue looking for additional relevant documents. As mentioned before, we will also conduct semi-structure interviews with key participants in the PROSOFT program.

We will develop a model and simulate the behavior of the factors trough time. As an initial phase we will generate a list of all the important factors to the problem, secondly we will analyze and describe each one of the behaviors of this factors by creating graphics over time. Once completed the initial phase we will link all the factors described in the first phase utilizing diagrams (Causal-Loop diagram) in order to visualize the feedback process and to facilitate the simulation process. During the construction of the model several test will be applied to validate the model. Finally, extensive experimentation with the model will yield insights about problems and opportunities in the implementation of the PROSOFT program and similar policies implemented in different countries.

REFERENCES

Baily M., Farrell D., & Remes J. (2006). The Hidden Key to Growth. T*he International Economy*, *Winter 2006,* 49-53

Colón S. L. (2006, August 18). México sería líder en el desarrollo de software. *El Economista*. Retreived December, 2006, from http://pymes.economista.com.mx/index.php?option=com_content&task=view&id=554&Itemid=27.

García de Alba Zepeda S. A. (2006, August-September). Tecnologías de la Información, motor de la economía. *Política Digital, 31,* I-XIII.

Hassan R. S. & Gil-Garcia J. R. (2006) *Institutional Tehory and E- Government Reseach: State of the Art and Research Opportunities*. Albany, NY: Author.

Martínez, J. C. (2001): La Economía de Mercado. In El crecimiento económico. Retrieved January 5, 2007, from http://www.eumed.net/cursecon/18/index.htm.

North D. C. (1994). *Institutions, institutional change and economic performance*. Cambridge, MA: Cambridge University Press.Richardson, G. P., & Pugh, A.L,III. (1981). *Introduction to System Dynamics Modeling with DYNAMO.* Cambridge, MA: Productive Press

Ruiz Durán, C., Piore, M., & Schrank A. (2005, September 9). Los retos para el desarrollo de la industria del software. *Comercio Exterior, 55,* 745-748.

Improving Access to E-Government Processes

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ABSTRACT

Much effort is spent in governmental institutions to provide citizens with access to government processes. However, there are still a lot of steps in these processes that rely on the exchange of printed paper. This is a problem for all people who have difficulties to read, among them humans with visual impairments, elderly people or immigrants. In this paper we present an approach followed in the FABEGG-System. It allows transforming either electronic or paper based documents, particularly forms into a representation that can be read by a computer. Furthermore, it provides the possibility to guide the citizen through a document or form. Thereby, FABEGG improves accessibility for many E-Government processes.

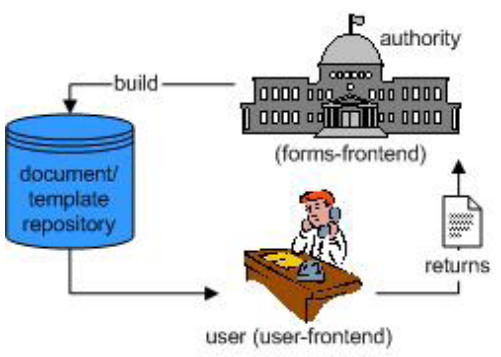
1. INTRODUCTION

In recent years governmental institutions have spent much effort in Human Computer Interfaces to improve access for handicapped persons to computer systems [1]. To a major extent these activities are enforced by legislative constraints that exist in the US (e.g. the Americans with Disabilities Act [2]) as well as in the European Union [3], and in its member countries, like in Germany [4],[5].

Looking closer at many of these systems we may recognize that many of these realizations allow citizens to download particular forms that then have to be printed, completed, and sent to the governmental institution. In processes where an institution contacts a citizen this usually happens by sending paper documents. Often, these documents are forms that are partially completed with data of the recipient related to the processes. The citizen is then asked to complete the form with additional information. This process step is clearly difficult to handle for visually impaired people, elderly or dyslexic people, or immigrants.

In this paper we present an approach which we pursue in the FABEGG system where we try to develop new techniques to improve access to this documents for the humans mentioned before. Figure 1 gives an overview of the document flow supported by the system.

Figure 1. Prozess overview



The document and template repository serves as an interface between citizens and authorities. An authority feeds the repository with relevant information (e.g. statutes of communal companies) or forms. In the latter case we speak of document templates. FABEGG provides modules to support the input of documents into the repository as well as modules to process these documents or templates. In the following we describe these modules in more detail.

2. THE USER FRONT-END

The FABEGG user front-end is an innovative terminal that could be placed in any administrative department. Figure 2 shows a possible configuration of the system with a digital document camera unit to capture printed documents, and a touch screen which is used as display and as an input device.

FABEGG allows to present documents on the display with special effects. For example a document can be enlarged, or different combinations of colours can be chosen, which provide better visibility for humans with particular visual defects. Furthermore, the document can be read by the computer in different velocities. Therefore, speakers are also included in the system. Due to privacy considerations they could be substituted by headphones in a real environment. While reading, the system highlights the text, which is actually spoken, e.g. by drawing a coloured rectangle around the text. This enforces auditory understanding. With a pointing unit (e.g. a mouse or a finger when a touch screen is available) the user can start/stop reading at any arbitrary position within the document.

A citizen who wants to process a governmental document gives a digital image to the FABEGG system, e.g. by taking a picture with the camera in the FABEGG station or by the camera in his mobile phone and sending it via Bluetooth or UMTS. FABEGG uses a component to automatically identify the type of the form. From

Figure 2. Prototype of the FABEGG system

its database it determines the fields that should be already filled by the sender and then guides the citizen through the process of filling the document. The system can read any information contained in the form and provide help information on filling the fields. FABEGG can perform validity checks for the input and can support the user to correct invalid inputs.

After the form is completed it is transformed into a document, which can be inserted into the workflow of the government department. Hence, FABEGG also achieves an improvement for the department, which is responsible for the next step in the process.

3. THE FORMS FRONT-END

The forms front-end is the interface for the governmental institution to insert documents or forms into the repository. It comprises digitalisation and indexing of a document in order to enable users to retrieve the document easily. In our discussion here we focus on the insertion of forms that normally would presented to the citizen as printed forms. An administrator or an official in charge who wants to deploy a form for the system starts with a digital image of the form. He attaches administrative data to the document, i.e. a unique ID, a name, a type etc. Then the official marks the input fields relevant for that form. There may be fields that are already filled when an instance of that form is sent to the citizen; other ones have to be completed by the recipient. The editor can specify the type or format of the requested input, like date, City Code, currency or numbers and he can specify functions to validate the input. This may be known from web-based formulas with JAVA-script. In the FABEGG environment one can do even more tests because we are not restricted to client-side computing. For each field a help text can be associated which can guide the user during completion of the field.

To be able to identify such a template given a scanned document image by a user the editor must define at least one unique anchor for a document. This can be a textual anchor, a barcode or an arbitrary image/pattern on the form. Of course, in large repositories choosing a unique anchor may be difficult. Therefore, we will work on an automated procedure for the anchor definition. This routine could crosscheck all possible anchors on a form with the database to prevent double entries in the database. Having done all this, the document template is stored in the document repository. We use an XML-format to glue together all the different information mentioned above. In this description it is possible to integrate layout information and procedural information (cf. [6]). The layout information includes for example words and their positions in the text, or reading order of fields in a form. Procedural information includes specification of validation functions for user inputs or a strategy to identify an anchor for a specific document.

Another core activity will be the development of an ontology for the application domain. In a first step we will represent the major departments and processes in such an ontology. This will provide a structure, which can be used to insert new documents and forms into the repository automatically. Furthermore, the hierarchical structure can be used to implement an ontology-based retrieval of documents as described in [7].

4. IMPLEMENTATION

The FABEGG system is implemented as a modular system. It contains components for processing and manipulating the document image, components to produce spoken output and components that establish control features, e.g. validity checking or the connection to other components as databases or workflow management systems. Many of these components, in particular the image processing components and the OCR software are only available for Windows based operating systems. Thus, FABEGG is currently a desktop application running only within this environment. Furthermore, we use a commercial speech synthesis component to generate the audio stream while reading the document that is also only available for Windows. For the form recognition we use techniques as described in [7]. Some modules for the image manipulation and for the system design may be found in [8], [9], [10].

The OCR is implemented as a component, which analyses the whole image. It yields the layout structure of the document, including the number and the position of all paragraphs, the position of images or graphical sections, position, style, and recognition confidence for all words in the text with. The result of this process is stored into the XML-file, which is adapted to the structure of the text (paragraph-block-sentence-word).

To capture a paper-based document we use an innovative digital document camera. The application shows a live stream of this camera until the user presses a button to take a snapshot of the actual document. Many of the components we use were developed in a project of the German Ministry of Economics and Labour, called LiveReader [11]. These components contain functions to process digital images, i.e. for zooming or colour manipulation. They also provide us with a software layer for accessing Text-To-Speech synthesis.

5. CONCLUSION AND FUTURE WORK

In this paper we have presented the FABEGG system, which significantly improves accessibility to documents for people with reading disabilities. Together with its form-handling engine which allows inserting forms into the system and retrieving them later on it implements a new functionality to present governmental forms to those citizens. A major advantage of FABEGG is that it can process either electronic or printed forms, which the user receives from the governmental institution. Thus, FABEGG avoids media disruption and integrates paper documents into electronic process chains. Furthermore, FABEGG copes with documents that have already been filled before with individual information before the user receives the form. This type of communication is quite general in nowadays business and governmental processes and cannot be replaced easily by switching to an electronic version.

We will evaluate FABEGG together with some local governmental departments in Germany. This will give further insight into the requirements of our specific user group. Furthermore, we consider implementing FABEGG as a client-server application thus, giving more possibilities for realizing the user front-end.

6. REFERENCES

[1] Muller, M. J., Wharton, C., McIver, W. J., and Laux, L. 1997. Toward an HCI research and practice agenda based on human needs and social responsibility. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (Atlanta, Georgia, United States, March 22 - 27, 1997). S. Pemberton, Ed. CHI '97. ACM Press, New York, NY, 155-161.

[2] Public Law 101-336. Text of the Americans with Disabilities Act, Public Law 336 of the 101st Congress, enacted July 26, 1990.

[3] Europäische Kommission: Gleichbehandlung Behinderter in Beruf und Bildung: Richtlinie des Rates 2000/78/EG vom 27. November 2000, ABl. L 303 vom 2. Dezember 2000.

[4] Verordnung zur Schaffung barrierefreier Informationstechnik nach dem Behindertengleichstellungsgesetz (Barrierefreie Informationstechnik-Verordnung - BITV) vom 17. Juli 2002

[5] Allgemeines Gleichbehandlungsgesetz der Bundesrepublik Deutschland vom 29.06.2006, http://www.gesetze-im-internet.de/agg/

[6] Bläsius K. H., Grawemeyer B., John I., Kuhn N.: "Knowledge-Based Document Analysis" in: Proceedings of the International Conference on Document Analysis and Retrieval (ICDAR '97), Ulm, 1997.

[7] Naumann, S., Krieger, R., Kuhn, N., Schürmann, C., Sommer, Christian: Adaption von Information Retrieval-Verfahren zur automatisierten Produktsuche und -klassifikation. In: Dittrich, Klaus; König, Wolfgang; Oberweis, Andreas; Rannenberg, Kai; Wahlster, Wolfgang (Hrsg.): Informatik 2003. Innovative Informatikanwendungen Band 2. Lecture Notes in Informatics (LNI), Volume P-35, Bonn 2003

[8] Hennen, Christian: Design and Implementation of synchronous manipulation of a camera image with special emphasis on ergonomics aspects. Diploma thesis, Birkenfeld, 2004.

[9] Richter, Stefan: Design and Implementation of a communication module for blind and visually impaired humans. Diploma thesis, Birkenfeld, 2003.

[10] Schäfer, Frank: Rotation detection in scanned images and photos. Student project, Umwelt-Campus Birkenfeld, 2003.

[11] Norbert Kuhn, Markus Hertzler: LiveReader Project Report, Umwelt-Campus Birkenfeld, 2004.

Incubation Strategies for Spinning-Off New Technology Ventures in Catalonia: The Case of the University of Girona

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1. PROBLEM STATEMENT

University-based scientific inventions that translate into spin-off companies represent a potentially important and increasingly utilised option to create wealth from the commercialisation of research (Carayannis, 1998; Clarysse et al.; 2005; Lockett et al., 2005; Siegel et al., 2003; Vohora et al., 2004). The conventional route to transfer knowledge from university to market has been generally through two means: 1) licensing the rights to use technological discoveries controlled by university owned patents (Intellectual Property-IP) and 2) contract research. In recent years, university spin-off companies have become an increasingly popular way of exploiting potentially valuable research and knowledge; however, understanding this phenomenon remains limited.

This research is motivated by the need to learn more about university start-up companies and particularly those created on the basis of technology developed in universities. We adopt a multi-dimensional approach to study the incubation strategy for spinning-off companies of the University of Girona (Catalonia – Spain). We analyse the strategy of these Public Research Institution (PRI) in terms of resources and activities, how the process of spinning-off ventures is organised and if the outputs fit with this PRI's objectives and the local environment.

This multi-dimensional dynamic approach involves two main different levels of analysis: the local environment at the PRI and the PRI with particular emphasis on the Technological Trampoline (a unit within the Technology Transfer Office in charge of new venture creation) and a secondary one, the spin-off. To guide our research we draw upon three streams of literature that contribute to the understanding of spin-off creation and support at PRIs.

This paper attempts to answer the following questions:

- What is the regional environment for spin-offs emerging from PRI in Girona (Spain)?
- How does the actual model of technology transfer employed by the TT of the University of Girona work and how has it evolved since its foundation?
- Which is the predominant incubation model of managing the spin-off process at the University of Girona?

2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

First, we make a brief note on the definition of spin-offs due to the complexity and multiple facets of this phenomenon. Then, we draw on the literature related to the resource-based view (RVB) of the firm literature. Next, we review institutional theory. Finally, we draw on the taxonomy of incubation strategies identified by Clarysse et al. (2005) within the European Institutions.

We adopt the definition of university spin-off provided by Pirnay et al. (2003:356) and supported by the majority of the scholars: "new firms created to exploit commercially some knowledge, technology or research results developed within a university". However, we expand this definition taking Nicolau and Birley's (2003:340) definition that stresses that the founding member(s) may include the inventor academic(s) who may or may not be currently affiliated with the academic institution.

2.1. Resource-Based View

A number of researchers have utilised the resource-based view and the resource-based dependence view to analyse issues related to the emergence of spin-off and the resources as a differentiator and a predictor of competitive advantage (e.g. Clarysse et al., 2005; Druilhe and Garnsey, 2004; Pirnay et al., 2003; Shane and Stuart, 2002; Wright et al., 2004). We reviewed the main studies related to the process of spinning-off ventures within PRI that have applied resource-based view and resource-based dependence view. We have identified the main resources analysed and classified them in six broad categories: organisational, social, financial, technological, physical and human resources.

2.2. Institutional Theory

Recent work on the heterogeneity of research-based spin-offs (Mustar et al., 2006) describes the institutional perspective of spin-offs as the relationship and the embeddedness with their parent organisation, which has its own culture, incentive system, rules and procedures. All these elements constitute the structure that needs to be embedded in a supportive context. This context is related to the institutional and policy environment, the culture and the history that has unfolded within the academic institution (Debackere and Veugelers, 2005). We have reviewed the main studies related to the process of spinning-off ventures within PRI that have applied institutional theory and we have identified a set of formal and informal factors.

2.3. Taxonomy of Incubation Strategies

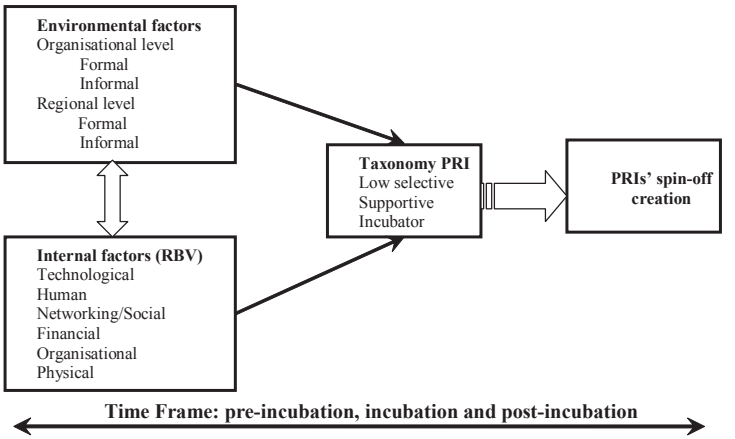
There are very few studies trying to shed light on the different existing taxonomies of European Research Institutions according to their objectives, strategies, resources and activities undertaken. After reviewing the scarce literature on this topic, Clarysse et al. (2005) offered a good comparative framework of taxonomies detected within European Institutions to map the activities, resources and activities undertaken. Based in an in-depth analysis of the seven cases from 13 European regions, Clarysse et al. (2005) identified three distinct incubation models of managing the spin-off process: Low Selective, Supportive, and Incubator.

Considering the previous arguments, we have built a model that combines the theoretical frameworks reviewed to give answer to our research questions. Figure 1 shows this model.

The first category refers to the environment and reflects the institutional view. The concepts included are institutional level factors - like strategy, technology transfer, links after start-up, parent features - and regional level factors - such as role models, social norms and entrepreneurial region.

Internal factors, drawn from the resource-based view of the firm, include all resources needed and provided by the PRI during the process of the new venture creation. We group these resources by the following categories: technological, human, networking, financial, organisational and physical.

Figure 1. Model of spin-off creation in PRIs



3. RESEARCH DESIGN

A two-stage methodology is employed. First, a qualitative approach was used to identify the strategy of the UdG's Technological Trampoline in terms of resources and activities and how the process of spinning-off ventures is organised. In this stage, several methods of data collection were used to address these issues, enabling to cross-check results. Finally, we pattern matched our findings with Clarysse et. al. (2005) typologies with the aim of classifying UdG's incubation strategies in the context of European research institutions and we also analysed its fit with the environment.

In performing this study, we followed procedures commonly recommended for conducting case study research (Eisenhardt, 1989; Yin, 1989). Data collection was performed at different levels and using a mix of techniques, avoiding common method bias. Our multi-dimensional dynamic approach involves: the local environment at the PRI, the PRI with particular emphasis on the Technological Trampoline and the spin-offs that emerged from the TT since its foundation in 2001.

We examined the organisation of incubation spin-off services from the perspective of the parent institute. This entailed looking at two interrelated levels: the internal activities geared towards spinning-off companies and the context in which resources are employed. At this stage, in order to track, analyse and identify resources, activities and changes over the time a history approach was necessary. Herein, the tracing of historic PRI documents (e.g. plans, contracts, etc.) was central and complemented with extensive interviews about the PRI's history and current operations. Thus, we carried out semi-structured interviews with representatives of the TT. Concretely, we interviewed the former and the current head of the TT and the two present business development assistants.

We also interviewed representatives of the spin-offs that emerged from the TT at UdG, focusing on the start-ups history and resource acquisition. Since the foundation of UdG's TT, ten companies have been created and we focused on understanding better the dynamics of venture formation and development as it is embedded in this particular PRI.

4. DISCUSSION

Due to space limitations, we do not provide the discussion of the findings because we consider more important to focus on: conclusions, implications, recommendations, future research and limitations. We would only contextualise our main unit of analysis: the Technological Trampoline.

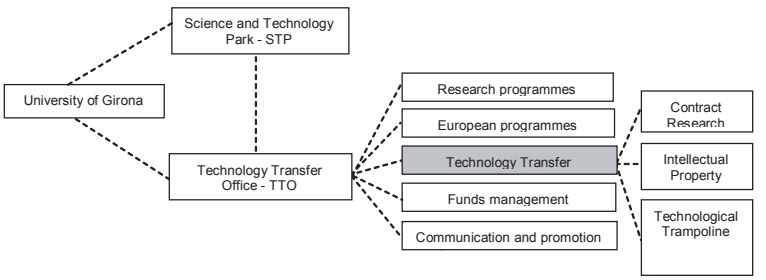
The Technological Trampoline (TT) is a public independent entity integrated in the Technology Transfer Office (TTO)[1] and responsible for promoting technology and knowledge exchange basically through spin-off creation. Although the TT is linked to the TTO in terms of office spaces and other physical resources, its functioning and budget are independent from both the University and the TTO.

5. CONCLUSIONS

The findings highlight that the region of Catalonia is highly entrepreneurial in Spain, but still far from other European scientific regions of excellence like Baden-Würtenberg or Ile-de-France (Clarysse et al., 2005). At the university level, the commercialisation of research happens similarly to the one described in Debackere and Veugelers (2005), but having different magnitudes. The regional environment clearly impacts on the resource acquisition process of the TT and its spin-offs. Concretely, the regional government is financially supporting this unit and at the same time is creating a network of advisors, business angels, IP specialists and other resources and capabilities to help in the success of such companies. Still, support mechanisms mainly come from the regional level, rather than local (city council, chamber of commerce), national or international levels.

Similarly to Germany (Krücken, 2003), where either the regional government (Lander) or the National Ministry of Science and Research were the main driving forces of the TTOs' institutionalisation process, the motivation of creating a

Figure 2. Main units of UdG's science-based and technology transfer activity



spin-off support unit at UdG was twofold. On the one hand, a general interest of a limited group of people to follow the international trend, including transfer-oriented professors and technology transfer officers. On the other hand, the regional government's initiative to help universities create the adequate structures to facilitate the commercialisation of research via spin-off creation. By that time, the university and its managers were still in the "ivory tower". This resulted into a laissez-faire university policy, where the TT followed its own path towards developing and diversifying its activities and finding resources in order to continuously assist and support researchers to carry out their ideas. Lately, the TT in Girona has already gone through a consolidation stage where an institutionalisation of the unit and routinisation of its services has been achieved.

The elements of the three typologies of incubation strategies in European research institutions can be identified at the University of Girona. Nevertheless, the predominant typology at the UdG is the Supportive model. This model stems from the general idea of commercialising technology developed at the RI through other means than licensing or contract research. Hence, the spin-offs are an alternative option to create value from technology and their returns are based on economic profitability rather than financial gains for investors upon exit. Once the TT decides to commercialise technology through a spin-off, the team of researchers is intensively coached, including help with looking for money. However, in the beginning the TT had to create awareness, entrepreneurial culture and role models, thus the spin-offs created did not follow their selection criteria and initial objectives. Therefore, we still can observe a mixed model between Low Selective and Supportive. According to Clarysse et al. (2006:212) "…it is important for RIs to be very clear about their objectives and specify clearly the resources that are needed/activities performed to meet these objectives". The lack of clarity about the TT's objectives results in hybrid types that can be either resource or competence deficient. In fact, we have observed a hybrid model as a result of the continuous change in its objectives as a consequence of a learning-by-doing, try-and-error process and lack of sufficient competitive research.

Another problem identified at the UdG is its shortage of competitive research, which hinders any support to technology transfer activity. In fact, the UdG is only capable of spinning-off one or two technological companies per year, the rest may not be based on a differentiating/unique technology. Thus, the main point at the UdG lies on whether the applied model and the resources employed are worth used. In our opinion, it appears to be inappropriate to acquire the resources required to perform a Supportive model and then try to perform activities associated with a Low Selective model because their research outcomes are not sufficient.

6. IMPLICATIONS AND RECOMMENDATIONS

Our research suggests that the University of Girona should have a deeper pool of research with commercial potential. There is a need to first become a research university, with high quality of research (knowledge exploration and creation), and regional, national or international recognition. This can be stimulated through: 1) the recruitment, retaining, and development of star scientists; 2) partnership with leading industries in the region; 3) further investment and resources for research activities; and 4) a change in its incentive structure, especially for tenures.

Next, the process of cultural transformation aiming at converting the university into a more entrepreneurial should happen at different levels: teaching centres, including students and professors, administration and institution government. A major diffusion and a higher number of subjects on entrepreneurship and new venture creation are part of this transformation.

Third, although the TT followed a positive development path strongly guided by learning-by-doing that can be observed in both activities and resources, some recommendations are needed:

- A project selection methodology based on well-defined concepts and procedures is needed. Although the criteria and objectives regarding technology are very clear, the results are not completely successful. A clear methodology would automatically drive to resource savings and a better and more efficient allocation of them.
- Recruit more technology transfer officers with an appropriate private sector background and links with the local industrial districts in order to discover new opportunities, including experience of starting a business.
- At the university level, an incentive mechanism targeted at research groups and individual researchers should be designed by this embedded institution taking into account: academics profile, specific needs and regional industrial districts. Knowledge on existing practices in European research institutions having a more advanced entrepreneurial culture might be a starting point when designing incentive structures and schemes for local academics willing to start a business.
- Although the decentralised organisation gives the TTO freedom of actuation by establishing their goals, mission and objectives, there are no monitoring mechanisms of the impact of their activities in the local environment. Despite spin-off companies are commonly used as a performance indicator, they should be a tool and not an aim when creating regional welfare.

Fourth, our analysis shows a high variety of institutions aiming to support and promote innovation in both enterprises and universities in the region. A frequent, regular and devoted process of continuous information about the existence and activities of such institutions and their initiatives (with special emphasis on national and European context) concerning spin-off creation and promotion could be a solution in enhancing the number of science-based entrepreneurial ventures.

7. LIMITATIONS AND FUTURE RESEARCH

First, examination of the broader technology-transfer strategies of the UdG and the research incentive structure was beyond the scope of this study. Further research should examine the rest of technology-transfer strategies and the balance of spin-offs versus other modes of technology transfer such as licensing and contract research. Second, our research does not deal with an in-depth analysis of the organisational or entrepreneurial culture within the PRI and the local environment. Third, the cultural transition of becoming entrepreneurial at both regional and university levels is a complex issue, and a more-detailed analysis based on historical, social and other criteria would make the analysis complete. Fourth, we do not show the results of the analysis aimed at characterising and analysing the success of the spin-offs created at this PRI. This is part of an undergoing research with the main objective of confronting both sides and show discrepancies if any in the model used by the TT and the expected results.

One main limitation and a primary future research field refers to the analysis and comparison of the resources, activities and success of the rest of PRI's incubation strategies in the same region (Catalan universities), then broadening the analysis to PRI's located in other regions within the Spain.

8. REFERENCES

Carayannis, E.G.; Rogers, E.M.; Kurihara, K.; Allbritton, M.M. (1998) "High technology spin-offs from government R&D laboratories and research universities". Technovation, 18 (1), pp. 1-11.

Clarysse, B.; Wright, M.; Lockett, A.; Van de Velde, A.; Vohora, A. (2005) "Spinning out new ventures: a typology of incubation strategies from European research institutions". Journal of Business Venturing, 20, 183-216.

Debackere, K.; Veugelers, R. (2005) "The role of academic technology transfer organisations in improving industry science links", Research Policy, 34, 321-342.

Druilhe, C., Garnsey, E. (2004) "Do academic spin-outs differ and does it matter?". Journal of Technology Transfer, 29 (3-4), pp. 269-285.

Eisenhardt, K.M. (1989) "Building Theories from Case Study Research". Academy of Management Review, 14, pp. 488-511.

Hindle, K; Yencken, J. (2004) "Public research commercialisation, entrepreneurship and new technology based firms: an integrated model". Technovation, 24, pp. 793-803

Krücken, G. (2003) "Mission impossible? Institutional barriers to the diffusion of the 'third academic mission' at German universities". International Journal of Technology Management, 25 (1/2), pp. 18-33.

Lockett, A.; Siegel, D.; Wright, M.; Ensley, M.D. (2005) "The creation of spin-offs at public research institutions: Managerial and policy implications". Research Policy, 34, pp. 981-993.

Mustar, P.; Renault, M.; Colombo, M.G.; Piva, E.; Fontes, M.; Lockett, A.; Wright, M.; Clarysse, B.; Moray, N. (2006) "Conceptualising the heterogeneity of research-based spin-offs: A multi-dimensional taxonomy". Research policy, 35, pp. 289-308.

Nicolaou, N., Birley, S., (2003) "Academic networks in a trichotomous categorisation of university spinouts". Journal of BusinessVenturing, 18 (3), pp. 333-359.

Pirnay, F.; Surlemont, B.; Nlemvo, F. (2003) "Toward a typology of university spin-offs". Small Business Economics, 21 (4), pp. 355-69.

Shane, S., Stuart, T., (2002) "Organisational endowments and the performance of university start-ups". Management Science, 48 (1), pp. 154-170.

Siegel, D.S.; Waldman, D.; Link, A. (2003) "Assessing the impact of organisational practices on the relative productivity of university technology transfer offices: an exploratory study". Research policy, 32, pp. 27-48.

Vohora, A.; Wright, M.; Lockett, A. (2004) "Critical junctures in the development of university high-tech spinout companies". Research Policy, 33, pp. 147-135.

Wright, M., Vohora, A., Lockett, A., (2004) "The formation of high tech university spinout companies: the role of joint ventures and venture capital investors". Journal of Technology Transfer, 29 (3-4), pp. 287-310.

Yin, R.K. (1989) "Case study research-design and methods". Newbury Park: Sage Publications.

ENDNOTE

[1] The TTO provides administrative and supporting services relative to the different transfer modalities

Resource Monitoring and Rule-Based Notification: Applications in Subsea Production Systems

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ABSTRACT

An industrially driven consortium launched the Integrated Information Platform project in 2004. The main objective was to extend and formalize an existing terminology standard for the petroleum industry (ISO 15926) in to formal ontology. The ontology is used in monitoring of drilling and production processes. The paper presents research in progress on development of rule-based notification in subsea production systems to monitor and analyze production data. The task is elaborated and exemplified by data from the real case.

INTRODUCTION

Subsea petroleum industry and production systems used there are information-intensive. When a well is put into operation, the production has to be monitored closely to detect any deviation or problems. Furthermore, the next generation subsea systems include numerous sensors that measure the status of the systems and send real-time production data to operation centers. For these centers to be effective, they need tools that allow them to understand this data, relate it to other relevant information, and help them to deal with the situation at hand.

This paper reports on research in progress on rule-based resource monitoring and notification in the IIP project (Sandsmark & Mehta, 2004; Gulla *et al.*, 2006). The project's primary objective is to extend and formalize an existing terminology standard for the petroleum industry, ISO 15926 (2003). Using OWL Full sublanguage, this standard is transformed into a real ontology that provides a consistent unambiguous terminology for subsea petroleum production systems. The ontology is used in monitoring of drilling and production processes. The objective of this paper is to elaborate on the research in progress regarding rule-based condition monitoring of the subsea devices.

One of the research questions is how to use the ontology together with a rule language (e.g., SWRL (Horrocks *et al*., 2004)). We are investigating how to combine rules with the ontology and what limitations are imposed by chosen OWL Full sublanguage to represent ISO 15926. A key requirement is to reason in a semantically consistent way by exploiting both the ontology and the rules. Since it is impossible to have at the same time decidability, soundness, completeness, performance and expressivity (Golbreich *et al.*, 2005; Horrocks *et al*., 2003), we analyzing limitations and possible rule inference scenarios based on the current version of the ontology in OWL Full sublanguage. In case of too restrictive usage scenarios with regards to the expected features of the application, an alternative of automatic translation from ISO 15926 to OWL DL might need to be considered (Hakkarainen *et al.*, 2006). Currently, we are experimenting with Protégé-OWL, ontology and SWRL editor, OWLJessKB for rule inference and Racer for reasoning.

The paper is structured as follows. Next we introduce the IIP project and ISO 15926 standard. Later we elucidate the task of rule-based condition monitoring and notification in the project. Finally, we conclude the paper by discussing future work.

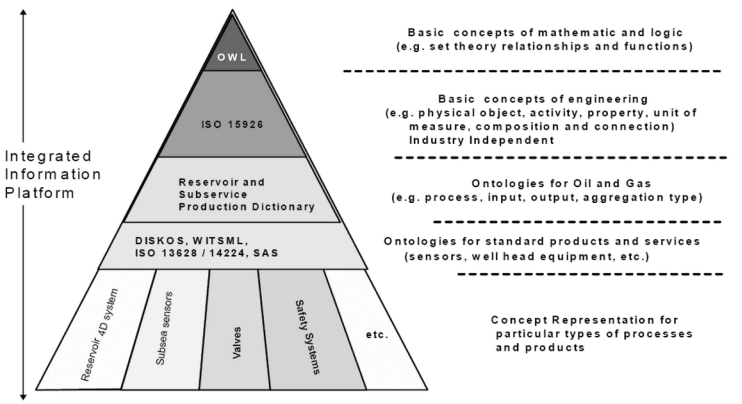
THE IIP PROJECT

The Integrated Information Platform (IIP) project is a collaboration project between companies active on Norwegian Continental Shelf and academic institutions, supported by the Norwegian Research Council. Its long-term target is to increase petroleum production from subsea systems by making high quality real-time information for decision support accessible to onshore operation centers.

The IIP project (Gulla *et al.*, 2006) addresses the need for a common understanding of terms and structures in the subsea petroleum industry. The objective is to ease the integration of data and processes across phases and disciplines by providing a comprehensive unambiguous and well accepted terminology standard that lends itself to machine-processable interpretation and reasoning. This should reduce risks and costs in petroleum projects and indirectly lead to faster, better and cheaper decisions.

The OWL web ontology language is chosen as the markup language for describing these terms semantically in an ontology. A major part of the project is to convert

Figure 1. The standardization approach in IIP



and formalize the terms already defined in ISO 15926 Part 2 (Data Model) and Part 4 (Reference Data Library). Since the ISO standard addresses rather generic concepts, though, the ontology must also include more specialized terminologies for the oil and gas segment. Detailed terminologies for standard products and services are included from other dictionaries and initiatives (DISKOS, WITSML, ISO 13628/14224, SAS), and the project also opens for the inclusion of terms from particular processes and products at the bottom level. In sum, the ontology being built in IIP has a structure as shown in Figure 1 and is exemplified in Figure 3c.

ISO 15926

ISO 15926 (2003) is a standard for integrating life-cycle data across phases (e.g. concept, design, construction, operation, decommissioning) and across disciplines (e.g. geology, reservoir, process, automation). It consists of 7 parts, of which parts 2 and 4 are the most relevant to this work. Part 2 specifies a meta-model or top-level ontology (Batres *et al.*, 2005) for defining application-specific terminologies. Part 2 includes 201 entities. It is intended to provide the basic types necessary for defining any kind of industrial data.

Part 4 of ISO 15926 is comprised of application or discipline-specific terminologies, and is usually referred to as the Reference Data Library. These terminologies are instances of the data types from part 2. Part 4 today contains around 50.000 general concepts. Standards for geometry and topology (Part 3), procedures for adding and maintaining reference data (Part 5 and 6), and methods for integrating distributed systems (Part 7) are under development.

RULES-BASED CONDITION MONITORING

There are envisioned several application areas of the above ontology. Interoperability in the highly multidisciplinary petroleum industry is the main goal, while the tasks of ontology-driven information retrieval and rule-based notification have main focus meanwhile. The rule-based approach will be mainly applied to information quality analysis (i.e. analyze anomalies in real-time data from subsea sensors) and condition monitoring of subsea production.

A scenario for the automatic production monitoring is depicted in Figure 2. A full case of condition monitoring will consist of three main steps: *Data processing*, *Health assessment* and *Treatment planning*. These three steps, including their activities, can be mapped to the corresponding machine condition assessment data processing and information flow blocks identified in ISO 13374 (2003): Data acquisition, Data manipulation, State detection, Health assessment, Prognostic assessment, Advisory generation.

Data processing is the first step including automated activities such as data acquisition and data manipulation. The latter activity includes mapping the actual measurements to data model (the ontology based on ISO 15926 and other standards regulating the petroleum domain), see a code excerpt in Figure 3b.

Figure 2. Rule-based condition monitoring

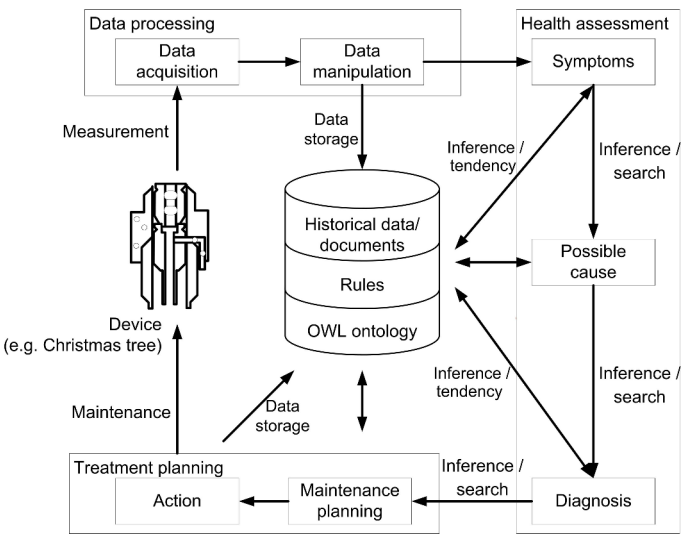
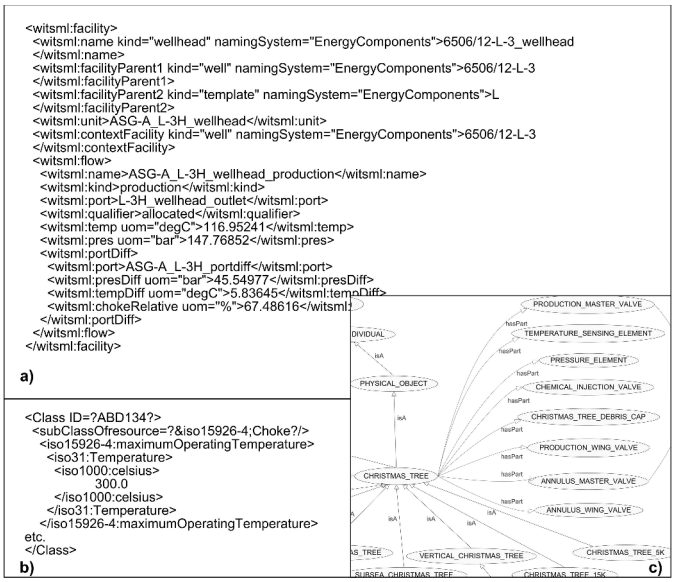


Figure 3. Exemplifications of a) daily production report in XML; b) definition of maximum operating temperature for a choke; c) ISO 15926 ontology



The *health assessment* step is heavily based on the rules and involves most of reasoning. The rules are used to identify possible symptoms, then possible causes, and finally infer a diagnosis. The activity concerning symptoms identification takes care of monitoring of states, i.e. analysis of data flow. Here an example of the rule would be: *if a choke has a temperature sensor and temperature is equal or above the maximum operating temperature then the choke is in critical state*. This rule is illustrated below using SWRL built-in predicate `swrlb:greaterThanOrEqual` (Horrocks et al., 2004), and incoming data in XML format are exemplified in Figure 3a. Then rules defining dependencies among measurement classes are used to infer possible causes and diagnosis.

```
hasTemperatureSensor(?x,?y)∧hasTemp(?y,?temp)∧hasMaximumOperatingTemp(?x,?maxtemp)∧
swrlb:greaterThanOrEqual(?temp,?maxtemp)→hasCriticalState(?x,?temp)
```

The *treatment planning* step takes care of the last two activities in the condition monitoring cycle, i.e., maintenance planning and actions that need to be taken in order to resolve the situation. This step either notifies the responsible controller who needs to perform the actions (e.g. *increase choke opening by 10%*) or executes the action automatically.

It is planned to integrate the rule-based condition monitoring and notification with ontology-driven information retrieval system (Tomassen *et al.*, 2006). As shown in Figure 2 searching for the relevant information is designed to be supplemental way of interaction with the system, since covering all possible cases by rules is a labor-intensive and not trivial task. Therefore, it is important to enable users to access previous reports and documents related to the problem on-hands. Smooth transition between these two different interaction ways is a big challenge as well.

CONCLUDING DISCUSSION AND FUTURE WORK

One problem in the project is that the full expressive power of OWL (OWL Full) is needed in order to represent the structures of ISO 15926-2/4. Reasoning with OWL specifications is then incomplete and inference becomes undecidable (Horrocks *et al*., 2003). Therefore, here we are investigating the limits of inference using the ontology implemented in OWL Full. This will allow identifying possible scenarios and restrictions in using OWL Full for a such scale project. We are exploiting the logical properties of OWL and experimenting with the rule-based notification using Protégé-OWL, OWLJessKB and Racer.

Furthermore, a certain future work will be an alignment of the method with Mimosa's open systems architecture for condition based maintenance (Mimosa, 2007). Mimosa is an alliance for machinery information management open systems with the main objective to enable open standards-based operations and maintenance interoperability.

ACKNOWLEDGMENT

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REFERENCES

Batres, R., West, M., Leal, D., Price, D. & Naka, Y. (2005). An Upper Ontology based on ISO 15926. *ESCAPE* 15.

Golbreich, C., Dameron, O., Bierlaire, O. & Gibaud, B. (2005). What reasoning support for ontology and rules? the brain anatomy case study. *Workshop on OWL Experiences and Directions*, Galway, Ireland.

Gulla, J.A., Tomassen, S.L. & Strasunskas, D. (2006). Semantic Interoperability in the Norwegian Petroleum Industry. In D. Karagiannis, H.C. Mayer (eds.), *5th International Conference on Information Systems Technology and its Applications* (ISTA 2006), Vol. P-84. Kollen Druck+Verlag GmbH, Bonn, 81-94.

Hakkarainen, S., Hella, L., Strasunskas, D. & Tuxen, S.M. (2006). A Semantic Transformation Approach for ISO 15926. *Proceedings of the ER 2006 Workshops*, Springer-Verlag, LNCS 4231, 281-290.

Horrocks, I., Patel-Schneider, P., Boley, H., Tabet, S., Grosof, B. & Dean, M. (2004). SWRL: A Semantic Web Rule Language. Combining OWL and RuleML. Retrieved January 5, 2007 from http://www.w3.org/Submission/ SWRL/

Horrocks, I., Patel-Schneider, P. & van Harmelen, F. (2003). From SHIQ and RDF to OWL: The making of a web ontology language. *Journal of Web Semantics* 1(1), 7–26.

ISO 13374. (2003). Condition monitoring and diagnostics of machines. Data processing, communication and presentation. Retrieved January 5, 2007 from http://www.iso.org/iso/en/CatalogueDetailPage.CatalogueDetail?CSNUMBER=21832

ISO 15926-2 (2003) Integration of life-cycle data for process plants including oil and gas production facilities - Part 2: Data model. Retrieved January 5, 2007 from http://www.iso.org/iso/en/CatalogueDetailPage.CatalogueDetail?CSNUMBER=29557

MIMOSA – Machinery Information Management Open Systems Alliance. (2007). Retrieved January 5, 2007 from http://www.mimosa.org/

Sandsmark, N. & Mehta, S. (2004). Integrated Information Platform for Reservoir and Subsea Production Systems. *Proceedings of the 13th Product Data Technology Europe Symposium* (PDT 2004), Stockholm.

Tomassen, S.L., Gulla, J.A., & Strasunskas, D. (2006). Document Space Adapted Ontology: Application in Query Enrichment. In C. Kop, G. Fliedl, H.C. Mayer, E. Metais (eds.), *11th International Conference on Applications of Natural Language to Information Systems* (NLDB 2006), LNCS 3999, Springer-Verlag, 46-57.

Cohesion in Distributed Teams

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ABSTRACT
In today's educational and work environments, teams often consist of members who are not co-located, and who interact through computer-mediation. Research on such distributed teams has focused on the effects of computer-mediation on decision making, performance, and performance measurement, but, with the exception of a few studies, little research has been done on the social-psychological effects of team distribution with regards to cohesion. This paper describes our current research investigating the effects of team member distribution on team cohesion.

Keywords: Computer-medicated communications; Human-computer interaction, Teams, Cohesion

INTRODUCTION
In today's educational and work environments, teams often consist of members who are not co-located, and who interact through computer-mediation. Research on such distributed teams has focused on the effects of computer-mediation on decision-making, performance, and performance measurement. With the exception of a few studies, (e.g.; Dewiyanti, Brand-Gruwel, Jochems & Broers, 2007) little research has been done on the social-psychological effects of team distribution with regards to cohesion.

This paper describes our current research investigating the effects of team member distribution on cohesion. We begin with a brief review of the literature on distributed teams, followed by a review of the cohesion-performance literature. We then briefly describe our method, and conclude with some discussion regarding further areas of research, and possible implications of our study.

DISTRIBUTED TEAMS
We know that communication technology has social system effects that result from changes in what and who people know, what people care about, and altered system interdependencies (Sproull & Kiesler, 1991). On a more specific level, we know that communications media may cause a variety of effects not found in face-to-face communications. It is, however, difficult to make sweeping generalizations about the impact of media on communications beyond those two points, as media vary in their richness and effects. One approach to discussing communications effects was suggested by Clark and Brennan (1991), who categorized different communication modes along the dimensions of sequentiality, audibility, visibility, co-presence, simultaneity, and co-temporality.

Co-temporality refers to whether a message is received at the time it is sent. Simultaneity means that interactants can send messages at the same time, and sequentiality means that interactants' messages stay in sequence. These three media characteristics regulate the flow and continuity of conversation. Without these attributes, the logical sequence of discussions becomes disjointed, and as a result, the psychological distance between communicators increases. This psychological distance brings about increased focus on the task, and a decreased emphasis on the transmission of social information (Kiesler, Siegel & McGuire, 1984; Silvester, Anderson, Haddleton, Cunningham-Snell & Gibb, 2000; Tu, 2000).

Visibility and audibility generate effects on communication through the presence or absence of non-verbal cues. These non-verbal cues also reduce psychological distance and regulate the flow of conversation (Daly-Jones, Monk & Watts, 1998; Grahe & Bernieri, 1999; O'Malley, Langton, Anderson & Doherty-Sneddon, 1996; Rockwell, 2000).

Co-presence simply means that interactants are located in the same physical setting; however, the implications of co-presence on communications are complex. One effect of co-presence is to make the dyadic partner more salient, more "real;" as a result, the primary impact of social presence is on psychological closeness. The absence of social presence results in: a) reduced other-awareness, b) more uninhibited behavior, c) less responsiveness to another's ideas, d) less public self-awareness, e) more social loafing, and e) more conflict (Anderson, Newlands, Mullin & Fleming, 1996; Chidambaram & Tung, 2005; Fletcher & Major, 2006; Hinds & Mortensen, 2005; Mortensen & Hinds, 2001; O'Malley, Langton, Anderson & Doherty-Sneddon, 1996; Sellen, 1995; Short, Williams & Christie, 1976; Wilson, Straus & McEvily, 2006).

COHESION
Cohesion is an important component of teamwork. With regards to cohesion and team performance, Mullen and Copper (1994) performed a meta-analysis and found a "small but significant effect," while Carron, Colman, Wheeler and Stevens (2002) conducted a meta-analysis of the cohesion-performance relationship in sports and found a significant moderate to large relationship.

In terms of specific studies, rather than meta-analyses, Michalisin, Karau, and Tanpong (2004) used a resource-based view of firm performance to test the idea that strategic assets, in this case top management team cohesion, would be significantly associated with superior performance, and found that cohesion was, in fact, associated with firm performance. Shamir, Brainin, Zakay, and Popper (2000) investigated the relationship between the perceived combat readiness of Israeli Defense Forces and a number of predictors, and found that the strongest predictor of perceived readiness was identification with the unit. Spink, Nickel, Wilson, and Odnokon (2005) examined male ice hockey players and found that task cohesion predicted variance in team task satisfaction. Zaccaro, Gualtieri, and Minionis (1995) focused on task cohesion as a facilitator of team decision making under stress, and found that highly cohesive teams under pressure performed better than teams low in cohesion. Similarly, Eys, Hardy, Carron and Beauchamp (2003) examined the effect of group cohesion on anxiety in sports teams, and found that cohesion was negatively correlated with anxiety.

METHOD
Two identical undergraduate classes, one on-line and one classroom–based, will be assigned a team project. At the end of the semester, students in both classes will be asked to evaluate their team's functioning and cohesion, using a modified version of a scale developed by Powers, Sims-Knight, Topciu, and Haden (2002).

Each team's final product and satisfaction with the process will be evaluated by two independent raters. Therefore, determining inter-rater reliability (IRR) is a pre-requisite before aggregating the data. Several methods exist for evaluating IRR; percentage agreement (Linn & Gronlund, 2000), the r_{wg} statistic proposed by James, Demaree, and Wolf (1993), Cohen's kappa (k) , pairwise correlation, various chi-square tests, and Kendall's coefficient of concordance (Tinsley & Weiss, 1975). Unfortunately, there is no obvious choice of an index of agreement. Dunlap, Burke, and Smith-Crowe (2003) suggest that IRR should assess that a reasonable consensus exists to aggregate individual level data to the group level, and that it should allow the conclusion that the apparent agreement for the group is significantly different from chance responding. Burke, Finkelstein, and Dusig (1999) proposed the average deviation (AD) index, which is the method chosen in this study.

Only those groups with AD on satisfaction scores that indicate acceptable levels of agreement will be used in further analysis. For the ratings of product quality, AD will be used as the metric to determine whether further rater training is required to reach acceptable levels of inter-rater agreement.

For all satisfaction measures, t-tests will be used to compare means between the two groups. In addition, we plan to stratify respondents by project quality, and examine differences in responses by strata.

CONCLUSION

In today's educational and work environments, virtual teams are becoming more common. Although the specific effects vary by the type of media used, commonalities are: increased psychological distance between communicators, increased focus on the task and a decreased emphasis on the transmission of social information; less responsiveness to another's ideas; more social loafing, and more conflict.

Improving cohesion in virtual teams may be a solution to some of these problems, as research indicates there is a significant relationship between cohesion and performance; cohesion and task satisfaction; cohesion and stress, and cohesion and perceived social loafing. One of the few studies that examined group cohesion in distance learning found that cohesion influenced students' satisfaction (Dewiyanti, Brand-Gruwel, Jochems & Broers, 2007). While not directly examining cohesion, Hinds and Mortensen (2005) investigated the relationship between distributed teams and conflict, and found that shared identity – an aspect of cohesion - moderated the effect of distribution on conflict.

REFERENCES

Anderson, A., Newlands, A., Mullin, J., & Fleming, A. (1996). Impact of video-mediated communication on simulated service encounters. *Interacting with Computers, 8*, 193-206.

Burke, M. J., Finkelstein, L. M., & Dusig, M. S. (1999). On average deviation indices for estimating interrater agreement. *Organizational Research Methods, 2*, 49-68.

Carron, A. V., Colman, M. M., Wheeler, J., & Stevens, D. (2002). Cohesion and performance in sport: A meta-analysis. *Journal of Sport and Exercise Psychology, 24,* 168-188.

Chidambaram, L., & Tung L. (2005). Is out of sight, out of mind? An empirical study of social loafing in technology-supported groups. *Information Systems Research. 16*(2), 149-168.

Daly-Jones, O., Monk, A., & Watts, L. (1998). Some advantages of video conferencing over high-quality audio conferencing: Fluency and awareness of attentional focus. *International Journal of Human-Computer Studies, 49*, 21-58.

Dewiyanti, S., Brand-Gruwel, S., Jochems, W., & Broers, N. (2007) Is out of sight, out of mind? An empirical study of social loafing students' experiences with collaborative learning in asynchronous computer-supported collaborative learning environments. *Computers in Human Behavior, 23*(1), 496-514.

Dunlap, W. P., Burke, M. J., & Smith-Crowe, K. (2003). Accurate tests of statistical significance for r_{wg} and average deviation inter-rater agreement indexes. *Journal of Applied Psychology, 88*, 356-362.

Eys, M., Hardy, J., Carron, A. Beauchamp, M. (2003). **The relationship between task cohesion and competitive state anxiety**. *Journal of Sport and Exercise Psychology*, *25*, 66.

Fletcher, T., & Major, D. (2006). The effects of communication modality on performance and self-ratings of teamwork components. *Journal of Computer Mediated Communication, 11(2)*, 557-576.

Grahe, J. & Bernieri, G. (1999). The importance of nonverbal cues in judging rapport. *Journal of Nonverbal Behavior, 23*, 253-269.

Hinds, P., & Mortensen, M. (2005). Understanding conflict in geographically distributed teams: The moderating effects of shared identity, shared context, and spontaneous communication. *Organization Science, 16(3),* 290-307.

James, L.R., Demaree, R.G., & Wolf, G. (1993). r_{wg}: An assessment of within-group inter-rater agreement. *Journal of Applied Psychology, 7*, 306-309.

Kiesler, A., Siegal, J., & McGuire, T. W. (1984). Social psychological aspects of computer-mediated communication. *American Psychologist, 39*, 1123-1134.

Linn, R. L., & Gronlund, N. E. (2000). *Measurement and assessment in teaching, (8th ed.).* Upper Saddle River, NJ: Prentice Hall.

Michalisin, M. D., Karau, S. J., & Tanpong, C. (2004). Top management team cohesion and superior industry returns: An empirical study of the resource-based view. *Group & Organization Management, 29*, 125-140.

Mortensen, M., & Hinds, P. (2001). Conflict and shared identity in geographically distributed teams. *International Journal of Conflict Management. 12*(3), 212-238.

Mullen, B., & Copper, C. (1994). The relation between group cohesiveness and performance: An integration. *Psychological Bulletin, 11*(5), 210-227.

O'Malley, C., Langton, S., Anderson, A., & Doherty-Sneddon, G. (1996). Comparison of face-to-face and video-mediated interaction. *Interacting with Computers*, *8*, 177-192.

Powers, T., Sims-Knight, J., Topciu, R., & Haden, S. (2002). Assessing team functioning in engineering education, *Proceedings of the 2002 American Society for Engineering Education Annual Conference & Exposition*.

Rockwell, P. (2000). Lower, slower, louder: Vocal cues of sarcasm. *Journal of Psycholinguistic Research, 29*, 483-495.

Sellen, A. (1995). Remote conversations: The effects of mediating talk with technology. *Human Computer Interaction*, *10,* 401-444.

Short, J., Williams, E., & Christie, B. (1976). *The social psychology of* telecommunications. New York: Wiley.

Shamir, B., Zakay, E., Breinin, E., & Popper, M. (2000). Leadership and social identification in military units: Direct and indirect effects. *Journal of Applied Social Psychology, 30*: 612-640.

Silvester, J., Anderson, N., Haddleton, E., Cunningham-Snell, N., & Gibb, A. (2000). A cross-modal comparison of telephone and face-to-face selection interviews in graduate recruitment. *International Journal of Selection and Assessment, 8*, 16-21.

Spink, K., Nickel, D., Wilson, K., Odnokon, P. (2005). **Using a multilevel approach to examine the relationship between task cohesion and team task satisfaction in elite ice hockey players.** *Small Group Research, 36,* **539-554.**

Sproull, L., & Kiesler, S. (1991). *Connections: New Ways Of Working In The Networked Organization.* Cambridge, Mass.: MIT Press.

Tinsley, H. E. A., & Weiss, D. J. (1975). Inter-rater reliability and agreement of subjective judgments. *Journal of Counseling Psychology, 27*, 358-376.

Tu, C. (2000). Critical examination of factors affecting interaction on CMC. *Journal of Network and Computer Applications, 23,* 39–58.

Wilson, J., Straus, S., & McEvily, B. (2006). All in due time: The development of trust in computer-mediated and face-to-face teams. *Organizational Behavior and Human Decision Processes. 99*(1), 16-33.

Institutions (Also) Matter in E-Government: The Case of Bolivia

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INTRODUCTION

For the past five years, several e-government global, regional, and local benchmarks have been carried out. Although not all of them have included Bolivia in their analysis, the ones that have coincide in their perceptions about the implementation of e-government in this country. Generally speaking, Bolivia usually ranks below both the Latin America and the world average. In *Benchmarking e-government*, Ronaghan (2002) classified the country as one with e-government medium capacity and interactive presence. Despite the fact that Bolivia performed better than most countries in Central America, East Asia, and Africa, it was still far from the most developed nations such as the United Nations, New Zealand or the United Kingdom as well as from some Latin American countries being the most remarkable the cases of Brazil, Mexico, Argentina, Chile, and Uruguay.

The *United Nations World Public Sector Report 2003*, on the other hand, also placed Bolivia in a worse position than other South and Central American countries. Its e-government readiness index score of 0.411 was lower than the regional average (0.442) and, in fact, it was closer to the South and Eastern Asia average (0.410).

Finally, in the *United Nations E-Government Readiness Report 2004*, of the twenty Latin American countries surveyed, only eight countries ranked below not only the regional average but also the world average. Again, that was the case of Bolivia whose score also dropped from 0.411 (position 78th) to 0.3863 (position 88th). Although this loss was not as dramatic as that of Paraguay, comparatively speaking, Bolivia's e-government performance was one of the worst in relation to the set of countries considered. This fact has to be seriously considered particularly because the region as a whole improved, as did the world globally speaking.

Although, as previously showed, Bolivia has tended to lose out in the set of world comparative rankings, during the last years, the country has designed and implemented several projects aimed at introducing the new information and communication technologies in the public sector. Therefore, it can be stated that the poor results displayed are not due to government inactivity. Instead, there are other variables that play an essential role in Bolivian e-government success or failure.

Several authors have already reported that a limited human and technological infrastructure has a decisive impact on how a country performs in terms of e-government. Bolivia is not an exception. But this cause-effect view can turn out to be too narrow. This unfinished research is aimed at making evident the existence of other more structural factors that also influence e-government accomplishment. So far, the literature review and the interviews conducted have focused on some of the more outstanding e-government projects that have been carried out in Bolivia. This has proved that, despite the results shown in the reports previously cited, Bolivia is striving to move towards the inclusion of ICTs in the public sphere. In the current stage, and a as a consequence of the perceived poor performance already stated, other (institutional) factors are being explored, besides ICTs penetration level and illiteracy, that are believed to have to be considered to understand why the country is not being successful in its efforts.

THE STATE OF E-GOVERNMENT INITIATIVES IN BOLIVIA

Bolivia has since 2005 a national strategy for the development of the information society (http://www.etic.bo/Default/default.htm) although the country has not developed an e-government strategic plan yet. Nevertheless, since 2002, when the supreme decree number 26.553 established ADSIB, the Agencia para el Desarrollo de la Sociedad de la Información en Bolivia (the Agency for the Development of the Information Society in Bolivia), the country has implemented several projects in order to make digital government a reality.

To start with, back in 2002, the government presented a document called *Lineamientos para la Estrategia de Bolivia en la Era Digital* ("Ideas for a Bolivian Strategy in the Digital Era") that gave the Vice-presidency of the Republic the responsibility to launch the program Bolivia en Línea (Bolivia Online) aimed at integrating all the public sector portals, at helping public agencies to design new web pages, at standardizing Bolivian web pages, and at strengthening local government computing systems (Ministry of Sustainable Development and Planning, 2002). Despite this effort, the document was too broad and the initiatives depicted were not concise. As a result, several e-government projects, related to both back office and front office adjustments, started to take place on a heterogeneous basis and without the required coordination.

Most of those projects pursued the integration and improvement of internal information systems. That was the case of the automation of the management and register system developed to enhance the implementation of the financial decentralization program ILACO II, or of SIGMA, the Sistema Integrado de Gestión y Modernización Administrativa (Integrated System of Management and Administrative Modernization), a project implemented by the Ministry of Finance aimed at automating the public budget management, the public provision of goods, and the human resources management.

Several front office initiatives have also been carried out in Bolivia. In this sense, it is important to note that there are more than 70 governmental web pages. Despite the growing number of web pages related to the Bolivian government, most of them (the Ministry of Sustainable Development and Planning, back in 2002, referred to the 85%) are merely informative pages that have been designed as simply broadcasting vehicles. Even the Guía Nacional de Trámites (National Requirements Guide), available at http://www.tramites.gov.bo/, is only a tool that provides information about how to proceed with certain formalities, which steps to take every second, and which institutions to consult if problems arise. In a country like Bolivia, geographically handicapped, where its citizens are still forced to travel for hours to access the governmental information, the possibility of retrieving it by the means of the Internet or other electronic devices is an important step forward.

Finally, despite the fact that many websites are open to the citizens' opinions and views, the e-democracy field is probably the less developed. This might be due to the socio-economic situation of the country, which leads to low levels of connectivity and, therefore, hinders the promotion of the democratic process by the means of online tools. Also, the current consolidation process of the Bolivian institutions shows that the priority is to achieve more social participation using those mechanisms that are closer and more familiar to the population.

THE E-GOVERNMENT DIVIDE IN BOLIVIA

Despite the described efforts, the yearly rankings on e-government do not show any important progress for Bolivia (see Table 1).

As a result, the existence of a so-called electronic government divide can be confirmed. In this sense, it can be stated that the country experiences both a regional e-government divide (or the digital gap that refers to e-government actions among countries that belong to Latin America) and a domestic e-government divide (which explains the difference between the advanced online public administrations and the more backward ones in the framework of Bolivia) regardless of the digital government initiatives that have been implemented throughout the years (Gascó, 2005).

Table 1. E-government readiness index

Year	Position in ranking	Index
2003	78	0.411
2004	88	0.3863
2005	85	0.4017

WHAT EXPLAINS THE POOR RESULTS?

Two variables are usually considered when studying what gives rise to differences in public sector technological projects. In the first place, e-government actions are useless if connectivity remains an unresolved issue because, when that is the case, only a very small percentage of people can have real access to the initiatives. Also, as Gascó (2005) explains, if the adoption of technology is slow and poor, governments experience their own technical and managerial difficulties. The availability of resources (that can be measured by the means of the human development index since it is strongly influenced by a country's economic and social composition) is the second factor that influences how decision makers, policy planners and public sector managers elect to approach, develop, and implement e-government programs (Ronaghan, 2002).

Bolivia's ICT diffusion rankings are shown below (to be able to make comparisons, it is important to note that the USA ranked second in 2004):

Also, the human development index in 2005 was of 0.687, which is lower than that of the USA (0.944), Italy (0.934), Chile (0.854), Costa Rica (0.838) or even China (0.755).

In spite of what has already been said, the researcher of this project believes that there is a third factor that explains the poor e-government results of Bolivia. According to this, the evolution of the use of ICTs by the public sector is parallel to the transformations that have taken place in the public administration as a result of the state reform processes. As a consequence, the role (and therefore the importance) of technology is different in each stage of the public sector modernization process. Also, it is the result of how that reform process is conceived and is taking place (see Table 3).

According to the preliminary findings of this research, Bolivia's public administrations are in the initial stage. These bureaucratic organizations are very resilient to change. What's more, in the case of Bolivia, one can state that the reform has hardly taken place due to the existence of odd, pre bureaucratic structures that has given rise to patronage practices patterns that are extremely difficult to eradicate. As the World Bank noticed back in 2000, "a weak private sector practically incapable of generating employment for the middle class, politicians' interest in obtaining electoral support from and control of the government bureaucracy, and a fragmented party system which forces political organizations to negotiate coalition agreements, are cited as sources of patronage and clientelism".

REFERENCES

Gascó, M. (2005). "Exploring the e-government gap in South America". *International Journal of Public Administration*, *28*(7&8), 683-701.

Ronaghan, S. (2002). *Benchmarking e-government. A global perspective*. New York: United Nations Division for Public Economics and Public Administration and American Society for Public Administration.

United Nations (2005). *Global e-government readiness report 2005. Froom e-government to e-inclusion*. New York: United Nations Department of Economic and Social Affairs and United Nations Division for Public Administration and Development Management.

United Nations (2004). *Global e-government readiness report 2004. Towards access for opportunity*. New York: United Nations Department of Economic and Social Affairs and United Nations Division for Public Administration and Development Management.

United Nations. (2003). *World Public Sector Report 2003: E-government at the crossroads*. New York: United Nations.

World Bank (2000). *Bolivia. From patronage to a professional state. Bolivia Institutional and Governance Review*. Washington D. C.: Poverty Reduction and Economic Management - Latin American and the Caribbean Region – World Bank.

Table 2. ICT diffusion rankings 1997-2004

1997	1998	1999	2000	2001	2002	2003	2004
123	123	124	125	120	120	119	122

Table 3. The evolutionary element

Type of organization	Modernization stage	ICTs role
Bureaucratic	Initial. The goal is to improve efficacy and efficiency	In the automation of work flows and internal processes reorganization
Professional	Advanced. The public management model has already been adopted (emphasis on efficiency but, also, on meeting the citizens' demands and expectations)	Without forgetting the previous achievements, ICTs make the interaction between the public administration and the citizens easier by the means of portals and web pages
Relational	Consolidating and institutionalizing the process. The governance paradigm has been adopted (the citizen is not only a customer but an important participant of the governability processes)	Key regarding transparency and accountability

Misplacing the Code: An Examination of Data Quality Issues in Bayesian Text Classification for Automated Coding of Medical Diagnoses

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ABSTRACT

In this article we discuss the effect of dirty data on text mining for automated coding of medical diagnoses. Using two Bayesian machine learning algorithms (naive Bayes and shrinkage) we build ICD9-CM classification models trained from free-text diagnoses. We investigate the effect of training the classifiers using both clean and (simulated) dirty data. The research focuses on the impact that erroneous labeling of training data sets has on the classifiers' predictive accuracy.

Keywords: Text classification, Bayesian machine learning, health care coding, ICD9-CM

INTRODUCTION

Most of the data in health care settings are recorded as free text in narrative form, and are therefore prone to typographical errors and misinterpretations of ambiguous terms and phrases. To try to solve this issue, researchers and practitioners have recurred to the manual coding of information contained in clinical documents, using different coding schemes. One of the most widely used coding systems is the International Classification of Diseases (ICD), published by the World Health Organization, and in particular the Clinical Modification of its 9th edition, known as ICD-9-CM. ICD-9-CM has a hierarchical structure through which diagnose codes may be aggregated into blocks of decreasing level of detail.

The problem with ICD-9-CM is that manual coding is a costly, non-trivial task, requiring well-trained human resources. ICD-9-CM is not a mere list of codes: it is a complex ruled-based system devised to assign codes to free text based diagnoses and medical procedures. The extant literature is replete with examples depicting the relationship between coding errors and the level of expertise of health care coders. The vast amount of data generated by health care production environments imposes a restriction on the feasibility of coding all the information in a cost-efficient and timely manner. For these reasons several authors have explored the possibility of automating the coding process. Different techniques have been considered to fulfill this task, including rule-based approaches that rely on grammar-based rules (Friedman et al, 2004), and statistical text classifiers based on machine learning algorithms (March et al, 2004)

When dealing with statistical classification for automated coding, the quality of the input data used for training purposes becomes an item of concern. The effective use of statistical machine learning algorithms requires that the input data attain a certain degree of quality. There is a tradeoff between the cost of guaranteeing input data quality and the cost of misclassification given by inadequate predictive accuracy of the models developed with the input data at hand.

Two types of input data errors can be analyzed: (a) free text diagnoses containing misspellings or semantic ambiguities; (b) erroneous assignation of ICD-9-CM codes. In previous work we have focused on text errors in diagnoses (Lauría & March, 2006), disregarding potential erroneous coding. In this paper we center on coding errors: we address the issue of building text classification models based on statistical machine learning algorithms using training data in which the quality of ICD9-CM codes is questionable. Our research deals with Bayesian classifiers, specifically naive Bayes and shrinkage-based naive Bayes (McCallum et al, 1998).

ICD9-CM codes are assigned by human experts who manually review cases. There are multiple factors that can give way to errors of judgment, including the amount of time dedicated to review each case, the resources at hand, the training and expertise of the coders and the complexity of the coding process. The training data set could therefore contain clean free text diagnoses but "dirty" codes.

BAYESIAN TEXT CLASSIFIERS

Text classification can be seen as the task of estimating the unknown target function $\mathsf{f} : \mathsf{D} \rightarrow \mathsf{C}$ that assigns each document $d_j \in \mathsf{D}$ to a given category value $c_i \in \mathsf{C}$, where C is a predefined set of categories, and D is a domain of free text documents. Through supervised learning from a set of documents $D \subseteq \mathsf{D}$, a model $\hat{\mathsf{f}} : \mathsf{D} \rightarrow \mathsf{C}$ can be built to approximate the target function f. Text classification is a well studied problem, with numerous machine learning techniques that have been proposed in the literature, including probabilistic (Bayesian) methods, regression methods, decision trees, neural networks, support vector machines, maximum entropy algorithms, and classifier committees.

Naive Bayes learners have proven to be quite successful when applied to text classification, as reported by Joachims (1997). In the naive Bayes learning framework, a document *d* is classified by computing the posterior probability of each class $\mathrm{P}(c_i \mid d) \propto \mathrm{P}(d \mid c_i) \cdot \mathrm{P}(c_i)$, and assigning the most probable class given the document's words. Naive Bayes makes the simplifying assumptions that a) the probability of each word in a document is independent of its surrounding words given the class; b) the probability of each word in a document is independent of its position in the document. The naive Bayes classification criterion results in:

$$c_{NB} = \arg\max_{c_i \in \mathsf{C}} P(c_i \mid d) = \arg\max_{c_i \in \mathsf{C}} P(c_i) \prod_{k=1}^{|d|} P(w_{d_k} \mid c_i) \qquad (1)$$

where w_{d_k} identifies the word in position *k* of document *d*. The subscript d_k indicates an index into the vocabulary V of training data set *D*. Priors $P(c_i)$ are calculated by computing frequency counts on training data set *D*. Each conditional probability $P(w_{d_k} \mid c_i)$ is calculated as:

$$P(w_{d_k} \mid c_i) = \frac{N_{ik} + 1(\ )}{\sum_k N_{ik} + |\mathcal{V}|} \qquad (2)$$

We define N_{ik} to be the count of the number of times that word w_{d_k} is present in the concatenation of all sample documents that belong to category c_i. Note that the relative frequencies are supplemented by standard Laplace smoothing to

avoid probability estimates equal to zero. For a detailed analysis of naive Bayes text classification see Mitchell (1997).

HIERARCHICAL NAIVE BAYES CLASSIFICATION

For text classification problems with a large number of categories, the training data for each category are sparse, rendering less reliable conditional probability estimates, which in turn affect the performance of naïve Bayes learners as effective classifiers. But if the set of categories has a hierarchical structure, as in the case of ICD9-CM, the accuracy of a naïve Bayes classifier can be significantly improved by taking advantage of the class hierarchy. McCallum et al (1998) have used a well known statistical technique, known as *shrinkage*, that smoothes the conditional probability estimates of data-sparse leaf nodes in the class hierarchy with those of their ancestors. Intuitively, it is easy to see that the probability estimates at the leaf level are more specific but less reliable since they are calculated using less training data. The probability estimates at higher levels are calculated using more data, and are therefore more reliable; but are less specific than their corresponding children levels. For each node (class value) in a class hierarchy of *r* levels, the algorithm computes maximum likelihood (ML) estimates

$$\hat{p}_{ik}^{(h)} = N_{ik}^{(h)} / \sum_{k} N_{ik}^{(h)}, \quad h = 1 \ldots r$$

(as in equation 1, but without Laplace regularization), using all documents in the training data set labeled with that class value. Each node's training data records are filtered to eliminate its child's data before computing the ML estimate, in order to ensure that the probability estimates along a given path remain independent. A uniform probability estimate $\hat{p}_{ik}^{(0)} = 1/|\mathcal{V}|$ is added beyond the root level to deal with unreliable (e.g. zero frequency) estimates caused by rare words. An improved estimate of each leaf node $\hat{p}_{ik}$ is then calculated by "shrinking" (i.e. interpolating) its ML estimate towards the ML estimates of its *(r+1)* ancestors in the tree path

$$\hat{p}_{ik} = \lambda_i^{(0)} \cdot \hat{p}_{ik}^{(0)} + \lambda_i^{(1)} \cdot \hat{p}_{ik}^{(1)} + \ldots + \lambda_i^{(r)} \cdot \hat{p}_{ik}^{(r)} \qquad (3)$$

where $\lambda_i^{(0)}, \lambda_i^{(1)}, \ldots, \lambda_i^{(r)}$ (interpolation weights among the ancestors of class c_i) add to 1.

McCallum et al use an iterative approach (resembling Dempster's EM algorithm) to calculate optimal values of the interpolation weights. For details of the algorithm see McCallum et al (1998).

EXPERIMENTAL SETUP

Training data were gathered and cleaned from 11776 free-text outcome diagnoses occurring in 7380 hospitalizations, which were previously coded by domain experts using the 1999 Spanish Edition of ICD-9-CM. Codes were aggregated at level 3 and level 4 of the hierarchy, corresponding to the Section and 3-digit code levels of ICD-9-CM. Level 3 contained a total of 408 leaf codes, of which 2687 were part of the data set; level 4 included 2687 leaf codes, of which 651 were used. We assessed the representativeness of the test data set to the training data, both in terms of vocabulary and ICD9-CM codes (class labels).

The experiments followed these guidelines:

i. Generate multiple dirty data sets with incremental perturbations of the set of training cases (5%, 10%, 15%,20%,25% 30%,35% 40%, 45%, 50%, 55%, 60%, 65% and 70% of the cases)
ii. For each of these data sets, randomly select 10% of the sample (1178 documents) to be used as hold-out data sets for testing purposes. Use the remaining 90% (10598 documents to train the text classifiers (Note: a test sample of 10% was selected to maximize the amount of training data)
iii. To simulate an error of judgment in the assignation of ICD codes, replace a correct code with another one picked from the ICD-9-CM catalog. The replacement code is selected using combined criteria that include the numeric proximity to the correct code, the semantic similarity of the corresponding diagnoses and the frequency of occurrence of the replacement code in the training sample.
iv. Train the statistical text classifiers using both clean and dirty data. Classifiers are built for every combination of machine learning algorithm (naive Bayes and shrinkage), class hierarchy (level 3 and level 4) and training data set (1 clean , 14 dirty), 2 x 2 x 15 = 60 models all in all
v. Evaluate the classifiers' performance by measuring their predictive accuracy (mean value, standard error, 95% confidence interval)

RESULTS

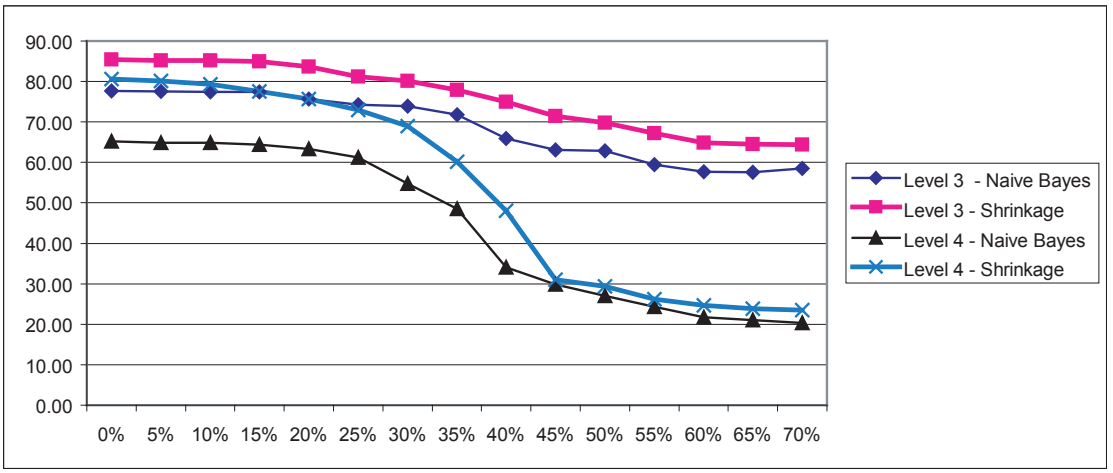
Table 1 shows the assessment of predictive accuracy performance of both text classifiers. Figure 1 displays the mean accuracy of the classifiers as a function of the percentage of label errors. The shrinkage algorithm

Table 1. Predictive accuracy of Bayesian text classifiers

	Level 3 hierarchy								Level 4 hierarchy							
	Naive Bayes				Shrinkage				Naive Bayes				Shrinkage			
%errors in data	Mean	SE	Lo (*)	Hi (*)	Mean	SE	Lo (*)	Hi (*)	Mean	SE	Lo (*)	Hi (*)	Mean	SE	Lo (*)	Hi (*)
0%	77.67	1.21	75.20	79.96	85.40	1.03	83.27	87.30	65.20	1.39	62.43	67.87	80.65	1.15	78.30	82.80
5%	77.50	1.22	75.03	79.79	85.23	1.03	83.09	87.14	64.86	1.39	62.09	67.53	80.14	1.16	77.77	82.32
10%	77.41	1.22	74.94	79.71	85.14	1.04	82.99	87.06	64.80	1.39	62.03	67.48	79.29	1.18	76.88	81.51
15%	77.39	1.22	74.91	79.69	84.97	1.04	82.82	86.90	64.35	1.40	61.57	67.03	77.59	1.21	75.12	79.88
20%	75.64	1.25	73.11	78.01	83.62	1.08	81.40	85.62	63.33	1.40	60.54	66.03	75.72	1.25	73.19	78.08
25%	74.20	1.27	71.63	76.62	81.15	1.14	78.82	83.28	61.21	1.42	58.40	63.95	72.92	1.29	70.31	75.38
30%	73.85	1.28	71.27	76.28	80.14	1.16	77.77	82.32	54.75	1.45	51.90	57.57	68.93	1.35	66.23	71.51
35%	71.82	1.31	69.18	74.31	77.84	1.21	75.38	80.12	48.47	1.46	45.63	51.32	60.19	1.43	57.37	62.95
40%	65.96	1.38	63.21	68.61	74.96	1.26	72.41	77.35	34.13	1.38	31.48	36.89	48.05	1.46	45.21	50.90
45%	63.07	1.41	60.28	65.78	71.48	1.32	68.84	73.99	29.80	1.33	27.26	32.47	30.98	1.35	28.40	33.68
50%	62.90	1.41	60.10	65.61	69.78	1.34	67.10	72.33	27.08	1.29	24.62	29.69	29.37	1.33	26.84	32.03
55%	59.50	1.43	56.67	62.27	67.20	1.37	64.47	69.82	24.33	1.25	21.97	26.86	26.20	1.28	23.77	28.79
60%	57.64	1.44	54.80	60.43	64.86	1.39	62.09	67.53	21.73	1.20	19.47	24.17	24.70	1.26	22.32	27.24
65%	57.55	1.44	54.71	60.34	64.50	1.39	61.72	67.18	21.02	1.19	18.79	23.44	23.90	1.24	21.55	26.42
70%	58.57	1.44	55.73	61.35	64.35	1.40	61.57	67.03	20.37	1.17	18.17	22.76	23.51	1.24	21.18	26.02

(*) confidence: 95%, test sample size: 1178 (10%)

Figure 1. Predictive accuracy as a function of % of errors in training data



surpasses naive Bayes in all cases (all combinations of level 3 / level 4 hierarchies and clean and dirty training data). Both text classifiers s are quite robust when subjected to training data with incremental perturbations in the labels. In particular, shrinkage evidences a rather high level of predictive accuracy with 25% of label errors (81% for level 3 and 73% for level 4). Beyond 30% the algorithm experiences an abrupt decline in performance.

CONCLUSION

Bayesian text classifiers are robust, useful tools for automated ICD9-CM coding. Preliminary results show that Bayesian text classifiers (shrinkage in particular) perform at an acceptable level, even with training data containing partially dirty labels (ICD9-CM codes). This may have a direct impact on the cost incurred in producing training data sets: predictive accuracy ca be maximized with minimum data quality enhancement cost. This kind of research could help derive policy associated with data quality procedures that precede automated coding. Investing in text classification tools should help enhance automated ICD9-CM coding while maintaining low operational costs.

REFERENCES

1. Friedman C, Shagina L, Lussier Y, et al (2004), Automated encoding of clinical documents based on natural language processing. J Am Med Inform Assoc 11(5):392-402
2. Lauría, E., March, A., "Effect of Dirty Data on Free Text Discharge Diagnoses used for Automated ICD-9-CM Coding", Proceedings of AMCIS 2006, the 12th Americas Conference on Information Systems, Acapulco, Mexico, August 4-6, 2006
3. March A, Lauría E., Lantos J. (2004),"Automated ICD9-CM coding employing Bayesian machine learning: a preliminary exploration", Proceedings of SIS2004 (Informatics & Health Symposium, SADIO), 33rd International Conference on Computer Science & Operational Research (JAIIO), Buenos Aires, Argentina
4. McCallum A, Rosenfeld R, Mitchell T, Ng AY (1998), Improving Text Classification by Shrinkage in a Hierarchy of Classes. In: Proceedings of the Fifteenth International Conference on Machine Learning. Morgan Kaufmann, San Francisco, pp 359-367.
5. Mitchell T (1997), *Machine Learning*, McGraw-Hill
6. Thorsten Joachims. A probabilistic analysis of the Rocchio algorithm with TFIDF for text categorization. In *Proceedings of the 1997 International Conference on Machine Learning (ICML '97)*, 1997.

Foreseeing Emerging Technologies: Towards a Scoresheet-Based Methodology

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"The future will surprise us, but we must not let it dumbfound us"

- Kenneth Ewart Boulding (1910-1993), Economist and Futurist

INTRODUCTION

There is scarcely any doubt that technological innovation has been an area of remarkable progress in recent decades. The cumulative effect of the thousands of innovations that have come to market has been to make technology central to human existence, be it in business, education, government or in everyday life. However, humankind's track record in *foreseeing* technology innovation - in terms of its rate, direction or impact – has been somewhat less than stellar. Early examples of foresight failures include Thomas J Watson, then IBM Chairman, opining that the world would need no more than 5 computers, and Lord Kelvin's celebrated 1895 dismissal of the possibility of powered flight. In the early 1970s, *Scientific American* wrote that the electronic watch was unlikely to become cheap enough to sell in large quantities - yet, by 1976, quartz watches were selling cheaply in large quantities.

More recent technology predictions that were off the mark – often egregiously - include 3G (third-generation telecommunications technology), the dot.com bubble, Iridium and AT&T's huge underestimate in 1984 for the cell phone market that led it to ignore that market. The ability to foresee the potential of emerging technologies is a big prize indeed – companies can boost the ROI on R&D expenditure manifold, they can predict much better which new products of theirs or their competitors' will succeed – yet this problem has received remarkably little focus.

What are the reasons behind this rather underwhelming track record in foresight? The successful emergence of a technology of importance to business is a function not just of innate superiority but of initial conditions, the scale of investment, the clout of entities backing that technology, and the actions of consumers, competitors and collaborators. Prediction needs the understanding of complex interactions between phenomena which straddle multiple disciplinary boundaries – technology, economics, sociology, organizational behavior, psychology, anthropology, culture, and so forth. Kochikar (2006) and Kochikar and Ravindra (2006) point out a few flaws in our view of technological evolution that further confound our ability to predict new technologies, and suggest some remedies. It has been our endeavor to devise a methodology that corporate managers can use to foresee the potential of emerging technologies, and we present here some early results of such a methodology that is under development.

PREVIOUS WORK

The import of factors other than sheer technological superiority that play a role in a technology gaining widespread business use has been recognized (Griliches 1957, Bresnahan and Pai-Ling 2005). Shapiro and Varian (1998) have identified various factors that determine technology success, including network effects, standards, pricing strategies, and so forth.

Yet, the literature is sparse when it comes to methodologies. In their seminal article, Brody and Stabler (1991) note that faulty predictive ability often implies an improper allocation of resources to R&D within corporations, and there is a need to improve prediction accuracy in order to boost the returns on R&D efforts. As SRI (2006) notes, "the management literature is short on practical solutions for methodically gleaning early signals of change from the surroundings or for cultivating a futures orientation in employees and managers."

Adner and Levinthal (2002) draw parallels with biological evolution (speciation) and provide insights that managers can use in understanding technological evolution. However, they provide no methodology for predicting or foreseeing emerging technologies.

Christensen et al (2004) have presented an exhaustive theoretical framework that can be used to systematically scan the future landscape and spot complex, usually business model-related, changes. However their methodology needs an understanding of 3 theoretical approaches that form the bedrock of their approach: the theory of disruptive innovations, the theory of resources, processes and values (RPV), and the value chain evolution theory (VCE).

SRI (2006)'s SCAN methodology is a promising step in the right direction; it envisages an approach that is strongly driven by intuition and interaction between groups of individuals who collectively have expertise in a set of disciplines including anthropology, business, economics, international affairs, communication, arts, marketing, life sciences, and chemical and electrical engineering. This methodology is suitable for answering open-ended questions such as, what technologies are emerging on the horizon?

We propose a methodology that is simple to use, and at the same time produces reliable results. The methodology is aimed specifically at answering the question, "what are the prospects for emerging technology X in my company (industry)?", where X represents a specific, identified emerging technology. Typically, technologies considered would be those that have shown promise in early applications, that have some backing entities who have invested in them, that have generated some buzz among the *cognoscenti* as well as the lay public, and that are poised on the cusp of widespread adoption.

A METHODOLOGY FOR FORESEEING THE POTENTIAL OF EMERGING TECHNOLOGIES

The methodology takes explicit cognizance of the multi-disciplinary nature of the technology foresight problem, and employs a scoresheet-based approach for arriving at a measure for the potential of a given technology. The methodology holds considerable promise for bridging the current yawning gap in the state of art in this important space – that of technology foresight.

Although, given the immense complexity of the problem, it is probably impossible to design a methodology that is based on purely objective inputs, our approach is a significant step in that direction. Apart from relying on easily available data, it is designed to need 2-3 people at the most to apply it in the context of a given technology and industry. The method is also, as outlined in the previous section, relatively closed-ended and focused. It can thus be used in conjunction with more open-ended approaches.

Our methodology is also designed to produce results that reflect the specific needs of the user and his/her industry, as a given technology may hold different potential for different environments. Finally, the methodology is quick to use and involves minimal effort.

Any approach that offers a modicum of hope for solving the thorny problem of foreseeing the potential of an emerging technology must take into consideration the complex canvas of factors and phenomena that impact success. Our methodology thus encompasses a multitude of factors: supply side or "push" factors, demand side or "pull" factors, as well as characteristics of the business and cultural environment within which the technology seeks to emerge as successful.

We consider the following classes of factors:

Market Action – measures of investment, market forecasts from analysts…, existing implementations if any.
Technology Features – measures of feature richness, pricing, and quality attributes of the technology concerned.
Consumer Psychology – measures of "soft" appeal
Applications – existence of applications by which the consumer or target audience can leverage the technology concerned.
Environmental Factors – competing and complementary technologies, standards, characteristics of the ecosystem,

Each such class is modeled as a 'dimension'. The methodology identifies 17 measures of market action, 30 technology features, 14 measures of consumer psychology, 5 measures of application characteristics, and 9 environmental factors.

Each factor is assigned a score on a scale of 1 to 5 and the score is entered into a scoresheet designed for the purpose. Importantly, not all the factors need to be scored – the users may choose to score as many as they feel sufficiently comfortable / knowledgeable scoring. In examples given, 18-25 factors were scored.

An important characteristic of the methodology, and one that vastly enhances its utility, is that the output is displayed graphically, as a radar plot (also called Spider Chart or Kiviat Diagram). Among other things, the spider chart allows the user to see readily and graphically the dimensions where the methodology has high potential / falls short.

We now present the use of the methodology for gauging a few emerging technologies.

Sample Emerging Technology: Utility Computing
The output produced is as in figure 1. As can be seen, consumer psychology is something of a concern, as organizations may not be overly keen on allowing applications, which often encode proprietary business logic and use sensitive data, to reside outside their enterprise boundaries. Thus, this technology may be more acceptable to an organization where such sensitivity and confidentiality are relatively less important.

Absence of applications is also a major handicap. Thus, a conservative CIO may be less likely to consider switching to utility computing. On the other hand, an intrepid CIO may, on seeing this plot, still decide that absence of applications is not going to deter him/her – as long as market action is high, and the features supported are adequate.

Sample Emerging Technology: Open Source
Here, (figure 2) technological features are a concern area. On drilling into the scoresheet, it can be seen that this shortfall on this front arises primarily from concern about support /maintenance. Customizability also is not a significant area of comfort. The applications dimension is also relatively anemic as robust, industrial-strength business applicaitons using the open source platform are lacking. Once again, it is up to the individual organization's risk appetite to decide whether to proceed with using open source.

Figure 1. Potential plot for utility computing

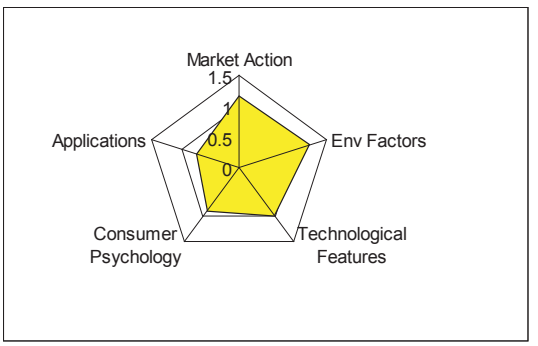


Figure 2. Potential plot for open source

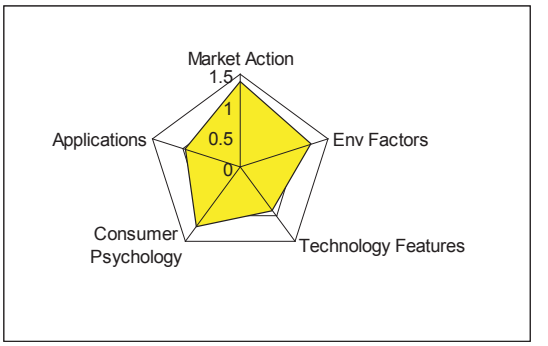
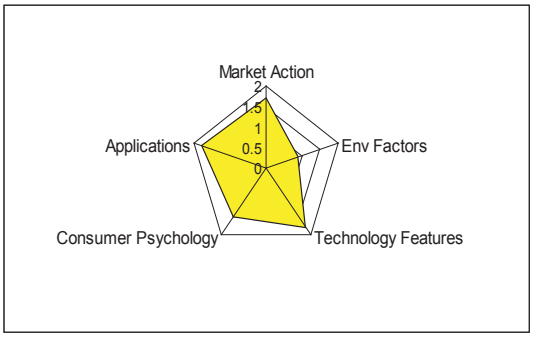


Figure 3. Potential plot for Firefox browser client



The consumer psychology dimension is also a moderate area of weakness – while concern about IP infringement is no longer a major deterrent, willingness to switch from conventional technology platforms is still not too high.

Sample Emerging Technology: Firefox Browser Client
Here too (figure 3), consumer psychology is a dimension where this technology is trumped – again, willingness of potential users to switch is low. However, the dimension along which this technology well and truly falls short is environmental factors. Clearly, the clout of the incumbent, which is a factor that carries significant weight under this dimension, is just too high!

USING THE METHODOLOGY

The methodology is intended to be used by corporate managers who are interested in gauging the advisability of / need to adopt an emerging technology in their business.

For example, a CIO of a large corporation may seek to decide whether s/he needs to invest in Open Source / Utility computing. The actual scoring may be done by the manager along with one or two technology specialists from within the organization. No expert in the technology concerned is called for. Also, since a given organization is likely to evaluate a relatively small number of emerging technologies, the effort involved is not significant.

The radar plot computation methodology also involves weightages at the factorial as well as dimensional levels, which can be adjusted based on the specific business characteristics, risk appetite, and so forth. It is also worth noting that managers may assign different ratings to individual factors, depending on their industry's needs, their company strategy, or individual preferences. Thus the methodology is not designed to produce a single, 'logically correct' output, but will produce outputs that differ slightly to reflect the needs and drivers of the user and his/her environment.

CONCLUSION: THE WAY AHEAD

The problem of accurately foreseeing how appropriate an emerging technology is for business use has proved itself to be as important as it is intransigent. We have presented a methodology that represents a significant step towards a solution. While considerably more piloting in more varied real life business environments remains to be done, the methodology has shown promise of substantially ameliorating the technology foresight deficit.

REFERENCES

Adner, R and **Levinthal, DA (2002)** The Emergence of emerging technologies. *California Management Review*, 45 (1), pp. 50-66.

Bresnahan, T.F., and **Pai-Ling, Y. (2005)** Economic and technical drivers of technology choice: Browsers. *Working Paper*, Harvard Business School.

Brody, H. and **Stabler, B. (1991)** Great Expectations: Why Technology Predictions Go Awry. *MIT Technology Review*, Vol. 94 Issue 5, pp. 38-45.

Griliches, Z. (1957) Hybrid Corn: An Exploration in the Economics of Technical Change" *Econometrics*, 25(4) pp.501-522

Kochikar, V. P. (2006) Re-engineering the Crystal Ball: Overcoming Our Deficiencies in Foreseeing Emerging Technologies. *Computerworld* Jan 30, 2006.

Kochikar, V. P. and **Ravindra M. P. (2006)** Hark! Did somebody say "Eureka"? *Working Paper*, Infosys Technologies.

Shapiro, C. and **Varian, H.R. (1998)** Information Rules: A Strategic Guide to the Network Economy. *Harvard Business School Press*, Soldier's Field, Boston, MA.

SRI (2006) Anticipating Futures: The SCAN Methodology http://www.sric-bi.com/Scan/ .

A User Profile-Based Approach for Adaptable Belief-Desire-Intention Software Agents

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ABSTRACT

An approach is proposed for the development of user profile-based, adaptable Belief-Desire-Intention (BDI) software agents. This proposed approach focuses on the integration of a user profile into the BDI software agent's beliefs and the adaptation of these additional beliefs either by a human user or the BDI software agent. The outcome of this user profile integration and adaptation is a more personalized and user-oriented reasoning process carried out by the BDI software agent and leading to a wider acceptance of software agent technology especially in human-centric fields of application. The realization of this approach is illustrated by applying it to a basic scenario based upon the open source agent framework JADEX (Java Agent DEvelopment eXtension).

1. INTRODUCTION

A Belief-Desire-Intention (BDI) software agent has the capability to adapt its desires, intentions and related plans to changing environmental conditions (beliefs), but it lacks the ability to adjust itself to the preferences and needs of an assigned human user. Especially in the case of interaction with a user and execution of tasks on behalf of a user the missing feature for personalization and adaptation states a significant disadvantage as the user cannot individually optimize his software agent. A user may have personal desires, intentions and preferences which he wants to be fulfilled by a BDI software agent under specific environmental conditions. The same is true for plans which are executed while pursuing a specific intention.

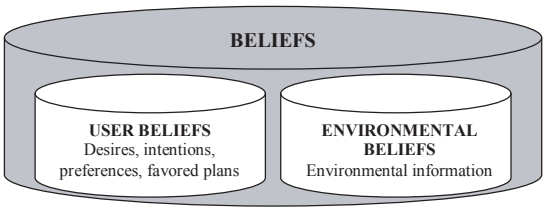
In the following, an approach is proposed to overcome the above-mentioned lack of individual adaptability and personalization of BDI software agents. Section 2 describes the conception of a user profile-based, adaptable BDI software agent and is structured in three subsections describing the basic idea (Section 2.1), the adaptation possibilities (Section 2.2), and the emerging agent architecture (Section 2.3). Section 3 outlines the realization of the proposed approach based upon the open source agent framework JADEX (Java Agent DEvelopment eXtension), while Section 4 presents some conclusions and discusses further work. Finally, in Section 5, the references are listed.

2. CONCEPTION OF A USER PROFILE-BASED, ADAPTABLE BELIEF-DESIRE-INTENTION SOFTWARE AGENT

2.1. Basic Idea

The integration of a user profile into the BDI software agent's beliefs should fix the above-mentioned lack of individual adaptability and personalization and represents the base for the development of an adaptable BDI software agent. Through the involvement of such user information about desires, intentions, preferences, and favored plans the usual BDI software agent's beliefs get separated into two parts: Environmental information (also called *environmental beliefs*) and user information (also called *user beliefs*), shown in Figure 1. These two components form the entire set of beliefs which – due to the integrated user information – allow an individual influence on the reasoning process of the BDI software agent. Especially the BDI functions *generate options*, *filter*, and *planning* are concerned.

Figure 1. Extended set of beliefs



2.2. Adaptation Possibilities

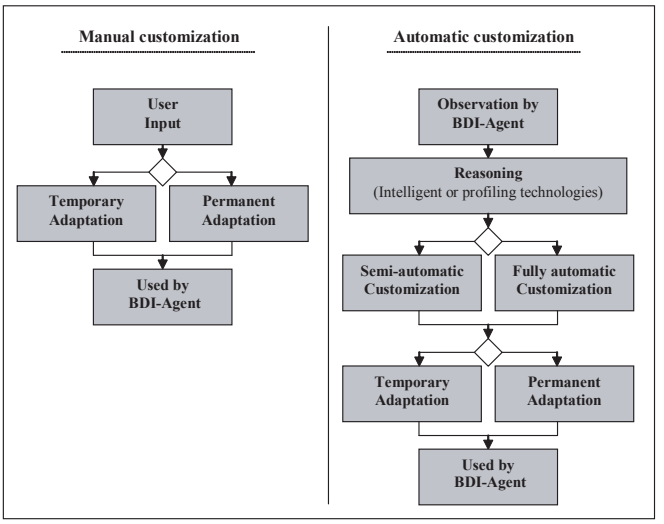
In addition to the integration of a user profile into the beliefs, a second important step towards an adaptable BDI software agent is the customization of this integrated user information. For this purpose, two different ways of user profile adjustment are intended. The first and easiest one is the *manual customization* accomplished by the human user. In contrast to this, the second way to adjust the user profile is an *automatic customization* which will be performed by the BDI software agent. Therefore, the software agent will observe the user's behavior and in case of need it will adjust the user profile, whereas two options of automatic customization should be possible: Either a *semi-automatic customization* at which the human user of the software agent has to confirm the adjustment or a *fully automatic customization* which will be performed autonomously by the software agent (the desired option should be manually adjustable by the human user). To achieve this automatic customization, either additional intelligent technologies (like neural networks or genetic algorithms) or profiling technologies will come into play. Finally, the time limit of a performed customization has to be considered. Either the performed customization refers only to the agent's runtime or beyond it. The first alternative is called *temporary adaptation* and enables the adjustment of the so-called *runtime user profile* located within the BDI software agent's beliefs (see the above introduced user beliefs). The second alternative, called *permanent adaptation*, adjusts the runtime user profile as well as a so-called *persistent user profile* located within a database. The human user gets the possibility to adjust its BDI software agent to one of these alternatives. Figure 2 depicts the sequences of the described adaptation possibilities en bloc.

2.3. Agent Architecture

Based upon the basic idea (Section 2.1) and the adaptation possibilities (Section 2.2) the architecture of a user profile-based, adaptable BDI software agent can be introduced. This architecture is subdivided into three layers, whereas the lowest layer represents the *database layer*, the middle layer represents the *application/agent layer*, and the highest layer represents the *presentation layer*. Figure 3 shows this layered architecture.

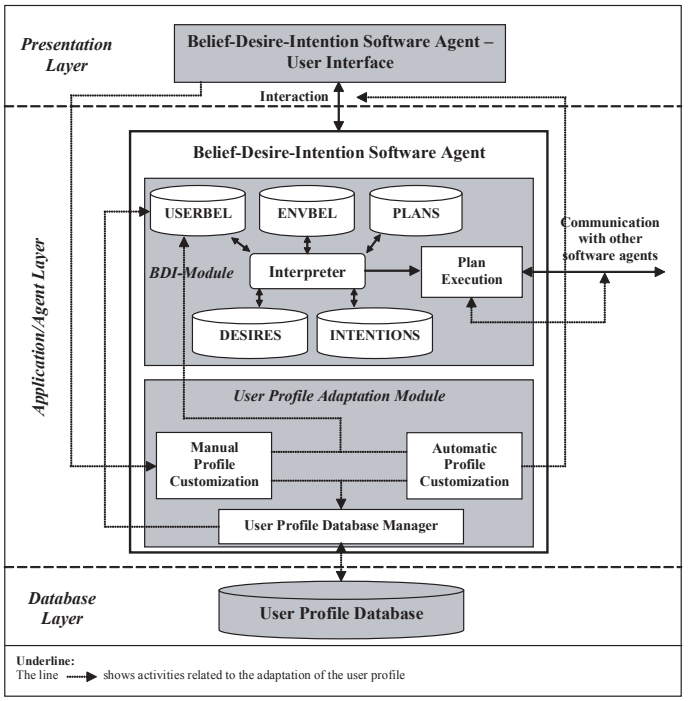
The presentation layer contains a user interface whereby a human user can interact with the underlying BDI software agent to perform custom-designed tasks relevant for a specific field of application. Additionally, the user interface provides the

Figure 2. Sequences of the adaptation possibilities



functionality to adjust the user profile (located within the BDI software agent's beliefs) manually. In the middle layer, also called application/agent layer, resides the adaptable BDI software agent composed of a *BDI-Module* and a *User Profile Adaptation Module*. In contrast to the classical BDI architecture, the BDI-Module gains two extensions: First, beliefs get separated into the introduced user profile/user beliefs (*USERBEL*), also known as the runtime user profile (see Section 2.2), and the environmental information/environmental beliefs (*ENVBEL*). Second, the component plan execution gets integrated, representing the execution of plans selected by the interpreter and providing the functionality to communicate with other software agents. The User Profile Adaptation Module realizes the above-mentioned adaptation possibilities (see Section 2.2) and is separated into two components: The first component is the *Manual Profile Customization*, processing the manual adjustment of the user profile performed by the human user via the user interface. The second component is the *Automatic Profile Customization*, responsible for the automatic adjustment of the user profile and therefore observing the interaction between human user and software agent as well as the plan execution and communication with other agents. The reason for the additional observation of plan execution and communication is that these activities could fail several times, thus requiring the adaptation of the user profile. E.g. a human user prefers a specific plan (specified in the user profile) to be executed by the software agent but the execution fails five times. The software agent observes these failures and provides an alternative plan which leads to an automatic adjustment of the user profile. This additional capability is the reason for the above-mentioned second extension of the BDI-Module concerning the component plan execution. Finally, both described adaptation components provide the functionality to adjust the runtime user profile (USERBEL) as well as the persistent user profile which is stored in the User Profile Database located within the database layer. The access to this User Profile Database is controlled by the User Profile Database Manager, responsible for all database operations.

Figure 3. Architecture of a user profile-based, adaptable BDI software agent



3. REALIZATION OF A USER PROFILE-BASED, ADAPTABLE BELIEF-DESIRE-INTENTION SOFTWARE AGENT

Based upon the open source framework JADEX (Java Agent DEvelopment eXtension) the basic characteristics of an adaptable BDI software agent are already implemented within the scope of the ongoing research. This includes the integration of a user profile into the agent's beliefs, an incorporation of this additional information into the reasoning process, and a manual and semi-automatic customization of the user profile. Additionally, an exemplary scenario is realized to demonstrate the operability of the adaptable BDI software agent. In this scenario two human users can get in touch with each other by means of assigned adaptable BDI software agents. On the basis of user information the contacted software agent identifies how an approach should be handled to satisfy the desires of its user and may come to an autonomous decision. In case of changed user interests the software agent can get informed and will adjust to this new situation. If changes in the user's behavior are detected autonomously by the software agent and a customization of the user profile appears necessary the software agent may perform this customization by itself which also leads to an adjustment of the agent's reasoning process. E.g. if a callee refuses an approach of a caller several times even though the callee's user profile specifies that an approach of this caller is allowed and welcome, the callee's software agent may adapt the user profile after precise observation. In consequence of this adjustment the next approach of this specific caller may end up in a refusal performed by the callee's software agent without the intervention of the human user.

4. CONCLUSIONS AND FURTHER WORK

The current development status shows, that the integration of a user profile affects the BDI software agent's reasoning process and enables user-oriented decisions. Thus, this extended BDI software agent can be used to serve a human user in an unobtrusive and personalized way by what this user can be relieved of secondary tasks and gains additional time to concentrate on more relevant topics. However, there are three key aspects defining further research and development. The first one is the realization of a more complex scenario which requires an extensive reasoning process by the adaptable BDI software agent based upon the introduced user profile. This is necessary to demonstrate the robustness of the elaborated approach. Second, the automatic customization of the user profile has to be improved. The idea is to develop a plug-in framework that allows several so called observation modules to plug in, to observe the user's behavior, and to adjust the user profile if necessary. This ought to result in multiple observation modules, interested in different and independent user behavior and able to modify various pieces of information of the integrated user profile. The last key aspect of further research and development is related to the above-mentioned observation modules. Each of these modules should work using either intelligent technologies or specific profiling technologies. For this purpose, an evaluation and integration of adequate intelligent techniques (like neural networks or genetic algorithms) or profiling mechanisms has to be accomplished with particular attention to the kind

of information required by specific observation modules, the user information which can be modified by specific observation modules, and the over-all context of the entire observation modules.

5. REFERENCES

Braubach, L., Lamersdorf, W., Pokahr, A. (2003). *Jadex: Implementing a BDI-Infrastructure for JADE Agents*. Retrieved January 09, 2007, from http://vsis-www.informatik.uni-hamburg.de/getDoc.php/publications/124/pokahrbraubach2003jadex-exp.pdf

Dickinson, I., Reynolds, D., Banks, D., et al. (2003). User profiling with Privacy: A Frame-work for Adaptive Information Agents. In Klusch, M., Petta, P. (Eds.), *Intelligent Information Agents – The AgentLink Perspective* (pp. 123-151). Berlin: Springer.

Georgeff, M., Rao, A. (1998). Rational Software Agents: From Theory to Practice. In Jennings, N.R., Wooldridge, M. (Eds.), *Agent Technology – Foundations, Applications, and Markets* (pp. 139-160). Berlin: Springer.

Rao, A., Wooldridge, M. (1999). Foundations of Rational Agency. In Wooldridge, M., Rao, A. (Eds.), *Foundations of Rational Agency* (pp. 1-10). Dordrecht: Kluwer.

Wooldridge, M. (2002). *An Introduction to Multi-agent Systems*. Chichester, West Sussex: Wiley & Sons.

Integrating Microsoft Dynamics GP Enterprise Resource Planning Software into a School of Business Curriculum: Research in Progress

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ABSTRACT

This research in progress paper looks at the use of Dynamics GP Enterprise Resource Planning software in a classroom environment. The article provides a brief overview of some pertinent literature and an explanation of why Dynamics GP was used instead of other packages such as SAP or Oracle. Finally, some discussion of how the software was used in three different undergraduate classes is provided as well as a brief explanation of plans for the future.

INTRODUCTION

Enterprise Resource Planning (ERP) software has become prevalent in a variety of organizations. ERP systems are information systems that assist in the management of accounting, finance, human resources, manufacturing, customer relationship management, logistics and other business functions by integrating these functions into a single system. This integration of information provides a more holistic view of the organization and allows for the more comprehensive and timely view of the business processes thus leading to more informed and hopefully, improved, decision making (Bradford, Vijayaraman, & Chandra, 2003; Davenport, 1998; Fowler & Gilfillan, 2003; Shoemaker, 2003).

While the integration of business functions has been occurring in organizations, the education of business students has not been evolving as rapidly. Historically, business education is fragmented with different bodies of knowledge taught in separate departments. Although students become specialized in their area, they can sometimes miss the big picture where interdependencies and interconnectedness among business processes create efficient synergies in achieving business targets (Becerra-Fernandez, Murphy, & Simon, 2000; Bradford, Vijayaraman, & Chandra, 2003; Cannon, Klein, Koste, & Magal, 2004; Jones & Lancaster, 2001; Shoemaker, 2003; Wygal & Hartman, 2003).

The use of ERP software in the curriculum can provide students a number of advantages from the conceptual to the practical. The use of ERP software allows students to better understand the flow of information across the organization (Bradford, Vijayaraman, & Chandra, 2003; Jones & Lancaster, 2001; Shoemaker, 2003; Wygal & Hartman, 2003). The use of ERP software in the classroom also provides students with practical hands on skills that are highly desired in industry. Students knowledgeable about ERP systems and who graduate with the much sought after combination of business management and IT skills can help enhance the credibility of a business school in the eyes of industry. Schools with ERP systems in place can also use the software as a marketing tool to attract potential students, and individual departments can attract potential students interested in hands-on knowledge of a real-world application (Becerra-Fernandez, Murphy, & Simon, 2000; Bradford, Vijayaraman, & Chandra, 2003; David, Maccracken, & Reckers, 2003).

However, due to various challenges in deploying ERP software, very few schools are integrating the software across the curriculum. These challenges can include: developing course materials; overcoming the technical and administrative hurdles in installing and maintaining the software and hardware; faculty support for learning and incorporating the software into their curriculum, as well as the associated monetary costs (Becerra-Fernandez, Murphy, & Simon, 2000; Bradford, Vijayaraman, & Chandra, 2003; David, Maccracken, & Reckers, 2003; Rosemann & Maurizio, 2005; Strong, Fedorowicz, Sager, Stewart, & Watson, 2005; Wygal & Hartman, 2003).

MICROSOFT DYNAMICS GP

There are a variety of ERP systems available that may be integrated into the curriculum. This author has been interested in incorporating ERP systems in his classes for roughly seven years. At the time when the process was started, there were effectively three alternative ERP systems that could be selected – Oracle's "Financials" system, SAP, and Microsoft Dynamics.

The University of Indianapolis is a relatively small liberal arts university located in Indianapolis, Indiana. Until recently, this author was the only full-time information systems faculty member in the School of Business. When the author started at the university, he had the school join Oracle's academic initiative as one of the early members of this program. For an annual cost of five hundred dollars, the university had full use of Oracle's database software. This did not include Oracle's Financials (their ERP system). While the database software was provided, the author found difficulties in obtaining support for the software. Oracle did provide access to their support system but unfortunately for various reasons, this support was not always useful. As a matter of fact, the author started an email list of Oracle users in academic environments for faculty to use to provide support to each other.

Thus when the idea of integrating an ERP package into the curriculum was first investigated, Oracle's Financials package was the obvious first choice to evaluate. Discussion with individuals at Oracle's Academic Initiative indicated that there was an annual cost of eight thousand dollars to access the Financials software. More importantly, the technical hurdles of getting the software running would be much greater than getting the database software running. The university's computer services department was stretched thin, as is usually the case at most universities, and was not in a position to provide much technical, nor hardware support, so the author would have to shoulder the responsibility of installing and maintaining the software in addition to a full-time teaching load. Thus, it was extremely unlikely that the university would be able to install the software and maintain it.

The author next looked at SAP. At the time, to use the software in the academic curriculum, SAP would have to be installed and configured on university equipment. The hurdle to accomplish this would be as great, if not greater, then installing Oracle Financials. Thus this was not feasible. As a note, since that time, SAP has initiated a program where a select few universities host the SAP installation and other universities access SAP through a graphical interface. This greatly reduces the effort for a university to incorporate SAP into the curriculum. However, at this point, this author chose not to take that alternative for two reasons. The first was all the effort already put into incorporating Microsoft Dynamics into the curriculum. The second, and more important reason, was that teaching certain aspects of ERP systems such as installation, configuration, and maintenance would not be easily feasible if the software installation was not local.

The third package reviewed was Microsoft Dynamics[1]. This package was not aimed towards large scale organizations but was geared more towards mid-sized organizations. However, in terms of functionality, the software had similar functionality

and capabilities as SAP and Oracle Financials. More importantly, the software and hardware requirements to install the software were much lower and made it feasible to install the software on lab machines running the Dynamics GP software and have the underlying SQL Server database run on the same machine. While running the software in stand alone mode is not optimal, it is certainly better than not having the software at all. Additionally, using the software, it was possible to have students install a stand alone ERP system on their home machines to work on. Finally, the support from Microsoft has been excellent from both a technical aspect and an administrative aspect (i.e., academic alliance support in providing the software, licenses, etc.) In terms of industry use of the software, approximately forty thousand companies are running Dynamics GP according to Microsoft. Thus students with GP experience have a number of opportunities to translate their knowledge of the software into internship and post-graduation jobs.

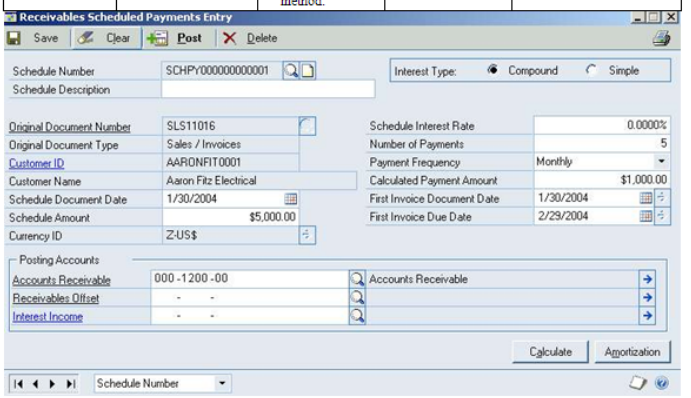
PROGRESS TO DATE

The first large scale use of Dynamics GP at the University of Indianapolis was done in the first semester of the fall semester 2006 with approximately one hundred students using the software in three different undergraduate courses. Unfortunately, access to a server-based system running Dynamics GP was still not available. Thus all student work was either performed on lab machines running Dynamics GP in stand alone mode or on the students' own machines.

The first class was an introduction to information systems class required by all School of Business students. Thus the students' majors included accounting, marketing, management, and business administration. Students received an exposure to Dynamics GP through some hands-on familiarization to the software as well as using the online electronic training material that Microsoft provides for free to members of the Dynamics Academic Alliance. Students also had to generate a report for various modules detailing the capabilities and benefits of incorporating an ERP system into an organization.

Figure 1. Using Dynamics GP to overcome the limitations of a non-integrated system

Potential Problem	Why is it a problem	Implications of Problem	How ERP corrects problem	GP Documentation
• Accounts are only posted on the day payment is received if time permits.	• There can be some delay between the time FS receives a check from the customer and when the customer's accounts receivable balance is actually reduced.	• This leads to accounts not accurately portraying the correct balances. • Also, some of the payments may not get posted because they are not being accounted for in the same method.	• Accounts are automatically adjusted when the payment is received whether there is time or not. • Accounts are always up-to-date.	• Sales Order Processing module; Ch. 18 pg. 115 • A deposit amount on an order will be posted immediately when the Sales Payment Entry window is closed.



The second class was a System Analysis class. Each group of students was assigned a specific module in Dynamics GP to analyze. This includes developing use cases, activity diagrams, class diagrams, etc. for a specific aspect of their module.

The third class was a senior level special topics class. The class was composed of both information systems majors and minors. The textbook the students used (Monk & Wagner, 2006) looked at the limitations of a small organization that used a number of non-integrated information systems. As a class project, students were required to document the limitations and their potential impact. Additionally, the students were required to document how Dynamics GP could be used to resolve the limitations as shown in figure 1. Figure 1 shows just a single entry in the document generated by the students.

Overall, students had a positive reaction to the use of Dynamics GP in the classes. They understand the value of knowing the software to better understand the integration of information between different functional areas as well as the potential value knowledge the software had when the students were looking for internships and post graduation jobs.

For the next semester, a server has been set up allowing a more realistic use of the software in a class setting. A major effort will be using Dynamics GP to create the company examined this past semester in the Monk and Wagner (Monk & Wagner, 2006) book. This effort should be aided by Microsoft's recent action of making the training materials for the software available for free.

REFERENCES

Becerra-Fernandez, I., Murphy, K. E., & Simon, S. J. (2000). Integrating ERP: in the Business School Curriculum. *Communications of the ACM, 43*(4), 39-41.

Bradford, M. M., Vijayaraman, B. S., & Chandra, A. (2003). The Status of ERP Integration in Business School Curricula: Results of a Survey of Business Schools. *Communications of AIS, 2003*(12), 437-456.

Cannon, D. M., Klein, H. A., Koste, L. L., & Magal, S. R. (2004). Curriculum Integration Using Enterprise Resource Planning: An Integrative Case Approach. *Journal of Education for Business, 80*(2), 93-10.

Davenport, T. H. (1998). Putting the Enterprise into the Enterprise System. *Harvard Business Review, 76*(4), p121-131.

David, J. S., Maccracken, H., & Reckers, P. M. J. (2003). Integrating Technology and Business Process Analysis into Introductory Accounting Courses. *Issues in Accounting Education, 18*(4), 417-425.

Fowler, A., & Gilfillan, M. (2003). A Framework for Stakeholder Integration in Higher Education Information Systems Projects. *Technology Analysis & Strategic Management, 15*(4), 467-489.

Jones, R. A., & Lancaster, K. A. S. (2001). Process mapping and scripting in the Accounting Information Systems (AIS) curriculum. *Accounting Education, 10*(3), 263-278.

Monk, E., & Wagner, B. (2006). *Concepts in Enterprise Resource Planning* (Second ed.): Thomson.

Rosemann, M., & Maurizio, A. A. (2005). *SAP-related Education – Status Quo and Experiences*. Brisbane Queensland University of Technology.

Shoemaker, M. E. (2003). What Marketing Students Need to Know About Enterprise Resource Planning (ERP) Systems. *Marketing Education Review, 13*(2), 69-77.

Strong, D. M., Fedorowicz, J., Sager, J., Stewart, G., & Watson, E. (2005). *Teaching with Enterprise Systems*. Worchester, MA: Worcester Polytechnic Institute.

Wygal, D. E., & Hartman, B. P. (2003). Partnering for Change: Infusing Enterprise Resource Planning in the Accounting Curriculum. *Management Accounting Quarterly, 4*(4), 63-67.

ENDNOTE

[1] Actually, at the time of initial review, the package was owned by a company called Great Plains. This company was purchased by Microsoft. Over the past few years, the specific software has undergone some name changes from Dynamics to Great Plains and now to Dynamics GP.

ERMA: Electronic Risk Management Architecture for Small and Medium-Sized Communities

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ABSTRACT
Project ERMA (Electronic Risk Management Architecture) aims to build a reference platform for risk management in the domains of natural as well as man-made disasters with a specific focus on needs of small and medium-sized communities. Communities might be public institutions as well as private sector organisations which share obligations and duties for risk prevention and response. Hence, specific attention will be devoted to a customisable platform, which can be tailored to the needs of the individual risk at hand as well as local equipment and requirements.

1. INTRODUCTION

Project ERMA strives to develop a reference platform for risk management. The engineering paradigm is based on a service-oriented architecture (SOA) in order to integrate components of existing and related systems. ERMA will study the requirements for risk management support in the domains of natural as well as man-made hazards, risks, and disasters. A specific focus will be placed on the needs of small and medium-sized communities. Communities include local authorities and other public institutions as well as private sector organisations with obligations for risk prevention and response. Due to the diversity of requirements, specific attention will be devoted to the customisation features of the platform in order to tailor it to the individual requirements of the individual risk situation.

The vast amount of information during risk incidents compounds any decision process for the responsible rescue organisations. Specific decision scenarios, such as management of rescue resources, are already supported by IT applications for command centres. Yet, workflow management services and key indicator systems are rarely found although their added value for crisis assessment has been proven.

Thus, the ERMA platform comprises:

- a key indicator-based decision support system combined with a workflow management system,
- an early warning system to alarm emergency staff and the concerned citizen,
- a citizen relationship management system to support the communication with the citizen as well as team collaboration software for rescue organisations and other authorities.

This paper will present research in progress of project ERMA by providing its main scientific and technological aims and objectives.

2. IT SERVICES FOR RISK MANAGEMENT

Risk management surfaces as emerging topic for the software industry. Yet, no reference platforms and standard components have been established so far.

The unique features of the ERMA system with such a combination of modules and functionality can not be found in the current market. In science, individual modules have been tested in the domain of emergency management. Examples include the simulation of events with training purposes (Pollak, Falash, Ingraham, & Gottesman, 2004), the support of information dispatching (Van Someren et al., 2005), or collaboration processes (Georgakopoulos, 1999). Unfortunately, no commercial system has emerged from these prototypes, and no prototype is available for testing for ERMA.

However, information technology support is still scarce and mainly focused on

- *Communication infra-structure* — Novel communication infra-structures enable the convergence of various and heterogeneous communication technologies in order to allow different organisations to communicate using their heterogeneous technologies.
- *Geographical information systems (GIS) for information warehousing* — GIS are employed to integrate various data sources about risk-related information. Once doing so, one has a uniform source of all information that are required to assess a crisis and also take measures for prevention. Besides prevention scenarios, such warehouses are also deployed during response and recovery scenarios such as the planning of counter actions.
- *Task monitoring* — Recent systems allow the monitoring of tasks decided in order to document the process and exchange information about resources required for their execution.
- *Resource management* — Since specific incidents might require dedicated equipment not available to everyone in sufficient numbers, repositories about resources and their location are taking-off. They allow for the identification of appropriate resources.
- *Command centre support* — Each command centre uses its own information resources mainly about locations and geographical information. They are management by GIS.
- *Simulation tools for impact analysis* — Simulation tools allow the prediction of impacts such as the dispersion of toxic materials or the spreading of forest fires.

All these types of support for risk management forces are unquestionable. There are also more tools for rescue-related services as well as relevant data sources which have given birth to major European research projects for designing a generic infra-structure platform. For example, Orchestra, OASIS and others are establishing information technology platforms for the integration of data sources and the orchestration of rescue-related services. The SOA approach is the key for a flexible design and adaptation from an information technology point of view. They basically provide the middleware services for the implementation of service portfolios for rescue operations. However, until now these platforms do not consider

- Process support to capture the know-how about rescue operations and support rescue forces during incidents,
- Public alerting, i.e. advising the public about risk incidents in a customised fashion.

This lack of services motivates the birth of ERMA. In addition, risk monitoring and assessment on the basis of indicator systems that take into account specific industrial and natural risks is included for automatic monitoring purposes.

Since ERMA uses a SOA approach, it is able to orchestrate services from existing systems. Compliance with specification patterns of major infrastructure projects is sought but not considered essential in detail, since all SOA-oriented approaches are based on similar principles: specify core business services provided by existing systems and configure them to customer-oriented services based on SOA or in the terminology of rescue forces: use IT services for the preparation and orchestration of rescue operations.

3. MOTIVATION FOR PROCESS MANAGEMENT

ERMA is going to employ a process engine, which supports emergency staff with predefined and ad-hoc process description. Know-how about processes furnishes an invaluable source of knowledge about tasks to be conducted in order to respond to specific events. This know-how is only available in terms of manuals for the most part, i.e. major fire brigades have specified their response patterns by so-called standard tactics. Each tactic describes certain patterns of actions to be taken depending on the event at hand. As such, predefined workflows collect experience, organisational and administrative knowledge about how specific actions are to be undertaken, like e.g. evacuations, securing of installations, mounting of flooding dams. Ad-hoc workflows allow one to plan end execute not yet modelled series of actions in specific occasions in order to customize pre-defined patterns to event-specific requirements. Once defined and completed, they can be adapted, stored, and reused later for similar situations. Until today, action plans of emergency situations like flooding are collected in large manuals with small or no IT support at all. Such manuals do not support tracing of actions, graphical overviews, showing of interdependencies, logging, or ad-hoc changes by nature.

A formal representation of such processes is required in order to embark for process guidance and analysis. Moreover, the use of workflow engines will ease the definition of complex scenarios, so that each step and respective information exchange can be modelled. In the case of an emergency, involved staff can concentrate on extreme and unusual events while routine jobs are guided by quality-assured workflow procedures.

By the same time, authorities have started an exchange of best practices with regard to risk assessment, monitoring, prevention, awareness, response, recovery and management. Although project SETRIC (SEcurity and TRust In Cities — www.setric.org) has established a platform for the publication, exchange and dissemination of best practices, information exchange is mainly based on text documents. Here it is where process modelling approaches will foster the reuse of process know-how.

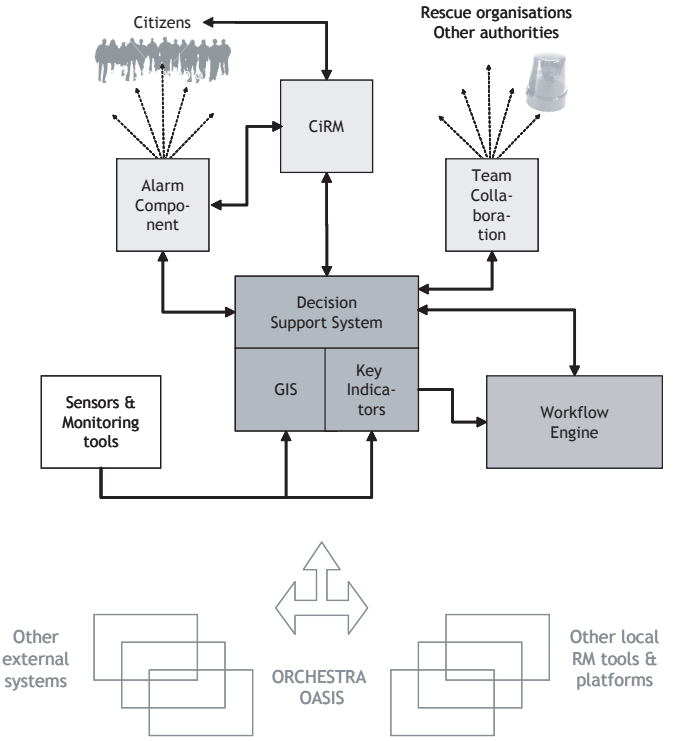
4. IMPLEMENTATION

ERMA will build an innovative prototype that targets the requirements of small and medium-sized communities. ERMA will establish links to existing risk management initiatives and pursue information exchange, discussion, and reuse of research results and components with a particular focus in mind: migrate these results to small and medium-sized communities. Of specific importance is the fact that the consortium includes several small to medium-sized companies with innovative product portfolios.

In detail, ERMA is going to assist small and medium-sized communities to:

- Access monitored sensor data related to various natural and industrial risks existing within their district, i.e. enable proper risk assessment.
- Define and employ process guidelines for risk management procedures, i.e. support proper workflow for risk analysis and response.
- Deploy and manage enhanced emergency telecommunications systems and implement a public communication system devoted to the communication with the citizen, i.e. support appropriate dissemination and warning procedures.
- Integrate and connect partners from various sectors, e.g. public, private and associated sectors, i.e. provide a collaboration platform for the exchange of information among different stakeholders.
- Prepare the elements (organizational/technical) for the implementation of a risk management network at a local scale, i.e. install and customize the platform to local requirements.

ERMA will develop a comprehensive risk management platform which is based on the orchestration of relevant systems thanks to the application of service-oriented architectures, and interfaces to other systems will augment the ERMA service portfolio where needed.



The planned architecture shows the different modules to be integrated. Some of them are provided by project partners, i.e. the alarm component, a customer relationship management tool, and the team collaboration system, which are already commercially available. They have to be adapted to the risk management domain taking especially into account the need of smaller communities and their respective citizen requirements. For example, the CRM (Customer relationship management) component has to be adapted to a citizen-oriented system supporting the specific work of rescue organisations and authorities in crisis situations.

The process/workflow engine as well as the decision system based on key indicators and visualised by maps of a GIS or mapping tool will be designed and developed during the course of ERMA.

ERMA's innovation lies in the combination of a key indicator system (KIS) and a workflow engine. While the KIS will collect sensor data, derive the current state of the event and give recommendations for further actions, the triggered workflow engines show the work schedule on how to perform the different steps of these actions. These are pre-modelled based on typical crises management procedures. But ERMA also wants to allow ad-hoc workflow in order to change, adapt and store for reuse.

External links to other projects and systems, especially the EC funded projects Orchestra and OASIS, will complement the service offer and provide additional means for information exchange.

The information flow between modules is presented in the following figure. Optional components (presented in light grey) will be linked by SOA to establish loosely coupled and interoperable services, which can be integrated or deselected for individual requirements. The decision system serves as core component integrating the application logic and scheduling other functions when demanded.

5. RESULTS

Scientific and technical results of the project will be:

- Research on a generic SOA for risk management systems with a holistic approach to flexibly integrate standards and components.
- Research on risk management for small and medium-sized authorities: decision making patterns, information needs, assets, and vulnerabilities.

- Application of process models and workflow and decision support systems to risk management tasks for small and medium-sized communities' requirements.
- Design of an information infrastructure dedicated to manage most aspects related to the management of risk to improve the confidence of citizens to their local governmental institutions.
- Design of an innovative method to "map" the risk environment.
- Design of an innovative method to optimize individual information flows between risk management actors.
- Design and implementation of a risk monitoring system configurable to a multitude of contexts, and centralization of risk measure data in the local authorities' system.
- Decision system based on key indicators with map-based visualisation tools.
- Mapping of basic best practices of risk management to process and workflow engines with online support in risks at present.
- Customised and instantaneous warning of citizens in affected regions via multi-channel means.
- Citizen relationship management – applying commercial oriented CRM systems to communication with citizens in the risk management context.

6. OUTLOOK

The ERMA project started in September 2006 with a two year perspective. It will provide a first prototype to be tested at two user sites in 2007. Final findings about the performance of the platform and its customisation prospects are expected by the end of 2008.

Due to the employment of service-oriented architectures, ERMA is going to adapt and build upon existing components for alarming, geographical visualisation, collaboration, and citizen relationship management. Specific components will be developed for indicator-based risk assessment as well as dedicated process support for risk management. Hence, ERMA will combine best-of-class components and best practices on risk management. Its innovative power is due to the combination of services and their customisation features.

7. ACKNOWLEDGEMENT

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8. REFERENCES

Georgakopoulos, D. (1999). Collaboration Process Management for Advanced Applications. *International Process Technology Workshop*.

Pollak, E., Falash, M., Ingraham, L., & Gottesman, V. (2004). Operational analysis framework for emergency operations center preparedness training. *Proceedings of the 36th conference on Winter simulation*, 839-848.

Van Someren, M., Netten, N., Evers, V., Cramer, H., De Hoog, R., & Bruinsma, G. (2005). A Trainable Information Distribution System to Support Crisis Management. *Proc. of the 2nd International ISCRAM Conference*.

Critical Success Factors of ERP Implementations

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ABSTRACT

This investigation will identify and examine critical success factors (CSF) that impact each stage of the implementation process related to the deployment of Enterprise Resource Planning (ERP) systems in diverse North American settings. Using business organizations in various locations throughout North America, the critical success factors associated with ERP implementation will be: (1) identified; (2) ranked for relative importance; (3) designated as relevant within a specific implementation stage; (4) examined for differences in setting; and, (5) classified as best practices in implementation by stage. The outcomes of this research will include the: (1) development of a taxonomy of critical success factors delineated by the specific stage of implementation where each CSF is most important; (2) creation of a framework that identifies country differences in critical success factor preference; (3) establishment of a comprehensive organizational guide that provides prescriptions for effective systems deployment; (4) dissemination of the research findings through academic publications; and, (5) integration of identified critical success factors within university curricula. This project study supports collaborative research between Canadian and U.S. institutions of higher education.

PROJECT OBJECTIVE

The objective of this research proposal is to document the critical success factors (CSF) necessary for successful implementation of Enterprise Resource Planning (ERP) systems within different organizational and national settings, regulatory venues and corporate cultures. Business organizations in North America that have completed an ERP project within the past two years will be identified and a request for their participation will be solicited. To accomplish this objective, the researchers have segmented the research agenda into two phases: (1) a qualitative phase where CSFs will be identified using a grounded theory approach (Glaser and Strauss, 1967) as detailed in this proposal; and, (2) a quantitative phase where CSFs will be modeled and empirically tested from data collected from questionnaires.

Based on a Grounded Theory approach (Glaser and Strauss, 1967), the researchers will employ Narrative Inquiry supported by the Long Interview Technique (McCracken, 1988) in a qualitative interview format to generate a comprehensive catalog of implementation CSFs. Content analysis will be used to examine diverse corporate cultures, to identify implementation success factors and application variance. The outcomes of this research project are to: (1) create a taxonomy of critical success factors that are linked to the specific implementation stage where each will produce the greatest impact; (2) establish a framework to delineate country differences in CSF preference; (3) generate a comprehensive implementation guide for business organizations; (4) produce research for publication in relevant academic journals; and, (5) incorporate the value-added knowledge gained from this research into the information systems curriculum in selected institutions of higher education. This project provides an opportunity to achieve a unified prescription for organizations to use in implementation.

This research is important because of the current and projected magnitude of the ERP market. In particular, the market for ERP systems is expected to reach $US 1 trillion by 2010 and ERP costs for companies range from $50,000 to hundreds of millions of US dollars. The growth of ERP systems can be attributed to the expected system benefits that include the integration of data and applications, the replacement of legacy systems, and expected cost advantages. Given these estimates, understanding what critical success factors are most important at each stage of the deployment process should help reduce the negative outcomes associated with ERP implementation.

What is missing from the available research reports is a detailed investigation of factors encountered at various stages of an ERP implementation and a comprehensive context based description of successful implementation processes, procedures and policies – best practices. Thus, at various stages throughout the ERP implementation project problems and challenges will be analyzed. These factors may be those that are anticipated and what plans exist for their resolution; or completed issues and how they were resolved. The goal of this study is to understand ERP implementation issues and how they differ across different business settings.

METHOD

Qualitative interviews will be conducted to gather stakeholder interpretations of critical success factors in each stage of the ERP implementation. The stakeholders who will be interviewed represent the most important opinion-holders within the company about issues that may arise during an ERP implementation project. Four stakeholders from each company will be interviewed. The interview approach will be based upon Narrative Inquiry and supported by the Long Interview Technique (McCracken, 1988).

Narrative Inquiry (Girden, 2001; Scholes, 1981) documents research participant's interpretations of events which are contextually rich and temporally bounded. The contextually rich concept relates to events that have been experienced first hand, and therefore are more vividly remembered (Swap et al., 2001; Tulving, 1972). The concept of temporally bounded suggests that the narrative will have a beginning, and end, and a chronological sequence of events in the interim. This sequential aspect supports the clarity of recollections (Bruner, 1990; Czarniawska-Joerges, 1995; Vendelo, 1998).

The Long Interview Technique (McCracken, 1988) supports the above Narrative Inquiry concepts. The technique employs three types of questions. First, "grand tour" questions are general allowing the respondent to decide upon the substance of the response. "Planned prompts" are those questions that are decided upon before the interview. These questions relate to the subject under investigation and may be gleaned from previous projects or a review of the available literature. These types of questions also facilitate comparisons across interviews because common areas will be discussed with each participant. During the interview "floating prompts" may also be employed. These questions relate to the researcher's decision to pursue a line of questioning in order to obtain more detail about a specific response. All interview data will be recorded with the knowledge and agreement of the research participant.

The Interview Protocol developed for this project represents the results of applying the Long Interview technique within the Narrative Inquiry approach to investigating ERP implementation. The first major section obtains information about the specific person. The second section gathers information about the company. The last section follows the Narrative Inquiry approach to obtain participants' perspectives on their experiences at various stages of an ERP implementation. Issues will be discussed chronologically based upon the stages of the ERP implementation.

EXPECTED OUTCOMES

The outcomes of this research will include the: (1) development of a taxonomy of critical success factors delineated by the specific stage of implementation where

each CSF is most important; (2) creation of a framework that identifies country differences in critical success factor preference; (3) establishment of a comprehensive organizational guide that provides prescriptions for effective systems deployment; (4) dissemination of the research findings through academic publications; and, (5) integration of identified critical success factors within university curricula.

REFERENCES

Bruner, J. Acts of Meaning. Cambridge, MA: Harvard University Press, 1990.

Czarniawska-Joerges, B. "Narration or Science? Collapsing the Division in Organization Studies", Organization, Vol. 2, No. 1, 1995, pp. 11-33.

Girden, E. R. Evaluating Research Articles, 2nd ed. Thousand Oaks, CA: Sage Publications, 2001.

Glaser, B. G. and A. L. Strauss. The Discovery of Grounded Theory: Strategies for Qualitative Research. Chicago, IL: Aldine, 1967.

McCracken, G. The Long Interview. New York, NY: Sage Publications, 1988.

Scholes, R. "Language, Narrative, and Anti-Narrative", in W. Mitchell (Editor), On Narrativity, pp. 200-208. Chicago, University of Chicago Press, 1981.

Swap, W., D. Leonard, M. Shields, and L. Abrams. "Using Mentoring and Storytelling to Transfer Knowledge in the Workplace", Journal of Management Information Systems, Vol. 18, No. 1, Summer 2001, pp. 95-114.

Tulving, E. "Episodic and Semantic Memory", in E. Tulving and W. Donaldson (Editors), Organization of Memory, pp. 381-404. New York, Academic Press, 1972.

Vendelo, M. T. "Narrating Corporate Reputation: Becoming Legitimate Through Storytelling", International Journal of Management and Organization, Vol. 28, No. 3, Fall 1998, pp. 120-137.

Real-Time Virtual Learning Environments

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ABSTRACT

Virtual Learning Environments (VLEs) have gained momentum in both industry and education as both segments have increased their use of technology to deliver training and education. This research represents a pilot study conducted to compare a complex information technology course taught in a real-time (synchronous) hybrid eLearning environment with one taught in a traditional classroom setting. The aim of the research is to provide additional insights into the effectiveness of synchronous hybrid VLEs and to compare their use with hybrid VLEs and traditional classrooms. Three courses were examined in the study and the results indicate the promise of synchronous hybrid eLearning for complex courses.

INTRODUCTION

Advances in technology have made real-time VLEs more affordable and as the capabilities of them have expanded (Seng & Al-Hawamdeh, 2001), so has the popularity in both the educational arena and corporate world (Alavi, Marakas, & Yoo, 2002; Dagada & Jakovljevic, 2004). VLEs are defined as "computer-based environments that are relatively open systems which allow interactions and encounters with other participants and providing access to a wide range of resources" (Piccoli, et al., 2001, p. 402; Wilson, 1996).

VLEs can be characterized by six dimensions which distinguish them from traditional classrooms and computer aided instruction: time, place, space, technology, interaction, and control (Piccoli, Ahmad, & Ives, 2001). The instruction delivery when defining the six dimensions in Piccoli, et al (2001) is asynchronous delivery. The definition for two of the dimensions, time and control, in synchronous (real-time) virtual learning environment is different from asynchronous virtual learning environment. Research still remains to uncover the effectiveness of these environments and also to determine their impact on the learning experience of the student (Alavi & Leidner, 2001; Alavi *et al.*, 2002; Hodges, 2005; Seng & Al-Hawamdeh, 2001).

BACKGROUND

The work on technology mediated learning (TML) has been the focus of researchers for some time and it has been noted that research still lags behind practice. Overall, there is a need to gain a deeper understanding into the effectiveness of the use of technologies for online learning (Alavi & Leidner, 2001; Alavi et al., 2002). One area that has recently come to light is the use of hybrid approaches to teaching online courses. A hybrid approach to learning with TML involves providing content in a variety of formats with a mixture of online and in-class instruction.

There have been a number of studies examining hybrid approaches to teaching. In an examination of the differences between pure versus hybrid approaches to teaching using the case method it was found that students' online discussions may enhance learning in case methods when taught using a hybrid approach (Webb, Gill, & Poe, 2005). When live versus hybrid formats were compared in sections of a business communication class, an improvement in writing skills was found in students who participated in the hybrid course, particularly for those whom English is a second language (Sauers & Walker, 2004). McCray (2000) found courses which combine online learning with the traditional classroom can help students to become more engaged in rich classroom interactions by appealing to different learning styles through variety in content delivery. A study examining the differences in learning outcomes for students training in basic information technology skills in a traditional classroom versus those in a virtual one found no major variation in the performance of students in the two environments; there were however, differences reported in computer self-efficacy (Piccoli et al., 2001). Research in this area also highlights the importance of the influence of self regulation (ability to control actions and decisions) and control of the learning environment (Hodges, 2005; Piccoli et al., 2001).

With the advances made in VLEs this study aims to answer the research question: Are VLEs ready for teaching complex subjects? A synchronous hybrid eLearning environment is one where portions of the interaction among the participants takes place virtually in real-time and the format for the course is a mixture of online and in-class instruction.

HYPOTHESES

Time flexibility and learner control are found to be benefits of VLEs (Piccoli et al., 2001), however synchronous VLEs fix the time of delivery, eliminating this advantage. In asynchronous VLEs, the learner has a greater degree of control during the time of instruction; learner control in synchronous VLEs takes on a different form. In synchronous VLEs, the responsibility for learning control is retained by the instructor and the burden of time management is removed from the student. In this type of environment, synchronous interaction maintains the familiar face-to-face classroom environment. The following is therefore hypothesized:

H1: Students in synchronous hybrid eLearning environments will report higher levels of computer self-efficacy than their counterparts in traditional learning environments.

H2: Students in traditional learning environments will report higher levels of satisfaction than students in virtual learning environments.

Piccoli et al., (2001) found that the level of student satisfaction in a VLE for difficult (or unfamiliar) topics like Microsoft Access dropped when compared to familiar topics like Microsoft Word and Microsoft Excel. Brown and Liedholm (2002) found that the students in the virtual course did not perform as well as the students in the live classroom settings and that differences between students in the live and hybrid sections, versus those in the virtual section, were shown to increase with the complexity of the subject matter.

A Systems Analysis and Design course is considered more complex when compared to the Project Management and IT Resource Management courses. Students in non-complex courses are therefore expected to be more satisfied than those in complex courses; this leads to the following hypotheses:

H3: Students in synchronous VLEs with non-complex courses will report higher levels of satisfaction than students in synchronous VLEs with complex courses.

RESEARCH DESIGN

The VLE framework (Piccoli et al., 2001) shown in Figure 1 was used as the theoretical background for the study.

This study was conducted in a large public four-year AACSB-accredited university.

Figure 1. Dimensions and antecedents of VLE effectiveness (Adopted from Piccoli et al., 2001)

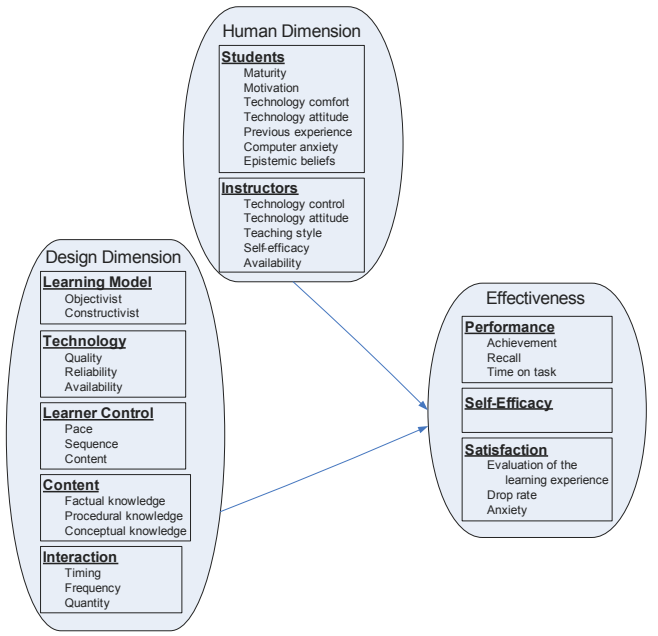

Figure 1: Dimensions and Antecedents of VLE Effectiveness (adopted from Piccoli et al., 2001)

Three courses were examined: first undergraduate System Analysis and Design course using Marratech[1]; second, undergraduate IT Resource Management course using Camtasia Studio[2]; and finally a graduate Project Management course using Marratech. All three classes were supported by a learning management system from WebCT[3].

The requirements for the Systems Analysis and Design course were a term project, a take-home midterm and final exam. Students in the IT Resource Management course were evaluated through case study analyses, oral presentations, career portfolios and term-research papers. Students in the Project Management course were evaluated based on six individual assignments and a simulation project; no exams were administered for the course

RESULTS

Data for the pilot study were collected through and online survey. Sixty three students participating in three courses completed the survey. Thirty percent of the students (19) were graduate students and 70% (44) undergraduates. Forty-four participants were male and 13 female, 6 participants did not provide information about their age. Participants' ages ranged from nineteen to over fifty years.

All respondents indicated that they had computer and internet access from home. Computer experience for participants was reported as 73% professional users; 17% frequent users and 2% reported being somewhat experienced; 3 respondents skipped this question. Eighty nine percent of respondents said they enjoyed working with computers and only 2% indicated that they felt threatened by computers. The majority of the respondents rated their software knowledge as high. On a scale of one to ten, with ten being the highest, respondents rated themselves high for self-efficacy (over 70% of the participants). Satisfaction with the overall class experience was measured on a 5-point Likert scale with 5 being very satisfying; over ninety percent of the respondents from each course reported their satisfaction a 4 or 5.

DISCUSSION

For the purpose of this study students were classified as traditional classroom students or synchronous hybrid eLearning students. The traditional classroom students were those students that attended all in-class sessions (44 students). The synchronous hybrid eLearning students were those students that attended some of the classes in the synchronous hybrid eLearning format (18 students). One student did not provide information.

Each respondent was asked a set of 10 questions on self-efficacy (Piccoli et al., 2001). T-tests were used to determine whether there were significant differences between eLearners and traditional classroom learners. Self-efficacy ratings between the two groups were not found to be significantly different.

The first hypothesis (H1) stated that students who tend to choose the VLE have a higher level of computer self-efficacy. This hypothesis however was not supported by the data, which indicates that the two groups have similar levels of self-efficacy. Further analysis of the data indicates that factors other than self-efficacy determined the students desire to participate in the synchronous hybrid eLearning. Satisfaction responses for the two research groups (synchronous hybrid eLearning and traditional classroom) did not show differences in satisfaction. For both groups, most respondents reported satisfaction with the class as either "somewhat satisfying" or "very satisfying".

The second hypothesis (H2) stated that students in the traditional classroom setting would report higher levels of satisfaction when the subject matter is complex. This hypothesis however, was not supported by the data. The Chi-Square test indicates that these two groups are not significantly different (χ^2=2.714, p=.438).

Responses from the two classes with options for synchronous hybrid eLearning (System Analysis and Design and Project Management) were used to assess the VLE impact on complex courses. The classes for IT Resource Management course were all in-class session so were therefore excluded from this analysis. The System Analysis and Design class required significant collaboration between group members. Students were required to develop complex diagrams and models which required significant interaction between the instructor and team members. In contrast, the Project Management course was lecture based with individual assignments; there were no group projects required for this course.

Responses for satisfaction for the complex (Systems Analysis and Design) and non-complex (Project Management) courses showed that the majority of participants found the courses "somewhat satisfying" (33% for the System Analysis and Design course and 22% for Project Management course) or "very satisfying" (56% and 67% respectively).

The third hypothesis (H3) states that students in a non-complex course will show higher levels of satisfaction than those in a complex course. The survey results do not show support for H3. The Chi-Square test shows no significant difference in satisfaction level between the complex course and non-complex course one (χ^2=2.291, p=.514).

LIMITATIONS OF THE STUDY

The sample size for the synchronous hybrid eLearning group in this pilot study was small and is therefore limited. The collection of additional data to further validate the findings of the study provide a natural extension of the study. The results of this study may also be limited to the specific courses and university examined in this study and may not be generalizable to other environments.

FUTURE RESEARCH

Research still needs to be undertaken for research and practice to gain a clearer understanding of the learning outcomes of synchronous hybrid and asynchronous hybrid eLearning versus traditional classroom environments. Future research on this study includes collecting additional data to increase the sample size to further ground the findings of the pilot study.

CONCLUSION

Synchronous hybrid virtual learning environments were examined in this pilot study. This pilot provides preliminary evidence to support the fact that synchronous hybrid VLEs are ready for teaching complex courses. Prior research using asynchronous VLE found differences in how VLEs support complex and less complex courses, indicating that students who take complex courses in VLEs are less satisfied. Many of the difficulties reported by students in an asynchronous VLE i.e., difficulty managing the high degree of control, feelings of isolation, etc. may be addressed by synchronous VLEs. It is believed that the difference in the

results from this study and prior research emanate from the differences between synchronous and asynchronous VLEs.

REFERENCES

Alavi, M., & Leidner, D. E. (2001). Research commentary: Technology mediated learning - a call for greater depth and breadth of research. *Information Systems Research, 12*(1), 1-10.

Alavi, M., Marakas, G. M., & Yoo, Y. (2002). A comparative study of distributed learning environments on learning outcomes. *Information Systems Research, 13*(4), 404-415.

Brown, B. W., & Liedholm, C. E. (2002). Can web courses replace the classroom in principles of microeconomics? *The American Economic Review, 92*(2), 444-448.

Dagada, R., & Jakovljevic, M. (2004). *'where have all the trainers gone?' e-learning strategies and tools in the corporate training environment.* Paper presented at the 2004 Annual Research Conference of the South African Institute of Computer Scientists and Information Technologists on IT Research in Developing Countires, Stellenbosch, Western Cape, South Africa.

Hodges, C. B. (2005). Self-regulation in web-based courses: A review and the need for research. *The Quarterly Review of Distance Education, 6*(4), 375-383.

McCray, G. E. (2000). The hybrid course: Merging on-line instruction and the traditional classroom. *Information Technology and Management, 1*, 307-327.

Piccoli, G., Ahmad, R., & Ives, B. (2001). Web-based virtual learning environments: A research framework and a preliminary assessment of effectiveness in basic it skills training. *MIS Quarterly, 25*(4), 401-426.

Sauers, D., & Walker, R. C. (2004). A comparison of traditional and technology-assisted instructional methods in the business communication classroom. *Business Communication Quarterly, 67*(4), 430-442.

Seng, L. C., & Al-Hawamdeh, S. (2001). New mode of course delivery for virtual classroom. *Aslib Proceedings, 53*(6), 238-242.

Webb, H. W., Gill, G., & Poe, G. (2005). Teaching with the case method online: Pure versus hybrid approaches. *Decision Sciences Journal of Innovative Education, 3*(2), 223-250.

ENDNOTES

[1] http://www.marratech.com The Marratech system has video, audio, chat, whiteboard, web-browsing, recording and playback features, which provide tools that enable the instructor and students to have real-time interaction.

[2] Camtasia Studio is a product specially designed for recording and publishing presentations and video on the Web and mobile devices.

[3] WebCT is a learning management system that supports online learning environments. URL: http://webct.com/

How Does a Hybrid Device of Training Reinforce the Extrinsic Motivation of Learning Adults?

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1. INTRODUCTION

The literature attached to the "blended learning" has become plethoric over the last few years, and a great number of comparative analyses of the benefits of the two systems (face to face vs. distance education) (Wegner, and *al.*, 1999; Aycock and *al.*, 2002; Ward and LaBranche, 2003). But the motivation of learning was only seldom studied, and in particular the extrinsic motivation (Wlodkowski, 1999). Recent works concerning more specifically adult learning tend to show the crucial role of the hybrid devices on training, placing the emphasis on the redesign of formation, collaborative device, and the redefinition of the tutorial system (Garrison and Kanuka, 2004; Aycock and *al*, 2002). Based on Wlodkowski's motivational dynamics model (1999), we show how a hybrid device can contribute to the motivation of learning, and how capital it is capital to the redesigning of courses. The experiment undertaken by Group ESSCA (Graduate School of Management in France) for an adult public aiming for the ESSCA Continued Education diploma, accounts for the significant impact of the hybrid device on the extrinsic motivation of learning.

2. WHAT IS "BLENDED LEARNING"

In higher education, the emerging tendency to blend Internet technology with the face to face training generated great hopes, but also great doubts. What is the definition of a hybrid education? It is a combination of face-to-face and online media, with "seat time" significantly reduced (Voos, 2003). Smith (2001) describes it as a method which combines technology and traditional education. Garrison and Kanuka (2004) define it as the thinking integration of experiments of face to face training in class, with experiments of training on line. But we have to distinguish the blended learning from the other forms of trainings, i.e. improved classroom on one side, and completely on line experiments on the other side. The real test of hybrid formation is the effective integration of the two major components beyond the simple addition of one to the other. In fact, it is necessary to significantly separate these two approaches (Garrison and Kanuka, 2004). If the use of the term "blended learning" is often associated with the simple link between traditional face-to-face education and asynchronous on line activities, researchers and experts argue today that a hybrid training scheme must combine other dimensions to be able to seem to support the training (Singh, 2003; Ward and LaBranche, 2003; Garrison and Kanuka, 2004; Bielawski, and Metcalf, 2002; Wlodkowski, 1999): for example, to study the articulation between face to face and distance education in course redesign, to benefit from the experiments of others to give value with human capital, to support practices of collaboration and creation, and to give direction via coaching. How can these dimensions be combined to better the motivation of adult learner, and, in particular, their extrinsic motivation?

3. HOW TO COMBINE DIMENSIONS SUPPORTING THE TRAINING

We took as a starting point Wlodkowski's motivational dynamics model on adult learning (1985, 1999); this model differs from the other motivational models applicable to normal educational system (Viau, 2003), not only because the adult learner starts the formation with a specific social status, but also because the divergences are more important with regard to age, marital situation, professional needs, and experience. This model integrates components of intrinsic motivation (which concerns the learner) and those of extrinsic motivation (the organization of the environment of training), on a temporal continuum from the beginning of training to the end.

3.1. To Redesign the Formation

The first track to be explored is the redesign of the formation, the redefinition of the articulation between face to face and distance education. Hybrid formation is not a substitute for face-to-face training (Garrison and Kanika, 2004), but the effective integration of the two components (face to face and Internet technology). We need to redesign and to reorganize the dynamics of teaching and training by starting from needs and specific contingencies of the context: disciplines, level of development, resources (*Ibid*, p. 97). Aycock and *al*, (2002) confirm this trend: "in order to create effective interactivity, full course redesign is essential for successful hybrid courses". Ward and LaBranche (2003) estimate that, in a redesigned hybrid formation, adult learners must profit from more options, from more time, and more freedom to explore their learning; hybrid education must help to overcome one of the limits of face to face: classroom and teacher availability.

3.2. Valuing the Development of Human Capital

What will make the difference "is the conjunction of a multidisciplinary approach and the development of human capital" recognize Bielawski and Metcalf (2002). The hybridization of the formation highlights the active adult learning, with experiment of strategies, better practices, tools, and approaches validated in the professional context. Hybrid formation uses these talents to help the learner to be more creative, more responsible, more effective, and more "team" thinking (Honold, 2001).

3.3. To Develop Collaborative Work

The most recent reforms in education encourage training by the peers, and thus encourage the development of competences linked to the ICT (Deaudelin and Nault, 2003). Collaborative work will allow learners to combine their own interest with the training (Johnson and *al*., 2000). The interaction is characterized by a positive interdependence between the sought for objective and individual responsibility; learners will accept a common objective on which the group will be evaluated, by integrating the individual responsibility for each one (*ibid*, 2000). When adults learn in a collaborative way, they develop relations of support through groups of kind, and different origins. Thus collaborative groups of training create a base (Wlodkowski, 1999, p. 105) on which the training can build and increase comprehension of what is taught through explanations and discussions of multiple prospects.

3.4. To Redefine the Role of the Tutors

The continuous increase in distance and on-line education requires two fundamental types of resources: an adapted design of courses, and a relevant tutorial system (Barker, 2002; Morgado and *al*., 2002; Beyth-Marom and *al*., 2005); on the second point, Barker (2002) recognizes the need to diversify the roles usually allocated to tutors, and to retain varied aptitudes according to the problems: teaching, technical or organisational. In ESSCA Continued Education diploma, the tutorial system will cover different sorts of problems: an administrator-tutor regulates technical problems inherent to the hybrid device; a organizer-tutor high-

lights absences, and establishes the link with the teacher; the motivator-tutor is in charge of the formation, and can manage the interpersonal relations; finally, the facilitator-tutor is the expert (the teacher), present in face to face and a motivating element through the forum.

4. AN EXPERIENCE OF BLENDED LEARNING: ESSCA CONTINUED EDUCATION DIPLOMA

ESSCA delivers a Master after five years of higher education, however, this is also possible through continued education. To answer the requests from companies, more flexibility was introduced into the formation thanks to a hybrid device. Indeed, we offer a 950 hours formation spread out over 18 to 24 months, and including two thirds of time in face-to-face and one third (350 hours remote) as distance learning via a digital campus. The formation has being completely reworked in order to link distance part and presence part dynamically. So, the courses were "redesigned", and divided into competences. Learners are together in periods of face to face two or three days every two or three weeks, after a phase of personal and collective work via the e-campus. The first three groups (2003, 2004, 2005) having completely tried out this device were agreed to carry out a complete assessment of the impact of such a diagram on their process of training.

4.1. Characteristics of the Sample

We identified learners by group, sex, group of age, qualification level at entry, and number of years run out since their initial formation. The 67 learners were divided into 21 from promotion 2003 (graduates 2005), 25 from promotion 2004 (graduates 2006), and 21 from promotion 2005. 74% were men, 61% were between 34 and 49 years old, and 37% less than 34 years; 67% had a higher formation "bac+2" level and 24% "bac+3" level or higher; finally 83% have been out of the state education system for more than 5 years. Learners had to fill out at the end of the formation a questionnaire comprising 21 items, in classroom or by email. The returns of the questionnaires were quasi exhaustive (90%). The questionnaire was divided into 7 groups of items: Identification of promotion, use of ICT, collaboration, management of time and distance, the quality of tasks, the hybrid device, and an assessment of the training.

4.2. First Results and Discussion

From Wlodkowski's model, and during the training, we validate the items:

a. Stimulations. The device proposes solutions to support a reinforced training:
   - A studied design: 93% of adults recognized that the design of hybrid formation helped them,
   - Tools of communication and collaboration ensured a strong link between members, especially during the distance phases: Strong use of forums, emails and chats, but also use of collaborative spaces.
   - A comforting tutorial system: 83% of the learners regarded the assistance as effective in the case of technical or teaching difficulties.

b. Affectivity:
   - Tools of communication and collaboration support the sharing of individual values, and personal objectives (67%); the forum constitutes the primary instrument, were especially for a temporary support in case of difficulties (83%).

From Wlodkowski's model, at the end of the training,

a. Competences. What evaluation a trainee has of his capacity to succeed when uncertainty is considered to be strong? The hybrid device is recognized as being comforting, reducing the fears of the trainees toward the task; thus, on a scale from 1 to 10, the trainees positioned their perception of their capacity to meet this challenge with 6 at the beginning of their formation, and 9 at the end if they were to face a similar challenge in the same way.
b. Reinforcement: the trainees recognized the importance of post-course and post-evaluation feedbacks: it was frequent, fast, and precise, and contributed in helping learning (82%). We also asked the trainees to note each assertion suggested on a scale from 1 to 5, where 5 corresponds to an appreciation "Completely agreed" and 1 to an appreciation "not at all agreed". All the values of T are higher than 2.01 with regard to a sample of size 67 and one alpha 0.05, and consequently, each answer is regarded as statistically significant.

We asked trainees to note each suggested assertion on a scale from 1 to 5, where 5 corresponds to "strongly or very strongly" and 1 to "no change"

5. CONCLUSION

These results have a limited impact due to the sample size and the context, and cannot expect any external validity. The study is currently continuing with promotion 2006, and the first results entirely corroborate the previous study: the redesigned device supports the formation, especially on distance; the tutorial system is omnipresent and effective; the sharing of the different experiences is an enrichment for the group; collaborative work is integrated in daily work, and fully contributes

Table 1. Assertions about the hybrid device

	Average (5 completely agreed ; 1 not at all)	***T-value Significant answer for p=0.05***
The hybrid device, overall, facilitated my training	4.2	6.78
The hybrid device facilitated my comprehension of the main concepts	4.1	7.42
The device helped to develop my interest and my curiosity for other resources outside the system	4.1	5.31
The device allowed a better access to private and professional resources	3.9	3.86
The device supported a better planning of absences, and a better preparation of the courses	3.8	3.73
The device supported an evaluation focused on comprehension, resolution of problems, and synthesis	3.8	4.64
The hybrid device enabled me to better plan my work	3.7	3.45
The hybrid device facilitated my commitment, in particular in collaboration	3.7	3.59
The hybrid device allowed a better adaptation of the workload to my personal constraints	3.7	3.27
The articulation was clear between objectives, methods and evaluations	3.5	4.2
The device encouraged an in-depth approach of the topics	3.4	3.5

Table 2. The hybrid device helped me to reinforce the following capacities

	Average(5 Strongly or very strongly – 1 no change)	***T-value Significant answer for p=0.05***
Ability to manage a project	3.9	4.7
Dialogue and coopération	3.9	5.58
Ability to work in a group	3.9	3.0
Awareness to my Abilities	3.7	2.62
Motivation	3.5	2.74
Perception of my ability to achieve difficult things	3.4	2.61
Ability to resolve a conflict	3.4	2.79
Sense of effort	3.2	2.72
Sense of decision making	3.2	2.72

to supporting motivation over a long period of time, and difficult training. The learner becomes an actor of his formation and not a consumer.

REFERENCES

Aycock, A., Garnham, C., & Katela, R. (2002). Lessons Learned from the Hybrid Course Project. *Teaching with Technology Today, 8*(6).

Barker, P. (2002). Skill sets for online teaching. *In Proceedings of World Conference on Educational Multimedia Hypermedia & Telecommunications,* Denver, 24-29 June 2002.

Beyth-Marom, R., Saporta, K. & Caspi, A. (2005). Synchronous vs. Asynchronous tutorials: Factors affecting students' preference and choice. *Journal of Research on Technology in Education, 37*(3), 245-262.

Bielawski, L. & Metcalf, D. (2002). *Blended eLearning*. HRD Press.

Deaudelin, C, & Nault, T. (2003). *Collaborer pour apprendre et faire comprendre*. Québec : Presses de l'Université du Québec.

Garrison, D.R. &Kanuka, H. (2004). Blended Learning: Uncovering its transformative potential in higher education. *Internet and Higher Education, 7*, 95-105.

Honold, L. (2001). *Developing Employers who love to Learn*. Davies-Black Publishing.

Johnson, D. W., Johnson, R. T. & Stanne, M.B. (2000). *Cooperative Learning Methods: A Meta-Analysis*. Minneapolis: Cooperative Learning Center, University de Minneasota.

Morgado, E.M., Yonezawa, W. & Nicolau, R. (2002). Exploring distance learning environments: A proposal for model catagorization. *In proceedings of International Academy for Information Management Conférence (IAIM)*, Barcelone, Espagne, 13-15 décembre 2003.

Singh, H. (2003). Building Effective Blended Learning Programs. *Educational Technology, 43*(6), 51-54.

Smith, J.M. (2001). *Blended learning: An old friend gets a new name*. GWSAE Network. At http://www.gwsae.org/Executiveupdate/2001/March/blended.htm, accessed 2 july 2005.

Voos, R. (2003). Blended Learning – What is it and where might it take us? *Sloan-C View, 2*(1), 3-5.

Ward, J. & LaBranche, G. (2003). Blended Learning: The Convergence of E-Learning and meetings. *Franchising World, 35*(4), 22-23.

Wegner, S.B., Holloway, K.C., & Garton, E.M. (1999). The Effects of Internet-Based Instruction on Student Learning. *Journal of Asynchronous Learning Networks, 3*(2), 98-106.

Wlodkowski, R. J. (1999). *Enhancing Adult Motivation To Learn*. San Francisco: Jossey-Bass.

Pricing Pervasive Services Using Policy-Based Mechanisms

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ABSTRACT

Network operators using next-generation networks have the potential to service users without pre-existing contractual arrangements. Several research groups are working on ways of developing and implementing that type of interaction with game theory techniques, market-based mechanisms (for example auctions) and techniques based on mesh networks among others. We believe the policy-based network management field provides some excellent ideas that can be borrowed and adapted to the field of ubiquitous or pervasive services pricing. This research-in-progress paper explores the prospects of using policy-based mechanisms to adequately price ubiquitous network services.

1. INTRODUCTION

One of the keys for the success of ubiquitous network services is the issue of assigning prices to those services. Furthermore, ubiquitous services based on a network of complementary technologies, both fixed and wireless, have created the expectation of services that can be obtained dynamically and automatically with the minimum possible of interaction between the users and potentially complex network systems. Intelligent agents would negotiate the best conditions to make sure the user obtains always the best possible connection (Voinov and Valladares, 2003). This best possible connection would be selected by comparing the different services, quality of the services offered, prices and reaching a decision based on the policies the user has configured in her intelligent agent and in conjunction with the policies being presented by the different service providers.

It is clear that, from the technical point of view, the scenario depicted above is feasible. There has been continued progress on the integration of technologies such as WiFi, "Mesh" and "Ad-Hoc" networks with the traditional phone networks and fixed sub-networks based on the TCP/IP family of protocols. Telecommunication companies have exploited the popularity of WiFi "hot spots" as access ramps to their 3G services (Legard 2003). However, there is work to be done in the area of agreeing how to price network services, especially when that "network" is supplied by different organizations and potential users may not have contractual agreements with all the players involved.

The current telecommunications environment, in which virtual operators re-sell network services, in which some firms are customers of a traditional "Telco" while at the same time offering services to many other smaller organizations, forces us to redefine many of the business models that had been used so far. Long term contracts are being challenged by many other arrangements that give more flexibility to the users. These changes, in most cases promoted by users' requirements and further "pushed" by competitive, and innovative, new entrants into the telecommunications arena have resulted on a profound transformation in the way services are acquired and billed. This fact will always clash with the tendency of traditional "Telcos" to keep billing as simple as possible (Meyer, 2003).

2. USING POLICY-BASED TECHNIQUES TO PRICE UBIQUITOUS NETWORK SERVICES

Policies have been used as a means of implementing flexible and adaptive systems for the management of Internet services, distributed and security systems. In the last five years policy-based network management (PBNM) received even more attention due to the fact that policies are considered an enabler of the autonomic networking paradigm (Serrano et al., 2006).

As defined in Sloman (1994), policies are rules governing the behaviour of a system. As in any rule-based system, one of the major issues is the detection and resolution of the conflicts. A policy conflict occurs when the conditions of two or more policy rules that apply to the same set of managed objects are simultaneously satisfied, but the actions of two or more of these policy rules conflict with each other. A model to deal with policy conflicts has been proposed by Baliosian et al. (2004) and has been used in the core of an autonomic networking environment proving to be functionally correct and computationally efficient (Vidales, P. et al. 2005). This approach may be used in our pricing context problem. In fact, a user may have policies to drive her access to the network services, whereas different service providers may also have different pricing policies to promote the use of their respective resources. The final outcome will be the result of solving a likely conflicting situation between the user's policies and the service providers' policies.

A different issue arises considering the policy deployment problem. A policy-based managed system (i.e. a pricing system) may be constituted by many different components and these components need to be driven by different enforceable policies that globally ensure a given system behaviour. Even in systems where only a few tenths of policies need to be deployed it would be almost impossible to design these policies independently and guarantee at the same time global system behaviour. Therefore a procedure, also known as policy generation and refinement, is needed that coming from a high level goal assists the policy designer to systematically derive system enforceable policies. In that area is worthy to mention the work of Rubio et al. (2005) that was later formulated as a holistic refinement approach and validated in a QoS management environment (Rubio, J. et al., 2006). This approach could be clearly adopted for the definition of pricing policies.

From a complementary point of view, pricing policies for a network providing ubiquitous services can then be defined using the policy management paradigm, so that when a potential client "walks" into the coverage area of a provider a basic exchange can inform the client about the active policies for accessing the network facilities. Policies may include price structures (tariffs), security restrictions (who is allowed in), and resource allocation schemes (e.g. bandwidth). The potential client (or an agent on her behalf) would analyze those policies which will be expressed on open format (XML) and standard technologies (such as J2EE and Web services; see Agrawal et al (2005)) and decide whether she would like to use the services.

3. FUTURE WORK

In the context of Next Generation services, is worthy to mention pervasive services for their impact on the final users. Nevertheless, deploying such services requires the convergence of several technologies; among those we highlight policy-based network management and pricing. In principle, the flexibility of the policy-based management paradigm is very promising and makes it a candidate for service management, but in a very dynamic and distributed context, not only in terms of the number of users but also in the environment diversity, as it is the case of generalised computing, is not possible to rely on human managers to undertake updating changes in the bulk of policies used in order to adapt to new services or

devices connected to the network, or to be able to cope with any potential policy conflict. Therefore, it is mandatory to make use of mechanisms, not yet available today, for automatic policy generation and refinement as well as for policy conflict detection and resolution.

On the other hand, deploying ubiquitous services requires that users and providers collaborate in order to assign prices to these services. The key factor in the pricing mechanisms in the context of such services is the dynamic adaptation to the environment (context awareness) and henceforth their temporal evolution as a function of the context. Then, we require pricing models that take into account the services context and particularly the availability of resources in a non-cooperative business model. Also, pricing must consider the mechanisms to make the users aware about the evolution of the current prices.

Our research aims to tackle four challenges related to the above described ideas: To develop an automatic generation model for service management policies intended to deal with a variety of devices and services not known beforehand; To develop a formal method to bring and automatic method for policy conflict detection and resolution; To establish dynamic pricing models to represent the real cost of context-aware services; To propose the necessary mechanisms to ensure that the user is aware of the price evolution and hence he/she can react in consequence.

ACKNOWLEDGMENTS

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REFERENCES

Baliosian, J. and Serrat, J. (2004) Finite State Transducers for Policy Evaluation and Conflict Resolution. *IEEE International Workshop on Policies for Distributed Systems and Networks, pp.250-259*

DaSilva, L.A. (2000). Pricing for QoS-Enabled Networks: A Survey. *IEEE Communications Surveys, Second Quarter*, available at http://www.comsoc.org/pubs/surveys

Gutiérrez, J. (2006). Pricing ubiquitous network services: A survey. In *Encyclopedia of Internet Technologies and Applications*, Mário Freire and Manuela Pereira (Eds). Idea Group publishers. In Press.

Legard, D. (2003). SingTel, NTT DoCoMo tie up to push 3G, IDG News Service.

Meyer, D. (2003). AT&T wireless tries simple rate plans, fewer freebies. *RCR Wireless News, 22(7)*.

Rubio, J. et al. (2005) Using Linear Temporal Model Checking for Goal-Oriented Policy Refinement Frameworks. *IEEE International Workshop on Policies for Distributed Systems and Networks, pp.181-190*

Rubio, J. et al (2006) A Methodological Approach towards the Refinement Problem in Policy-based Management Systems. *IEEE Communication Magazine, October*

Sloman, M. (1994) Policy Driven Management for Distributed Systems . *Journal of Network and Systems Management*, 2:333

Serrano, M. et al. (2006) Policy-Based Management and Context Modelling Contributions for Supporting Services in Autonomic Systems. *Lecture Notes in Computer Science, Vol. 4195/2006, 172-187*

Vidales, P. et al. (2005) Autonomic System for Mobility Support in 4G Networks. *IEEE Journal on Selected Areas in Communications, Vol.23, pp.2288-2304*

Voinov, I. A. and Valladares, T. R. (2003). An enhanced socket interface for next generation systems. In the 1st International Workshop on Wireless, Mobile & Always Best Connected pp. 73–85. University of Strathclyde, Glasgow, UK.

Personal Information Privacy: The World Has Changed

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ABSTRACT

Individuals can no longer manage their own personal information privacy. Rather, corporations and organizational entities with which individuals interact must recognize vulnerabilities and actively manage their data to guarantee known data sharing and to prevent data leakages. A more complete model of consumers' personal information privacy that includes not only data gathering, but also data sharing and data leakage is presented and defended here.

1. INTRODUCTION

Daily, we read of some new data loss of millions of individuals' personal information [1, 17, 32]. As losses amass, the realization that personal information privacy (PIP) is no longer manageable by individuals becomes clearer. Yet, research to date proposes that PIP is the responsibility of individuals' forging contracts with corporations for protection of their data [28], that it is the responsibility of government to protect the individual [29], or the responsibility of corporations to manage internal use [27, 28]. These views are all corporate-centric but threats have expanded beyond the corporation to its data-sharing partners. This shortcoming appears due, in part, to an incomplete view of corporate vulnerabilities. In this research, we build on past privacy research to develop a model of data sharing from the individual to the corporation and from the corporation to its data-sharing partners.

The premise of this research is that the individual-to-corporation link, while still needing research, is well understood. However, what businesses *do* with the data, once collected, is less understood and is becoming more important to privacy maintenance [cf. 1, 32]. Corporations, having spent billions creating secure corporate silos, do not operate in a silo-like vacuum. Rather, corporations routinely share data with business partners and legal entities that in turn, share that data with other organizations. In this data-sharing environment, we develop three types of data sharing *partners* with which corporations interact and the need to actively manage or prevent different types of data access and use. Once the full extent of data movement is understood, it is clear that corporate policies and procedures need extension and regulation to control multi-party access. In the next sections personal information privacy (PIP) research to date is summarized, the expanded model and data supporting it are presented, and suggestions for further research are developed.

2. PERSONAL INFORMATION PRIVACY MODELS

Two distinct periods of PIP research are summarized. Pre-Web maturity research concentrated on organizational data gathering, usage, and access practices, seeking to articulate the issues relating to PIP and organizational data gathering and use. Post--Web maturity research shifted focus to Internet transactions that generate more and different data, use more and different methods of data collection, and have different persistence issues. Through these discussions we argue that the World Wide Web (Web), a new technology 13 short years ago, changed many of the issues relating to PIP and furthermore, the Web and emerging technologies enable new abuses of data that require corporate relationship and data management.

2.1 Personal Privacy Before Web Maturity

Research published before Web capabilities matured had few references to Web information gathering practices [cf. 10, 28]. Much research in the 1990s sought to determine the scope of the privacy problem and how to frame privacy issues [8; 11, 18, 28,]. Privacy, at a minimum, concerns collection, unauthorized secondary use, ownership, accuracy, and access [18, 28].

Culnan & Armstrong's [10] privacy leverage model relates corporate use of consumers' collected personal data to the trust that either leads to retention or defection of customers. Culnan's model demonstrates an understanding of the issues in organizational data collection and use but assumes solid control over all use and also assumes firm's have some policy (whether explicit or not) on PIP protection. Transaction decisions are based on a 'privacy calculus' that is an idiosyncratic trade-off between trust, risk, cost/benefit, and other consumer assessments [2, 3, 10; 14, 20, 24, 25]. Further, this research assumed that 'demographic' and transaction data were the types of data gathered; this is no longer the case.

2.2 Personal Privacy After Web Maturity

Research published after 1998 (when Web transaction technology matured) demonstrates that the Web enables novel methods of obtaining information on individuals, some of which is unrelated to transactions between consumers and corporations. Web privacy issues include where and how information is collected, whether or not the collection is known or unknown by the consumer, trust in the vendor (see Figure 1) [15, 20], the life and breadth of information collected [13], perceived benefits and risks of information sharing [12], methods of storing and using the information and corporate privacy policies [13]. Web purchase transactions research includes consumer, product, medium, merchant, and environment characteristics [2, 3, 5, 6, 13, 14, 15, 19, 20].

The research summarized in Figure 1 addresses part of the transaction chain and tends to omit feedback from a transaction as paramount to future transactions though some research includes feedback [cf. 3, 10]. Omitting feedback implies similarity of evaluation for any transaction with a company whereas evidence supports the notion that every transaction is affected by all past transactions and transactions with other companies as well [21, 22]. There is conceptual confusion on whether the individual's assessment of a potential transaction results in perceived risk or perceived trust, or both [6, 13, 14, 15, 19, 20]. Most research never states what data is collected, or describes a limited domain of data that oversimplifies breadth of data that might be collected [cf. 13, 14, 20].

3. AN EXPANDED MODEL OF INFORMATION PRIVACY

This section builds on past privacy research to present a more complete view of the current state of PIP. The expanded model of information privacy has as its basis, the past research on how an individual, the 1st party, comes to transact with a company, the 2nd party vendor/provider (5, 10). Each unshaded box in Figure 2 and the arrows depicting the relationships between them represent areas in which significant research has already been conducted and incorporates the bodies of work summarized in (10) and (5). Part of the individual's decision includes what data to provide to the 2nd party based on the expected life and use of that data, perceived reasonableness of the data collected, expected benefits, and expectations of corporate use of the collected data (9). These new concepts are in Figure 2. The shaded boxes and arrows depicting their interrelationships represent areas in which little or no research has been published.

The type of data requested leads the consumer to draw conclusions about the perceived reasonableness of data being collected. Perceived reasonableness of data is a new construct in the decision calculus that arises from corporate use of smart technologies that can surreptitiously collect such data as click streams, personal movements, food and medicine usage, genetic markers, DNA, health, or other biological data, and criminal, genealogical, or financial history [9]. The decision calculus results in an assessment of trust and risk, to either consummate or cancel the transaction and, if consummated, which data to share and the sharing duration.

Figure 1. Summary model of Web transaction issues (Adapted from 5)

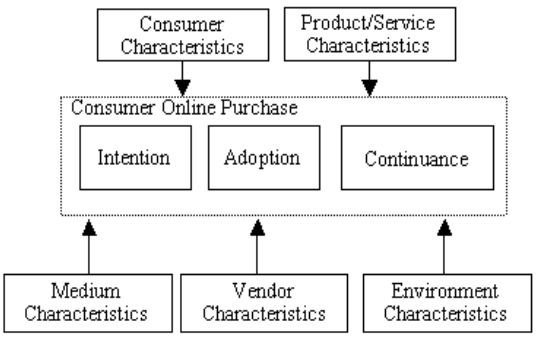
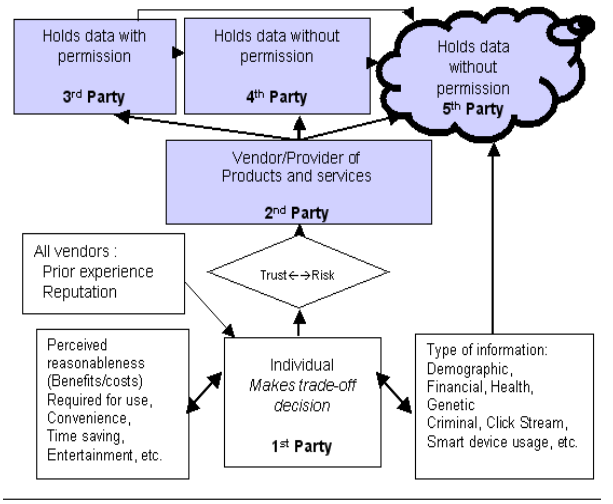


Figure 2. Expanded privacy model (Adapted from 9)



Data may be collected before; during, or after an actual business transaction and the data collection may be known or unknown by the consumer. Combined with other transactional and post-transactional data, this data enables the building of a consumption profile for a family that could affect their insurance or medical coverage. Combined with the other purchase information, a decision profile for the household might be developed and used for discrimination [9].

Consumers appear ignorant of corporate privacy policies and rely heavily on organizations that vouch for the trustworthiness of the vendor (20). The proposed model incorporates real policies and procedures (P&P), perceptions of those P&P, and indications of trustworthiness on Web or other sites.

After a transaction is complete, the information is shared with any number of legal data-sharing entities, the 3rd-party data user who is a known external data-sharing partner, for example, a credit reporting company such as Experion who shares data with 2nd-party permission. Companies, such as Experion, generate their revenues by matching consumer information to transaction information, profiling consumers, and reselling the expanded information. The Experions of the world are not necessarily the problem unless their use or access to data violates their legal and contractual agreements. The greater vulnerabilities arise from Experion's data sharing partners, the 4th parties.

Third-party organizations resell or provide their information to 4th-party organizations through legal requests. Problems arise when 4th-party partners use data without 1st-party and/or 2nd-party permission. Such partnerships might be governmental pre-emption of data (8) or legitimate data-sharing partners of the 3rd-party who violate the terms of their agreements. There is no actual way for, for instance Experion, to ensure proper use since compliance is self-reported. Further, government cooption of data has come under increasing scrutiny as violating constitutional rights to privacy provisions (32).

The nebulous cloud with fuzzy boundaries identifies the last category: 5th-party data users. This category of 5th-party users, are unintended, unwanted, and often unethical and/or illegal users of vendor data. Fifth-party usage results from non-compliant employee behaviors that result in leakages or from illegal activities. Fifth-party data users obtain data without permission or knowledge of their sources, which may be 1st, 2nd, 3rd or 4th parties (4, 17, 32). People who steal computers and who leak names, addresses, and, e.g., financial information, are in this category (32).

From ChoicePoint's infamous identity theft in February, 2005 through 2006, there have been 438 thefts, hacks, or leakages of consumer information of which 335 organizations reported losses over 181 million individual accounts with social security information (33). The 103 organizations either not reporting or not including SSNs, would approximately double the number of transgressions (33).

4. DISCUSSION AND FUTURE RESEARCH

Leakages of data by corporations and governments, while serious, are only evidence of inadequate or unmanaged policies and procedures. This section discusses research needs to determine both a more accurate scope of these problems and how to obtain equitable, workable solutions.

As much as the individual decision process has been researched, there is no known research on parties three through five, nor is there research on the impacts of data leakages or data sharing, in general. While there is a growing body of research on privacy policies and procedures [e.g., 22, 26], no evaluations to date include the impact on consumer decisions. Sample hypotheses for evaluating companies' data sharing management practices might include the following:

- The extent to which the individual's experience with this company's and other companies' data leakages affects the current decision.
- The impact of vendor policy and procedure management for internal users on actual data access and use, and the related impacts on consumer decisions.
- The impact of vendor policy and procedure management for data sharing with known 3rd-party and 4th-party companies on the consumer's beliefs about the company trustworthiness, and related impacts on consumer decisions.
- The impact of vendor policy and procedure management for preventing data leakages to 5th -party users on consumer beliefs about the company trustworthiness, and related impacts on consumer decisions.

The expanded model of personal information privacy described should become the basis for future PIP research.

5. SUMMARY

The expanded model of personal information privacy builds on past research to address emergent issues relating to heretofore unprecedented information demands of governments, unacknowledged corporate information sharing, and the spate of leakages of information from business organizations. The model describe five type of information users from the original owner to the vendor with which they conduct business transaction, to the data vendor, to legal fourth parties, to illegal fifth parties. Individuals are incapable of managing five sets of relationships. Rather, each vendor collecting any customer information must become responsible for actively managing the same criteria with its data-sharing partners *and* their data-sharing partners. Further, all organizations need to improve their management of data leakages to stem the deluge of data losses.

6. REFERENCES

Available on Request

Towards an Integrated Framework of Project Performance

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ABSTRACT

Successful management of projects is an important value-creating activity for organizations worldwide. Billions of dollars are invested annually in the creation of new systems and processes to ensure some level of sustained competitiveness. These projects are usually assessed based on the "triple constraints" variables; scope, time and cost. This model is championed by the project management (PM) bodies worldwide and is widely adopted within industries. As the project landscape changed over the last couple of decades due to factors such as globalization and increased competitiveness, it has become increasingly evident that this level of assessment is incomplete, as both researchers and practitioners have raised questions. In response, researchers have begun to evaluate alternative measurements of project performance. Despite this trend, the academic literature on alternative performance metrics remains limited. This paper proposes a measurement framework; the Project Performance Scorecard that incorporates information systems (IS) success perspectives and the Balance Scorecard approach. Six dimensions of assessment are proposed: Project Process, Stakeholder, Learning & Innovation, Benefit, Quality and Use perspectives. It is believed that this approach may provide a more cogent perspective on project performance while providing industry analysts with an alternative measurement tool to value project contribution.

Keywords: project; project success; project performance; IS Success; project management; project performance scorecard; balanced scorecard

INTRODUCTION

Projects and the successful management of projects provide strategic benefits to organizations. Trillions of US dollars are invested in information systems (IS) related projects worldwide annually (Seddon et al., 1999). With these significant investments, organizations have a vested interest in the successes of these ventures. Furthermore, it is prudent to have an accurate depiction of the state of project activities and outcome to assist in the strategic management process. Despite this apparent need, there has been a conundrum within the field on the best, most appropriate method to assess the performance of these projects. Empirical studies have unearthed severe problems with of IS projects (Ewusi-Mensah & Przasnyski, 1991; King, 1997; Standish, 1994, 2004) and successful IS projects are quite rare (Agarwal & Rathod, 2006).

The widely cited 1994 Chaos Report revealed that a staggering 84% of IS projects have failed, or are challenged, and only a meager 16% succeed (Standish, 1994). However, there was a slight improvement in 2004 with a 29% success rate (Standish, 2004). These failures have given rise to the perception of a "software crisis" (Duggan, 2004; Glass, 2006). As a consequence, researchers and practitioners moreso have been struggling with providing a remedy for these failed systems. Researchers have contended that there are apparent disparities between research and practice (Glass, 2005, 2006) and have called for a "new theory of project success" (Glass, 1999). This phenomenon presents some interesting questions. *Do these studies depict an accurate picture? Are the current performance measures accurate or sufficient? Will alternative measurements provide a different outlook?*

This paper seeks to address the latter question by providing an integrated framework for measuring project performance, the *Project Performance Scorecard*. This will be achieved through the integration of multiple perspectives of performance measurement, including IS Success models and the Balanced Scorecard. Based on empirical evidence, the "triple constraints" methodology has been widely accepted in practice as the de facto standard for measuring project performance for decades. While there is merit in this approach, projects involve complex and dynamic activities, and evaluation of IS investments is a notoriously difficult area (Fitzgerald, 1998), thus performance criteria needs to take into consideration all aspects of the project (Wateridge, 1998). Additionally, as the dynamism of organizations evolves due to factors such as increased globalization and institutional pressures; questions have been raised as to the sufficiency of this method for the complex and dynamic project process. In an effort to extend the cumulative tradition in project management (PM) research, a multi-dimensional approach is proffered to provide a parsimonious assessment that can be adopted by practitioners.

Several alternatives to the triple constraint methodology have been explored in the literature (Atkinson, 1999; Bryde, 2003, 2005; Morris & Hough, 1987; Nelson, 2005; Wateridge, 1998) yet the adoption in practice is not yet widespread. Additionally, researchers have primarily focused on identifying critical factors for providing some level of assurance in achieving a predetermined level of project performance, e.g. (Cooke-Davies, 2002; Ewusi-Mensah & Przasnyski, 1991). This research therefore adds to the extant literature through the provision of an integrated and cogent perspective grounded in IS theory. The seminal contribution of Delone and McLean (1992) and subsequent studies (DeLone & McLean, 2003; Seddon, 1997; Seddon et al., 1999) are considered a strong theoretical pillars for the *Project Performance Scorecard*. The models posit that service quality, information quality, system quality, information use and user satisfaction are dimensions of IS Success. Empirical evidence supports that these dimensions provide strong theoretical support (Rai et al., 2002). The well cited balanced scorecard presents an approach to measuring organizational performance (Kaplan & Norton, 1993). It is aimed at providing a comprehensive view of the performance of the organization through four perspectives: financial, customer, business process and learning. One can therefore conjecture that these models may be used as the basis for evaluating IS projects.

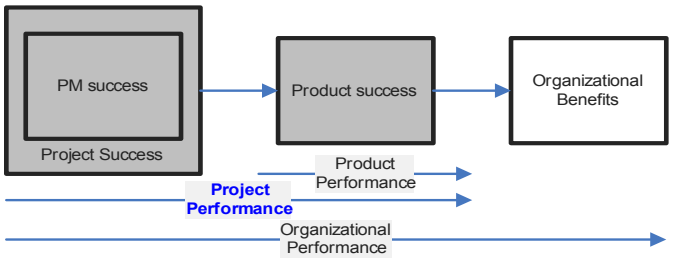
Performance measurement involves the processes of assessing the progress against predetermined objectives (Bourne et al., 2003). Project performance can therefore be considered as the process by which the project progress is measured against predetermined objectives to determine "success" or "failure" of which the triple constraints methodology is the standard. Atkinson (1999) suggested that it is time to move on from time, cost and quality criteria of success due to its limitations. Despite this advice, empirical evidence suggests that the triple constraint assessment is largely adopted by PM bodies such as Project Management Institute (PMI) and Association of Project Management (APM). The evaluation, more so the accurate evaluation of project performance is of strategic importance; according to (Ewusi-Mensah & Przasnyski, 1991), evaluating information systems is increasingly becoming a major concern among senior management.

The perspectives of project success are briefly discussed in the following section as it is important to understand success in order to provide an accurate view of performance. This is followed by a summary of the literature on project performance/success along with the perspectives on performance/success criteria. The exploratory framework, the *Project Performance Scorecard* is then explicated to provide an alternative integrated measurement tool and the paper ends with some concluding remarks including research limitations and research directions and implications.

DEFINING PROJECT SUCCESS

Projects bring about change and project management (PM) is seen as the most efficient way of managing these changes (APM, 2006). The management of projects ranges from unstructured to highly structured initiatives. The inclusion of PM best practices provides credence to the structure and organization of the projects managed by organizations. Project is defined by the PMI as *a temporary endeavor*

Figure 1. Project performance



undertaken to achieve a unique product, service or result (PMI, 2004), or a *unique, transient endeavors undertaken to achieve a desired outcome* (APM, 2006). PM is therefore defined as *the process by which projects are defined, planned, monitored, controlled and delivered such that the agreed benefits are realized* (APM, 2006) and *the application of knowledge, skills, tools and techniques to project activities to meet project requirements* (PMI, 2004).

The realization of these project benefits or requirements is necessary for the achievement of strategic objectives. There is very little agreement in previous studies as to what really constitutes project success (Shenhar et al., 2001) as researchers have put forward various views on project success. Project success is measured against project objectives while PM success is measured against the triple constraints criteria (Baccarini, 1999; deWit, 1988). Baccarini (1999) further outlined project success as consisting of two components: PM success and product success, where product success is seen as the effects of the project's final product. The divergence in perspectives has resulted in a lack of consistent definition of project success, it is therefore uncommon to present both processes as a single homogenous group (Baccarini, 1999).

It is apparent that there are three distinct processes that are considered in the project success discourse; *PM success, project success and product success*. (Wateridge, 1998) suggests that there is need to address the process and the outcome in assessing project success. The paper's interpretation supports the perspective the processes are intrinsically linked and considers that project success may be seen as an outcome of PM success. This complex interrelationship culminates into product success and organizational benefits over time (see figure1). Thus, project performance is based on PM success (*measured against PM objectives, inclusive of triple constraints*) and project success (*measured against overall project stakeholders objectives*) and product success (*measured against the value of the project outcome to the project and client organizations*). Therefore in analyzing this phenomenon the paper will consider the full spectrum of the project performance components.

PERSPECTIVES ON PERFORMANCE CRITERIA

Project being a complex and dynamic endeavor has numerous objectives, therefore criteria for measuring project success must therefore reflect different views (Struckenbruck, 1986). A survey (Sofian, 2003) of 142 respondents confirmed that project stakeholders have various perspectives on project success. The majority agreed that cost, schedule, quality, functionality and customer satisfaction were good assessment of project success. The creation of organizational learning, effectiveness and efficiency performance, and ability to execute changes were other consideration. Similarly (Agarwal & Rathod, 2006) research among software projects found that cost, schedule functionality and quality were important criteria while customer satisfaction, unique priorities being relatively minor considerations.

Several other researchers have formulated perspectives on success and performance criteria with the common theme being triple constraints. Atkinson (1999) suggested that practitioners should try to prevent type II error by moving away from the triple constraints criteria assessment. (Linberg, 1999) suggested that substantial learning which can be applied to future projects was the critical criteria from the developer's perspective. Organizational value, benefit or profitability were also considered (Morris & Hough, 1987; Nelson, 2005; Turner, 1993; Wateridge, 1998). Atkinson (1999) formulated the Square Root model that incorporates Deleone & McLean's IS success factors and organizational and stakeholder benefits. Organizational benefits include improvements in efficiency, effectiveness, profitability and learning. Benefits to stakeholders consider satisfaction of project results, learning impact to environment. (Nelson, 2005) used similar measures with the dimensions being value, use and learning from the project, and suggested that these be a part of the project retrospectives process. (Bryde, 2003) considered the quality perspectives based on the EFQM Excellence model in developing the PMPA, Project Management Performance Assessment. The model includes tools used to measure the level of performance amongst project including leadership, team, policy and strategy, partnerships and resources, KPIs. Additionally, eight quality dimensions should be considered for organizational leveraging; performance, features, reliability, conformance, durability, serviceability, aesthetics, and perceived quality (Garvin, 1987). Especially, for IS projects, these criteria are important in assessing not only the project but the project outcome.

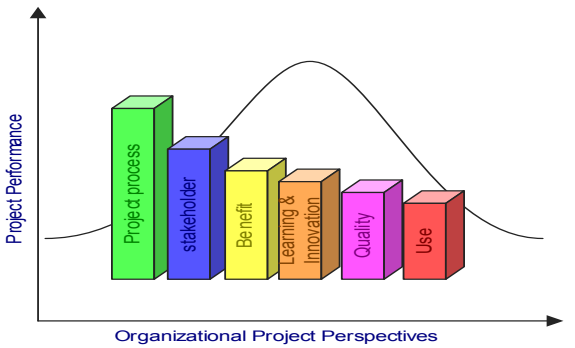
It is widely accepted that IS success is the principal criteria for IS assessments (Rai et al., 2002), with multiple perspectives. Delone & McLean (1992) found through extensive literature review that IS success could be explained by six dimensions: information quality, system quality, information use, user satisfaction, individual and organizational impact. The framework was extended to include service quality (DeLone & McLean, 2003) while Seddon (1997) posits that IS use is a consequence of IS success. Another performance measurement, the balance scorecard posits that the business process, client, financial and learning perspectives are the balanced approached to measuring performance within the organization (Kaplan & Norton, 1993).

PROJECT PERFORMANCE SCORECARD

In extending the literature, an exploratory framework is constructed that is primarily underpinned by IS Success and Balance Scorecard. It is put forward that this approach provides a cogent perspective as it accounts for the complexity and dynamism of projects. The *Project Performance Scorecard* seeks to theorize a perspective that span the realms of the project processes while taking into consideration the expectations of all the stakeholders. Based on the context, each dimension may play greater importance. The six dimensions interact as each has an influence on its counterpart, for example the stakeholder requirements may include quality and usability items. The dimensions are:

1. **Project Process perspectiv**e. Measures indicating key project processes, including triple constraints criteria. The key knowledge areas of integration, scope, time, cost, quality, human resource, communication, risk and procurement management (PMI, 2004) are assessed to measure the extent that they were adopted throughout the project.
2. **Stakeholder perspective**. Measures indicating stakeholders' expectations and objectives. It is essential that project managers obtain consensus from all stakeholders on the criteria for success (Wateridge, 1998). Based on the nature of the projects stakeholders may differ. The major stakeholders include the customer, client/sponsor and project team. The defined expectations, objectives, requirements and specifications are considered against actual outcome.
3. **Benefit perspective**. Benefits indicate the gains or advantages garnered throughout the project process. This involves measures indicating the financial and non-financial performance of the project outcome. Such an assessment may be over a period of time as the results may not be seen immediately.
4. **Learning and Innovation perspective**. Measures indicating project learning from the perspective of the project organization and/or client organization. Additionally incorporating formal and informal knowledge management practices of the project process may provide short and long term benefits to the organization, e.g.(Barclay & Osei-Bryson, 2006). Tiwana (1999) suggests that organization may face additional expenditure and challenges through repeated mistakes. Therefore, it important to manage learning and knowledge in such a way to have it accessible for the current project and future projects
5. **Quality perspective**. Garvin's (1987) discussion on dimensions of quality is applicable within this perspective. Depending on the nature of the project, environmental context and the stakeholders' requirements particular variables may be more applicable than others.
6. **Use perspective**. Measures indicating the use and usability of the project outcome. TAM (Davis, 1989), the seminal adoption model criteria, which also formed the basis of IS success models, are applicable instruments in accessing the performance of projects.

Figure 2. Project performance scorecard



A conceptualization of the six dimensions of the *Project Performance Scorecard* to depict the dynamism of the measurements based on the project and organizational context is shown (see Figure 2).

CONCLUDING REMARKS

The research is at its embryonic stage and is limited in its coverage of other alternative performance measurements. Future research directions involve the extension of the breadth of the study and the inclusion of other domain perspectives to refine the assessment framework. The identification and explication of goals and measures for each dimension are also recommended. Empirical case studies to improve the understanding of the how the *Project Performance Scorecard* will perform under different organizational project contexts and the investigation of alternative measurements under similar contextual framework also offer interesting research.

Possible research direction include two main paths; a consistent taxonomy on project success, and additional project performance metrics that are aligned to organizational strategic objectives. A consistent taxonomy is sought as the PM discipline evolves which will help in providing practical solutions, consistent with Delone & Mclean's (1992) view that if IS research is to make a contribution to practice then well defined measurements are important. Projects differ on various endogenous and exogenous factors such as complexities, purpose, organizational context, skill complement, it is therefore important to consider multiple perspectives and related disciplines to help explain this phenomenon.

Realistic performance measurements and assessments are becoming increasingly important as organizations continue to face internal constraints and institutional pressures. The research asserts that *Project Performance Scorecard* will provide a different outlook on project performance. It is a tangible tool for practitioners to adopt and assist in the management and assessment of their projects. Additionally the research adds to research through the provision of an additional perspective to help measure project performance.

REFERENCES

Agarwal, N., & Rathod, U. (2006). Defining 'success' for software projects: An exploratory revelation. *International Journal of Project Management, 24*(4), 358-370.

APM, A. o. P. M. (2006). *The APM Body of Knowledge* (5th ed.): The Association of Project Management.

Atkinson, R. (1999). Project management: cost, time and quality, two best guesses and a phenomenon, its time to accept other success criteria. *International Journal of Project Management, 17*(6), 337-342.

Baccarini, D. (1999). The Logical Framework Method for Defining Project Success. *Project Management Journal, 30*(4), 25-32.

Barclay, C., & Osei-Bryson, K. M. (2006). *KnowIT: An Exploratory KM Architecture of Caribbean Cricket.* Paper presented at the 37th Annual Meeting of the Decision Sciences Institute, San Antonio, Texas.

Bourne, M., Franco, M., & Wilkes, J. (2003). *Corporate Performance Measurement. Measuring Business Excellence*.

Bryde, D. J. (2003). Modelling Project Management Performance. *International Journal of Quality & Reliability Management, 20*(2), 229-254.

Bryde, D. J. (2005). Methods for Managing Different Perspectives of Project Success. *British Journal of Management, 16*(2), 119-131.

Cooke-Davies, T. (2002). The "real" success factors on projects. *International Journal of Project Management, 20*, 185-190.

Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly, 13*(3), 319-340.

DeLone, W. H., & McLean, E. R. (1992). Information Systems Success: The Quest for the Dependent Variable. *Information Systems Research, 3*(1), 60, 36p.

DeLone, W. H., & McLean, E. R. (2003). The DeLone and McLean Model of Information Systems Success: Ten year update. *Journal of Management Information Systems, 19*(4), 9-30.

deWit, A. (1988). Measurement of project management success. *International Journal of Project Management, 6*(3), 164-170.

Duggan, E. W. (2004). Silver Pellets for Improving Software Quality. *Information Resources Management Journal, 17*(2), 1-21.

Ewusi-Mensah, K., & Przasnyski, Z. H. (1991). On Information Systems Project Abandonment: An Exploratory Study of Organisational Practices. *MIS Quarterly, 15*(1), 67-89.

Fitzgerald, G. (1998). Evaluating Information Systems Project: A multidimensional approach. *Journal of Information Technology, 13*(1), 15-27.

Garvin, D. A. (1987). Competing on the Eight Dimensions of Quality. *Harvard Business Review*, 101-109.

Glass, R. L. (1999). Evolving a New Theory of Project Success. *Communications of the ACM, 42*(11), 17-19.

Glass, R. L. (2005, May - June). IT Failure Rates - 70% or 10-15%. *IEEE Software*.

Glass, R. L. (2006). The Standish Report: Does It Really Describe a Software Crisis? *Communications of the ACM, 49*(8), 15-16.

Kaplan, R. S., & Norton, D. P. (1993). The Balanced Scorecard: Measures That Drive Performance. *Harvard Business Review, 71*(5), 134-.

King, J. (1997). Project Management Ills Cost Businesses Plenty: Poor Planning Kills Projects, Pushes Costs Up. *Computerworld,, 31*(38), 6.

Linberg, K. R. (1999). Software developer perceptions about software project failure: a case study. *journal of Systems & Software, 49*(2-3), 177–192.

Morris, P. W. G., & Hough, G. H. (1987). *The Anatomy of Major Projects: A Study of the Reality of Project Management*: John Wiley & Sons.

Nelson, R. R. (2005). Project Retrospectives: Evaluating Project Success, Failure and Everything in Between. *MIS Quarterly Executive, 4*(3), 361-372.

PMI. (2004). *A Guide to Project Management Body of Knowledge* (3rd ed.): Project Management Institute.

Rai, A., Lang, S. S., & Welker, R. B. (2002). Assessing the Validity of IS Success Models: An Empirical Testand Theoretical Analysis. *Information Systems Research, 13*(1), 50-69.

Seddon, P. B. (1997). A Respecification and Extension of the Delone and McLean Model of IS Success. *Information Systems Research, 8*(3), 240-253.

Seddon, P. B., Staples, S., Patnayakuni, R., & Bowtell, M. (1999). Dimensions of Information Systems Success. *CAIS, 2*(20).

Shenhar, A. J., Dvir, D., Levy, O., & Maltz, A. C. (2001). Project Success: A Multi-dimensional Perspective. *Long Range Planning, 34*, 699-725.

Sofian, A. (2003). *Project Success in Relation with Organizational Roles and Capabilities and Project Managers' Skills and Capabilities* (Survey): PMI.

Standish. (1994). *The Chaos Report*: The Standish Group International.

Standish. (2004). *2004 Third Quarter Research Report*: The Standish Group International.

Struckenbruck, L. (1986). *Who determines project success*. Montreal: PMI Annual Seminar and Symposium.

Tiwana, A. (1999). *Knowledge Management Toolkit, The: Practical Techniques for Building a Knowledge Management System*: Prentice Hall.

Turner, J. R. (1993). *The Handbook of Project-based Management: Improving the Processes for Achieving Strategic Objectives*: McGraw-Hill Book Co.

Wateridge, J. (1998). How can IS/IT projects be measured for success? *International Journal of Project Management, 16*(1), 59-63.

An Approach for Rapid Creation of a Virtual Software Development Team

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Nowadays, companies dealing with software development are often facing problems related to cadre as a consequence of rapid technology changes and varying project requirements. Knowledge of the companies' software engineers is quickly becoming outdated and it is virtually impossible for a single developer to master all the latest technologies and approaches in his field of expertise. Consequently older technologies often remain in use. Yet another difficulty is that cadre requirements of software development companies change from project to project. Frequently, when a new project is commenced additional workforce is required, but after the project is finished these additional employees are not needed anymore.

The usual solution would be to (temporary) employ more people and to additionally educate some of the existing employees. However it is often difficult to find enough people locally that have suitable knowledge and expertise and therefore additional training of new employees is required also. If these additional employees are not needed after the project is finished, educating them only for the needs of a project is a costly solution.

An alternative solution might be to form a virtual team. The main advantage of such solution is that team members can be selected form a large pool of people having appropriate skills and knowledge (Furst, Reeves, Rosen, & Blackburn, 2004). Nevertheless, different problems have been reported that arise in such teams (Johnson, Heimann, & O'Neill, 2001) and many projects relying on a virtual team failed (Furst, Reeves, Rosen, & Blackburn, 2004). The most exposed problems in virtual teams were related to communication (Gould, 1999) and different human factors (Townsend & DeMarie, 1998). Researchers suggest that people working in virtual teams need special social and communication abilities and should be trained to work in such teams (Gibson & Cohen, 2003).

The goal of our research is to create methodological approach that would enable a software development company to instantaneously start an ad hoc virtual team when required. A company should be able to use such virtual team to implement a whole system or only parts of a system. As most of the problems in virtual teams arise due to communication and human factors our aim is to lessen their impact. A backbone of the approach comprises of core system architecture, project management, core development process and human resource management. The purpose of the backbone that is managed centrally is to enable synchronisation of virtual team members.

- **The core system architecture** facilitates construction of the system from relatively small system parts. The backbone of the architecture is a system framework that connects these parts into a functioning system. Each system part is precisely defined by a detailed description of its functions and a definition of its interface. To support such architecture we intend to use existing technologies and architectures like SOA (Erl, 2005).
- **The project management** is modified in a way that it minimises human factor risks. Work is divided into small independent tasks. Each task is defined in a way that it can be executed by a single team member in a relatively short period of time and that its execution is as independent as possible to minimise needs for communication between team members. This way the progress can be monitored precisely and problems detected more easily. To further minimise the risks more critical tasks are assigned to more dependable team members and less critical tasks to new or less dependable team members. Because tasks are relatively small it is also possible to assign highly critical tasks to more than one team member and after two or more developers completed such task only the best solution (system part) is selected for inclusion in the final system.
- **The core development process** gives detailed instructions on how to perform different types of tasks. To lessen communication problems each team member is given only the instructions that are necessary to perform the type of task he was assigned. Furthermore, instructions are adapted to the skills and knowledge of each team member. The adaptation is based on principles of situational method engineering (Brinkkemper, Lyytinen, & Welke, 1996). Program support will be created that will automate the creation of adapted task instructions. It will be based on our existing research (Bajec, Vavpotic, & Krisper).
- The intention of **the human resource management** is to create a large pool of potential team members and to monitor of the performance and skills of current team members. Search for new team members is performed via internet. Recruitment of team members is based on their previous work record, on reported knowledge and skills and on task requirements. We intend to create program support that will automate search for new team members, team members monitoring and recruitment. The automation of human resource management will be based on existing approaches that automate formation and management of virtual teams (Norman et al., 2004), (Suter, 1999), etc. Although these approaches do not focus on software development they bring many interesting ideas in the field of virtual teams' management.

Figure 1 shows the model of the proposed approach.

In our opinion, the proposed approach could offer interesting advantages as it would enable software development companies to quickly assemble a virtual team when additional workforce is needed. It would also minimise the needs for special communication and social abilities of virtual team members, as each member would be given precise instructions on how to perform the task he was assigned and tasks would be as independent as possible. However, we are aware that there are many difficulties that will have to be resolved. The main question is whether it is possible to assemble a functioning system from system parts created by many different developers and there is also the problem of maintenance and efficiency of such system.

So far we have delineated the backbone for the approach and identified its basic properties. In the next step we will detail parts of the backbone and develop the required program support. To test the approach we intend to create an experimental team comprised of university students. The purpose of this test will be to identify weak parts of the approach and to gain experience. The results of the test will enable us to improve the approach. Finally, we plan to test the approach in a real life environment.

REFERENCES

Bajec, M., Vavpotic, D., & Krisper, M. Practice-driven approach for creating project-specific software development methods. *Information and Software Technology, In Press, Corrected Proof*.

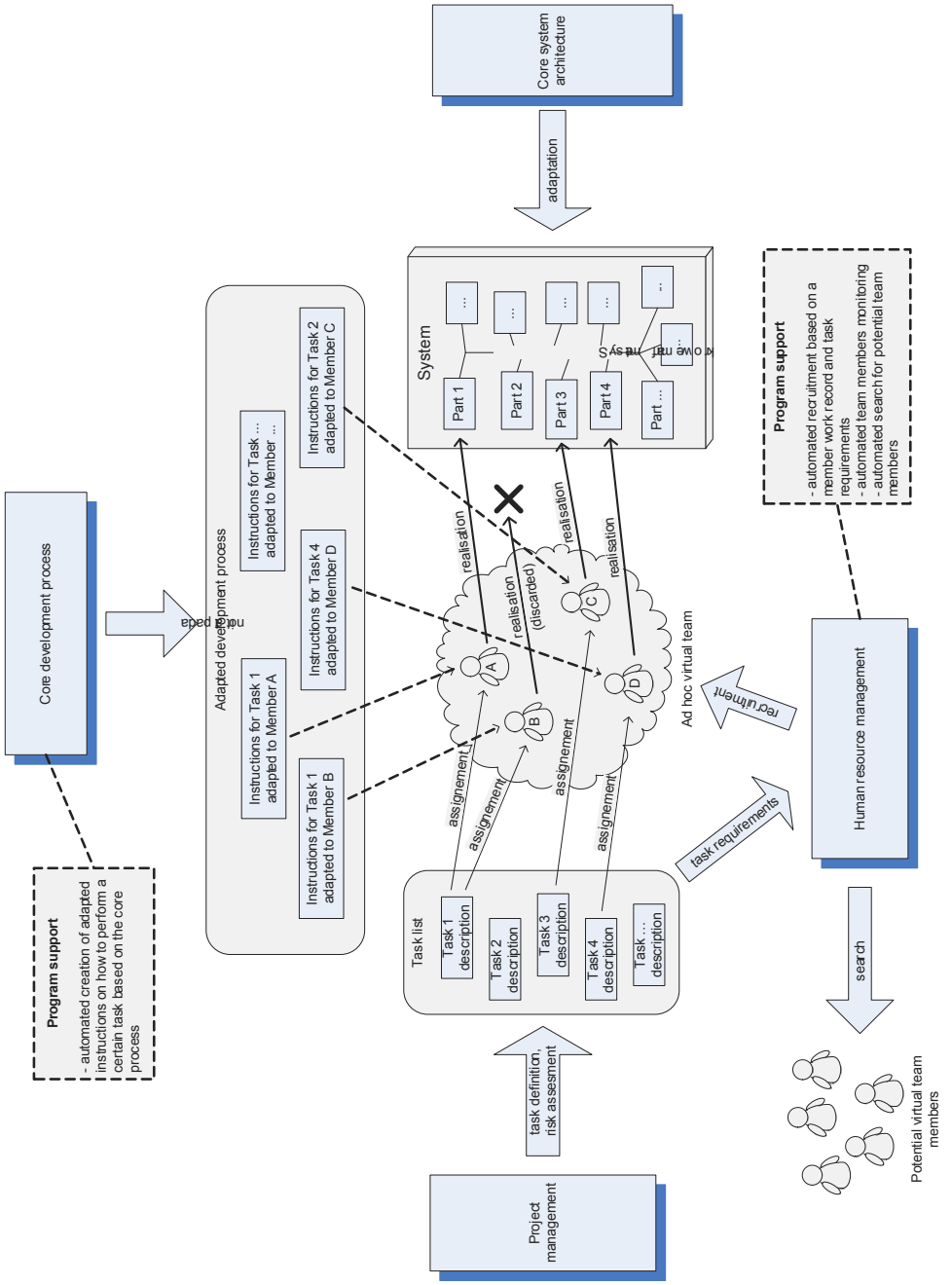
Brinkkemper, S., Lyytinen, K., & Welke, R. J. (Eds.). (1996). *Method Engineering – Principles of method construction and tool support*. Atlanta, USA: Chapman & Hall.

Erl, T. (2005). *Service-oriented architecture : concepts, technology, and design*. Upper Saddle River, N.J. ; London: Prentice Hall Professional Technical Reference.

Furst, S. A., Reeves, M., Rosen, B., & Blackburn, R. S. (2004). Managing the lifecycle of virtual teams. *Academy of Management Executive, 18*(2), 6-20.

Gibson, C. B., & Cohen, S. G. (Eds.). (2003). *Virtual Teams That Work: Creating Conditions for Virtual Team Effectiveness*. San Francisco: Jossey-Bass A Wiley Imprint.

Figure 1: Model of the proposed approach that enables instantaneous formation of a virtual development team



Gould, D. (1999). Virtual organization, Leading Virtual Teams [Electronic Version]. Retrieved 1/4/2007 from http://www.seanet.com/~daveg/ltv.htm.

Johnson, P., Heimann, V., & O'Neill, K. (2001). The "wonderland" of virtual teams. *Journal of Workplace Learning, 13*(1), 24-30.

Norman, T. J., Preece, A., Chalmers, S., Jennings, N. R., Luck, M., Dang, V. D., et al. (2004). Agent-based formation of virtual organisations. *Knowledge-Based Systems, 17*(2-4), 103-111.

Suter, B. (1999). *The VEGA* Cooperation Platform: Providing Real Support for Virtual Enterprises.* Paper presented at the International VoNet - Workshop, Zurich.

Townsend, A., & DeMarie, S. (1998). Virtual teams: technology and the workplace of the future. *Academy of Management Executive, 12*(3), 17-29.

Collaboration Models or What Does It Take for Collaboration to Become a Common Asset?

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1. INTRODUCTION

The topic that is subject to the paper is the standardization and interoperability of Enterprise Architecture Frameworks with respect to cross-border and cross-country trade in selected EU member states. The topic fits into the EU wide initiative of the European Commission to implement electronic customs. The expected outcome is the reduction of the administrative burden for governmental authorities and business partners, the compliance of logical, data and product flows as well as assuring secure trade lanes.

The paper will give in the first part a background to the field of collaboration and its elements. In the second part it will discuss the research area, introducing some research questions and the research methodology.

1.1 Traditional Context of eCommerce Initiatives

Traditionally academic research in collaborative topics started with a specific focus on the individual elements of collaboration. The relevant elements that have been investigated are Enterprise Architecture Frameworks, Business Process Management and eCommerce, namely B2B, as well as eGovernment standardization initiatives.

1.2 Enterprise Architecture Frameworks

Interoperable solutions and standards are in the focus of research since the first introduction of an Enterprise Architecture Framework by Zachman[1]. Since then various different aspects of interoperability and building elements have been added to apply, adopt and promote interoperable enterprise architectures.

One example of interoperable enterprise architectures is HL7[2], conceptualized by Blobel. Another example is the development of the client-server architecture and application standardization, conceptualized and engineered by SAP[3].

Complementing the research of enterprise architectures, the analysis how these frameworks set the ground rules for cross-organizational collaboration is not fully explored yet. Part of the analysis has been carried out in the work of Henriksen (Henriksen, 2002).

1.3 Cross-Organizational Business Process Management and Modelling

This topic focuses on the business process and cross-organizational perspective. Starting with business process re-engineering and the integration of workflow and BPR companies gained deeper understanding of their cross-departmental business processes and enhanced their internal process management capabilities. Having set the ground in a basic understanding of business process management, the cross-organizational perspectives are being extensively discussed in research projects like ATHENA[4] and PICTURE[5].

1.4 Standards and Standardization Efforts

In the arena of standardization efforts, the nature of the research was mainly focusing on individual standards and their usability to companies. With the introduction of marketplaces and the web itself, organizations got an accessible tool that enabled the proliferation of their own business models. Governmental institutions themselves commenced with eCommerce scenarios by publishing information and later forms and documents on the web.

Gathering counterparts and sparing partners from a range of alike companies and industry sectors, standardization organizations and initiatives (for example UN/CEFACT[6], AIAG[7], RosettaNet[8]) evolved the eCommerce commencements by setting ground rules for the composition of standards in their specific business / research field. They allowed companies to contribute to cross-organizational business models and process management by providing standardized processes and / or data schema. Today, we encounter more than 200 standards that are offered in the market.

1.5 Collaboration in Present and Future Perspectives

With respect to global trade, collaboration is a critical success factor where business and governmental institutions meet. Through the entire supply chain, the connected document flow and back-and-forth-approvals there are public process elements, commonly relevant for each of the business partners. They play the role of providing a common denominator to collaborative business scenarios.

Historically, collaboration research analysed the nature of networks (internal and external networks), business as well as cultural relationships. Through the introduction of local networks like the *keiretsu* phenomenon in Japan (Satoshi Hamaya, 2004) eCommerce and collaboration moved towards IT enabled collaborative scenarios for many to many relationships and away from the one to one focus in eCommerce. As *keiretsu* is specifically linked and limited to the Japanese cultural and business environment, the research will introduce the term ecosystem. The ecosystem illustrates participants and contributors in a pre-defined business environment such as the trade environment and their interactions.

2. RESEARCH APPROACH

2.1 Research Problem

The collaboration elements that have been discussed above still leave a (growing) community of business and governmental partners who seek for constant and reliable effects of collaboration beyond the traditional one to one solutions. In the area of electronic customs for example, business and governmental partners are confronted with an increasing demand for secure trade, compliant and accessible data at any time for any business partner participating in trade processes. Today's trade business is also characterized by new business partners entering existing and already collaborating ecosystems.

A substantial effort in proper and necessary business process re-engineering has been made in the past years. They aimed to analyse existing process scenarios, identified potential process breaks and resulted in a number of best practice approaches. One of the major achievements in research is the development of business process re-engineering models and their visualization through modelling techniques. These emerged from the usage of Petri nets, unified modelling language (UML) activity diagrams, business process modelling notation (BPMN), event triggered process chains (EPC), business process execution language (BPEL) to business process modelling language (BPML). Donath among others is introducing the evolvement of these modelling techniques.(Donath, 2006) Another major achievement has been made by integrating process modelling techniques with workflow modelling. (Wittges, 2005)

Proprietary IT solutions and industry standardization facilitate collaboration within industry sectors (MATTHEW L. NELSON, 2005; Sanna Maria Kallioranta, 2002; Sissonen, 2002). These efforts eased the ground of commencing discussions and research on appropriate collaboration (Wittges, 2005).

However, process modellers, IT developers and technical providers as well as business partners still see standards dynamically changing. Various studies and research projects have been conducted on standards and their evolution. They reviewed different aspects such as standards dynamics like in the research project NO-REST[9] under the sixth framework. Studies have been conducted on the evolvement and usability of standards in specific industries, specific scenarios like B2B or B2G and their diffusion (The European e-Business Report 2005, Studie eBusiness-Barometer 2006/2007, Global E-Government Readiness Report 2005, et.al.)(Commission, 2005; Myriam Fricke, 2006; Nation, 2005; NIELS BJØRN-ANDERSEN, 2004).

Due to high investments in IT, skill development and interface development, organizations find it still difficult to manage proprietary standards on the one hand and to limit the restrictions in collaboration caused by proprietary solutions and caused by the smaller number of personnel that is trained and capable to deal with standardization in ICT. Investments however have been made. Business and governmental partners seek a way to build upon their existing software solutions applying proper standard. They envision successfully deployable standards for collaborative business scenarios where companies and governmental institutions are not limited to any lack of skills, IT budgets or time constraints.

The expectation in the market is to overcome any effort that is needed to transform collaboration into a common (accessible, understandable and available) asset. Collaboration should be an out-of-the-box or better built-in-characteristic of any solution being offered in the market.

Accompanying the previous discussion there is a number of research questions that may be formulated:

- *What are the main elements of collaboration in the traditional context? Why is electronic collaboration still not a common asset to support daily business operation?*
- *What are the main factors driving collaboration needs in present and future business operations? How does the content and purpose of collaboration evolve in the context of the ecosystem?*
- *How could we invite technically, content and document wise a new business partner to join a trade ecosystem?*
- *Which standards related to technology, content and documents would the business partner need to apply or adopt to do business?*

2.2 Research Approach

Based on the various angles of collaboration the dissertation will map the research approach to various research methods.

Table 1 describes the main activities

The on-going research, relevant to Phases 2b and 3, is mainly linked to ITAIDE (ITAIDE, 2006) and further activities in Europe focusing on the Living Lab approach as a research method to investigate in ecosystems. ITAIDE is an integrated project funded by the IST 6th Framework Programme of the EU which has been initiated at the beginning of 2006 to address some of the key issues related to cross-border trade. Since I am involved in ITAIDE and the Living Lab approach, I will take the opportunity to carry out the various assessments, interviews and case studies in co-operation with these projects.

Phase 4 will draw assumptions of the key findings of Phase 3. Assumptions derive from three dimensions, the technical, the cultural and the process dimension.

To verify (heuristically) the assumptions, they will be confronted with a set of contradictions. In addition, the assumptions will be applied to future sub-sets of the ecosystem. There is no certainty for example that collaboration based on the UN/CEFACT methodology will not work tomorrow, although past experience (in the sub-sets of the ecosystem) would make such an occurrence seem unlikely. Phase 5 verifies the collaboration approach of UN/CEFACT in additional sub-sets of the ecosystem.

2.3 Research Progress

The following activities are currently carried out:

- Interviews with governmental institutions in the area of global trade and customs processes in the European Union
- Study about the ecosystem for the Finnish paper industry including the involved business and governmental partners and their interactions
- Study about the ecosystem for the Dutch beer manufacturing industry including the involved business and governmental partners and their interactions
- Study about process drivers for cross-organizational business with relevance to global trade, filtering public process views and assessing key performance indicators for successfully conducting customs and trade related processes
- Study about value drivers for each of the individual participants in the ecosystem, starting with small and medium sized enterprises and the customs authorities.

Further accompanying activities are the following:

- A questionnaire to form the basis for structured interviews on both process and value drivers is drafted and currently under review.

Table 1. Overview of research activities

Phases	Research Method	Means	Focus Area
Phase 1	Qualitative Research	• Literature Study • Unstructured and structured Interviews (with experts in the focus areas)	• Evolvement of Enterprise Architecture Frameworks • Business Process Management • eCommerce Development (early stages of collaboration, interoperability and standardization)
Phase 2a	Qualitative Research	• Case Studies	• Ecosystem Trade and sub-sets of the ecosystem throughout the research project
Phase 2b	Qualitative Research	• Literature Study • Unstructured and structured Interviews (with ecosystem participants and contributors in the focus area)	• Ecosystem Trade and sub-sets of the ecosystem throughout the research project
Phase 3	Qualitative Research	• Case Studies applying the collaboration scenario • Scenario study applying the standardization and collaboration methodology (UN/CEFACT)	• Ecosystem Trade and sub-sets of the ecosystem throughout the research project • UN/CEFACT standardization methodology as common denominator for collaboration

- The analysis of the state-of-art literature is an on-going process and will be done in parallel to the activities outlined above.
- Structured interviews are an on-going process. Knowledgeable interview partners are coming from the academic, governmental and business area.

The result from the activities described in this chapter will form the basis for a PhD dissertation concerning collaboration models and the research questions what it takes for collaboration to become a common asset.

3. CONCLUSIONS

Companies and governmental institutions are more and more forced to lower process definition efforts and diminish transaction costs. Time is running and companies as well as their counterparts in governmental authorities are faced with a growing competitive business environment that urges them to dynamically adapt and extend their process models. A research work like this will support both the research community and the European business and governmental ecosystem in introducing on the one hand research techniques to assess complex standardization efforts and to transform that feedback on the other hand into feasible technical, process and academic concepts.

REFERENCES

Commission, E. G., Enterprise & Industry Directorate. (2005). *The European e-Business Report: A portrait of e-business in 10 sectors of the EU economy*. Luxembourg.

Donath, S. (2006). *Aktuelle Techniken für die Geschäftsprozessmodellierung*. Unpublished manuscript, Aachen.

Henriksen, H. Z. (2002). *Performance, Pressures, and Politics: Motivators for Adoption of Interorganizational Information Systems*.Unpublished manuscript, Copenhagen.

ITAIDE. (2006). Information Technology for Adoption and Intelligent Design for E-Government (project nr. 027829). from http://www.itaide.org

MATTHEW L. NELSON, M. J. S., WILLIAM QUALLS. (2005). Interorganizational System Standards Development in Vertical Industries. *Electronic Markets, 15*(4), 15.

Myriam Fricke, W. G. K. G., Wegweiser GmbH; Dr. Axel Pols, BITKOM; Thomas Renner, Fraunhofer IAO. (2006). *Studie eBusiness-Barometer 2006/2007*. Berlin: Wegweiser GmbH.

Nation, U. (2005). *Global E-Government Readiness Report 2005 - From E-Government to E-Inclusion* (No. UNPAN/2005/14): Department of Economic and Social Affairs

Division for Public Administration and Development Management.

NIELS BJØRN-ANDERSEN, K. V. A. (2004). *Diffusion and Impacts of the Internet and E-Commerce: The Case of Denmark*.

Sanna Maria Kallioranta, R. P. V. (2002). *Some Thoughts on eCommerce in the US Paper Industry*.Unpublished manuscript, Baton Rouge, Louisiana.

Satoshi Hamaya, D. T., Koh Yukawa. (2004). *Diffusion and Impacts of the Internet and E-Commerce in Japan*. Irvine: Center for Research on Information Technology and Organizations.

Sissonen, A. (2002). *Wireless Applications Evaluation and Development Process: Case -Paper Industry Logistics*. Unpublished Master, LAPPEENRANTA UNIVERSITY OF TECHNOLOGY, Lappeenranta.

Wittges, H. (2005). *Verbindng von Geschäftsprozessmodellierung und Workflow-Implementierung*. Hohenheim: DUV Dissertation Universität Hohenheim.

ENDNOTES

1 www.zifa.com, http://apps.adcom.uci.edu/EnterpriseArch/Zachman
2 www.hl7.org
3 www.sap.com/germany/solutions/business-suite/erp
4 www.athena.org
5 www.picture-eu.org
6 UN/CEFACT stands for United Nations Centre for Trade Facilitation and Electronic Business.
7 www.AIAG.org
8 www.rosettanet.org
9 www.no-rest.org

Recognizing Constraints on Project Success

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ABSTRACT

The Standish Group (2004) claims only 29% of IT projects are completed on time and on budget, with all features and functions originally specified. The use of a development methodology as long ago as 1970 has been considered critical in project success when building systems, however, the choice of which methodology is best suited for these projects is still under debate (Glass, 2004). This research-in-progress begins to identify the relationships between organization, project, and team variables that lead to project success.

INTRODUCTION

System development methodology was first formalized by Royce in the 1970s (Royce, 1970). It provided a consistent and reproducible approach in the analysis, design and delivery of data processing systems. This complex process was divided into plausible and coherent, linear steps that applied techniques and resources at appropriate times. Boehm (1986, 1988) introduced an iterative approach with the primary focus of reducing project risk associated with long implementation times. Aoyama (1993) documented a parallel methodology where concurrent development focused on the simultaneous execution of multiple processes to shorten cycle time. Agile development models developed most successfully by Beck (1999) had the primary goals of rapid value and responsiveness to change (Boehm & Turner, 2003). However, none of these methodologies is best suited to system development of all information systems, and Web Information Systems appear to demand a different methodology than that which has been used for traditional Information Technology projects (Steinbach & Knight, 2005). This study explores the relationships among a variety of organization, project, and team variables with the goal of better understanding the relationship between these variables, system development methodology, and project success.

METHODOLOGY

The variables to be studied were based on an extensive literature review of existing system development methodologies. These methodologies were analyzed for situations where they were most likely to be beneficial. For example, when there is need for rapid implementation of the project, an iterative methodology may be more suitable than a parallel one. See Steinbach and Knight (2005) for the complete analysis. Using the variables from this analysis, a Web-based explanatory survey was conducted using a purchased, opt-in mailing list purchased from a major Website frequented by information system developers. Respondents were asked to rank qualitative variables related to organization, project, and team variables.

SUMMARY OF RESULTS

One hundred thirty-one self-qualified IT project managers responded from a mailing list of 5,750 for a response rate of 2.29%. The majority of the organizations represented by the respondents were large (greater than 5,000 employees) entities from service, financial and government sectors (*Figures 1 and 2*).

DATA ANALYSIS TO DATE

At this point, ten hypotheses, out of a total of 15 hypotheses in the entire study, have been tested using **the chi square test of independence which measures the strength of associations between variables**. Of these ten, five provided unexpected results and are highlighted by bold type in the list below.

Figure 1

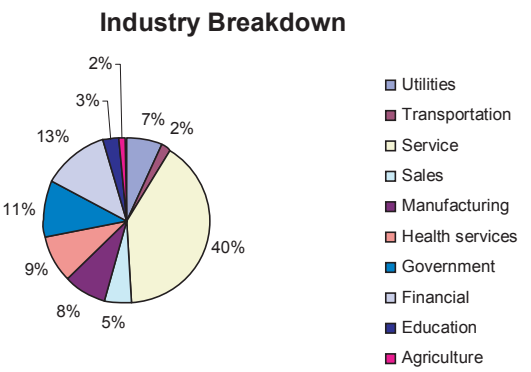
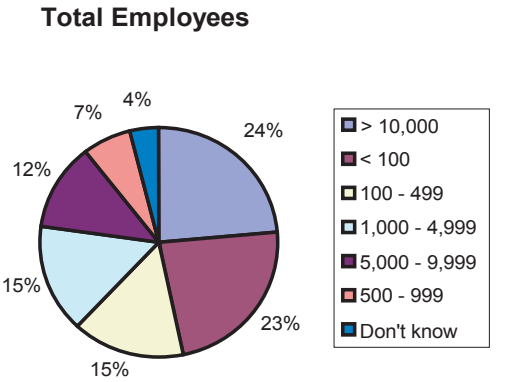


Figure 2



Users' Objectives

H1: *If the users' objectives for the project were clear, the project requirements were clear.* As expected, there is a strong association between the variables.

H2: ***If the users' objectives for the project were clear, the project's users were satisfied.*** There is no association between users' objectives and satisfaction. This is an unexpected result and warrants further discussion.

H3: ***If the users' objectives for the project were clear, project approvals were not required.*** There is no association between users' objectives and approvals. This is an unexpected result and warrants further discussion.

Project Approvals

H4: ***If project approvals were required, the culture in the organization is controlled.*** There is no association between project approvals and the culture in the organization. This is an unexpected result and warrants further discussion.

H5: ***If project approvals were required, the strategy of the organization is clearly defined and committed.*** There is no association between project approvals and the strategy of the organization. This is an unexpected result and warrants further discussion.

Knowledge of Users

H6: *If the users were known to the project's managers, the users' objectives were clear.* As expected, there is a strong association between the variables.

H7: *If the users were known to the project's managers, the project requirements were stable.* As expected, there is a strong association between the variables.

Project Risk

H8: *If project risks were well identified, the project was completed on time.* As expected, there is a strong association between the variables.

H9: *If project risks were well identified, the project was completed within budget.* As expected, there is a strong association between the variables.

H10: ***If project risks were well identified, the project was completed with expected features and functionality.*** There is an association between the variables, but not as strong as expected.

DISCUSSION

Discussion of these results and other results that are analyzed between now and the final paper deadline will be included in the expanded submitted paper.

REFERENCES

Aoyama, M. (1993, July/Aug). Concurrent-Development Process Model. IEEE Software, 10:4, 46-55.

Boehm. B. (1986, August). A Spiral Model of Software Development and Enhancement. ACM SigSoft Software Engineering Notes, 11:4, 21-42.

Boehm, B. (1988, May). A Spiral Model of Software Development and Enhancement. Computer, 61-72.

Glass, R. L. (2004, May). Matching Methodology to Problem Domain. Communications of the ACM, 47:5, 19-21.

Royce, W.W. (1970, August). Managing the development of large software systems: concepts and techniques. Proceedings , WESCON.

Standish Group (2004). 2004 Third Quarter Research Report. Accessed October 1, 2006 from http://www.standishgroup.com/sample_research/PDFpages/q3-spotlight.pdf.

Steinbach, T.A. & Knight, L.V. (2005). System Development for E-Business. In M. Khosrow-Pour, R. Davies, J. Travers, & A.Appicello (Eds.), Encyclopedia of Information Science and Technology (pp. 2712-2718). Hershey, PA: Idea Group Publication.

Business and IT Strategic Alignment and Strategic Use of IT in Small Firms

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ABSTRACT

In businesses large and small, information technology has become an integral part of operation. To compete with large businesses, IT savvy small firms are at an advantage (Beheshti, 2004; Lin, Vassar, & Clark, 1993; Schaefer, 1995). Studies have shown positive impact of IT on small businesses, from helping small firms enhance their operational efficiency (Beheshti, 2004; Penhune, 1998) to driving business growth (Eckhouse, 1998), to integrating marketing operations with marketing strategies (Roge & Chakrabarty, 2002). In addition to the operational and strategic importance of IT, given small businesses' limited financial resources (Small Business Administration, 2000), small firms must invest wisely by making sure that their IT resource allocation properly reflects their business priorities. In other words, they must ensure their IT strategies are inline with their business strategies. This study examines the impact of IT and business strategic alignment in small firms, their business strategic orientations, and owner characteristics on the strategic use of IT.

LITERATURE REVIEW

Information technology strategic alignment is the fit between business strategy and IT strategy (Chan, Huff, Barclay, & Copeland, 1999; Hussin, King, & Cragg, 2002). According to Henderson and Venketraman (1993), strategic alignment involves strategic fit and functional integration. Chan et al., (1999) extended Henderson and Venketraman's work and developed instruments to measure strategic alignment. They studied the impact of strategic alignment on business performance and perceived IS effectiveness. They found that IS strategic alignment was a better predictor of business performance and IS effectiveness than either business strategic orientation or IS strategic orientation. Focusing on small businesses, Bergeron, Raymond, and Rivard (2004) studied 110 firms and found that firms with conflictual coalignment pattern of business strategy, business structure, IT strategy, and IT structure exhibited lower levels of business performance.

IT use in small firms is often characterized as tactical and lacking in sophistication (Bridge & Peel, 1999; Hassan & Tibbits, 2000; Igbaria, Zinatelli, Cragg, & Cavaye, 1997; Lin & Wu, 2004). Temtime, Chinyoka, and Shunda (2003) found that small firms more frequently used microcomputers for operational tasks—such as accounting, payroll, budgeting, production and sales planning, and stock control activities—than for managerial activities such as strategic analysis, investment appraisal, market research, and cash flow and profit forecasting. The tendency of small firms to focus on short-term operational efficiency instead of using IT for business planning, supporting business strategies, monitoring business performance, and improving competitive advantage could be attributed to several factors. Kyobe (2004) compiled a list of factors inhibiting strategic utilization of IT in small firms including lack of top management vision, lack of computer experience/expertise, and poor planning and inability to identify strategic use of IT. Among the inhibitors, management vision and support is clearly an important factor. The importance of management/owner influence is corroborated in studies that show small firms' owners' innovativeness, knowledge and perception of the relative advantage of IT played a critical role in IT adoption decisions (Cragg & King, 1993; Igbaria et al., 1997; Lee & Runge, 2001; Thong &Yap, 1995). The relationship between small firms' IS investment and strategic context was studied by Levy, Powell, and Yetton (2001). They found that small firms' IS use was a reflection of their strategic focus (cost reduction vs. value added) and market positioning (high or low customer dominance).

STUDY FOCUS

The purpose of this study is to examine IT and business strategic alignment in small firms by comparing aligned and not-aligned small firms' IT use, business strategic orientations, and owner characteristics. Specific research questions and hypotheses include the following:

- Do aligned and not-aligned small firms differ in their IT use? Are aligned firms more strategic in their IT use?
  - o H1: Aligned firms use IT for strategic analysis and planning more than non-aligned firms.
- Do aligned and not-aligned firms' owners differ in characteristics? Are aligned firms' owners more knowledgeable in IT? Are they more involved in IT implementation and management?
  - o H2a: Owners of aligned firms are more knowledgeable in IT than their non-aligned counterparts.
  - o H2b: Owners of aligned firms are more involved in IT implementation and management than their non-aligned counterparts.
- Do aligned and not-aligned small firms differ in their business strategic orientations? Are aligned firms more divergent in their business strategies such as focusing beyond cost and quality and on product/service differentiation also?
  - o H3: Aligned firms are more divergent in their business strategies than non-aligned firms.

By comparing characteristics of small firms with aligned and not-aligned IT and business strategies, this study seeks to determine the impact of strategic alignment, owner characteristics, and business strategic orientations on IT use in small firms.

RESEARCH METHOD AND EXPECTED STUDY OUTCOMES

Data for this study is based on input from small business owners (businesses with fewer than 500 employees) in several Midwest states in the U.S. While the study adopts the standard categorization of small-medium enterprises (500 or fewer employees), the survey included a "number of employees" question to aid classification of firms based on firm size in data analysis. The data collection instrument is a two-page questionnaire on the small firm's business and IT strategies, types of IT currently adopted, and business owner's IT knowledge and involvement in IT implementation and management.

To answer the research questions, several statistical analyses will be performed. First, cluster analysis will be used to identify firms with similar strategic alignment. Once clusters have been identified, additional analysis will be carried out to validate the clusters: t-test or analysis of variance will be used to determine whether significant differences exist between/among the clusters in the extent of IT and business strategic alignment of each cluster. Types of IT used and owner characteristics of firms in various clusters will also be compared. In addition, factor analysis will be used to detect existence of underlying dimensions of business strategies employed by small firms; the business strategic orientations of small firms in different clusters will then be compared. Finally, multiple regression analysis will be used to develop models for predicting small firms' strategic IT use based on various independent variables.

Expected findings from this study should enhance current understanding of IT utilization in small firms and its relationship with several variables (including

strategic alignment, owner influence, and business strategic orientation). While IT use in small firms has been a popular research topic, particularly studies that focus on e-commerce adoption in small firms (e.g., Grandon & Pearson, 2003; Martin & Matlay; 2003), this study explores the relationship between business and IT strategic alignment and IT use (including e-commerce), and examines the impact of mediating variables (business strategic orientation and owner characteristics) on strategic IT utilization. Such findings should add to existing literature on IT use in and strategic value of IT for small firms

REFERENCES

Beheshti, H.M. (2004). The impact of IT on SMEs in the United States. *Information Management and Computer Security*, 12(4), 318-327.

Bergeron, F., Raymond, L., & Rivard, S. (2004). Ideal patterns of strategic alignment and business performance. *Information & Management*, 41, 1003-1020.

Bridge, J. & Peel, M. J. (1999). Research note: A study of computer usage and strategic planning in the SME sector. *International Small Business Journal*, 17(4), 82-89.

Chan, Y. E., Huff, S. L., Barclay, D. W., & Copeland, D. G. (1999). Business strategic orientation, information strategic orientation, and strategic alignment. *Information Systems Research*, 8(2), 125-150.

Cragg, P.B., & King. (1993). Small-firm computing: Motivators and inhibitors. *MIS Quarterly*, 17(1), 47-60.

Eckhouse, J. (1998, November). Technology gives edge to smaller businesses. *InformationWeek*, SR2-4.

Grandon, E., & Pearson, J.M. (2003). Strategic value and adoption of electronic commerce: An empirical study of Chilean small and medium businesses. *Journal of Global Information Technology Management*, 6(3), 22-43.

Hassan, H., & Tibbits, H. (2000). Strategic management of Electronic Commerce: An adaptation of the balanced scorecard. *Internet Research: Electronic Networking Applications and Policy*, 10(5), 439-450.

Henderson, J. C., & Venkatraman, N. (1993). Strategic alignment: leveraging information technology for transforming organizations. *IBM Systems Journal*, 38(1), 472-484.

Hussin, H., King, M., & Cragg, P. (2002). It alignment in small firms. *European Journal of Information Systems*, 11, 108-127.

Igbaria, M., Zinatelli, N., Cragg, P., & Cavaye, A. L. (1997). Personal computing acceptance factors in small firms: a structural equation model. *MIS Quarterly*, 279-305.

Kyobe, M. (2004). Investigating the strategic utilization of IT resources in small and medium-sized firms of the Eastern Free State Province. *International Small Business Journal*, 22(2), 131-158.

Lee, J. & Runge, J. (2001). Adoption of information technology in small business: Testing drivers of adoption for entrepreneurs. *Journal of Computer Information Systems*, 42(1), 44-57.

Levy, M., Powell, P., & Yetton, P. (2001). SMEs: Aligning IS and the strategic context. *Journal of Information Technology*, 16, 133-144.

Lin, B., Vassar, J.A. & Clark, L.S. (1993). Information technology strategies for small business. *Journal of Applied Business Research,* 9(2), 25-30.

Lin, F. H., & Wu, J. H. (2004). An empirical study of end-user computing acceptance factors in small and medium enterprises in Taiwan: analyzed by structural equation modeling. *Journal of Computer Information Systems*, 98-108.

Martin, L.M., & Matlay, H. (2003). Innovative use of the Internet in established small firms: The impact of knowledge management and organizational learning in accessing new opportunities. *Qualitative Market Research*, 6(1), 18-26.

Penhune, J. (1998, Fall) A quiet revolution: Technology fuels the entrepreneurial dream. *Forbes*, 12-15.

Roge, J.N. & Chakrabarty, S. (2002/2003). Waiting for the other shoe to drop: Has information technology integrated marketing operations with marketing strategy? *Journal of Computer Information Systems*, 43(2), 16-22.

Schaefer, S. (1995). How information technology is leveling the playing field. *Inc. Technology*, 17(17), 92-95.

Small Business Administration. (2000). The third millennium: small business and entrepreneurship in the 21st century. Retrieved October 3, 2004 from http://www.sba.gov/advo/stats/thirdmill.pdf.

Temtime, Z.T., Chinyoka, S.V., & Shunda, J.P.W. (2003). Toward strategic use of IT in SMEs: A developing country perspective. *Information Management & Computer Security*, 11(5), 230-237.

Thong, J. Y. L., & Yap, C. S. (1995). CEO characteristics, organizational characteristics, and information technology adoption in small businesses. *Omega*, 23(4), 429-442.

The Quality of Human-Centeredness in CRM for SFA

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RESEARCH PROPOSAL

At present relationship marketing is increasingly geared towards the development and utilization of information systems (IS), which sets a new domain of interest also for the viewpoint of human-centered use and development of IS. However, after several years of implementing information technology to support relationship marketing, up to 55% of all Customer Relationship Management (CRM) projects do not produce expected results (Rigby et al. 2002). In CRM success literature one can find several human related factors as potentially affecting a successful CRM implementation. Incentive alignment, resistance, commitment, and the fear for change of power relations are just a few (Wikström 2005; Fjermestad and Romano 2003; Ba et al. 2001; Morgan and Inks 2001).

CRM has been defined in many ways. CRM is seen as processes and technologies that support the planning, execution and monitoring of coordinated customer, distributor and influencer interactions through all channels (Wilson et al. 2002). CRM is also defined as any application or initiative designed to help an organization optimize interactions with customers, suppliers, or prospects via one or more touch points for the purpose of acquiring, retaining, or cross-selling customers (Goodhue et al. 2002). In order to manage a relationship with an individual customer, the company must be able to see the relationship with the customer as a whole (Ryals and Payne 2001). Seeing the relationship with the customer as a whole involves all the interactions the customer has with the firm, regardless of the channel the customer uses. In order to achieve the whole view of customer relationships it is necessary to collect, store, and manage data on every interaction with them whether the data comes from a salesperson, a call centre, or the Web.

Ryals and Payne (2001) in their empirical study explicate several barriers to successful implementation of CRM. The human being is intertwined in at least three of these barriers: lack of skills, low awareness of benefits and functional boundaries. An example of the sensitivity of the personal relationship between the human being servicing a customer and the customer herself is depicted in Colgate and Danaher (2000), who show how the customer perceived satisfaction of a personal banker had a significant effect on the overall perceived satisfaction of the company as a whole. Essential from the human perspective in their list of the "four perils of CRM" (Rigby et al. 2002) is the apparent need for changes in an organization to match the chosen customer relationship marketing strategy. This potential need for change affects human beings in as well the sales, marketing as the service organization. The need for change may affect employees' job descriptions, performance measures, compensation systems, and training programs (Rigby et al. 2002).

Chen and Popovich (2003) explore the critical components that can enable (or hinder) the successful implementation of CRM initiatives and introduce a CRM implementation model that integrates the dimensions of people, process, and technology. In the category of "people" the authors note that "implementation of enterprise technology, such as CRM, requires changes to organizational culture". Customer-centric management requires top management commitment and support to CRM throughout the entire CRM implementation. The importance of a project champion is mentioned as a person who can persuade top management for continuous change efforts. In addition to enhancing employee skills and knowledge Chen and Popovich (2003) argue that education boosts motivation and commitment of employees and reduces employee resistance.

The above definitions of CRM explicate some of the most common organizational roles of the human being in the CRM context: as a member of the company's sales or service organization. Sales-oriented CRM applications, (sales force automation (SFA) applications) refer to salespeople's use of computer hardware, software, and telecommunication devices in their selling and/or administrative activities (Morgan and Inks 2001). To be specific, we focus in this study on human beings as users of SFA applications.

According to Zablah et al. (2004) the CRM phenomenon is best conceptualized as "an ongoing process that involves the development and leveraging of market intelligence for the purpose of building and maintaining a profit-maximizing portfolio of customer relationships". Thus, they introduce knowledge and interaction management as the two major sub processes of the CRM macro level process. Therefore, the interaction management process is highly dependent upon the human resources of a firm. In particular, the market intelligence of a salesperson plays an essential role in the process of transferring customer knowledge to the firm's portfolio of customer relationships. The salesperson's capability of understanding human qualities and recognising the factors essential to maintaining customership is the significant micro process establishing market intelligence. Then human qualities should be reflected against a holistic point of view concerning the very nature of the human being. In our holistic view, we draw on philosophical anthropology and the works of John Dewey and Michel Polanyi. We reflect humans in terms of physical, cognitive, emotional, social and cultural modes of being. Human knowledge creation is then seen to occur within two intertwined elements: knowledge and knowing, which include the tacit and explicit dimensions in human action.

We argue that for CRM to be successful a CRM system should be implemented and used in such a way that the users – in our research the salespeople – are empowered, motivated, committed, and willing to utilize the CRM system for knowledge management. In successful CRM culture salespeople gather and store essential information from crucial interaction episodes with their present and potential customers in order to collect into the CRM database information of customers' needs and wants. The tacit knowledge, which salespeople possess, can be made more explicit and thus help the organization to better utilize it. This knowledge may help the company in retaining its present customer relationships and enhance their profitability by enabling more targeted and effective cross-selling and up selling activities.

In our analysis, we take into account definitions of CRM as they arise in related research works, and the implications of the non-instrumental role of the human being (Isomäki 2006) as it appears in diverse application domains of CRM. We argue that research concerning CRM success should focus more on human-centered issues. The central argument is that humans should be understood in a holistic manner to fulfil the demands of human-centredness. Our analysis is carried out with the following aims: 1) to illustrate the importance of human qualities in implementing CRM successfully, 2) to be specific of the nature and delineation of the human qualities in CRM, 3) to explicate the nature of the image of the human being in CRM success, and to make visible the variety and limitations of human-centeredness in CRM.

To establish the concept of human-centeredness within the domain of CRM, we carry out a conceptual analysis (as presented by Järvinen 2001) with a normative orientation that draws on the previous findings of CRM research. In this way our analysis emphasises the utility aspect of the concept of human being in understanding the underlying assumptions rather than representing different interpretations of human-centeredness (cf. Järvinen 2001). Concepts are of utmost importance in theory formulation, since they establish, first, the boundaries that define a theory's domain of interest, second, the key constructs and their relationships within that domain, and third, the values or contents those constructs can take on (Järvinen 2001). To establish sound concepts, it is necessary to carry out conceptual analysis. This is especially important in new emerging domains that draw on earlier research drawing on different disciplines with varying underlying epistemological

and ontological notions. The recent research on CRM applications is a typical example of this kind of new research area in which concepts are applied from one domain to another. We aim to bring to the fore and discuss the nature and qualities of people in CRM theorization, and thus offer new explications of the construct to serve as means for further research and also development of CRM applications. We use the following framework to accomplish the analysis:

Questions/Means	Objectives/ Ends
1) What is the role of the human being in the context of CRM?	1) to clarify the specific role and activities of people in CRM
2) How the notion of the human being appears as a success factor in CRM?	2) to illustrate the importance of human qualities in implementing CRM successfully
3) What is the framework for a holistic view of people in CRM?	3) to be specific of nature and delineation of the human qualities in CRM
4) What are the human qualities present in the previous research on CRM success?	4) to explicate the nature of the image of the human being in CRM success, and to make visible the variety and limitations of human-centeredness in CRM

In our analysis, we set the boundaries that define a theory's domain of interest by first defining the prevailing image of the human being in CRM, and specify the significance of the notion of the human being as a CRM success factor. Further, we establish the framework for outlining the nature of the human being by drawing on a metamodel illustrating what kind of quality assumptions may be connected to humans in the CRM context, and continue by analysing what kind of human qualities there is within the domain of CRM. In this way we explicate the contents that the concept of human-centeredness can take on within this domain.

REFERENCES

Ba S., J. Stallaert and A.B. Whinston, *Research commentary: Introducing a third dimension in information systems design - The case for incentive alignment*, Information Systems Research 12, 3, 225-239, (2001).

Chen, I. J. and Popovich, K., *Understanding customer relationship management – People, process and technology*, Business Process Management Journal, 9, 5, 672-688, (2003).

Colgate, M.R. and Danaher, P.J., *Implementing a customer relationship strategy: The asymmetric impact of poor versus excellent execution*, Journal of the Academy of Marketing Science, 28, 3, 375-387, (2000).

Fjermestad, J. and Romano, N.C. Jr., *Electronic customer relationship management. Revisiting the general principles of usability and resistance - an integrative implementation framework*, Business Process Management Journal, 9, 5, 572-591, (2003).

Goodhue, D.L.; Wixom, B.H.; and Watson, H.J., *Realizing business benefits through CRM: hitting the right target in the right way,* MIS Quarterly Executive, 1, 2, 79-96, (June 2002).

Isomäki, H., *A Non-instrumental Notion of the Human Being for Information Systems*. Paper presented in the Academy of Management Annual Meeting 2006, Organization and Management Theory/New Thinking about Organizational Identity and Identification paper session, August 11-16, Georgia, Atlanta.

Järvinen, P., *On Research Methods*, Opinpajan Kirja, Tampere, Finland, (2001).

Morgan A.J. and Inks, S.A., *Technology and the sales force - Increasing acceptance of sales force automation*, Industrial Marketing Management, 30, 463-472, (2001).

Rigby, D.K.; Reichheld, F.F., and Schefter P., *Avoid the four perils of CRM*, Harvard Business Review, February (2002).

Ryals, L. and Payne, A., *Customer relationship management in financial services: towards information-enabled relationship marketing*, Journal of Strategic Marketing, 9, 3-27, (2001).

Wikström, C-E., *A design science approach to investigating the piloting of customer relationship management.* In the Proceedings of 2006 IRMA International Conference, Washington.

Zablah, A. R., Bellenger, D. N. and Johnston, W. J., *An evaluation of divergent perspectives on customer relationship management: Towards a common understanding of an emerging phenomenon*, Industrial Marketing Management, 33, 475-489, (2004).

Can We Codify Professional Knowledge?

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INTRODUCTION

The management of organizational knowledge has become an issue of immense strategic and economic importance. There are many types of organizational knowledge including administrative, professional, structural and relationship knowledge (Roos and Roos 1997). Here, we will mostly confine ourselves to the issue of *professional knowledge* (PK) which we define as the knowledge required to perform a professional task such as auditing a company, designing a shock absorber or preparing a contract. There has been little research in this area and our understanding of such knowledge is still vague (Haider 2003).

Most of the knowledge management literature is concentrated on the soft techniques of managing knowledge such as KM strategies, knowledge transfer mechanisms, cultural issues etc (Amaravadi 2005). But as IS professionals, it is also incumbent on us to address the issue of technology support. A study of KM practice by the American Council on Productivity concluded that without an information technology model, KM efforts will end up in chaos (Amaravadi & Lee 2005). Most of the available KM technologies provide passive support in the form of ability to store knowledge, but they fall short in retrieval. Query capabilities based on keywords are contingent on entering the correct keywords. In addition, precision and recall could be affected by large volumes that are expected in KM systems. Ontological methods are intended to address this problem, but have several limitations. They are tailored to a particular domain and have limited ability for question answering (Anonymous 2007, Davies et al. 2003). Artificial Intelligence based approaches are more promising in this respect, but here also there are classic stumbling blocks, the most challenging of which is knowledge codification. Codification has been addressed primarily in the context of knowledge-based systems which use rules and frames. The domain models are classified as shallow rather than deep. For example, an expert system for stock selection will be able to explain rules used to select stocks, but will not know the difference between a common stock and a preferred stock. To properly manage PK requires deeper models for which we have to rely on logic or semantic nets. A representation scheme known as AEI-3 to manage administrative knowledge has been proposed in the literature (Amaravadi 2005). In this paper, we will first discuss the nature of PK, introduce AEI-3 and use it as a platform to model professional knowledge.

THE NATURE OF PROFESSIONAL KNOWLEDGE

There is a paucity of literature concerning organizational knowledge and especially more so in the case of professional knowledge. Lacking empirical evidence, we will hypothesize some characteristics based on samples from Luthardt et al. (2005). In their foreword, they state "The American Institute for Chartered Property Casualty Underwriters and the Insurance Institute of America are committed to *expanding the knowledge of professionals* in risk management, insurance, financial services, and related fields through education and research." Thus their comments establish the rationale for using the text as an example of explicit professional knowledge. A few representative samples are illustrated in *Table 1*.

Instances of PK in the insurance domain appear to exhibit one or more of the following characteristics:

a. They elaborate or define the concept as (*item#5)*, The concepts are both *concrete* such as "automobile," "property," and "underwriter" as well as *abstract* such as "loss" "depreciation," and "indemnify" but tend to be predominantly abstract. Abstract concepts are usually defined in terms of other concepts. For example, *mortgaged asset* is defined in terms of *asset.*.
b. They elaborate or define the concept with additional conditions or restrictions,
c. They describe structural relationships (*item#1*).
d. They describe axiomatic, mathematical or logical relationships (*item#4*).
e. They describe abstract and complex relationships such as an obligation to act in a certain way (*item#7*), f) They describe events, actions, objectives or policies.

It is the arbitrary and complex manner in which concepts, relationships and conditions are combined that makes knowledge engineering for PK a daunting task.

KNOWLEDGE ENGINEERING FOR PROFESSIONAL KNOWLEDGE

The objective of the representation is to serve as a foundation to manage professional knowledge. Since visual representations facilitate this task, we are committed to one that has a graphical notation. Additionally, the representation ought to provide sufficient storage mechanism or *expressivity* so that knowledge may be stored and queries, answered (Davies et al. 1993). Here, we will focus only on intensional or conceptual knowledge. The ability to *draw inferences* is a potential ancillary benefit.

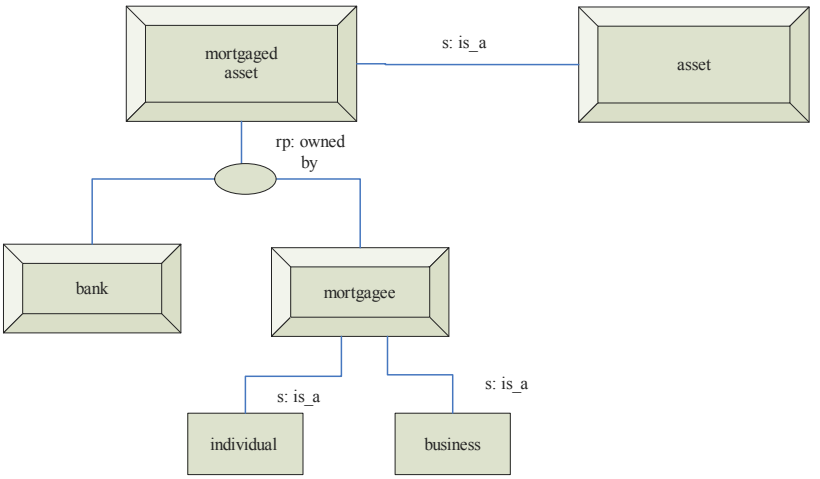
A method to represent administrative knowledge known as AEI-3 was recently proposed. AEI-3 is based on semantic networks and makes use of two node types

Table 1. Samples of professional knowledge (Luthardt et al. 2005)

Item#	Example
1.	Property includes real property and personal property. Real property is land, buildings and other property attached to it. §1.6.
2.	A liability loss exposure is any condition or situation that presents the possibility of a claim alleging legal responsibility of a person or business for injury or damage suffered by another party. §1.6.
3.	Types of insurers include stock insurers, mutual insurers and reciprocal exchanges. §1.11.
4.	Underwriting expenses include acquisition expenses, general expenses, premium taxes and licenses § 3.8
5.	Contingent commission is a commission that an insurer pays, usually annually to an independent agency based on premium volume and profitability of the agency's business with that insurer § 4.15.
6.	Depreciation is allowance for physical wear and tear or technological or economic obsolescence §6.14.
7.	A contract of good faith is an obligation to act in an honest manner and to disclose all relevant facts §7.7.

Note: "§" refers to section numbers, there are no page numbers in the cited reference.

Figure 1. Modeling concepts with AEI-PK



("class," "instance") and two link types ("structural," "descriptive.") to represent administrative knowledge. In this respect, it is similar to protégé a public domain ontological project (anonymous 2007). AEI-3 is designed to represent large volumes of routine knowledge such as "Manugistics is a client of BSS" or "the van leaves BSS at 11:00 am." It overcomes some of the traditional limitations of semantic nets such as tractability, separation of descriptive and structural knowledge and the ability to handle large volumes (Amaravadi 2005) but is a minimalist design owing to the relative simplicity of administrative knowledge. The basic ability echoed in all conceptual models including AEI-3 is to model concepts and relationships. In view of the nature of PK we will impose further requirements on the representation scheme.

Complex concepts such as premium are defined in terms of other concepts such as insurance coverage which may themselves be complex. Therefore it is convenient to refer to such concepts without having to redefine the entire concept, leading to the requirement of *supporting abstractions*. Abstractions support modularity and reuse. Another issue that arises is the *multiplicity* of definitions. A single concept has alternative definitions making this a requirement as well. For example, the value of an asset could be defined by its market value or by its book value. *Relationships* among concepts can be simple (concrete) or complex (abstract). A class-subclass relationship is an example of a simple relationship. Abstract relationships are complex because they are qualitative, involve multiple concepts and involve complex conditions. Thus the second requirement is to model both simple and complex relationships. We will not attempt to model mathematical and logical relationships (>, <) here because they do not lend themselves to visual schemes. Using AEI-3 with enhanced semantics, we will explore the question posed by this research.

AEI-PK

We will refer to our scheme as AEI-PK. Following the discussion from the previous section, the scheme will have constructs to model concepts and associations. Unlike in AEI-3, we do not have classes and instances. Instead we have concepts which are either atomic or complex. The former are depicted by rectangles while the latter by double-walled rectangles. At the present time, there does not seem to be any satisfactory way to demarcate concept boundaries except by drawing dotted lines around it. AEI-3 supported only one type of structural relationship and any number of descriptive relationships. In contrast, AEI-PK has an additional type of structural relationship for "part-subpart" relationships, abbreviated as "p-sp." Instead of descriptive relationships, we have "p:" links to depict properties of a concept and "rel" links to depict non-structural type of relationships. Some properties are required properties. Consider, *the board of directors consists of elected officials*. Here the required property is that officers must be elected. Such properties are depicted by "rp:" link types.

Testing AEI-PK with examples of knowledge indicated that well defined knowledge items are readily modeled. For example a mortgaged asset is defined as an asset for which some percentage is owned by a bank i.e. rest is owned by the mortgage. As shown in Figure 1, *mortgaged asset* is connected by "s:is_a" structural link to *asset*. It has the required condition that it should be partially owned by a bank. There is an "rp: owned by" link between the *mortgaged asset* and *owners* which in this case are both the *bank* and *mortgagee*. Note the use of ellipse for multiple arguments. A more abstract concept such as *insurance coverage* is difficult to represent. *Insurance coverage is the legal obligation of an underwriter to compensate the insured in the event of a loss.* The concept is challenging because it involves a number of abstract concepts such as "legal obligation," "compensate," and "loss." It needs to be represented as three assertions:

Event1: insured suffers loss
Event2: underwriter compensates insured
Axiom: If Event1 then Event2 with the restriction that compensation <= loss amount.

The representation can deal with depicting Events1 and 2 individually, but cannot deal with the idea that Event1, 2 and the axiom together define insurance coverage. It also fails if we have to define conditions. The issue becomes even more important when there are other ideas such as *salvage rights* that require using part of the knowledge about insurance coverage: Event1 with the restriction that it is a property loss and Event 2 and an additional fact that underwriter owns damaged property.

CONCLUSIONS

We have started with AEI-3 and attempted to add additional link types such as "p:" "s:p_sp" "rp:" in order to enhance the semantics. Even with certain simplifications, the modeling task is awkward. The main stumbling block is that abstract ideas are inherently complex and cannot be easily represented. The challenge arises from ideas being defined in terms of other complex ideas and having conditions/relationships, both of which can also be complex and interrelated. It is also difficult to represent PK without mathematical and logical foundations both of which are difficult to achieve in graphical form. The answer to the question posed by the research, "can we codify professional knowledge," is "not yet." Further research is required in understanding the nature of abstract ideas and in expressing conditions.

REFERENCES

Amaravadi, C. S. (2005) "Knowledge Management for Administrative Knowledge," *Expert Systems*, 25 (2), pp 53-61, May.

Amaravadi, C. S., and Lee, I. (2005). "The Dimensions of Process Knowledge," *Knowledge and Process Management Journal*, 12(1), pp 65-76, January.

Davies, J., Fensel, D., Harmelen, F. (2003). Towards the semantic web: Ontology driven Knowledge Management. John Wiley & Sons: Chichester, England.

Davis, R., Shrobe, H., and Szolovits, P. (1993). What is a Knowledge Representation? *AI Magazine*, 14(1), pp. 17-33.

Haider, S., (2003). "Organizational Knowledge Gaps: Concept and Implications," DRUID Summer Conference on "Creating, Sharing and Transferring Knowledge: The Role of Geographical Configurations, Institutional Settings and Organizational Contexts" Copenhagen/Elsinore June 12-14.

Luthardt, C.M., Wiening, E.A. and Frappolli, M.J. (2005). *Property and Liability Insurance Principles*, American Institute for Chartered Property Casualty Underwriters/ Insurance Institute of America Malvern, PA, fourth edition.

Anonymous (2007). The Protégé project. http://protege.stanford.edu/doc/users.html current January 2007.

Sowa, J. F. (2000). *Knowledge Representation: Logical, Philosophical, and Computational Foundations*, Brooks Cole Publishing Co., Pacific Grove, CA.

Roos, G. and Roos, J. (1997). "Measuring Your Company's Intellectual Performance". *Long Range Planning*, 30, pp 413-426.

ERP Contribution to Long-Term Financial Performance and the CIO's Membership in the Top Management Team (TMT)

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ABSTRACT

The difference in the contribution of Enterprise Resource Planning (ERP) systems to financial performance between firms that have a Chief Executive Officer (CIO) in the top management team (TMT) and those without a CIO in the TMT is investigated. A new and robust method to measure this contribution is proposed. Preliminary results showed that the mean contribution of ERP for firms with a CIO in the TMT is higher than those without a CIO but did not show any statistical significance.

INTRODUCTION

Although it is generally believed that the relationship between the CIO and the TMT is an important factor influencing the performance impact of information technology (IT), empirical support for this belief is nonexistent. Since IT has increasingly been an important enabler of business strategies and innovation in organizations (Karahanna and Watson[6]), IT leadership becomes critical especially when implementing and maintaining large-scale ERP systems. The inclusion of IS executive in the TMT might help to make the effective decisions needed to reap the maximum benefits of the technology. According to information Systems (IS) leadership research, the role of CIO is crucial in the assimilation of ERPs through his or her IT and business knowledge (Smaltz, et al.[13]) and also critical in enabling IT to enhance business performance (Karahanna and Watson[6]). However, this suggestion comes more from anecdotal cases than from empirical research.

This paper addresses two issues. First, drawing from upper echelons theory, the study argues that CIO in the TMT significantly influences the contribution of the ERP to long-term business performance. Second, a robust and innovative method to measure such contribution is proposed.

LITERATURE REVIEW AND RESEARCH HYPOTHESIS

Several studies have investigated the ERP impact on organizational performance (Hunton, et al.[4], Nicolaou[9]). These studies have examined important organizational factors such as financial health, firm size, industry, number of ERP modules, vendor choice. However, the influence of the CIO on the ERP contribution to business performance has not been researched.

The effect of top management support on ERP implementation has been consistently found to be one of the most critical ERP implementation success factors (Nah, et al.[8]). In addition, the close CEO-CIO relationship is key to get top management support to IT initiatives (Jarvenpaa and Ives[5]). On the other hand, the upper echelons perspective views the organization's actions and outcomes as reflections of its top managers (Hambrick and Mason[2]). Thus, we believe that composition of the TMT influences the extent of top management support on the level of ERP contribution to business performance. TMTs with more technological savvy should be more effective on resource allocation, ERP implementation, and post-implementation. Thus, those TMTs with a CIO might help make the assimilation of ERP systems more effective. Accordingly, the following hypothesis is proposed:

H1: organizations whose CIO is a member of the TMT will experience a higher ERP contribution to business performance than organizations whose CIO is not included in the TMT.

METHODOLOGY

Data Collection

Firms that already implemented any type of enterprise system in the period between 1995 and 2001 will be identified through media announcements using wired news from Lexis Nexis. Annual financial information for each firm will be pulled from Compustat. The composition of the TMT will be examined using the ExecutiveComp database, which includes the highest top five executives..

ANALYSIS

Previous research has used both market (Hayes, et al.[3], Ranganathan and Brown[12]) and accounting metrics (Hunton, et al.[4], Nicolaou[9], Poston and Grabski[11]) to measure the extent to which the ERP contributes to business value. However, few of these studies have controlled for important factors such as firm performance and industry. The studies that have used accounting metrics simply compare financial ratios before and after the ERP was adopted.

This study investigates the contribution of the ERP in two steps. First, an expected financial performance of the firm will be computed at the year t+3, being t the year when the firm finished the ERP implementation. The ERP business value literature has suggested that the ERP benefits are more likely to be observed after two or three years after the implementation (Poston and Grabski[11]). This estimate will be based on both past firm performance and past performance of companies from the same industry and similar size. To do this, regression analysis using a composite score based on accounting fundamentals (Lev and Thiagarajan[7]) for t and t-1 will be used. The dependent variable will be the financial performance at t+3 measured by return on assets (ROA). The method to compute this composite score will be the F-score version of Piotroski (2000) (see Appendix A). Components of this score include annual improvements of firm profitability, financial leverage, and inventory turnover. The F-score measure has been found to be significantly associated with future firm performance (Piotroski[10]).

In order to control for firm size, industry and industry tendency, the following regression model is proposed for each firm in the sample:

$$ROA(i)(j, t+3) = \beta o(i) + \beta 1(i) * FScore(i), (j, t) + \beta 2(i) * FScore(i)(j, t-1) + \varepsilon(j)$$

Where:

ROA i (i, t+3) = ROA of firm j from the sub-sample i at t+3; t= year of implementation
FScore (i), (j, t) = F-Score at t for firm j from the sub-sample i
FScore (i), (j, t-1) = F-Score at t-1 for firm j from the sub-sample i
i = [1.. N]
N = Number of firms

To compute the β parameters for the regression function i, one sub-sample composed of firms that are similar to the firm i in terms of size and industry will be extracted from Compustat, which is consistent with previous research that have used the matching sample method (Barber and Lyon[1]).The error term of the function i, which is the difference between the actual future ROA and the predicted future ROA, will be the ERP contribution to performance for firm i.

Finally, an ANOVA analysis will be performed to test which group has higher ERP contribution to long-term financial performance.

PRELIMINARY RESULTS

The following results are based on the period from 1995 to 1999. Descriptive sample statistics are shown in Table 1.

From 276 announcements, public firms with a CIO right after the implementation were reduced to 16. A matching sample of 16 cases was selected out of the remaining firms considering firm size, industry, and number of modules implemented. With these 32 cases, 32 sub-samples where constructed. Then, regression analysis was performed to calculate the ERP contribution to business performance using the error term of the regression for each sub-sample. Table 2 describes the mean differences between two groups.

Although the mean of ERP contribution for firms with CIO is higher than those without a CIO, this difference was not significant. We believe that it might be due to the small sample size. Once we include announcements from year 2000 to 2001, we can validate our findings.

To further explore this result, we did another analysis using all firms without CIO and those without a CIO.

We can see that the mean of ERP contribution for firms with CIO was still greater than those firms without a CIO. This might be a sign of a possible significance difference once we finalize the analysis.

EXPECTED CONTRIBUTION

This study will contribute to the IS leadership research by extending upper echelons theory to the context of ERP systems. Results will shed some light about whether CIO in TMT can influence ERP contribution to financial performance. In addition, the study will contribute to the IT business value literature by providing a robust methodology to measure the financial impact of ERP systems that might be generalizable to other types of large-scale IT systems.

APPENDIX A. CONSTRUCTION OF F-SCORE.

Piotroski (2000) considers nine accounting fundamentals posited to capture annual differences in firm's profitability, financial leverage/liquidity and operational efficiency. The profitability fundamentals are ROA, cash flow from operations, change in ROA and accruals (Earnings – CFO). All variables are scaled by beginning of the year total assets. The financial leverage/liquidity variables are long-term debt to average total asset ratio, current assets to current liabilities ratio, and equity. The operational efficiency fundamentals are gross margin ratio and current year inventory turnover. For each component, if there is an improvement from one year to another, it is assign 1, and 0 otherwise. The composite score is the sum of these binary variables. FScore can range from 0 to 9.

REFERENCES

[1] Barber, B. M. and Lyon, J. D. "Detecting abnormal operating performance: the empirical power and specification of test statistics," *Journal of Financial Economics*, Vol. 41, Number 3, 1996, pp. 359-399.

Table 1. Number of ES implementation announcements

	1991-1995	1996	1997	1998	1999	Total
# ES implementation announcements	24	20	30	55	147	276
# announcements related to public firms	5	5	19	33	88	150
# announcements of public firms with a CIO in the TMT during 1993-2005	2	1	8	6	18	35
# announcements of public firms with a CIO right after the year of the implementation	0	0	3	3	10	16

Table 2. Mean difference statistics using a matching sample

	N	Mean of ERP contribution	Std. Deviation	Significance of mean differences	
Without CIO	9	-0.00445	0.04837	t-value	-0.4
With CIO	11	0.01891	0.17633	Significance	0.71

Table 3. Mean difference statistics using all public firms

	N	Mean of ERP contribution	Std. Deviation	Significance of mean differences	
Without CIO	63	.00139	.11710	t-value	-0.42
With CIO	11	.01891	.17633	Significance	0.67

Note: the sample size was reduced due to lack of data in Compustat

[2] Hambrick, D. C. and Mason, P. A. "Upper echelons: the organizationa as a reflection of its top managers," *Academy of Management Review*, Vol. 9, Number 2, 1984, pp. 193-206.

[3] Hayes, D., C., Hunton, J., E and Reck, J., L. "Market Reaction to ERP Implementation Announcements," *Journal of Information Systems*, Vol. 15, Number 1, 2001, pp. 3-18.

[4] Hunton, J., E, Lippincott, B. and Reck, J., L. "Enterprise resource planning systems: comparing firm performance of adopters and nonadopters," *International Journal of Accounting Information Systems*, Vol. 4, Number 2003, pp. 165-184.

[5] Jarvenpaa, S. L. and Ives, B. "Executive involvement and participation in the management of information technology," *MIS Quarterly*, Vol. 15, Number 2, 1991, pp. 205-227.

[6] Karahanna, E. and Watson, R. T. "Information Systems Leadership," *IEEE Transactions on Engineering Management*, Vol. 53, Number 2, 2006, pp. 171-176.

[7] Lev, B. and Thiagarajan, S. R. "Fundamental information analysis," *Journal of Accounting Research*, Vol. 31, Number 1, 1993, pp. 190.

[8] Nah, F. F.-H., Zuckweiler, K. M. and Lee-Shang Lau, J. "ERP Implementation: Chief Information Officers' Perceptions of Critical Success Factors," *International Journal of Human-Computer Interaction*, Vol. 16, Number 1, 2003, pp. 5-18.

[9] Nicolaou, A., I. "Firm performance effects in relation to the implementation and use of enterprise resource planning systems," *Journal of Information Systems*, Vol. 18, Number 2, 2004, pp. 79-105.

[10] Piotroski, J. "Value investing: the use of historical financial investment information to separate winners from losers," *Journal of Accounting Research*, Vol. 38, Number 1, 2000, pp. 1.

[11] Poston, R. and Grabski, S. "Financial impacts of enterprise resource planning implementations," *International Journal of Accounting Information Systems*, Vol. 2, Number 4, 2001, pp. 271-294.

[12] Ranganathan, C. and Brown, C. V. "ERP investments and the market value of firms: toward an understanding of influencial ERP project variables," *Information Systems Research*, Vol. 17, Number 2, 2006, pp. 145-161.

[13] Smaltz, D. H., Sambamurthy, V. and Agarwal, R. "The antecedents of CIO role effectiveness in organizations: an empirical study in the healthcare sector," *IEEE Transactions on Engineering Management*, Vol. 53, Number 2, 2006, pp. 207-222.

Information Shaping During Data Flows in Professional Kitchen Processes

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1. INTRODUCTION

Organisational knowledge include a documented part – as tools and documents – and a tacit component, which resides in individual skills, understanding and collaborative social arrangements (van Baalen, Bloemhof-Ruwaard, & van Heck 2005). Knowledge is always a result of the interpreter, which depends on the entire previous situation and on its position in a tradition (Winograd & Flores, 1986). When we focus on work practices, actors' social situation and traditional environment are formed in the work place and its community of practice. Knowing is not a stable disposition of actors, but rather an ongoing social accomplishment, constituted and reconstituted as actors engage the world of practice (Orlikowski 2002). Likewise, the community's shared knowledge and beliefs are constantly under construction (van Baalen et al., 2005).

In this paper, we focus on the use of information technology (IT) in a community of practice. The use of technology (or technologies-in-practice) is connected to the actors' experiences of awareness, knowledge, power, motivations, time, circumstances, and the technological artifacts (Orlikowski, 2000). We study the use of data flows in shaping organisational knowledge. The term "data" is used to refer to objective data items which can be documented, such as name or date. "Information" refers to interpreted data; for example, the data of the number of customers becomes information for the one who prepares lunch for them. Furthermore, "knowledge" refers to skilful to do something with information; for example, modifying menus.

The specific case which we focus on is the data flows in professional kitchens. The term professional kitchen is used here in reference to private catering companies, such as restaurants and personnel canteens, or institutional kitchens, such as those of schools, day-care centres and hospitals. The use of IT has reached almost all areas of working life; professional kitchens have been some of the last to exploit it. There is a variety of IT applications available for the needs of professional kitchens, which may be exploited for food production planning and instruction provision purposes: to design recipes and menus, to assess nutritional content, to manage raw material stocks, purchasing and cash register functions, etc. (Tuikkanen, Taskinen, Riihikoski, & Työppönen, 2005; Feinstein, McCool, & Cobanoglu, 2005; Cobanoglu & Heiberger 2003). Technology related trends in the restaurant industry are customer feed-back mechanisms, management of repeated business, management of marketing and service, IT and restaurant operations management, human resource management, (Oronsky & Chathoth 2006), nutritional analysis, cost-control techniques and systems, menu-mix management (Keiser, DeMicco, Cobanoglu, & Grimes 2007), and data mining (Collins, Cobanoglu, , & Malik, 2003).

We study data flows in professional kitchen processes. In this study, the professional kitchen processes were examined in two dimensions: (1) the iterative character of information, which means that information shaping is happened gradually within a repetition process, and (2) those reasons why iterativity is typical for professional kitchens. The current low level of exploiting technology makes professional kitchens an interesting case to study technology shaping in daily practices. Our focus is on how information is built iteratively through kitchen processes. This is partly achieved through planning tasks but is fully accomplished through the practical implementations of food production.

2. CASE: PROFESSIONAL KITCHENS

The practical objective of this study was to provide a holistic picture of data flows relating to the food production processes in Finnish professional kitchens, focusing on practical situations. The empirical information was gathered from professional

Table 1. Differences between the studied professional kitchens

Features of action		Professional kitchens							
		k 1	k 2	k 3	k 4	k 5	k 6	K 7	k 8
Scale	Local				x	x	x	x	x
	Nationwide	x	x	x					
Form of enterprise	Municipal organisation						x		
	Municipal unit					x		x	x
	Business	x	x	x	x				
Line of business	Institutional food service					x	x	x	x
	Profit making business	x	x	x	x				
Type of kitchen	Central kitchen						x	x	x
	Kitchen	x	x	x	x	x			

kitchens and aimed to generalise the results, pointing out those processes and data flows which are shared by all kitchens, and which recur in an identical form in food production planning, implementation and monitoring, thus enabling the formulation of a model at the general level. An additional objective was to establish what information is required to implement the processes in question, what type of information the processes produce, and what type of interactive communication there is between the said processes.

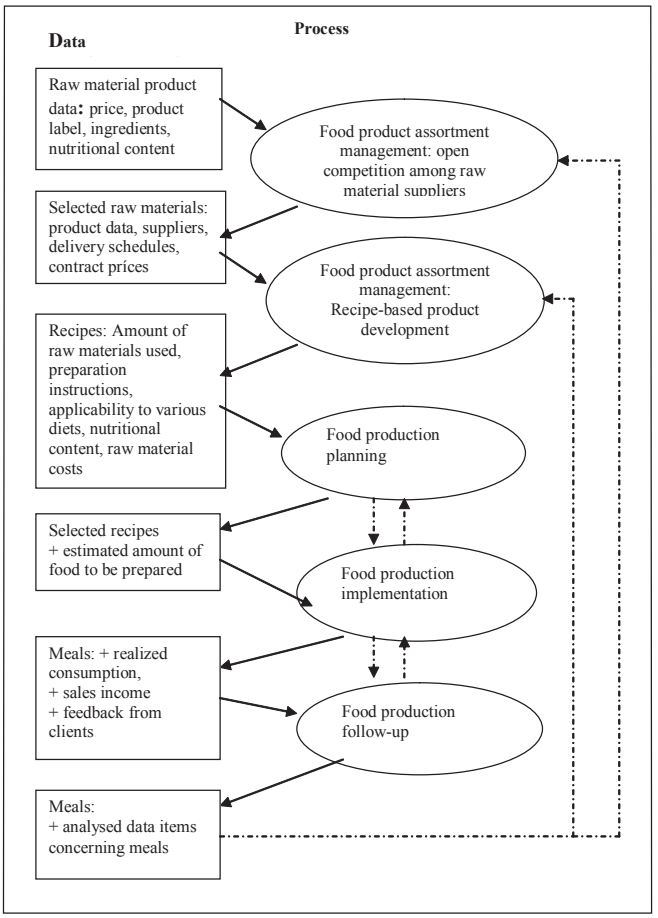
Eight professional kitchens were chosen as research objects, whose food production processes and related data were modelled. The research objects represented networking food service organisations operating in Finland. The research objects were selected so that there are differences between operation scale, form and function of enterprise (see Table 1). Due to their large size and special information management needs, these organisations rely on IT in their information management applications. The research objects consisted of national and local organisations that operate as businesses, municipal business units or municipal organisations. The research objects' kitchens were responsible for food production in personnel canteens, student canteens, restaurant chains, a la carte restaurants, health care institutions or hospitals. A number of these research objects operated as central kitchens, which means that they supplied food to several distribution kitchens. Some prepared meals to be served to their own clients, others combined both functions. On a daily basis, the number of food portions prepared varied from 300 to 7,000.

Empirical material for the study was collected by using theme interviews (based on Kvale 1983). The objective is to describe the kitchen data flows based on practical needs and that the kitchen workers know them in their own work situation. The interview themes were selected from views presented in recent Finnish professional literature on food production processes (Heikkinen 1995, Saarela, Hyvönen, Määttälä, & von Wright, 2005).The interviews focused on the following themes: food production planning, raw material acquisitions and storage, food preparation, food production monitoring, and food-related communication.

The interviewees were selected from among supervisors responsible for planning at the executive level, and food productions supervisors. They were interviewed since they are responsible for the progress of entire food production processes, their comprehensive view of the entire communication process and related information requirements and for their ability to verbally express their views and observations. The research material was collected from the eight research objects through 12 thematic interviews during 2005 -2006 with 17 interviewees. Most studied kitchens had more than one person who was responsible for planning and implementation of food production. Several informants in each of the research objects improve the quality of the interview material (see e.g. Rock 2001). The duration of each interview was approximately 90 minutes.

The analysis aimed to modelling the information flows, process-required information, and process-generated information of various professional kitchen types' food production processes. The modelling language consisted of UML 2 activity diagrams.. Modelling was based on a process division that was applied to the diagrams by the interviewers. Based on these, a maximum number of processes were drafted which the research objects had in common. To achieve a uniform level of abstraction, some processes were combined into higher level functions or divided into lower level functions. Modelling was used as a tool to find out similarities and differences between processes and used information.

Figure 1. The processing and specification of raw material data flow during the food production processes



3. COMPLETION OF THE INFORMATION USED IN PLANNING PROCESSES

Food production operations are usually viewed as series of stages consisting planning, purchasing, storage, production and service (Jones & Lockwood 1995, Saarela et al., 2005; Sivonen & Työppönen 2006). In this study the focus was information related to processes and the main food production processes were generated as: planning of offered food service activities, food product assortment management, food production planning, implementation and follow-up., This study indicates that decentralised kitchens need a large amount of planning work with plenty of information. The planning process was geared towards ensuring the profitability of food production, plus the high quality of food, throughout the organisation, under centralised instruction provision. A typical outcome was that information was edited and specified during the planning process. Planning took place in intertwining periods of varying durations.

The raw material information, as an example of one data flow, was essentially dependent on food production planning, instruction provision, implementation, and follow-up data collected from production. Figure 1 sets out a simplified example of how the various raw material data items are processed and specified during the food production process. The raw material data consists of items that the kitchen receives from various suppliers, for example. The kitchen combines the raw material data items into recipes. The recipe data items undergo changing specifications up until the food preparation moment. The recipes are converted into meals during the food production implementation phase. Following this, the raw material data items constitute a portion of the follow-up data that is collected based on the meals prepared.

4. ITERATIVE CHARACTER OF PLANNING PROCESS

The information obtained is processed and handled in an iterative manner in professional kitchens' food production processes. Some of the information flows reverted to the beginning of the process in a specified form, constituting additional information for the subsequent planning round. During food production implementation, the plans were adjusted in accordance with changing situations and more detailed information (See Figure 1). The kitchens use an iterative approach on two levels: in long-term planning on the one hand, and almost simultaneously during food preparation, on the other hand. The kitchen personnel participate in the food production planning and implementation processes in the capacity of an information provider.

The nature of the food service industry, as a service industry, requires that the production processes are very flexible. Flexibility is needed throughout the food production process. It has to be possible to adjust the production process to fit the changes: e.g. menus have to be modified in cases of customers' feedback and the recipes have to be brought up to date.

5. DISCUSSION

One of the principal findings of this study was that professional kitchens' information flows are built though interaction between people and processes. Process-generated information, people's skills and competence are used to steer the subsequent process cycle, to make the processes increasingly effective in accordance with the clients' needs and requirements. The generation of information flows requires people's skills and competence, as well as their tacit knowledge to a significant degree. These skills and competencies are partly converted into a visible form with the aid of information systems. In addition, the implementation of an iterative food production process requires the use of tacit knowledge, as well as its manifestation into a visible form. Regardless of the fact that the personnel play an important role, they convey their expertise-related knowledge face-to-face to the management, not through the IT systems. Furthermore, it is the supervisor who can decide how to apply the employees' knowledge to the process.

As information technology in kitchens is an almost unexamined area, our study opens several interesting study lines. For example, the focus on financial issues and management of information in professional kitchens requires further research. Besides focusing on hospitality and business issues, studying technology shaping by using professional kitchens as a empirical field, is also promising; for example, a deeper study of technology-in-use by using ethnography and the theory of ICT domestication (Silverstone, Hirsch, & Morley, 1992).

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REFERENCES

van Baalen P., Bloemhof-Ruwaard, J.,, & van Heck , E. (2005). Knowledge sharing in an emerging network of practice: The role of a knowledge portal, *European Management Journal* 23(3):300-314.

Cobanoglu, C.. & Heiberger, L. (2003). Test Driving e-Procurement. *Hospitality Technology*, 6, (2), 19-24.

Collins, G., Cobanoglu, C., & Malik, T. (2003). Hospitality Information Technology: Learning How to Use it. (5th Ed.) Dubuque, IA : Kendall Hunt.

Feinstein, A.H., McCool, A., & Cobanoglu, C. (2005). 7th annual restaurant technology study: Driving Restaurant Productivity. *Hospitality Technology*, 8 (4)

Gefen, D., Karahanna, E., & Straub, D.W. (2003). Trust and TAM in Online Shopping: An Integrated Model. *MIS Quarterly*. 27(1):51-90.

Heikkinen, V. (1995), Tuottava keittiö. Ruokapalveluiden kannattavuuden ja taloudellisuuden parantaminen. SR-julkaisut, Helsinki, Finland.

Jones, P. & Lockwood, A. (1995) Hospitality operating systems. International Journal of Contemporary Hospitality Management. 7 (5): 17-20.

Keiser, J., DeMicco, F., Cobanoglu, C. & Grimes, R., (2007). *Analyzing and Controlling Foodservice Costs, A Managerial & Technology Approach*. (5th Ed) Upper Saddle River, NJ : Prentice Hall.

Kvale, S. (1983). The qualitative research interview - A phenomenological and a hermeuneutical mode of understanding. *Journal of Phenomenological Psychology* 14(2):171-196.

McKnight, HD.,Choudhury, V., & Kacmar, C. (2002). Developing and Validating Trust Measures for e-Commerce: An Integrative Typology, *Information Systems Research,* 13(3).

Orlikowski W. (2000). Using technology and constituting structures: A practice lens for studying technology in organizations, *Organization Science* 11(4):404-428.

Orlikowski W.J. (2002). Knowing in practice: Enacting a collective capability in distributed organizing, *Organization Science* 13(3):249-273.

Oronsky, C.R.,& Chathoth, P. K. (2006) An explatory study examing information technology adaption and implementation in full service restaurant firms. Intrenational Journal of Hospitality Management.

Rock, P. (2001). Symbolic Interactionism and Ethnography, In P. Atkinson, A. Coffey, S. Delamont, J. Lofland, and L. Lofland (Eds.), *Handbook of Ethnography*. SAGE Publications, London, UK, pp. 477-492.

Saarela, A.-M.,Hyvönen, P., Määttälä, S.,& von Wright, A. (2005). Elintarvikeprosessit. Savonia-ammattikorkeakoulun julkaisusarja B 3/2005. Savonia-ammattikorkeakoulu, Kuopio, Finland.

Silverstone, R., Hirsch, E. & Morley, D. (1992). Information and communication technologies and the moral economy of the household. In R. Silverstone and E. Hirsch (eds.) *Consuming Technologies. Media and information in domestic spaces,* pp.15-31. London and New York: Routledge.

Sivonen, S., & Työppönen, K. (2006). Ruokapalvelujen toimintajärjestelmä. Efeko. Helsinki, Finland.

Tuikkanen, R., Taskinen, T.,Riihikoski, J, & Työppönen, K. (2005). IT-järjestelmien hankintaopas ammattikeittiöille. Efeko. Helsinki, Finland.

Winograd, F., &Flores, F. (1986). *Understanding Computers and Cognition: A new Foundation for Design.* Ablex Publishing Corporation, New Jersey.

Management of IT Systems in Primary Health Care (PHC): A Finnish Case Study

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INTRODUCTION

National guidelines in Finland call for nationwide access to electronic patient data by 2007 (1, 2). Most of the technical infrastructure to meet this demand has been implemented, in particular all health care providers (Health Centres) in PHC have utilised electronic patient record (EPR) systems for some time. In addition to the technical infrastructure itself, however, it is also necessary to develop management, support and training required for EPR systems to function as efficiently as possible.

A long term project was started in the Finnish region of South-Ostrobothnia in 2003 to study the impact of EPR systems on availability and flow of information between public PHC and secondary care. As part of this major project, it will also be evaluated how well EPR systems in PHC can meet the needs of general practitioners (GPs) and other health care professionals for specific information. Previous studies have indicated differences in quality of data in EPR systems (3). Previous research has also indicated differences in performance and ranking of patient data for different EPR systems (4).

The focus of this study is to investigate further what reasons govern the performance or utility of EPR's in use in PHC, and in particular to investigate the role of IT management and user training in the overall performance of these systems.

METHOD

This study was conducted in the South-Ostrobothnia region. The total population of the region is 196 000; PHC is provided by 16 Health Centres. Secondary care is provided by Seinäjoki Central Hospital (560 beds) and Ähtäri hospital (28 beds).

In the first phase of this project, GPs from the research group identified all patients who received anticoagulant (AC) treatment on 1st April 2004 from the EPRs of eight Health Centres (population base 132 621). The GPs were requested to access 20 specific types of agreed-on information from patient journals (EPR). This patient group was deemed appropriate for this type of study because the information dealt with is specific and thus relatively easily quantifiable, for instance: start date of treatment, main reason for treatment, Internationalized Normalized Ratio (INR) target level, last INR value. The INR value is an indication of blood coagulation, and thus a important idex that must be determined for patients receiving anticoagulation (AC) treatment.

After analysis of information accessibility from EPR's for this patient group was completed, feedback and discussion sessions were carried out with GPs participating in this study (4). Reports on IT management and staff training practices in the Health Centres were requested initially in a non-structured format. Based on these reports, a more detailed and structured questionnaire compilation has been started. The collection and analysis of this data is currently taking place.

RESULTS

The Health Centres participating in this study used three different types of EPR, with one system being utilised in 5 Health Centres. The EPR systems had been operational for a relatively long time: up to 9 years. The total number of AC treatment patient cases analysed was **2 389**. All of the 20 specific types of agreed-on information requested was available via the EPR for 73% of all the cases, ranging from 52% to 93% for different Health Centres (table 1). There were major differences within individual EPR system performances which did not correlate with the period of use of the system.

It is expected that the additional information currently being gathered from the Health Centres will shed more information on the correlation between data quality and general IT management practices.

DISCUSSION AND CONCLUSIONS

The feedback and discussion sessions conducted with GPs participating in this study indicated that there were few if any purely technical reasons why certain information was or was not available in the EPR. It appears that user behaviour and general aspects of how the IT systems were managed were significant. Factors like number of staff substitutes that were previously untrained in the use of a particular EPR, and the training and delegation of tasks within professional groups seemed to have an impact on how the EPR systems were used and on the quality of data entered in these systems.

Table 1. Accessibility of specific information from EPR for AC treatment patients in 8 Health Centres in South Ostrobothnia, Finland

Health Centre	EPR system	Years in use	Proportion of cases for which all information requested obtained (%)
a	x	2,2	86
b	y	4	55
c	y	4	61
d	y	9	93
e	y	8	71
f	y	7	80
g	x	1,8	74
h	h	6	52

Initial results also indicated that the workflow in all Health Centres might not be optimal for EPR use. This study implies that in addition to the direct expenditure in EPR systems, more emphasis should be placed on IT management, training and "best practices" dissemination.

REFERENCES

1. http://www.stm.fi:80/Resource.phx/publishing/documents/1350/summary_en.htx
2. http://www.stm.fi:80/Resource.phx/publishing/documents/2897/summary_en.htx
3. Thiru K, Hassey A, Sullivan F. Systematic review of scope and quality of electronic patient record data in primary care. *BMJ* 2003; **326**: 1070
4. Mäkelä K, Virjo I, Aho J, Kalliola P, Koivukoski A-M, Kurunmäki H, Kähärä M, Uusitalo L, Valli M, Vuotari V, Ylinen S. Electronic patient record systems and the GP: an evaluation study. Journal of Telemedicine and Telecare, 11: S2: 66-68, 2005.

Component Based IT Software Project Management: A New Paradigm Shift

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ABSTRACT

Component based IT Software Project Management – a new Paradigm Shift is a critical need for Information Technology Software Projects. Can we focus on small individual components which in turn can ensure a smooth and successful project implementation? Can we use these components to build a healthy portfolio or a group of projects? In a project world, the customer is at the core without which a project cannot exist. An organization is the primary component surrounding the core without which there can be no way a project can be executed. Small secondary components which revolve around the primary component and interact and contribute to each other together ensure that they can win the customer delight and contribute to the organizations goals. This paper provides details to these thoughts.

Keywords: Software Project Management, Component based IT Software Project Management, Paradigm Shift, Component, Primary component, Core component, Secondary components)

1. INTRODUCTION

The world is changing at a very rapid pace. With the advancements in Information Technology (IT) and the ever increasing need for IT professionals, constantly increasing project size and complexity, shrinking turnaround times – the focus needs to shift today from handling multiple aspects of Project Management to Component based IT Software Project Management.

By focusing on the individual components of IT Software Project Management, and then ensuring that they feed into and onto each other, we may assure the success of the project. The key here is to handle one component at a time from the perspective of the area of work.

The Project World can be likened to the solar system (Figure 1). There is a single core component, which is the **"Customer" –** can be internal or external. The core component is surrounded by the **primary component** – this primary component is the **"Organization"** which fulfills the requirement(s) of the core.

The primary component is surrounded by the **secondary components** for a project. These secondary components, along with the primary and core component, if built successfully and improved upon, may result in a successful project. The components need to communicate with each other at all times.

Knowledge, Configuration, Defect Prevention, Tools, Technology, System, Business, Events and Project Management are the secondary components.

These components need to complement each other before, during and after that component has been developed in the project.

2. COMPONENT DETAILS

There are three key components when we talk of component based IT software Project Management.

2.1. Core Component

Logical functional grouping governed by a single expert entity which ensures the existence of the project world.

This component (customer) is essential for the very existence of a project.

2.2. Primary Component

Logical functional grouping governed by a single expert entity which can ensure the build of this project world.

Why do we treat organization as the "Primary Component" The secondary components cannot thrive without the primary component. The focus of an organization is to set trends and provide management support for the core and the secondary components.

Without the organization resources, support and willingness, trying to maintain secondary components may not be feasible.

On one hand the organization supports the secondary components and on the other it helps build a shield of confidence around the core component.

Figure 1. Project world – solar system

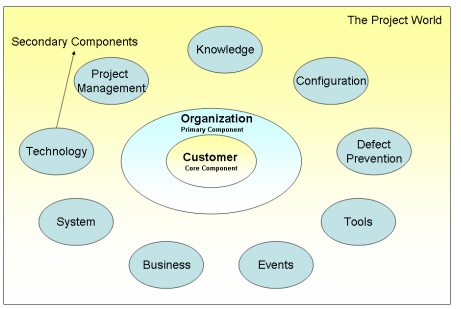
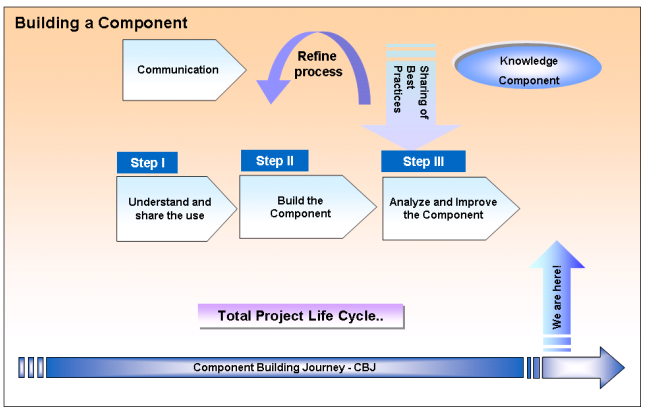


Figure 2. Building a component



The core component ensures that a project is created while the primary component ensures that the project is build. The maturing of the organization component may help in stabilizing and improving the organization.

2.3. Secondary Component

Logical functional grouping of the individual tasks and activities that need an expert entity towards governance.

In any project there are multiple logical functions which need to be performed to attain the final deliverable.

Independent of the nature or the type of the project, the secondary component can be handled by an expert of that area.

As defined in 3.1 of [2] "The main idea of the component-based approach is building systems from pre-existing components"

These components will communicate with each other in one way or the other – with the focus always being on meeting the needs of the primary and the core component and be complimentary to other secondary components.

3. THE BUILDING OF A COMPONENT

Each component is built and made robust by a continuous improvement cycle of Understanding, Building, Analyzing, Improving and Communicating (UBAIC). A failure in successful building of a single component is a potential failure of the project.

The advantage of componentization is an enhanced and committed focus towards a specified area at any given point in time.

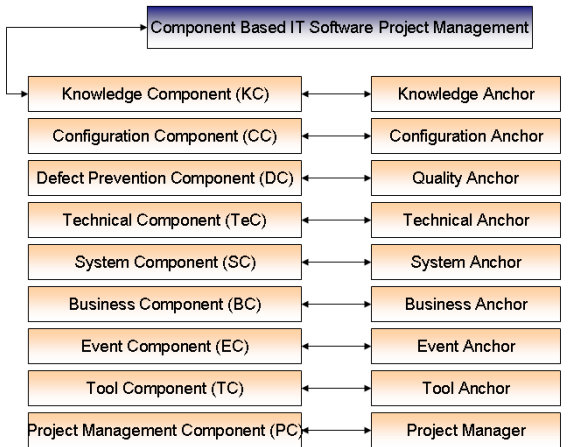
4. APPROACH: GOVERNANCE MODEL

The multiple secondary components can be streamlined in a project by defining a proper structure towards defining and building the individual component (Figure 3). An anchor is identified for each component. The anchor is a person who has expertise and is a Subject Matter Expert in that particular component. One person can play multiple anchorship roles and depending on the nature and size of the project the scope of the component can be defined at the project level. This person can be a member of the existing team or a member outside the current project team as well. This anchorship is vital towards building the component.

The anchor can guide the current project around building and utilizing the component most effectively.

A query is posed in [3] "Would an individual own a component or would a team of engineers own a component?" Our approach is there would be no separate owner but only an anchor. The final owner would be the organization.

Figure 3. Governance model



#	Nature of Project	Size	Secondary Component								
			KC	CC	DC	TeC	SC	BC	EC	TC	PC
1	Maintenance	<6 months	M	M	M	M	M	M	C	C	M
		> 6 months	M	M	M	M	M	M	M	M	M
2	Development	< 6 months	M	M	M	M	M	M	C	C	M
		> 6 months	M	M	M	M	M	M	M	M	M
3	Testing	< 6 months	M	M	M	M	M	M	C	M	M
		> 6 months	M	M	M	M	M	M	M	M	M
4	Production Support	< 6 months	M	M	M	M	M	M	C	C	M
		> 6 months	M	M	M	M	M	M	M	C	M
5	Consulting		M	M	M	M	M	M	C	C	M
	M	Mandatory									
	C	Customizable									

5. VALIDATION IN FIELD AND IMPLEMENTATION EXPERIENCE

Because of the basic observable premise that the building of different components is similar in nature but may vary in terms of the end use at the individual component level, the component based approach has been validated on three different projects within two different portfolios. "Cost, benefit and risk are the factors that need to be balanced and should be reassessed in order to maximize competitive advantage" [6]. The implementation experiences in the next two sub-sections will highlight the advantage of building a component in one project and will follow with the usage of multiple components to the benefit of two different projects.

5.1. Implementation Experience A

The knowledge component was build for a project in our Communication Service Provider division. This project was associated with maintenance of a set of applications by a team with varied experience.

Team Size: 22
Nature of Project: Maintenance
Project Time Size: >6 months
One subject matter was identified to anchor the Knowledge Component. Every knowledge bit was retained towards successful building of the knowledge component. The component comprised of multiple building blocks:

- Documentation of the understanding
- Best practices
- K-Tips
- Presentations
- Inter/intra team sessions

Moving an experienced team member to another module became very easy without impacting the project and with a minimal transition time. This was possible due to the knowledge component in place. Additional benefits were realized in terms of taking up more work equivalent to 1FTE (One Full Time Employee) with the existing team.

5.2. Implementation Experience B

The component concept was implemented in two projects working for the same client within the same portfolio in Communication Service Provider division. Each project developed the secondary components.

Team Size (Project 1: 18)
Team Size (project 2: 9)
Nature of Projects: Maintenance, Production Support and Testing
Project Time Size: >6 months
The experience from implementation of the System Component is shared.

The systems for two different applications were documented, their interfaces identified and the data within the application analyzed. These two components were shared between the two projects. The teams identified that the outputs from one project were actually an input to an interface of the other project. This enabled the teams to work more closely in terms of understanding the system flow and using that knowledge in preparing the data flows. This gave both the project teams a much better understanding resulting in catching some underlying defects in the system and fixing them to the delight of the client.

6. CONCLUSION

Following is what we conclude based on our implementation experience.

To ensure the success of a project for a customer and for an organization, we should focus on improving the business, technical and system skills of the team. There should be effective knowledge, configuration and quality management. There should be events in the project to make the project lively. The work should be supported by tools to make it automated and of course there should be effective project management. Each of these functional groups should be built upon and improved as components to derive the maximum benefits.

The component based approach can have multiple benefits:

- Across the organization – each component can be reused. Best practices towards building each component can be shared.
- Successful project world – delighted customer.
- Focused areas of attention at any point in time.
- Expert availability
- Enhanced precision and accuracy
- Easy forecasting
- Higher probability of success

On a comparative study, as [6] specifies that "The success of a project will depend critically upon the effort, care and skill you apply in its initial planning". Component based Project Management extends this to continuously building on the components identified during initial planning. In [7] – Models in perspective on CMMI "The model tells you what to do, not how to do it" – the component approach gives a thought on how to do it. Where [2] analyzes the component based development process and component life cycle, and [8] highlights a component based knowledge management system – component based IT software project management tries to look at components from a project perspective.

7. ACKNOWLEDGMENT

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8. REFERENCES

[1] Team's experiences across 3 different projects spread over a time span of 8 months.
[2] Ivica Crnkovic, Stig Larrson, Michel Chaudron, Malardalen University, ABB Corporate Research and Technical University Eindhoven "Component based Development Process and Component LifeCycle" - http://www.mrtc.mdh.se/publications/0953.pdf
[3] Management of Component-Based Software Engineering By Shahzad (Shah) Bhatti, R&D Project Manager, Hewlett Packard
[4] http://www.infosys.com
[5] Internal Infosys website http://sparsh
[6] Gerard M Blair "Planning a Project" - http://www.see.ed.ac.uk/~gerard/Management/art8.html?http://oldeee.see.ed.ac.uk/~gerard/Management/art8.html
[7] http://www.csie.ntu.edu.tw/~pangfeng/Trend2003/slides/ntu_030520.ppt.
[8] Tom Finneran, "A Component Based Knowledge Management System" - http://www.tdan.com/i009hy04.htm

Managing IT Development Collaboration

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INTRODUCTION

Ten hospital districts in Finland have joined forces in the 'Proxit' project to develop common health care IT solutions. The participating organisations include half the national health districts that cater for the health care needs of roughly a third of the national population.

Previous attempts at national health care IT development have resulted in a large number of independent, relatively small IT projects. These individual approaches were later replaced by a single regional IT effort in 1998-2002 - the 'MacroPilot' project in Pori region. This project attempted to create a unified information solution for regional needs covering most levels and organizations of health care (Nissilä, 2002). The MacroPilot project suffered the same fate as similar attempts in many countries previously: due to unrealistically large expectations and limited resources, the project did not meet its goals. Subsequently the Ministry of Social Affairs and Health resumed funding of regional or municipal health care IT projects, but in contrast to the strategy of the mid 1990's, large development projects were favoured. This emphasis on larger, joint ventures culminated in the Proxit project described in this report.

METHOD

Ten hospital districts decided in late 2004 to start a joint IT development project to meet Finnish health IT targets. These call for national integrability of hospital IT systems by 2007 and require adherence to common health record structuring and common standards such as HL7/CDA-R2 and DICOM (Ministry of Social Affairs and Health, Finland, 2003).

The health districts that decided to start a joint development project were installing, developing or considering to purchase the same healthcare EPR and HIS platform, the 'Effica' system by TietoEnator Plc. By launching a joint project, it became possible to share development work and best practices between all participants. The Proxit project started in 2005 and will continue until 2007. This is the largest single health care IT project in Finland to date: the total estimated budget is 10 million euros. Approximately 50% of these costs are covered by the Ministry of Social Affairs and Health, and the rest is covered by individual participating organisations. All the health districts participating in Proxit are public sector organisations. Overall project management and support is provided by LifeIT Plc.

Proxit consists of four main development and implementation sub-tasks or work packages:

- Structured electronic patient record system (EPR)
- Patient and hospital administration software (administration)
- Exchange of data between organisations (referrals, reporting)
- Joint IT project management

The first three modules are primarily IT development tasks specifically geared toward meeting national goals of intercommunicability between organizations in health care. The last module, joint IT project management and support for hospital districts on this scale, has not been achieved in Finland until now. 'Proxit' is the first time such a large consortium has embarked on a joint project by mutual consent.

RESULTS AND DISCUSSION

All main Proxit modules have shown significant progress. A new highly structured EPR version has been installed in most participating hospital during 2005 and early 2006. Common structuring and choice of formatting and datafield labelling has resulted in development of a single operational EPR version that can be adjusted to take into account the different needs of individual hospitals.

Somewhat more difficult has been changing hospital's working practices and workflow to accommodate a common EPR and administration system, but so far this work has also shown signs of progress. Data exchange solutions in the form of referrals and reports that can be sent between primary and secondary health care as well as between participating hospitals in Proxit, have also advanced to implementation stage by early 2006.

The progress achieved in all individual modules will be tracked and evaluated during this project. The level of national health IT target compliance of the solutions implemented by Proxit participants will be evaluated and compared to the situation in hospital districts that did not participate in this project. In this way it is hoped to show the benefits and gains achievable by common IT project management and collaboration in large scale health care IT development.

CONCLUSIONS

Development of joint solutions needs a joint development approach. It can be argued that the time for this type of national project was ripe: the benefits of a common effort were seen clearly enough by all participants, and definite national IT targets set by the Health Ministry set precise goals.

Changing working practices within individual organisations or hospitals is not easy, but if the benefit to all participants is seen as outweighing the problems caused to individual organisations, the work will none the less be carried out (Berg, 2001; Littlejohns, Wyatt & Garvican, 2003). Through common management of the project it is easier to demonstrate the rationale for this type of change. Learning to work together in this type of project has in itself been a significant achievement.

REFERENCES

Berg M. (2001) Implementing information systems in health care organizations: myths and challenges. *International Journal of Medical Informatics*, 64(2-3), 143–56.

Littlejohns P., Wyatt J. and Garvican L. (2003) Evaluating computerised health information systems: hard lessons still to be learnt. *British Medical Journal*, 326: 860–63.

Ministry of Social Affairs and Health, Finland (2003) Working Group Memorandum of the Ministry of Social Affairs and Health 2003:38. (See also: http://www.stm.fi:80/Resource.phx/publishing/documents/2897/summary_en.htx)

Nissilä, L., ed. (2002) Macropilot. Social welfare and health care into the 21st century (in Finnish). Ministry of Social Affairs and Health, Finland, Helsinki. (English summary: http://pre20031103.stm.fi/suomi/tao/julkaisut/makropilotti/summary.htm)

Financial Services in Web-Based Platforms

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1. INTRODUCTION

Information and communication technologies offer sophisticated approaches to optimize the e-Business processes including financial services between companies. However, these services are often not integrated, which can increase costs and decrease options to exploit flexibilities. This was not of great importance as long as companies and customers were close geographically, but it has become critically important in today's "globalized" world. In this paper we give a short overview of the results of the field study of two European IST projects, „FLUID-WIN" and „SEAMLESS", in the context of financial services.

The FLUID-WIN project is the process of implementing an innovative, interdisciplinary and dynamic business model. This model will enable the European manufacturing companies to achieve quick response and competitive prices by integrating their suppliers whether international or domestic. This model is supported through readily adoptable e-commerce applications. The objective is to develop a means for a B2(B2B) service, adapting services into a complete existing network instead of manually creating individual relations to the network members. The scope of the FLUID-WIN project covers the material flow among a supply network as well as logistic and financial services flows associated with this flow.

The SEAMLESS project studies, develops and tests an embryo of the Single European Electronic Market (SEEM) network, where a number of e-registries are started in different countries and sectors. The SEEM vision is towards a web-based marketplace where companies can dynamically collaborate without cultural, fiscal and technological constraints.

Considering this background, we will discuss a bank's view on doing business with the participants on a web-based platform. The main activities of both projects are to define a collaboration framework and proper business models, to realize evolving ontology, to develop a technological infrastructure and a number of related applications and services. Distinctive features are addressing companies through their respective mediators (chambers of commerce, entrepreneurial associations, local development agencies, etc.) and in establishing interactions based on a collaboration framework.

Financial service providers are essential in any supply chain relationship. Among financial service providers one can also find insurance and other institutions providing transaction services related to handling large business volume in manufacturing and distribution. As customers still perform transactions, e.g. sales, outside of the closed supply chain platform economic trends are likely to impact even on a closed system. This is to be expected as the output from a closed system is still being marketed "externally". Though being integrated into a closed supply chain, financial service providers may still encounter competition as producers and suppliers can theoretically be provided with financial instruments from ex-platform or company sources. Therefore, the financial service provider market is of dual character and can't be exhaustively defined. The potentials to improve financial services in the web-based platforms as FLUID-WIN and SEAMLESS will be considered.

2. FINANCIAL SERVICES

Financial service providers would have to determine what financial instruments to offer when entering a closed supply chain or e-market. We list here some potential to improve their performance. On the other hand, we present the requirements for the services offered through the platform. The finance domain within web-based platform is certainly the most challenging area. However, it is one that can reap real benefits once it is integrated or interfaced within the B2(B2B) marketplaces. It is important to state here that finance is at the bottom of all real commercial endeavors and traditionally this has been a sector mostly ignored in many aspects. In fact large departments within companies are required to deal with the sheer volume of papers and documents that the financial area requires.

2.1 Potentials to Improve Financial Performance of Financial Service Providers Within Web-Based Platforms

Banks and lending/factoring institutions mostly give access to financial instruments and price their services according to the perceived risk element involved. The single item that gives confidence to banks is accurate and detailed information. This is however extremely difficult to deliver to the institutions. It is very normal for financial service providers (FSPs) to mostly receive historical reports or optimistic potential figures. Banks and other financial services institutions would have to collect information by running respective information mining and monitoring processes to guide financial instruments such as loans and trade financing documents for instance. The integration of finance and documentation processes enables manufacturers, suppliers, and financial service provides to perform trade and financing more efficiently and quicker. It is apparent that bureaucracy is still the name of the game when it comes to collate documents for trade financial instruments, and each bank has its own subset and version of how it requires these documents to be provided. The platform has sustained potential to streamline, to increase transparency, and to simplify document creation and related processes as an additional value to SMEs that want to trade within the internal market.

2.2 Requirements from the Financial Providers Point of View

There seems to be a certain concerted view when it comes to the requirements and wishes of the financial service providers. These can be summarized as follows:

Positive stance on potential B2(B2B) networks: All FSPs said that if they can have a group of SMEs that are integrated within each other, and normally carry out trade between them, they would be willing to offer services to the group. Banks have asked whether the transactions could be somehow guaranteed and this could actually be possible if there is an insurance company interested in taking up this role.

More information = less risk: All Banks and Factoring Houses mentioned that the more real time and not historic information can be give to them, the greater the willingness to lower costs to the companies. They all requested a sort of "window" where they can view real-time data on their clients and potential clients.

More automation where possible: It would be interesting for the FSPs (all types) to have direct interfacing, report generation and where possible transfer of data in order to speed up requirements for giving/sending information to and from manufacturers

More education to SMEs: It seems vital that manufacturers are trained and informed on the various services on offer by their own and other banks and

financial service providers since this speeds up initial proceedings and avoids errors and delays later on. Many small companies are not aware of Factoring Houses, or Credit Guarantee Institutions and they keep forging on in a much more difficult environment just because of not knowing about the existence of these financial services.

Potential cross-border financial business - In a European perspective this is extremely interesting due to the Internal Market enabling free movement of capital, goods, and labor.

Wish for more Trust and Confidence - All parties (FSPs and Manufacturers) need to have much more confidence in the security offered by web-based platforms (see also Section 3).

2.3 Potentials from the Financial Providers Point of View

The following potentials will follow the requirements:

Access to view data by FSPs: a system needs to be put in place where managers assigned to particular clients can be given a view only access to transactions and information on their clients. An approval system needs to be put in place for both sides.

Direct Data interface gateway: All FSP's information systems need to be interfaced to send/receive data from the platform to make sure that information is complete in a FLUID-WIN context.

e-Learning for SMEs: A simple guide how to the use financial instruments offered by banks, factoring houses and credit guarantee or insurance institutions needs to be developed resulting in a sound preparation and smooth transactions when inquiring and making use of financial services. By offering e-Learning financial services can experience additional quality and effectiveness as the knowledge is being spread among FSPs customers and decreases "frictional losses".

Increase Financial Performance: Doing business within the platform is likely to affect the financial performance of financial service providers. Financial service providers are to obtain increased capability to anticipate financing and investment needs and enhance their portfolio financing and investment decisions. They will still be able to generate interest income and fee income from traditional banking activities, and being sustainable profitable by providing tailor made solutions at competitive rates to known business partners.

3. TRUST ISSUES IN FINANCIAL MEDIATION ON B2B MARKETPLACES

Though operating within a closed supply chain system, locally spread information technology destinations (users of manufacturer, suppliers and financial services institutions) need to be linked, which brings up the need for trust, privacy and security. It is to be expected that security is at least of equal importance than in an open system as limitation of access plays a vital role. Within project Seamless, we have realized research regarding the trust issues on B2B e-marketplace based on P2P architecture. As input to the implementation of the P2P business platform was to examine the trust level of relevant trust building mechanisms (TBM) which will be supported by different types of mediators. The purpose of such analyze was to identify the most suitable and also minimum sets of TBM for Seamless platform and analyze potential future shifts in trust perception, acceptance and requirements according to e-experiences. The TBM was divided according to several contractual phases. One of the required trust services was identified escrow services (ES). For P2P platform we had analyzed three strategies how to solve providing such a service. First was model (1), where internal mediator (verifying information about participant, member of project team) will provide service integrated on the platform with other contractual phase (searching, negotiation, contract execution support). In the second model (2), ES provider was the bank (as the strategic alliance), which will cooperate with platform but will be not fully integrated. Last model (3) provided possibility to use services by specialized outsourced company, as for example Escrow.com. Every model has different implementation and business claims. For example, bank can be more expansive as specialized company and can refuse escrow service for the platform participant, if this company will be not trusted for them. We have examined, which model is most suitable according to different factors. The implications are as follow:

- Generally, companies preferred as a minimum necessary model (2) in 46% against (1) 38% and (3) 29%.
- Generally, companies trust more to banks as mediator for ES (57%).
- Companies which are dominantly focusing on one side business (selling or buying) prefer (1) or (2) 30% as the model with specialized company 8,7%
- The more e-skilled company, the higher trust to the bank or specialized company and lower trust to internal service (1). Together, most e-skilled companies requires in 83% bank for ES provider as a necessity.
- Micro sized companies trust more to (1) in 40% as to other models (26%). Within small and medium sized companies are not significant differences in trust between all models. Large companies definitely prefer (2) in 85%. (more detailed analyses will be published on Seamless webpage or papers by R. Delina)

From mentioned analyses and projects results, the bank as a dominant financial institution play a significant role also on web based business platform for B2B relations. Although, for the initial phase of some e-marketplace, where most participant have low skills in electronic commerce, the internal model where known mediator provide ES is appropriate. The main benefit against other models is maximum acceptance of e-marketplace participant by such a mediator. After achieving some level of skills, participants tend to trust and require more bank or specialized company as a trusted third party for escrow services. These results together with positive stance of banks on potential B2(B2B) networks and automation shows future best practice scenario in the field of escrow services on B2B networks.

REFERENCES

- Giuliano, A., Azzopardi, J., Mihók, P., Bucko, J., Ramke, Ch. (2007). *Integration of financial services into multidisciplinary Web platforms.* To appear in: Ambient Intelligence Technologies for the Product Lifecycle: Results and Perspectives from European Research, IRB Stuttgart, 2007
- FLUID-WIN Finance, logistics and production integration domain by web-based interaction network. FP6 IST STREP 27083 funded by European Commission. www.fluid-win.de
- SEAMLESS, Small enterprises accessing the electronic market of the enlarged Europe by a smart service infrastructure. FP6 IST STREP 26476 funded by European Commission. www.seamless-eu.org
- SWAMI - Safeguards in a world of ambient intelligence- Final report, August 2006, http://swami.jrc.es
- TRUSTe: - Security guidelines 2.0 - http://www.truste.org/pdf/SecurityGuidelines.pdf, 2005

Setting-Up a Business Process-Support Organization

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1. ABSTRACT

This paper reflects on the organizational consequences when introducing Business Process Management methodologies in the organization. As Business Process Management (BPM) is a stage by stage approach of continuous improvement, it will influence the way integration efforts are organized in an optimal way. This paper considers the importance of centralized and decentralized governed integration efforts, and the evolving balance between them. A prescriptive model is suggested and followed by a validation, based on literature review and case study research.

2. INTRODUCTION

In contemporary organizations we see more often that several methodologies, combined in the general term *Business Process Management* (BPM), are studied and applied in order to gain efficiency and effectiveness, and with that competitive advantage (Davenport, 1993; Rummler & Brache, 1995; Hammer, 1996). BPM focuses on integrating and cross-linking the organization's departments, business units, sub-groups, etc. by actively managing the organization through defining end-to-end value creating processes (Paul Harmon, 2003). Research has proven that the development of a business process oriented view in organizations to integrate the differentiated and fragmented subsystems, leads to positive outcomes (McCormack, 2001).

Evolutions in the business needs such as the creation of more product lines, bigger geographical markets, a larger number of functional specializations, etc. necessitate more differentiation of organizations into sub-units and -systems. By differentiating the organization in homogeneous sub-systems (business units, departments, specialists teams, etc.), the organization becomes more efficient in their collaboration with specific sub-environments (Lawrence and Lorsch, 1967; Galbraith, 1995). This rising necessity for differentiation, in combination with a more demanding customer, the development of global collaboration mechanisms and the growth of technology opportunities, induces more than ever increasing integration needs. In this, the success of the BPM movement, which is focusing on sustained integration, without diminishing the efficiency and effectiveness of homogeneous subsystems, can be situated.

The switch in the early nineties in popularity from Business Process Reengineering, with specific one-time process improvements as subject, to Business Process Management, with the focus on continuously improving business processes (Hammer, 1996; Davenport 1993) induces a more formalized set-up of this specific management function. Depending on difficulty and time required for certain management tasks, different integration levels can be distinguished, from informal and ad hoc collaboration (e.g. frequent meetings) to highly procedural mechanisms (e.g. obliged collaboration policies or integrated ICT-systems) (Galbraith, 1995). As organizations currently evolve to more sustainable and longer term integration, an important impact on the way integration efforts are managed, can be expected. For that reason organizations need insight in which integration efforts optimally impact the organizational performance. An important consideration here is the role of *centralized* versus *decentralized* integration efforts. *Centralized integration* focuses on integration efforts applicable to all organization's departments, sub-divisions, etc., while *decentralized integration* focuses on efforts that obtain integration on a lower level and based on a particular and well defined processes or sub-processes.

3. PROBLEM SETTING

This paper investigates the effect of integration efforts and the evolving balance between centralized and decentralized integration efforts. From own empirical case study research, the authors have seen that the relative balance between centralized and decentralized integration efforts varies for different organizations. Next to more traditional contingency variables, such as company size, environment, strategy, technology (Birkinshaw et al., 2002), the level of yet accomplished process integration, due to cumulative integration efforts, seems to influence the balance between central and decentralized integration.

4. RESEARCH METHODOLOGY

Based on empirical findings and related case study research a general prescriptive model is proposed (see figure 1). Conceptually, the *level of integration efforts* influences (1) the *impact on the organizational performance* and (2) the *balance between centralized and decentralized integration efforts.*

To measure the *level of integration efforts,* a survey, based on previous work of McCormack (2001) and Gemmel et al. (2006), was conducted in 20 organizations, each represented by a significant selection of employees. To have comparable data, the survey probes extensively for the presence of sector and industry independent process characteristics, which collectively indicate a certain 'state of maturity' in obtaining benefits from accomplished integration efforts. A distinction is made between specific organizational characteristics (*'organizational state of maturity'*) and overall process characteristics, considered from different perspectives, i.e. customers, performance, strategy, suppliers, employees, technology, etc. (so called *'overall state of maturity'*).

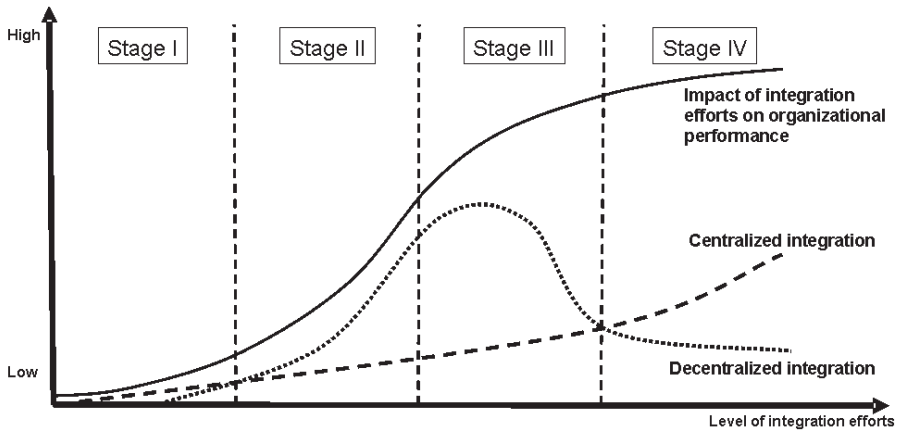
In addition to that, for each company semi-structured and peer checked interviews with several key persons in the organizations were conducted to gain insight in the present integration mechanisms. This is measured by means of total number of full-time equivalents (FTEs) dealing with process management, both centralized and decentralized.

5. A PRESCRIPTIVE MODEL ON INTEGRATION EFFORTS

Figure 1 describes three variables:

- **Impact of integration efforts on organizational performance:** In a strongly differentiated organization, there is an increasing need for compensating measures to encounter this differentiation with integration efforts. These efforts vary for each company and within each company over time in focus and size, depending on the accomplished benefits of previous integration efforts. In complex organizations these efforts have a positive impact on the organizational performance (Lawrence and Lorsch, 1967).
- **Centralized integration:** From empirical case study research the authors notice that for the execution of such centralized integration efforts, many organizations appoint a dedicated staff team with high-level responsibility, often called a *'business process office'* (BPO). Nevertheless the exact working modus, degree of control, empowerment and services provided by this central office vary from company to company, they share the central and company wide character. Other variants and names have been proposed in literature (Burlton 2001; Smith & Fingar, 2003; Kaplan & Norton, 2005)

Figure 1. Centralized and decentralized integration efforts, and their combined impact on the organizational performance



- **Decentralized integration**: For the execution of decentralized efforts in contemporary organizations, employees are more and more empowered to take up this responsibility. Specific process roles, such as process owner, process responsible, process facilitator, process coach, etc. are created. In addition complementary integration mechanisms are installed such as Process Improvement Teams (Harrington, 1991) and regular interdepartmental meetings.

Further the evolving role of both centralized and decentralized integration efforts will be discussed through 4 arbitrary stages, indicated on figure 1.

- In the first stage, mainly ad hoc initiatives to integrate differentiated departmental units are done on several levels, in an informal and discretionary way, for smaller and also quick-win type tasks (Galbraith, 1995).
- In the second stage, there is an emergence of centrally allocated initiatives with an impact on the organization as a whole, grown from previously installed and dispersed activities. To aggregate these initiatives consequently, a more formalized and high-level approach is required. In this stage a BPO is usually initiated to manage strategically linked integration tasks, such as process strategy formulation, definition of general process metrics, standardization of methodologies, etc. to analyze and redesign business processes.
- In the third stage, important centrally managed activities are set up to get the whole company involved in deploying a full-blown process oriented strategy, as it as it was initiated in stage 2. Centrally, the BPO takes up a more participating role to manage and deploy a full program of improvement projects enhancing on large scale the integration capabilities of the organization. Due to a large investment in centralized integration efforts, both the quick rise in *the impact on the organizational performance*, and the large volume of *centralized integration efforts* is explained. In this stage, the BPO influences and works together with some people more decentralized in the organization, who start taking up some responsibilities over certain (parts of the) processes.
- In the last stage, when costs for central integration efforts have become higher and when additional investments only give marginal results, the role of the BPO becomes more governing. Due to the improvement program deployed in stage 3, business process management has become a shared responsibility which is now more decentralized and dispersed throughout the whole organization. In this final stage the BPO takes a more coaching role with regard to methodologies, techniques and tools and manages the complete process knowledge repository.

6. FIRST RESEARCH FINDINGS AND DISCUSSION

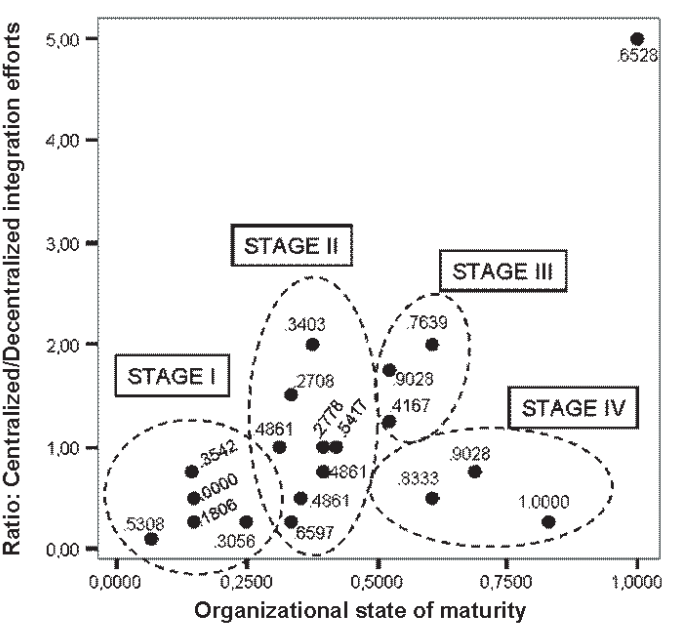
While the model in figure 1 has a more prescriptive character, figure 2 represents a descriptive situation comparing 20 different organizations, scattered graphically for two dimensions:

- The balance between centralized and decentralized integration, based on FTE allocations, shown as a *ratio: centralized over decentralized integration efforts*.
- The specific '*organizational state of maturity'*, calculated from the survey results based on the presence of specific organizational process characteristics.

Further for each organization, the '*overall state of maturity'* is shown (score between 0 and 1), based on the presence of process characteristics in all relevant domains (see methodology).

The substantial difference between the prescriptive character of the model in figure 1 and the descriptive character of the representation in figure 2, forces the authors to make a distinction between on the one hand the organizations which are in a situation represented by the prescriptive model of figure 1, and on the other hand

Figure 1. Scatter plot (20 organizations) centralized/decentralized integration efforts versus the "organizational state of maturity"



organizations which can be classified as exceptions. To estimate the value of the model, a thorough case study analysis comparing exceptions with the 'main stream' organizations, based on their integration performance, is necessary. This to ensure that what the model prescribes really leads to 'good/best practice', while for the exceptions valid indications of a sub-optimal approach should exist.

From figure 2 the varying trend between centralized and decentralized integration efforts can be distinguished. Most organizations can be roughly classified in one of the 4 groups confirming the prescriptive model of figure 1. Most clearly are the groups validating stage I, III, and IV, while for stage II, the balance between centralized and decentralized integration efforts is less clear. Further in-depth research must reveal the variables causing variance between different cases, especially for cases currently classified as stage II.

One clear exception is the case in the right upper corner of figure 2. This company has the highest score concerning '*organizational state of maturity'*. And contrary to the prescriptive model, the relative amount of central steering is noteworthy higher than other companies. However it is noticeable that the 'overall state of maturity' is lower than any case classified in stage IV. This suggests that this organization's additional investments in centralized integration efforts have less marginal impact on the overall state of maturity. Therefore in order to obtain the optimal impact on organizational performance, a more balanced set of integration efforts also in other relevant domains, such as e.g. cultural and technological integration efforts, is proposed.

Also here further research must disclose more detailed insights in the actual contribution on the organizational performance of both specific and combinations of certain integration efforts.

7. REFERENCES

Birkinshaw, Julian; Nobel, Robert; Ridderstrale, Jonas, "Knowledge as a Contingency Variable: Do the Characteristics of Knowledge Predict Organizational Structure", Organizational Science 2002 Vol 13, No. 3, May-June 2002, 274-289

Burlton, Roger T., "Business Process Management, Profiting from processes", Sams Publishing, 2001

Davenport, Thomas H., "Process Innovation, reengineering work through information technology", Ernst & Young, 1993

Galbraith, Jay R., "Designing Organizations, an executive briefing on strategy, structure, and process", Jossey-Bass Publishers, 1995

Gemmel, Paul; Vandaele, Darline; Tambeur, Wim, "Hospital Process Orientation (HPO): the development of a measurement tool", Conference Proceedings of the 9th International Research Seminar in Service Management, La Londe les Maures, France, pp. 281-299, 2006

Hammer, Michael, "Beyond Reengineering: how the process-centered organization is changing our work and our lives", HarperCollins Publishers, 1996

Harmon, Paul, "Business Process Change, a managers guide to improve, redesign and automating processes", Morgan Kaufmann Publishers, 2003

Harrington, H. James, Business Process Improvement, the breakthrough strategy for total quality, productivity and competitiveness, McGraw-Hill, 1991

Kaplan Robert S., Norton, David P., "The office of strategy management", Harvard Business Review, October 2005

Lawrence, Paul R., Lorsch, Jay W., "Differentiation and Integration in Complex Organizations", Administrative Science Quarterly, 1967

McCormack, Kevin P. Johnson, William C.; Business Process Orientation, Gaining the E-Business Competitive Advantage, St. Lucie Press, 2001

Rummler G. and Brache A., "Improving Performance: How to manage the white space on the organization chart", Jossey-Bass Publishers, 1995

Smith, Howard., and Fingar, Peter, "Business Process Management, the third wave", Meghan-Kiffer Press, 2003

Integrating Stability and Dynamics of Organizational Capabilities Through Informal Knowledge Transfer

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In the knowledge management literature it is widely accepted that organizational core competencies are the basis for competitive advantages because of their stable and reliable inimitable character (Prahalad/Hamel, 1990; Grant, 1996). Due to increasing dynamics of the global environment, however organizations are forced to integrate changing demands and adapt or develop new competencies to be able to stay flexible and dynamic (Lei/Hitt/Bettis, 1996). The challenging question remains how to integrate the advantages of stability and the advantages of flexibility, simultaneously.

Answers to this question are already given by authors like Teece, Pisano & Shuen (1997) as well as Eisenhardt & Martin (2000). What is missing however is a discussion from the perspective of knowledge management based on a precise definition of explicit and non-explicit knowledge. Another missing link is the importance of informal knowledge transfer through social networks as a possibility to balance between the stable and dynamic dimension of core competencies and capabilities. We will focus on both aspects in this paper.

TRADITIONAL KNOWLEDGE MANAGEMENT STRATEGIES

"*Knowing who*" and also "*knowing who knows what*" is an important pillar when it comes to knowledge management strategies. According to empirical results of Hansen et al., (1999) two different strategic directions for knowledge management can be followed: In some companies, the strategy centers on the computer. Knowledge is carefully codified and stored in databases, where it can be accessed and used easily by anyone in the company. We call this the codification strategy. In other companies, knowledge is closely tied to the person who developed it and is shared mainly through direct person-to-person contacts. The chief purpose of computers at such companies is to help people communicate knowledge, not to store it. We call this the "*personalization strategy*" (Polyani, 1962:17). Also Dennis and Vessey (2005) identified these two strategic orientations for knowledge management as a result of their empirical study. They call the first one "knowledge hierarchies" and the second one "knowledge markets".

KNOWLEDGE COMMUNITIES AS SOCIAL NETWORKS

Both traditional knowledge management strategies as mentioned before undergo an extension if the focus on communities displaces the focus on the individual. This third strategy can be called "socialization strategy", or – with the words of Dennis and Vessey (2005) – "knowledge community". The aim here is to get access to explicit and non-explicit knowledge of non-hierarchical communities by tapping into their informal social trust-based network relationships.

When looking at knowledge communities we are taking on a social network perspective. Social network theories are the basis for social network analysis in which people and collective actors (e.g. organizations) are regarded not as "social islands" who are primarily be described by specific characteristics or attributes of single actors. Rather, a network approach looks at pairs of actors who are characterized by their relations with other actors: „A social network consists of a finite set or sets of actors and the relations defined on them." (Wasserman/Faust, 1994:20). Radcliff-Brown (1940) calls it the "social structure" of networks.

Besides the above described structural components of social networks, where researchers mainly study the impact of different positions within the overall network on network outcome – it is also important to understand the actual content that flows through the network ties. In terms of knowledge management, the content of a tie represents the knowledge in form of resources and information that is being transmitted through the network ties. Relationships can therefore also be described as an "opportunity structure" through which connected actors have access to explicit or non-explicit knowledge. Besides the formal reporting structures in form of hierarchy through which mainly explicit or codified knowledge is transported, the informal aspect of information flow is important when it comes to knowledge networks. The structure enhances access to explicit as well as non-explicit knowledge that would otherwise not be accessible if the relationship does not exist. The network constrains as well as supports the diffusion of knowledge.

INTEGRATION OF STABLE AND DYNAMIC CAPABILITIES THROUGH SOCIAL NETWORKS

Social (knowledge transfer) networks as discussed above are informal in nature with regard to their character – they usually evolve bottom-up and overlap the formal and intended organizational structure. They allow for informal access to explicit as well as non-explicit knowledge.

Knowledge comprises cognitive-emotional capabilities as well as body-related skills, both in the sense of existing capacities in order to be able to take action (Senge 1990: 9). In so far, knowledge can be understood as "*knowing how and why*". The "tacit dimension" of knowledge can be theoretically demarcated from the "explicit dimension" of knowledge by pointing to the fact that "(w)e can know more than we can tell" (Polanyi 1962: 5). Polanyi's thesis is that all knowledge is rooted in tacit knowledge (Polanyi 1966: 195). The difference however is that explicit knowledge is articulated, documented, directly accessible and relates to what is called "declarative knowledge" (Squire 1987) or "discursive consciousness" (Giddens 1984).

If explicit knowledge is exchanged or the procedural part of non-explicit knowledge (operational routines) is made explicit, social networks draw back on the "architectural competences" of corporations (Henderson/Cockburn, 1999; 2000). These competences stand for the advantages of stability and reliability.

If non-explicit knowledge in terms of creative expertise is made explicit within the social network, new problems drive the explication and as a result dynamic capabilities are the outcome of respective learning processes especially in the sense of double-loop and deutero-learning and deutero-learning (Argyris/Schön, 1978).

Therefore, social networks can either contribute to organizational core competencies or to dynamic capabilities of organizations. In so far, they are potentially an informal way of balancing the advantages of both concepts.

RESEARCH DESIGN

We suggest applying a multi-method research design: a quantitative survey of networking activities among members of an IT department, accompanied by interviews to prepare the questionnaire and understand the findings. We have chosen IT departments as an area where the tensions between stability (due to technological standards) and change (due to permanent technological evolution)

are very characteristic. We conducted preliminary interviews in a single company to be able to identify the relevant actors within the chosen IT department, consolidate common vocabulary used in the company, and to pretest our survey items. The quantitative survey was sent out to all employees within the IT department and we had a 90% response rate. One employee refused to answer questions regarding his professional ties.

In the questionnaire, we included two pairs of questions regarding the perceived information sharing (-> knowing that and what; explicit knowledge and procedural operative routines) and advice networks (-> knowing how and why; special creative expertise), asking for bidirectional ties for both networks types: "Who do you turn to for information/advice regarding IT Governance?; and "Who turns to you for information/advice regarding IT Governance?". This allowed us to understand both the reciprocated ties as well as the uni-directional ties.

The main result of our research study is that the two different types of informal knowledge networks really exist and are overlapping the formal organizational hierarchy of the company. In addition to that, the informal information sharing network contributes to the stability of the IT department's capability with regard to the usage of ITIL. It stands for the explicit, declarative knowledge the department members share between each other about more than presently 30 ITIL volumes. Through this process of reinforcement, knowledge about ITIL is incrementally tuned and a common stable and reliable understanding of ITIL developed.

The informal advice network contributes to the dynamic capabilities of the IT department's knowledge about ITIL. Problems are seen as the source for detailed discussions about ITIL and further developments with regard to IT Governance. Respective advice takes place on the level of special creative expertise. The members of the department cannot simply remind themselves of routines but have to initiate creative processes of problem solving. Questions which have to be answered here are for example "How do I implement this with what consequences for whom?". Non-explicit knowledge except what was elaborated as "unconsciousness" is made explicit and shared between the members of the IT department. This dynamic process guarantees for the needed flexibility in the area of IT Governance.

Both explanations were confirmed by the department head when we presented our results and discussed the findings in the company.

REFERENCES

Argyris, C. and Schön, D.A. (1978): Organizational Learning: A Theory of Action Perspective. Addison-Wesley, Reading, MA.

Dennis, A.R. and Vessey, I. (2005): Three Knowledge Management Strategies: Knowledge Hierarchies, Knowledge Markets, and Knowledge Communities. MIS Quarterly, 4 (4): 399-412.

Eisenhardt, K.M. and Martin, J.A. (2000): Dynamic Capabilities: What are they? Strategic Management Journal, 21 (10-11): 113-135.

Giddens, A. (1984): The Constitution of Society: Outline of the Theory of Structuration. University of California Press, Berkeley, Los Angeles.

Grant, R. M. (1996): Toward a Knowledge Based Theory of the Firm. Strategic Management Journal, 17 (special winter issue): 109-122.

Hansen, M. T., Nohria, N. and Tierney, T. (1999): What's Your Strategy for Managing Knowledge? Harvard Business Review, 77 (2): 106-116.

Henderson, R. and Cockburn, I.M. (1994): Measuring Competence? Exploring Firm Effects in Pharmaceutical Research. Strategic Management Journal, 15 (1): 63-84.

Henderson, R. and Cockburn, I.M. (2000): Untangling the Origins of Completive Advantage. Strategic Management Journal, 22 (10-11): 1123-1145.

Lei, D., Hitt, M. and Bettis, R. (1996): Dynamic Core Competencies through Meta-Learning and Strategic Context. Journal of Management, 22 (4): 549-569.

Polanyi, M. (1966): The Tacit Dimension. Doubleday Anchor, New York, NY.

Polanyi, M. (1962): Personal Knowledge. Chicago: The University of Chicago Press.

Prahalad, C.K. and Hamel, G. (1990), The Core Competence of the Corporation. Harvard Business Manager, 2 (May-June) 79-91.

Radcliff-Brown, A. (1940): On Social Structure. Journal of the Royal Anthropological Society of Great Britain and Ireland, 70 (1): 1-12.

Senge, P.M. (1990): The Fifth Discipline: The Art & Practice of The Learning Organization. Currency Doubleday, New York, NY.

Squire, L.R. (1987): Memory and Brain. Oxford University Press, New York, NY.

Teece, D., Pisano, G. and Shuen, A. (1997): Dynamic Capabilities and Strategic Management. Strategic Management Journal, 18 (7): 509-533.

Wasserman, S. W./Faust, K. (1994): Social Network Analysis: Methods and Applications, Cambridge University Press, Cambridge.

Assessing IT Strategy with the STEP Model

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INTRODUCTION

It has now become abundantly clear to most business organizations that any so-called "IT strategy" must encompass more than just IT (i.e., the technology) *per se*. Having the "latest and greatest" technological gadgetry (i.e., computers) does not necessarily translate into an effective IT strategy without sufficient attention being paid to the *people* who will be using the technology or the *business processes* for which the technology will be used. To gain competitive advantage in today's turbulent and highly competitive business environment, organizations need to be prepared for continual transformation in order to be successful and be able to respond quickly and effectively to changes in the environment. This includes, among other things, transformation in structure, processes, culture, and philosophy. Additionally, they need to be able to exploit relevant information technologies for their advantage—indeed IT is a major driving force for many organizational transformations and competitive positioning. The focus of this paper is primarily on the technology, process, and staff dimensions of IT strategy.

Increasingly, IT's contribution to a firm's bottom line has come under scrutiny by CEOs, who have invested significant resources into IT systems and projects (Haag et al., 2006, Luftman, 2004, Applegate et al., 2003, Wen and Yen, 1998; Axson, 1996) and are now beginning to seek results and accountability from these investments. While there have been many business successes reported in the literature about corporate IT investments (e.g., Stratopulos, 2000, Hitt and Brynjolfsson, 1996), there has also been an impressive number of failures resulting from unsuccessful IT projects. According to a survey by the Standish Group, 73 percent of corporate America's IT projects in 1996 were late, over budget, or canceled. Project failures cost an estimated $145 billion per year (Thorp, 1999). Notable among the reasons given for IT project failures are the following: a lack of alignment of IT projects with business strategy (Luftman, 2004, Boar, 1994, Floyd and Woodridge, 1990) and a lack of integration of IT into the activities of the people who use it (Bates, 1999). Both of these factors can be mitigated by an IT strategy which incorporates technology, people, and business processes, all within the context of overall corporate business strategy.

The need for a multi-dimensional approach to IT strategy has been articulated by other authors. For example, Bartlett and Ghoshal (1994, 1995) proposed the dimensions of *Purpose*, *Process*, and *People*. The present study uses another model, the STEP model, proposed by Wysocki and DeMichiell (1997), which looks at IT strategy along the dimensions of *Technology*, *Process*, and *Staff (People)*. Specifically, the 'STEP' in STEP model stands for ***S**trategy for **T**echnology **E**nablement through **P**eople*. This model recognizes that organizations cannot rely on technology, by itself, for competitive advantage but, rather, need to have an information-empowered staff which is able to utilize information technology effectively, as well as efficient business processes, all working together in concert. Using the STEP model, an organization can assess its standing on each of the model's three dimensions of technology, process, and staff to give an indication of how well it is positioned with respect to its ability to exploit IT opportunities for competitive advantage. Such an assessment can also help organizations in the formulation of an effective IT strategy (or the revision of current strategy) by focusing attention on the dimension(s) most in need of improvement.

RESEARCH OBJECTIVE

The objective of this study is to utilize the STEP model to determine how well various organizations are addressing the important performance dimensions of technology, process, and staff. This assessment gives an indication of the ability of these organizations to effectively utilize information technology for competitive advantage and for overall corporate performance.

METHODOLOGY

The STEP model, as proposed by Wysocki and DeMichiell, was strictly conceptual. Therefore, to convert it into a useful and practical assessment tool, it was operationalized as a questionnaire which could be administered to organizations. The questionnaire was created by developing a set of questions that addressed each dimension of the model (technology, process, and staff) as well as a few additional questions seeking demographic and other relevant information from the respondents; approximately 40 questions were developed in total. For those questions pertaining to the model's dimensions, respondents were asked to assign a numerical score ranging from 1 to 10 to each question. Before sending out the questionnaires to the actual respondents, a pilot study was conducted, in which the questionnaire was first sent to eight senior IT and business executives in various organizations in southern California for their comment, feedback, and suggestions with respect to the appropriateness of the questions, the length and duration of the questionnaire, etc. Based on the feedback received from these executives, the questionnaire was refined and mailed to about 350 senior IT and business executives in a variety of companies in various industries in the United States.

DATA ANALYSIS

Some completed questionnaires have been returned and data analysis is still ongoing. The plan of the data analysis is to:

a. determine the relative score on the technology, process, and staff dimensions of the STEP model for each organization (respondent)
b. see if there are any significant differences in the responses given by IT professionals and business professionals
c. see if there is any correlation between the given scores and various demographical factors such as company size and industry.

REFERENCES

Available upon request.

A Model to Explore IT Career Barriers for Girls/Women

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ABSTRACT

Previous researchers have cited a number of plausible explanations for the under-representation of women in the Information Technology (IT) field. However, there has not been a comprehensive study of the barriers women face in this field or the facilitators that encourage them toward IT, and the studies we have do not provide a cohesive picture of the situation as a whole. The primary reason for this deficiency is the broad nature of the problem. Studying such a wide-reaching problem requires careful, guided segmentation into manageable and logically cohesive slices. Toward this end, this research proposes a model of the IT Career Lifecycle that can be used both to categorize the work of prior researchers and to design future studies.

INTRODUCTION

Over the past two decades, numerous researchers have reported on the diminishing number of women interested in IT careers. In this research, IT is defined as the broad subject concerned with all aspects of accessing, managing, processing, and transmitting information, especially within a large organization or company (Webopedia, 2006). IT careers consist of occupations that require designing, developing, and implementing software and hardware systems, providing technical support for software and hardware systems, and creating and maintaining network or database systems (Creamer et. al, 2004). Camp (1997) in her classic article, *The Incredible Shrinking Pipeline,* emphasizes, "The ratio of women involved in computer science from high to graduate school has been dwindling at a startling pace over the past decade" (p.129). Sanders (2005) states that with the growing role of technology in the world at the beginning of the 21st century – in education, communications, occupations, and entertainment, and as a tool for solving the world's problems – American women's low and decreasing representation is a major concern. Furthermore, the percentage of women receiving bachelor's degrees in the Science, Technology, Engineering, and Mathematics (STEM) disciplines in the United States has increased in every category except Technology (National Center for Educational Statistics, 2005). From 1984 to 2004, the percentages of women receiving bachelor's degrees in the Physical Sciences ranged from 27.6% to 41.7%, Biological/Biomedical Sciences from 46.7% to 62.2%, Engineering from 14.1% to 20.5% and Mathematics from 44.3% to 46.0%. Technology started strong in 1984 with 37.1% women receiving bachelor's degrees; however, 2004 brought a dismal decrease to a low of 25.1%, near the level of three decades ago. The proliferation of computers and information technology in our society, businesses, schools, and homes would have suggested an increase in the participation of women in technology bachelor's degrees, but instead we are faced with a state of clear and continuing decline.

IT CAREER LIFECYCLE MODEL

Carlson (2006) reports that women who want to pursue a career in IT face barriers as early as grade school, in high school, through college and into the work world. Ahuja (1995) developed a model that depicted the factors that constrained women throughout multiple aspects of their recruitment and advancement in the IT field. Ahuja grouped factors influencing women's professional IT career choice into three stages: 1) Early Educational 2) Career Choices and 3) Career Advancement. In Stage I, Early Educational, Ahuja referred to positive and negative experiences that may have influenced a child's attitude and perception toward computers. Stage II, Career Choices, consisted of factors that influenced the critical career choices women made during their university education experience and initial entry into the job market. Finally, in Stage III, Career Advancement Stage, Ahuja considered factors that impede promotions to higher-level IT careers.

Ahuja's model, put forth over ten years ago, is updated by the model proposed here. This new model recognizes that young women begin to make their career choices before Stage II, and it distinguishes more clearly between the university experience and entry into the IT field. In addition, it includes career retention along with career advancement. The new model, proposed here, is shown in Table 1. This model, entitled IT Career Lifecycle, expands Ahuja's three stages into four: 1) Stage I - Contemplating choice of IT major, 2) Stage II - Validate or redefine IT major, 3) Stage III - Initial entry into IT field, and 4) Stage IV - Retention and advancement in IT field.

Table 1. IT career lifecycle model

Stage	Description	General Timeframe	Selected Researchers
I	Contemplating a decision of IT major	Early Childhood to juniors and seniors in high school	AAUW report (2000), Bleeker (2006), Jepson and Perl (2002)
II	Validate or redefine IT major	College	Cuny and Aspray (2000), Pearl et al. (1990), Margolis & Fisher (2002)
III	Initial entry into IT field	One to three years in IT profession	Teague (2000)
IV	Retention or advancement in IT field	Three or more years in IT profession	Trauth (2006)

The arrows in the new IT Career Lifecycle (See Table 1) represent the ability for women to enter or exit the model at any stage. The entry arrows illustrate potential barriers in recruitment of women in each of the four stages of the model, whereas the exit arrows illustrate potential barriers in retention. As the model indicates, a female high school student could decide to major in IT in Stage I of the IT Career Lifecycle Model, and leave the IT field during college in Stage II, due to the long hours in the computer lab and the perception of not having enough time to have a life outside of school. On the other hand, a woman could major in another discipline and enter into the IT Career Lifecycle in Stage III, as a self-taught IT professional. This same woman could leave her IT career in Stage IV due to a lack of opportunities for advancement. Thus, the IT Career Lifecycle model facilitates the ability for the IT community to concentrate and focus their research in a specific stage where girls/women may encounter barriers in their IT careers and target their intervention recommendations in either recruitment strategies, retention strategies, or both.

RELATING KEY STUDIES TO THE MODEL

Stage I consists of barriers a young girl may encounter from her early childhood years to the later years of her high school experiences. The American Association of University Women Educational Foundation report (2000) explains that many girls have a concern with the computer culture and express a "we can, but I don't want to attitude toward computer technology" (p.7). Jepson and Perl (2002) surveyed 652 high school students. Their study revealed several reasons why girls did not choose IT careers: not enough role models in the IT field, other interests, lack of knowledge of the industry, limited opportunity or access to computers, and the image of IT people as nerdy. Bleeker's (2006) study of 460 high school students concluded that the boys surveyed reported a significantly higher expected level of success and interest in IT jobs than the girls. The barriers that create this IT disinterest for girls must be examined to obliterate pipeline leakage in the beginning of the career lifecycle.

In Stage II, a young woman who has decided to major in an IT discipline may encounter barriers while she is validating her major during her college experience. Pearl et al. (1990) focused on the shrinkage of women in the IT pipeline from the pre-college level through graduate school; however, their primary focus was at the college level. Pearl et al. determined three primary barriers for women attempting to enter the field: "difficulties with self-esteem, lack of role models and gender discrimination." Cuny and Aspray (2000) reported on a workshop that developed 20 intervention strategies to increase women's participation in IT graduate programs across the United States. Margolis and Fisher (2002) conducted a study at Carnegie Mellon to investigate computer science education and the experiences of computer science students at the university level. As a result of their research, Margolis and Fisher discovered various differences in computer career decisions, interests, attitudes, and experiences of men and women at Carnegie Mellon. The goal of their research was to understand the differences and develop strategies to increase the participation and retention of women in IT.

Stage III barriers could restrict a young woman's growth and development of her IT career during her initial years in the IT industry. During Stage IV, an experienced IT professional woman may encounter barriers in the industry that impede her opportunity to advance her career. Trauth conducts research on women in the information technology workforce. Teague (2000) studied 15 IT women professionals to explore their reasons for entering the IT industry, what they liked about the industry, and what they didn't like. Some of the explanations for disliking the computer field were being in a male-dominated environment, lack of mentors, and discrimination in salaries. Trauth's research (2006a) examines the "Individual Differences Theory of Gender and IT." This Individual Differences Theory depicts the variation of how IT professional women from different backgrounds perceive and respond to the IT environment, computing culture and societal influences. Moreover, Trauth's contribution as Editor-in-Chief of the Encyclopedia of Gender and Information Technology is an international compilation of over 200 articles highlighting the emerging research and trends on men and women in IT (Trauth, 2006b).

CONTRIBUTIONS AND FUTURE USES OF THE MODEL

By breaking the broad area of women's under-representation in the IT field into more easily studied stages, this model provides both a way of categorizing, relating, and identifying gaps in prior work, as well as guidance for future research.

REFERENCES

[1] American Association of University Women Educational Foundation (2000). *Tech-savvy: Educating Girls in the New ComputerAge*. Washington, D.C.: Author.

[2] Ahuja, M. K. Information technology and the gender factor. Proceedings of the 1995 ACM SIGCPR conference on supporting teams, groups, and learning inside and outside the IS function reinventing IS, Nashville, Tennessee, 1995.

[3] Bleeker, M. Gender differences in adolescents' attitudes about IT careers. *Encyclopedia of Gender and Information Technology*. 1, 507-514.

[4] Camp, T. (1997). The incredible shrinking pipeline. *Communications of the ACM*, 40(10), 103-110.

[5] Carlson, S. (2006). Wanted: Female computer-science students. Retrieved February 16, 2006, from www.chronicle.com/free/v52/i19/19a03501.htm

[6] Creamer, E. G., Burger, C. J., & Meszaros, P. S. (2004). Characteristics of high school and college women interested in information technology. *Journal of Women and Minorities in Science and Engineering*, 10, 67-78.

[7] Cuny, J., Aspray, W. Recruitment and retention of women graduate students in computer science and Engineering: results of a workshop organized by the Computer Research Association. *ACM SIGCSE Bulletin,* 34(2), 168-174.

[8] Jepson, A., & Perl, T. (2002). Priming the pipeline. *ACM SIGCSE Bulletin*, 34(2), 36-39.

[9] Margolis, J., & Fisher, A. (2002). *Unlocking the clubhouse: Women in computing.* Cambridge, Massachusetts: MIT Press.

[10] National Center for Educational Statistics. (2005). U.S. Department of Education, Postsecondary Studies Division, Washington, D.C. Retrieved February 1, 2006, from www.nces.ed.gov/programs/digest/d05/

[11] Pearl, A., Pollack, M. E., Riskin, E., Thomas, B., Wolfe, E., & Wu, A. (1990). Becoming a computer scientist. *Communications of the ACM*, 33(11), 47-57.

[12] Sanders, J. (2005). Gender and technology in education: A research review. Retrieved February 12, 2006, from www.josanders.com/pdf/gendertech0705.pdf

[13] Teague, J. (2000). Women in computing: What brings them to it, what keeps them in it? *GATES*, 5(1), 45-59.

[14] Trauth, E. (2006a). Environmental context and women in the IT workforce. *Encyclopedia of Gender and Information Technology.* Hershey, PA: Idea Group Reference. 1, 276-281.

[15] Trauth, E. (2006b). *Encyclopedia of Gender and Information Technology* (Vols. 1-2). Hershey, PA: Idea Group Reference.

[16] Webopedia. (2005). Online Encyclopedia Dedicated to Computer Technology. Retrieved March 20, 2006, from www.webopedia.com

ERP Conception to Completion: Issues Experienced by Indian SMEs

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1. INTRODUCTION

Enterprise Resource Planning (ERP) system comprise a suite of software modules that lets an organization share common data and practices across the enterprise to access information in real-time environment(Marnewick and Labuschagne, 2005). ERP if implemented successfully can have a significant impact on organizational performance through automation and integrating the majority of business processes (Davenport 1998) on small, medium and large sized organizations.

Small and medium sized enterprises (SMEs) have become a major contributor to the economies of the countries throughout the world (Fillis *et al.,* 2004). Not only in developed countries but also in the developing countries like India, during the past 50 years, the small-scale sector has played a very important role in the socio-economic development of the country. It has significantly contributed to the overall growth in terms of the Gross Domestic Product (GDP), employment generation and exports (Economic Survey, 2003-04). This is the reason in studying these enterprises in this research and more importantly to understand how their efficiency can be increased through successful ERP implementation.

All over the world, a number of SMEs have begun to recognize the significance of ERP. In recent years, many ERP system developers and vendors have begun developing ERP software modules especially targeted at SMEs. For example, SAP, a market leader in ERP solutions has recently launched All-In-One package for 23 industrial practices for Asia –Pacific SMEs (SAP, 2006). However, examples of successful ERP implementation in the Indian SMEs sector are limited. ERP systems are complex. They require large investments in terms of capital, staff and management time (Adam and O'Doherty, 2000) and SMEs usually have limited financial resources, and less technological expertise and management skills (Blili and Raymond, 1993) compared to large enterprises. These constraints make it even more important for SMEs to implement ERP successfully because compared to large enterprises, it would be very difficult for them to survive a failed implementation (Muscatello *et al.,* 2003). Therefore, SMEs need to identify and understand the factors that will lead to successful implementation and those factors that may inhibit such success.

The literature review clearly indicates that most of the reported studies on these systems have focused on large ERP installations with individual investment costs of well over $ 100 million (Muscatello *et al.,* 2003). A literature review had revealed a gap in explaining ERP implementation issues faced by SMEs. In particular, there is very limited research on such implementation in the specific context of Indian SMEs. Given the importance of such firms to the Indian economy and, in turn, the importance of the Indian economy to the global economy, this is a significant gap, which this study seeks to address.

2. CONCEPTUAL FOUNDATION AND RESEARCH METHODOLOGY

The ERP systems experience cycle model (Markus and Tanis, 2000) has been adopted to classify implementation issues experienced by Indian SMEs during various phases of the implementation process. This process theory approach developed by Markus and Tanis (2000) focuses on the sequence of events leading to implementation completion.

The literature provides evidence that the definition of a SME generally depends on one or more than one factor (for instance, number of employees, sales turnover,

Table 1. Firm profiles

	Firm A	Firm B	Firm C	Firm D	Firm E	Firm F	Firm G	Firm H
Year of firm establishment	1999	1994	1985	2000	1986	1988	1997	1990
No. of employees	100	120	200	175	95	100	100	50
Industry	Retail	Retail	Retail	Manufacture	Manufacture	Service	Manufacture	Manufacture
Year of ERP installation	2004	2000	2006	2001	2006	2005	2005	2005
Implementation duration	9 months	6 months	6 months	8 months	8 months	8 months	6 months	1 year
ERP vendor	Oracle	Imaging pro	Wipro	SAP	Oracle	SAP	Movex	In-house
Interviewee	IT Head	IT Head	IT Manager	Manager IT	Manager -systems	General manager	IT Manager and user	Chief information officer and user

investments in assets, and so on) and it is country specific. For the purpose of this study, the Government of India definition of SMEs has been used. According to this, small enterprises are those with an investment of not more than Rs. 50 million(approximately 0.6 million pounds) and medium enterprises are those with an investment of over Rs. 50 million but less than Rs. 100 million(approximately 1.2 million pounds) in plant and machinery(Ministry of Small-Scale Industries, 2004).

The research questions of the study were investigated through qualitative methods. Fieldwork was carried out in India through semi-structured face-to-face and open-ended interviews with IT managers/Head/Deputy General Manager in eight SMEs in India. In addition to this, data was also collected through company reports and documents. All interviews were recorded digitally. The duration of each interview was about 60-80 minutes. The particulars of the SMEs interviewed are presented in Table 1.

3. SUMMARY OF FINDINGS

The section 3.1 explains the issues that Indian sample SMEs faced during the implementation process. The process of ERP implementation, the stages and their corresponding critical success factors have also been studied in this research. Based on the findings, an integrated model for successful implementation has been developed and presented in section 3.2. Due to the constraint on the words limit, the findings are discussed briefly.

3.1 Issues Faced by the Sample Firms

The major issues faced by sample firms in the implementation process has been examined and are then linked to the stages of implementation process based on ERP systems experience life cycle model(Markus and Tanis, 2000).

A. Chartering Phase

Detailed business requirements: During project planning stage, detailed business requirements based on business growth for the future were not looked into by most of the sample SMEs. Due to this, ERP customization was required later on and this increased ERP implementation costs. To tackle this challenge, SMEs should plan carefully what kind of changes in the business processes might occur in the next few years.

Financial support: Though ERP installation was a management decision in the entire sample of SMEs most of the IT Managers found it difficult to get the budget sanctioned. One respondent suggested that management has to be influenced and explained about return on investments for both short and long term.

Dedicated team: Dedicated team for the entire duration of the implementation process was among most common challenge faced by SMEs. The reason for this was the team members were given these additional responsibilities while they were still performing their earlier duties. Therefore, they had to perform extra work for the duration of ERP implementation. This can be tackled if team members can be allowed to work only on ERP implementation. This will lead to successful implementation within time limit.

Vendor selection: Most of the SMEs were not aware of the fact that appropriate vendor selection is an extensive process and it took more time to select vendor than as initially planned.

B. Project Phase

Mindset of users: Changing mindset of users to have ERP was pointed out by all the interviewees. This can be handled only if senior management gives a clear decision that everyone in the company has to accept it.

Update on project progress: Lack of effective communication on the part of management to update the progress of ERP project led to incomplete information with the employees of the firm. This resulted in the resistance from the employees at the later stages.

Training to team members: Lack of systematic and comprehensive training has been raised as one of the main issues. Respondents suggested that initial training should be conducted in different city where all the training members will be completely involved in training. Then, in-house training can follow as and when required.

C. Shakedown Phase

ERP benefits: Management and end users expect ERP benefits from the day one. It was a major task for IT managers to make them understand that it takes few months for ERP benefits to be realized.

Users feedback: Once ERP is implemented, users feedback plays an important role. Users generally do not give complete feedback. Due to this, it takes more time to make the corrections.

D. Onward and Upward Phase

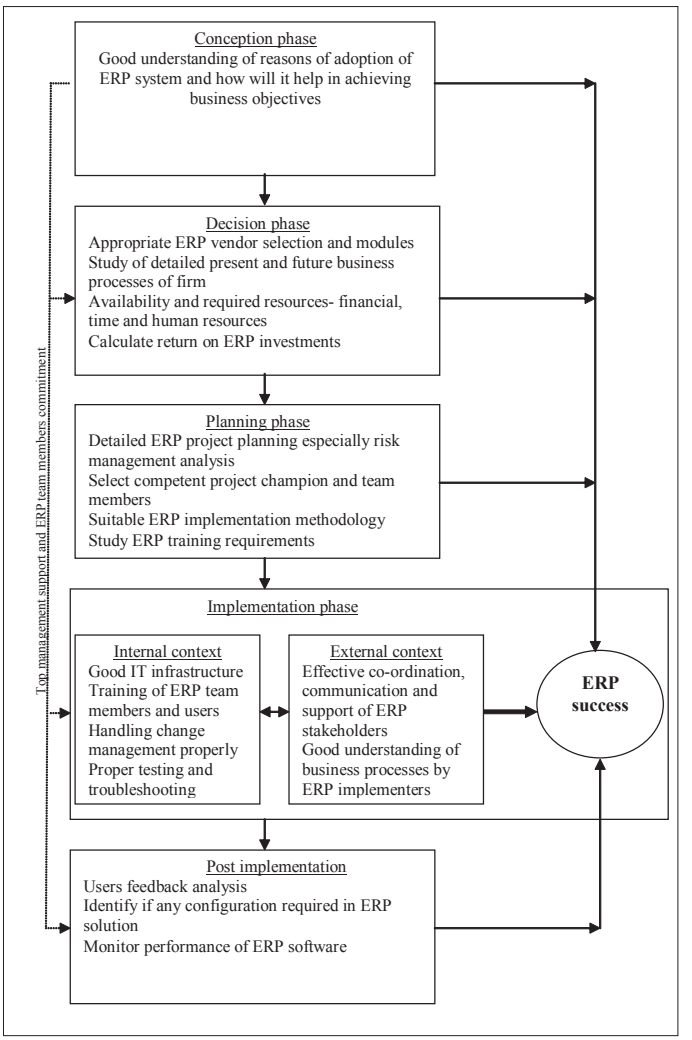
Performance measurement: The respondents recognize that there was no performance measurement technique accepted by the firm at various stages of implementation process. This would have helped the team members to know the status of implementation process as compared to planned initially.

Adaptability of new solution: Even when the system was in place, end users have to be convinced of the importance of the new technology from time to time.

3.2 An integrated Model for Successful ERP Implementation Process

Based on the results of the interviews, an integrated model for successful ERP implementation has been developed that is particular to Indian context (figure 1). This model summarizes and highlights only the most common factors leading

Figure 1: An integrated model depicting ERP installation stages and associated key success factors in Indian SMEs



Source: Compiled by the authors

to implementation success as identified by the respondents. All the interviewees emphasized the important role of top-level management during the implementation process. However, IT managers/consultants and users have a more significant role to play in implementation and post implementation phase respectively. Another interesting factor pointed out by most of the interviewees was that top management has to follow a firm approach to make ERP successful in Indian SMEs. This is mainly because resistance of users was found to be of major concern in most of the SMEs. The brainstorming sessions, training, involvement of users from the very beginning were some of the suggestions given by interviewees as ways of addressing the concerns of users. Other critical success factors have been mentioned in the figure 1.

4. CONCLUSION AND FUTURE RESEARCH

The findings of the study will assist ERP researchers and practitioners to be aware of challenges that can come while implementation process, and how these can be handled for ERP success. Specifically, an integrated model can be used by SMEs to gain knowledge of systematic stages and their corresponding critical success factors specific to Indian SMEs.

This work represents work in progress. In the near future, case studies will be conducted for further developing the framework based on the perceptions of senior management, IT managers and end users. In addition to this, quantitative surveys will be conducted to validate the findings.

REFERENCES

Adam, F. and O'Doherty, P. (2000) 'Lessons from enterprise resource-planning implementations in Ireland: towards smaller and shorter ERP projects', *Journal of Information Technology*, vol.15, pp. 305-16.

Blili, S. and Raymond, L. (1993) 'Information technology: threats and opportunities for small and medium sized organizations', *International Journal of Information Management,* vol.13, pp. 439-48.

Davenport, T.H. (1998) 'Putting the enterprise into the enterprise system', *Harvard Business Review*, vol.8, no.25, pp. 121-31.

Economic Survey (2003-04) 'Performance of SSI', available at:indiabudget.nic.in/es2003- 04/chapt2004/chap711.pdf.

Fillis, I., Johansson, U. and Wagner, B. (2004) 'A qualitative investigation of smaller firm e-business development', *Journal of Small Business and Enterprise Development,* vol.11, no.3, pp. 349-61.

Markus, M. L. and Tanis, C. (2000) 'The enterprise systems experience- From adoption to success' in *Framing the domains of IT research: Glimpsing the future through the past*, Zmud, R. W.(ed.), Pinnaflex Educational Resources, Inc., pp. 173-207.

Marnewick, C. and Labuschagne, L. (2005) 'A conceptual model for enterprise resource planning (ERP)', *Information Management and Computer Security*, vol. 13, no. 2, pp. 144-55.

Ministry of Small-Scale Industries (2004) 'Report - India global summit on SMEs: Emerging challenges and opportunities', New Delhi, India.

Muscatello, J. R., Small, M. H. and Chen, I. J. (2003) 'Implementing enterprise resource planning(ERP) systems in small and midsize manufacturing firms', *International Journal of Operations and Production Management*, Vol.23, No.8, pp.850-71.

SAP-www.sap.com, accessed on 15 Sept 2006.

A Dynamic Capabilities Theory Assessment of E-Learning in Jamaica

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ABSTRACT
Many governments are looking to e-Learning to foster the growth and further development of their educational systems. Despite the potential of e-Learning as a development tool, there are no guidelines given as to the capabilities necessary for the successful implementation of e-learning infrastructure within a developing country and how these capabilities should be shaped. This research examines how Jamaica plans to use e-learning to address the educational problems faced in the country. Several factors, deemed necessary, are identified within the literature and are used initially to outline the capabilities that may be necessary for e-learning infrastructure implementation success. Applying a dynamic capabilities lens and drawing on the lessons learned from the case study this paper will propose a framework for e-learning infrastructure implementation success in a developing country context.

Keywords: e-learning; dynamic capabilities; education; developing country.

1. INTRODUCTION

As economic and social disparities emerge between the countries of the world, most developing countries struggle to find a path to development. The literature has identified varying options for developing countries to achieve economic and social benefits. Some of these include IT-enabled services (Davis et al 2002), software exports (Carmel 2003) and e-government (Ndou 2004; Sipior et al 2005). However in order for a developing country to offer these services or benefit from them it is reasonable to assume that it will need people with the requisite level of education. Drucker (1996) argued that in this knowledge-based era "there would not be poor countries but only ignorant ones". The development of a country's human capital is essential in a global and knowledge based economy. Knowledge is recognized as the driver of productivity and economic growth. Kante & Savani (2002) further emphasized the importance of developing countries acquiring and enhancing knowledge as a competitive tool.

Kaplan-Leiserson (2001) defines e-learning as "a wide set of applications and processes such as Web-based learning, computer-based learning, virtual classrooms, and digital collaboration. It includes the delivery of content via Internet, intranet/extranet (LAN/WAN), audio- and videotape, satellite broadcast, interactive TV, and CD-ROM". Although it has been argued that technology does not improve the delivery of pedagogy, it can promote understanding by individuals with different learning styles (Zhang et al., 2004). E-learning as defined by Kaplan-Leiserson 2001 includes various delivery media that cater to differing abilities and learning styles of students.

E-learning has been identified as one of the contributors to a country's development (Kante and Savani 2002). Various governments have employed e-learning to assist in the education of their people. Some of the countries in which e-learning has been implemented at a national level include the Philippines, Thailand and Singapore. In 2001 Singapore implemented a national e-learning strategy which included using e-learning to enhance the delivery of education in schools but also a component which dealt with the use of e-learning within the corporate and government entities for staff training. By 2003, the majority of Singapore households had access to a computer and the Internet. In fact, The World Economic Forum and other indices rank Singapore as one of the most network ready countries in the world.

Despite the evidence that e-learning can propel a country on the path to development, there are no guidelines given as to the capabilities necessary for the successful implementation of e-learning infrastructure within a developing country and how these capabilities should be shaped. Countries have put e-learning infrastructure in place without full knowledge of all that is needed (Trinidad 2002, Pagram and Pagram 2006). A prescription for successful e-learning infrastructure implementation is needed for developing countries striving to become competitive as a result of increasing the educational level of their population.

The case of e-learning infrastructure implementation in Jamaica will be examined. The objectives of this initiative by the Jamaican government are:

1. Improve the quality of education
2. Enhance the learning experience
3. Ensure high levels of passes in the CXC Exams (a standard set of examinations taken by Caribbean high school students).

The questions that this research will answer are: What are the necessary capabilities for a successful e-learning infrastructure implementation? How does Jamaica develop these capabilities? Examination of this Jamaican case study will add to the body of knowledge on e-learning and provide insights to other researchers on the type and nature of capabilities that are needed in the implementation of similar projects in a developing country context.

The rest of the paper is organized as follows: section 2 gives background on the case study, section 3 proposes to use a dynamic capabilities theory lens to assess the project, section 4 proposes a work plan to engage in the research, section 5 looks at the preliminary findings and section 6 concludes the article.

2. JAMAICAN CASE STUDY

Jamaica has made great strides in integrating technology within its society, particularly voice telephony. The Economist Intelligence Unit's e-readiness rankings for 2006 ranks Jamaica as 43rd out of 68 countries while the Networked Readiness Index for 2005-2006 ranks Jamaica as 54th out of 115 countries of the world. There is access to the Internet and data related services but the use of these technologies is greatly inhibited by the low level of education of the nation's people. Several challenges are identified in the educational system. There are wide disparities in standards among schools, absence of standard instructional materials for teachers and students, an absence of a standard assessment system, inadequate equipment in schools to enhance teaching and learning using modern technologies and an inadequate remedial programme to enable weak students to cope with high school work (Feasibility Study - www.mct.gov.jm\elearning).

The e-learning project, executed mainly through e-Learning Jamaica, a government corporation, in collaboration with two government ministries, was developed with the goal to improve the quality of education in high schools. It proposes using technology to enhance the educational experience. Students in Jamaica's High Schools will benefit from a mix of formal methods with informal approaches to stimulating learning. Proponents of the e-learning project envision applying a blended learning approach that would see e-learning technologies complementing traditional classroom teaching.

The Jamaican e-learning project will be implemented in two phases as indicated in Table 1. The research phase will be "the testing ground for the project design, approach to implementation, the use of teaching and learning materials, the technology applications and software as well as the support systems that must

Table 1

Phases of the E-Learning Project	
1. The Research Phase – The Pilot Programme	• September 2006 – August 2007 • Grades 10 and 11 • 28 selected schools • Includes 5 subjects • Three teachers colleges will be included in the pilot
2. The Implementation Phase - All Island Access to e-Learning	• September 2007 – August 2009 • Includes all eleven (11) subjects in the high school CXC CSEC syllabus • Implementation will take place from grades 7 – 11 in remaining 166 high schools

Adopted from www.mct.gov.jm

Table 2

E-Learning Project Objectives
• To develop a comprehensive set of standard ICT-based instructional materials for teachers and students, in 11 CXC CSEC subject areas
• To provide schools with ICT equipment and software for use in the teaching and learning process • Establish a Central Repository for the Educational Materials (CREM) at the Ministry of Education
• To enhance the skills of teachers through training programs in the use of software and equipment and in modern methodologies for delivery of the high school CXC syllabus;
• To provide modern technologies to existing remedial programs in high schools to ensure that all children keep pace with the schools' programs
• To institute standard examinations that will measure and track the performance of students in each grade in high schools, as well as, measure performance among schools.

Adopted from www.mct.gov.jm.

be in place" (www.mct.gov.jm\elearning). The project has various objectives as shown in Table 2.

3. THEORETICAL FOUNDATION

Teece et al. (1997) define dynamic capabilities as 'the ability to integrate, build, and reconfigure internal and external competencies to address rapidly-changing environments'. Dynamic capabilities theory has been applied within various contexts. Ayuso et al. (2006) used two case studies to identify important capabilities necessary to successfully integrate stakeholders' insights into innovations. We have reviewed e-learning literature and this has suggested the existence of several factors necessary for a successful e-learning infrastructure implementation success (see Table 3). This will be our starting point for identifying the necessary capabilities. The dynamic capabilities theory can be effectively used to analyze the processes employed within the e-learning project.

4. RESEARCH DESIGN

The research approach that will be used in this initial assessment of e-learning in Jamaica will be qualitative. The use of a qualitative methodology is appropriate because it may be difficult to identify dynamic capabilities through quantitative research (Eisenhardt & Martin 2000). We will use an exploratory case study research strategy (Eisenhardt 1989).

A longitudinal study will be performed from 2006 to 2008. Interviews will be conducted. The personnel at the various entities, e-Learning Jamaica, the two government ministries involved in the initiative and at the schools where implementation will take place will be interviewed. This will be done at various intervals during the study. The initial interview instrument will include several open ended questions so that the feedback from the respective parties can be as rich as possible. Documentation from a variety of secondary sources will be examined. The different dynamic capabilities emerging will be identified through a review of the information that is gathered. A framework will be developed. It

Table 3

Factors Identified by Literature Review as Contributing to E-Learning Infrastructure Implementation Success
Adequate IT infrastructure and Equipment Implementation(Trinidad 2002)
Trainer Training (Crichton & Labonte 2003, Trinidad 2002)
Pedagogy Development (Pagram & Pagram 2006)
Matching of social and cultural issues to the delivery of the pedagogy (Pagram & Pagram 2006, Edmundson 2003)
Government and Private Sector Support (Trinidad 2002)

is expected that these capabilities will be linked to the factors identified in table 3, among other factors.

5. PRELIMINARY FINDINGS

There are no preliminary findings as yet since the project and our research into it are in their early phases. With regards to the project, the development of instructional materials is currently underway. The equipment will be supplied by a world-renowned company. Orientation and training of teachers in using ICT to train is also currently taking place.

6. CONCLUSION

There is no research on the implementation of e-learning in a Caribbean country. This research will examine the implementation issues related to Jamaica's e-learning project. E-learning has been used as a developmental tool in countries such as Singapore. It will be useful to learn more about successfully implementing e-learning infrastructure in a developing country.

REFERENCES

Ayuso, S., Rodriguez, M., Rickart, J. (2006). "Using stakeholder dialogue as a source for new ideas: A dynamic capability underlying sustainable innovation." *Working Paper no. 633, Center for Business in Society, University of Navarra.*

Carmel, E. (2003). "The New Software Exporting Nations: Impacts on National Well Being Resulting From Their Software Exporting Industries". *EJISDC (2003) 13, 3, 1-6*

Crichton, S., and Labonte, R. (2003). "Innovative Practices for Innovators Walking the Talk Online Training for Online Teaching." *Educational Technology and Society, 6, 1, 1-5.*

Davis, C., McMaster, J., Nowak, J. (2002). "IT-enables Services as Development Drivers in Low-Income countries: The Case of Fiji" *EJISDC 9, 4, 1-18*

Drucker, K. T. (1996). Organisation of the secondary school. *Unpublished manuscript, East End Senior High School, Sydney.*

Edmundson, A. (2003). "Decreasing Cultural Disparity in Educational ICTs: Tools and Recommendations. " *Turkish Online Journal of Distance Education-TOJDE July 2003 ISSN 1302-6488 Volume:4 Number:3*

Eisenhardt, K.M. (1989), "Building theories from case study research." *Academy of Management Review, Vol. 14 No.4, pp. 532-550.*

Eisenhardt, K.M. and Martin, J.A. (2000). "Dynamic capabilities: what are they?" *Strategic Management Journal, Vol. 21 No. 10/11, pp. 1105-1121.*

Kante, C and Savani, V. (2003). "The New Frontier in the Developing World." *Gia:Internet Journal of Technologies for the Advancement of Learning and Knowledge 5, 1.*

Ndou, V. (2004), "E-Government For Developing Countries: Opportunities and Challenges." *EJISDC 18, 1, 1-24.*

Pagram, P., and Pagram, J.(2006). "Issues in E-Learning: A Thai Case study." *EJISDC 26, 6, 1-8.*

Sipior, J. C. and Ward, B. T. (2005). Bridging the Digital Divide for e-Government inclusion: A United States Case Study. *Electronic Journal of e-Government Volume 3 Issue 3, 137-146.*

Teece, D. J., G. Pisano, and A. Shuen (1997) "Dynamic capabilities and strategic management." *Strategic Management Journal (18) 7, pp. 509-533.*

Trinidad, Arnie. (2002). "An Initial Assessment of the Philippines' Preparedness for E-Learning." *Kasarinlan - Philippine Journal of Third World Studies. Vol 17 No. 2. pp.167-192*.

Zhang, D., Zhao, J., Zhou, L.. and Jay F. Nunamaker, Jr.(2004). "Can E-Learning Replace Classroom Learning?" *Communications Of The ACM. May 2004/Vol. 47, No. 5.*

The Role of Citizen Trust in the Success of E-Government

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CONTEXTUALIZATION

When it began over a decade ago, e-commerce quickly encountered difficulties preventing it from reaching the potential level of success regarded as possible by specialists of the field. After having identified trust as being an important factor of success for e-commerce, both researchers and online retailers were quick to put emphasis on the mechanisms and software that make online transactions possible, and on the need to study and improve security of the Internet infrastructure. At first, researchers were interested in the various mechanisms that enable secure transactions, and also in the visual signs imbedded in web sites that convey security to consumers and let them gain the level of trust necessary for online transactions. But after a while, they came to realize that a secure infrastructure, though essential, was only one factor of success among many others. Additionally, they became aware of the necessity of simultaneously taking into account the trustworthiness of the organizations behind the Web sites as well as the risks that users perceive in using them.

Thus, according to IS literature, the lack of trust users have towards both the internet infrastructure of e-commerce, and the organizations that provide the products and services, counts much for the slow adoption (Wang et al, 1998). Trust and its influence (Chatterjee et al., 2002) on e-commerce have been the subjects of several studies, some of which have in the last few years investigated what influences the degree of trust (Gefen, 2000) and the success of information systems (DeLone and McLean, 2003).

PROBLEM FORMULATION

After retailers, governments of all levels are now showing a growing interest towards setting up various online relations with their citizens, and this mainly for reasons of cost reduction and quality improvement of services rendered. A significant part of e-government projects are related to the implementation of various systems of online transactions that allow citizens a fast and easy access to services that were previously accessible only by mail, phone or in person. The setting up of these online governmental services is facilitated by the expertise that e-commerce specialists acquired during the last decade, particularly in the usability and security of systems. And because governments, for various reasons, feel pressured to do so, they assign major resources for the implementation of these online services while making sure that they meet the highest standards of usability and security.

Citizen trust towards information systems such as applications of e-government has until now not been studied much, Warkentin et al (2002) and Carter and Bélanger (2005) being some of the few authors in IS literature who have published on the subject of user trust building in e-governments. We find that the dynamics of trust building and the adoption of governmental web transaction processing systems are still poorly understood.

OBJECTIVE

Taking these problems into account, the main goal of this research is to provide a better understanding of the opinions held by different stakeholders of the role citizen trust has in the success of governmental web transaction processing systems in the province of Quebec (Canada). Success is expressed here through the six interrelated dimensions DeLone and McLean (2004) define for e-commerce success: system quality, information quality, service quality, use, user satisfaction, and net benefits.

METHODOLOGY

In an exploratory study carried out in the province of Quebec (Canada), interviews are done with e-government specialists of both the municipal and provincial civil service and of non-governmental organizations with a strong interest in e-government, such as citizen groups, e-government information system solutions suppliers, and university researchers. Table 1 below presents a brief portrait of the stakeholders met so far.

Table 1. Identification and role of stakeholders

stakeholder	type of organization	role in that organization
# 1	provincial government	e-government planning
# 2	provincial government	e-government planning
# 3	provincial government	e-government operationalization
# 4	provincial government	e-government operationalization
# 5	municipal government	e-government planning
# 6	municipal government	e-government planning
# 7	municipal government	e-government planning
# 8	e-government IS solutions provider	general management, sales
# 9	e-government IS solutions provider	strategic planning and marketing
# 10	university	research, commercial law on internet
# 11	university	research, ethics in IS
# 12	IS research institute	management, research
# 13	community and citizenship development organization	management
# 14	community and citizenship development organization	management

Because of the exploratory nature of the study, the interviews are semi-structured qualitative interviews done according to the methodology proposed by Rubin and Rubin (1995). On account of the flexible design of these interviews, they are considered guided conversations using a questionnaire built to facilitate the exploration of main themes and the comparison of answers. This type of interview allows for the examination of themes that emerge during the conversation and for the use of follow-up questions when there is a need to clarify certain topics. Interviewed individuals are selected to reflect different points of view. This is done in accordance to their knowledge of the dynamics of e-governments and their having developed, through their professional activities, a founded opinion concerning the way in which citizens react to governmental web transaction processing systems. The number of individuals interviewed is not pre-defined. Rather, interviews are carried out until attaining saturation of data.

Once saturation is attained and interviews are over, a content analysis using the methodology proposed by Krippendorf (1980) will be carried out on the information collected during the interviews in order to identify emerging new results.

PRELIMINARY RESULTS

Preliminary results show a real divide in the opinions of the different stakeholders that were interviewed. Indeed, e-government specialists that participated so far in this exploratory study perceive citizen trust as having a role of variable importance to the success of governmental web transaction processing systems. First, municipal e-government specialists consider trust as being a minor factor of success of e-government applications that municipalities have put on the web. In fact, according to them, the trust that citizens have in municipal governments or in an e-government application has very little effect on the level of success encountered by e-government applications. They perceive that citizens trust municipalities and municipal organizations, and therefore have no reason not to trust the governmental web transaction processing systems they have put in place. They also attribute the non-attainment of the anticipated level of success of e-government applications to citizen's lack of knowledge in their advantages or even their existence.

This perception of citizen trust as not being an important stake for the success of municipal e-government might be explained by the fact that they consider that citizens have no reason to mistrust governmental web transaction processing systems since the infrastructure is secure and that they are dealing with governmental authorities. Furthermore, it might also be explained by the nature of the transactions between citizens and their municipalities, even large ones, since these transactions do not usually imply an exchange of sensitive data, hence a relatively low perceived risk by these citizens.

At the provincial level, the situation is slightly different. Indeed, some of the provincial e-government specialists participating in the study perceive citizen trust as absolutely not an important stake for the success of provincial government web transaction processing systems. For some others however, citizen trust is undeniably an important factor. Just as their municipal e-government peers, those who think trust is not a big stake consider that citizens have no reason to mistrust governmental web transaction processing systems because the infrastructure is secure and that they are dealing with governmental authorities. As at the provincial level where exchanged information is more sensitive and perceived risk higher, some other e-government specialists consider a secure infrastructure as not a sufficient condition to guarantee user's trust and perceive citizen trust is a major concern. For these specialists, it is important that the government and the individuals responsible for the setting up of on-line government applications be conscious of the importance of the trustworthiness of e-government and that they work to increase and to ensure it. It deserves to be noted here that among the specialists met, those for whom citizen trust is not an important stake are those whose task is to plan the setting up of e-government and have thus a more macro vision of it. Whereas those whose task is more closely related to the operationalization of e-government, thus closer to citizen concerns, regard citizen trust an important stake and one which they have to work on in order to ensure the success of e-government applications.

The other stakeholders involved in the study are e-government specialists working for non-governmental organizations with a close interest in e-government. They are university researchers, representatives of citizens groups, and suppliers of e-government information system solutions. Though these specialists have very different interests in e-government, they nevertheless share the same opinion about the importance of citizen trust. They all think it is a factor of success of e-government not to be ignored. According to these e-government specialists, it is a lure to think that a secure infrastructure and the general confidence people have in governments will easily make citizens adopt e-government. In fact, they consider these factors insufficient because, rightly or wrongly, and in spite of the posted security of the systems put online, citizens keep certain fears and express a certain level of mistrust towards governmental web transaction processing systems.

According to these e-government specialists, this lack of trust is articulated particularly around concerns related to security, confidentiality, ethics, and the integrity of the data transmitted to governments or held by them. As their peers who are responsible for of the operationalization of provincial e-government, they consider that emphasis must be put not only on the infrastructure of governmental web transaction processing systems but also on its general trustworthiness. In fact, in their opinion, e-government specialists who do not consider citizen trust an important stake are at the same level as the e-retailers who a few years back considered that the main factor of consumer trust was security.

CONTRIBUTION OF THE RESEARCH

In IS, the study of e-government is still new and this field of research has not yet reached its maturity, so a certain number of problems still remain to be studied in order for the knowledge pertaining to the IS field to be more complete. One of these problems in particular is the important role trust has in the success of governmental transactional web sites. Still very little studied, these applications, which evolve in a context distinct from that of traditional e-commerce where governments are the providers of services, seem to induce a different dynamics of user trust building. The contribution of this research will thus consist of a better and essential comprehension of this dynamics from the perspective of the various stakeholders that are e-government specialists.

REFERENCES

Chatterjee, D. et al. (2002). Shaping up for e-commerce: institutional enablers of the organizational assimilation of web technologies. *MIS Quarterly*, 26(2), 65-89.

Carter, L., et Bélanger, F. (2005). The utilization of e-government services: Citizen trust, innovation and acceptance factors. *Information Systems Journal,* 15(1), 5-25.

DeLone, W.H. and McLean, E.R. (2003). The DeLone and McLean model of information systems success: a ten-year update. *Journal of Management Information Systems*, 19(4), 9-30.

DeLone, W.H. and McLean, E.R. (2004). Measuring e-commerce success: applying the DeLone & McLean information systems success model. *International Journal of Electronic Commerce*, 9(1), 31-47.

Gefen, G. (2000). E-Commerce: the role of familiarity and trust. *Omega - The International Journal of Management Science*, 28(6), 725-737.

Krippendorf, K. (1980). Content analysis: an introduction to its methodology. New York: Sage Publication.

Rubin, H. J., et Rubin, I. S. (1995). *Qualitative interviewing: the art of hearing data*. New York: Sage Publication.

Warkentin, M. et al. (2002). Encouraging citizen adoption of e-government by building trust. *Electronic Markets*, 12 (3), 157-162.

A Study into the Critical Success Factors When Implementing Business Process Management Systems

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1. INTRODUCTION

Nowadays the interest in Business Process Management (BPM) and Service Oriented Architecture (SOA) is rising enormously. There are a lot of software developers and consultancy firms that are jumping to the occasion and are selling Business Process Management Systems (BPMS) that are based on these concepts (Hill, 2006). Hearing these companies talk, it is mostly about 'What' the BPM and SOA concepts are and 'Why' companies should start projects. Often the aim of such projects is turning a company's current application portfolio to a Service Oriented Architecture that can make the business more agile by using Business Process Management concepts and putting the business in the lead where it concerns the use of IT.

Business Process Management Systems are based on developments in both the business and IT domain (figure 1). First, two major business trends that relate to BPM are Total Quality Management (TQM) and Business Process Reengineering (BPR) (Deming 1982, Hammer and Champy 1993). Second, we can identify a rise in the implementation and use of new types of information systems like Enterprise Resource Planning (ERP) systems, Workflow Management (WFM) systems, advanced planning systems and so on. What once started as the automation of a company's internal processes has now become digitization of supply chains (Davis and Spekman 2003). One of the key contributors to this has been the Internet and the associated network standardization.

Because existing methods to implement management concepts were not equipped to handle complicated IT developments as part of a project (Kettinger et al, 1997), and IT implementations started to impact the way in which business were run more and more, all these trends slowly converged into new types of information systems, that some (Smith and Fingar 2003) call Business Process Management Systems (BPMSs). A BPMS can be defined as "a generic software system that is driven by explicit process designs to enact and manage operational business processes" (Weske et al. 2004).

Due to the fact that both BPM and SOA are relatively new concepts, for the business as well as the IT world, the before mentioned emphasis on the 'What' and 'Why' is to be expected. But looking from a customer's perspective, i.e. a company that wants to start a BPM and SOA project and is gathering information for this purpose, the 'How' is most important. Especially if we keep in mind the list of failed ERP implementations during the fifteen or so years. Unfortunately most vendors and resellers largely neglect the implementation aspect, and companies that do claim to have an implementation methodology on BPMS are scarce. In most cases regular software development methodologies or project management principles are used to implement BPM and SOA. The reason for this is that most software developers and consultancy companies regard the implementation of a BPMS as a software development project; which even from a SOA perspective is no longer true (Krafzig et al. 2005). These companies use existing methodologies for software development such as the waterfall method, rapid application development (RAD) or rational unified process (RUP). By doing this, they ignore the business side of a BPMS implementation such as process analysis, performance measurement and continuous (quality) improvement. To cope with this, companies regularly use the Prince 2 project management methodology. Although this may sound like a good implementation approach it is far from tested and validated.

Figure 1. Emergence of business process management systems

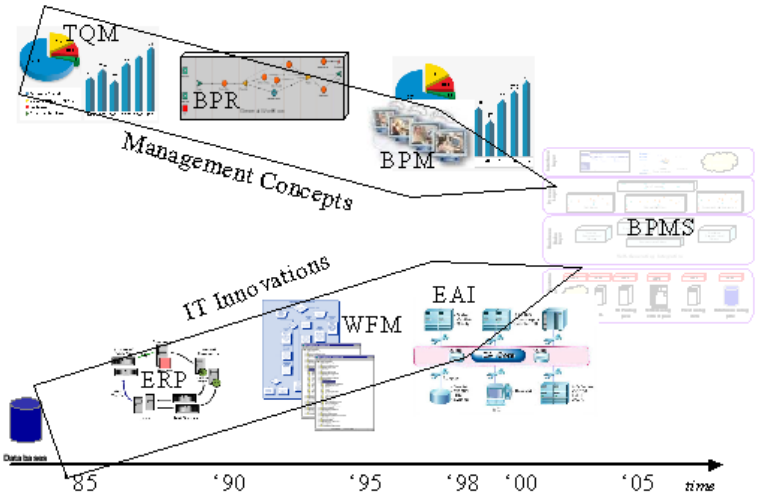
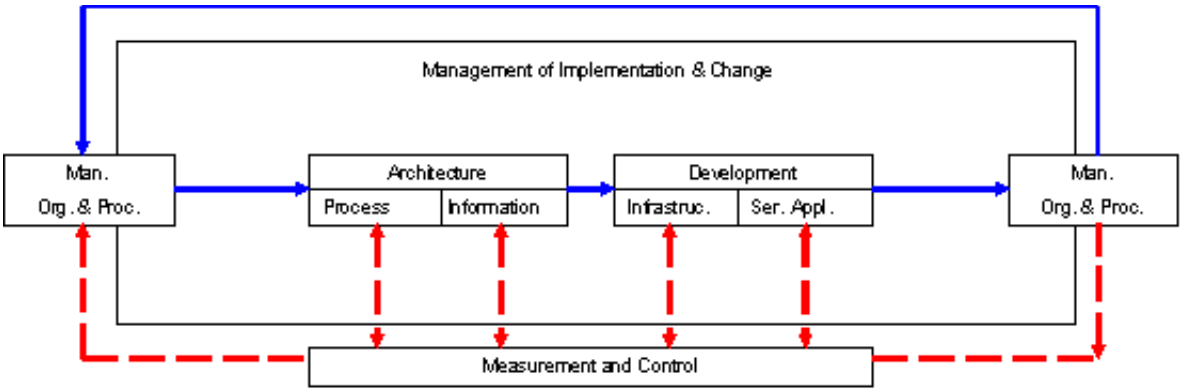


Figure 2. BPMS implementation framework



2. RESEARCH APPROACH AND PRELIMINARY FINDINGS

Based on what we have seen so far, it is possible to state that currently there are no proven implementation methods for a BPM and SOA project. In this paper it is argued that a different implementation paradigm is needed for the implementation of a Business Process Management System. A literature study of 104 articles and books[1] was conducted and based on a meta-analysis of the literature a list was compiled with over 337 critical success factors from the different background principles of BPMS (as depicted in figure 1). This list was based upon the principles according to the following composition: 3.86% of the factors came from TQM, 17.51% from BPR, 29.97% BPM, 11.57% WFM, 12.76% EAI, 2.08% BAM, 12.17% from the BPMS domain and 10.08% from various other related areas. Factors relating to SOA are not mentioned separately but as part of the EAI and BPMS.

Based on the list of critical success factors, a distinction is made between factors that are mentioned in only one domain, and factors that are common among more domains. For example, quantitative measuring and use of statistics to control the effectiveness of improvement actions is only mentioned in relation to TQM, while the importance of top management support is mentioned throughout almost all domains. Next, the frequency a success factor was mentioned is recorded to determine if a ranking or weight can be attached to the factors. Finally, a clustering is made in the following 5 themes that are partially based on the business and IT alignment model of Scheper (2002).

1. Management of Organization and Processes;
2. Architecture Design;
3. Developing an IT Solution based on SOA;
4. Management of Implementation and Change;
5. Measurement and Control.

Within these themes the 'architecture design' is subdivided into designing a process model and an information model, and the 'developing an IT Solution' consists of the realization of an infrastructure and the development of services oriented business applications.

Based on the ranking of the critical success factors a top three per theme can be given:

1. Understanding the BPM concept, management involvement, and strategic alignment;
2. Understanding the process, quality of modeling technique, and quality of data sources;
3. Managing process integrity, granularity of services, and integration of existing applications via services;
4. Quality of project management, change management, and involving people;
5. Defining performance metrics, availability of data, and organizing for continuous optimization.

3. IMPLEMENTATION FRAMEWORK

Based on the outcome of the literature study a BPMS implementation framework is developed that shows the most important aspects that should be part of a BPMS implementation methodology (see figure 2). When implementing a BPMS it is important to understand the underlying principles of Business Process Management and Service Oriented Architecture. It should also be clear that a BPMS implementation is a continuous process consisting of many different projects. This continuous character is shown in the framework by the blue line.

Furthermore the framework distinguishes three different areas, (1) the ongoing domain of the business organization itself, (2) the measurement and control function and (3) the BPMS implementation project area. In most cases a business that wants to implement BPMS will already have an established organization with running processes, which then will be the starting point for the implementation. Also, any business that is already in operation will have some type of measurement and control function. For small businesses this will probably be only the accounting function. For medium and large organizations other functions will provide information about the organization and processes, such as a quality department etc. To succeed in implementing a BPM and SOA there should be sufficient measurement information available about the processes that are going to be modeled. If this is not the case, the implementation should not be started. Metrics on processes are important to be able to continuously measure the effects of any changes.

The BPMS implementation area consists of two phases, the 'architecture design' phase and the 'development phase'. In the first phase a process and information architecture should be developed, i.e. the business process management part. Subsequently, this can be used in the realization of the technical infrastructure and creation of service oriented business applications, both part of the second phase. The two phases are supported by project and change management simultaneously because applying the BPM and SOA paradigm implies that while working on a project there can already be changes in processes and IT applications. The BPMS implementation can be regarded as a project or series of small projects as long as it is understood that both the organization and its processes and the measurement and control function are in fact just a small part of the project.

4. CONCLUSION

The first findings from this study suggest that a BPMS implementation should take into regard both the different management concepts and IT Innovations on which it is funded. To do so, BPMS implementations should start with the business objectives, processes and the metrics by which they are measured from the management side. These processes should then be aligned to a company's strategy and if necessary be (re)designed before starting to identify and develop services as part of a SOA.

The critical success factors that are derived from the different background principles to BPMS are expected to influence the outcome of a BPMS implementation. Based on these factors it is advocated to use aspects of both implementation methodologies for management concepts such as TQM and BPR, and software

development principles. The proposed framework shows the continuous nature of BPMS and is based on the concepts from both business and IT.

5. DISCUSSION AND FUTURE RESEARCH

In this paper a first attempt at is made at describing how a BPMS implementation is different than the implementation of a management concept or the development of an IT application. It can be argued whether such an implementation is really different from any other software implementation. Therefore further research should be done to have this notion validated.

Also the constructed framework is based mostly on the outcomes of the literature study. Comparisons to other implementation frameworks should be done to determine if there is no better-validated alternative already available.

At this stage the research focusing on comparison of the developed framework to others. Simultaneously a series of interviews (approximately 25) are held at Dutch consultancy firms, software developers and organizations that have implemented a BPMS to validate both the critical success factors that were found and the proposed framework. When an improved framework is available several case studies will be held to further validate and test the practical applicability.

REFERENCES

Davis, E.W. & Spekman R.E. (2003). *The Extended Enterprise: Gaining Competitive Advantage Through Collaborative Supply Chains.* Financial Times Prentice Hall.

Deming, W. E. (1982). Quality, productivity, and competitive position. Cambridge, MA: MIT Center for Advanced Engineering Study.

Hammer, M., & Champy, J. (1993). *Reengineering the Corporation: A Manifesto for Business Revolution.* New York: Harper Business.

Hill, J. B., Sinur, J., Flint, D., & Melenovsky, M. J. (2006). *Gartner's position on Business Process Management:* Gartner.

Kettinger, J. W., Teng, J. T. C., & Guha, S. (1997). Business process change: a study of methodologies, techniques, and tools. *MIS Quarterly, 21*(1), 55-80.

Krafzig, D., Banke K., & Slama D. (2005). *Enterprise SOA: Service-Oriented Architecture Best Practices*. Upper Saddle River, New Jersey.

Scheper, W. J. (2002). Business IT Alignment: (1 ed.). Utrecht: Deloitte & Touche.

Smith, H., & Fingar, P. (2003). *Business process management: the third wave* (1 ed.). Tampa, Florida: Meghan-Kiffer Press.

Weske, M., Van der Aalst, W. M. P. & Verbeek, H. M. W. (2004). Advances in business process management. *Data & Knowledge Engineering, 50*, 1-8.

ENDNOTE

[1] A complete list is available upon request

Surviving Domestic Violence: Seeking Support in Cyber-Space

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RESEARCH PROBLEM

Domestic violence (DV) continues to be a substantive criminal issue with profound personal, health, and economic consequences for survivors as well as a complex impact on society at large. Almost 5.3 million victimizations by intimate partners occur every year among U.S. women age 18 and older (Centers for Disease Control, 2003). These attacks include stalking, verbal abuse, sexual assault, rape, beating, and murder. Although women who live below the poverty line and young women are more likely to be abused, domestic violence crosses all social, economic, educational, racial, and cultural boundaries (Heise & Garcia-Moreno, 2002). In households with children, forty to sixty percent of perpetrators also abuse their children (Goelman, 2004).

Numerous studies confirm that DV survivors prefer using informal support networks rather than official legal, medical, or social service support (Grayson & Smith, 1981; Bowker, 1983; Harris, 1988; Harris, Stickney, & Grasley, 2001). Cyber-based social networks, such as discussion lists, exemplify this preferred type of support. They can provide, therefore, a unique window on the information needs and resources shared among DV survivors.

RESEARCH CONTEXT AND LITERATURE REVIEW

Although the Internet is certainly not universally available, used, or accessible, it is increasingly commonplace in the homes of even lower income American families. For DV survivors, the electronic bulletin boards of the Internet provide opportunities for support that can be, quite literally, life-saving. People who are reluctant to approach formal support systems (e.g., police, doctors) or informal support systems (e.g., pastors, family, friends), may feel safe enough in the Internet's digital anonymity to express their concerns and seek answers on critical questions of survival within a community of peers. Issues of cyber-safety, notwithstanding, the affective and cognitive experiences of sharing concerns in an online community can be of tremendous value to survivors, particularly those whose abusers force them into social isolation.

Little substantive examination of the nature and efficacy of information structures used to support DV survivors has been conducted since the advent of the Internet. The only nationwide, overarching analysis of formal information support systems that serve DV survivors was conducted in Canada in, essentially, a pre-Web environment, i.e., Roma Harris and Patricia Dewdney's *Barriers to Information: How Formal Help Systems Fail Battered Women* (1994). Those findings indicate that information was needed on 18 separate problems including housing, emotional support, professional counseling, money, protection, medical attention, children's needs, and transportation (Harris & Dewdney, 1994, p. 79). A total of 23 different agencies or services were expected to be able to provide help in solving these problems including women's shelters, police, pastors, the Salvation Army, community centers, taxi companies, and the YMCA (Harris & Dewdney, 1994, p. 80).

Survivors actively seeking assistance must move through at least three layers of service providers: emergency aid (e.g., police and ER staff), DV assistance centers (e.g., shelters and referral centers), and then an array of specialized support services (e.g., WIC, victim's assistance, mental health services) (Harris, Stickney, & Grasley, 2001). To make these steps, women use an array of information supports. For example, women involved in safety planning (i.e., structuring a plan to use in case of immediate physical danger) sought information from religious organizations, health care providers, shelters, hotlines, counselors, and families (Goodkind, Sullivan, & Bybee, 2004, p. 520). In certain situations, moving into the formal social service system as a victim of domestic violence results in "less control over their lives and being required to attend counseling, parenting classes, or go into a domestic violence shelter" and even the possible loss of their parental rights (Postmus, 2004, p. 113).

Reijo Savolainen's work on the "Everyday Life Information Seeking" (ELIS) model serves as the theoretical framework for this study. ELIS posits that active information-seeking behavior can be used with varying degrees of success to support problem-solving that maintains or develops a mastery of life (Savolainen, 1995; Savolainen & Kari, 2004). The ELIS model notes that "people commonly look first for advice and information from interpersonal sources, especially those similar to themselves" (Wathen & Harris, 2006, n.p.).

RESEARCH METHODOLOGY

This study is the first to examine the information issues of DV survivors functioning in an online environment. It seeks to identify the information needs and resources noted by participants in an active bulletin board community over the course of a single year. The anonymous community under study has been functioning for 2.5 years, includes 1,326 threads, and 7,566 responses to those threads. Only screen names are used and the community self-regulates to encourage solid cyber-safety practices; the members appear to feel comfortable expressing their concerns.

The analysis was completed in three phases. First, a stratified random sample was taken to cover 20% to 30%, depending on the traffic level, of every month's threads from October 2005 through September 2006. Second, the sample postings were prepared for coding by removing potentially identifying information. Finally, the resultant postings were analyzed (using HyperResearch to record the codes and their applications) to delineate information needs (e.g., legal, medical, social) and resources (e.g., web sites, safe houses). Using the constant comparison method of content analysis, the researcher noted, defined, and applied the codes which emerged from the data (Krippendorff, 1980; Miles and Huberman, 1984; Strauss, 1987). The final coding scheme employed 121 codes which were applied to 341,382 words in 1,793 separate postings.

The limitations inherent in any qualitative study pertain to these findings. The individuals who posted on this forum are not statistically representative of any full population so the findings only apply to these individuals. While this moderated forum uses common techniques to eliminate artificial postings, there is no way to guarantee the authenticity of any particular post. Certainly other coders may identify additional codes but these codes reached saturation (i.e., a point at which no new codes were added) at the end of the tenth month; two additional months were completed to insure that all critical items had been recognized.

FINDINGS

The community norms influenced the intent and focus of the postings and, therefore, the codes applied to them. Open to anyone, the forum is housed in a web site which provides extensive resources on domestic violence; the forum and the overall web site include cyber-safety information. In that relatively safe space, the most common pattern for posting is the identification of a problem, need, or acute situation by a single individual followed by a series of responses from community members who provide emotional support and concrete advice regarding tactics, resources, and referrals. Since some posters were just starting to verbalize their abusive situations, their descriptions did not always explicitly identify information needs; nevertheless, obvious examples of such need were coded appropriately.

INFORMATION NEEDS

Information needs fell into five broad categories: finances, law, mental health, domestic violence, and logistics. Understanding bankruptcy options, separating checking/credit card accounts, breaking apartment leases to move away from a stalker, and loans are a few of the financial issues explained in postings. The following post is typical: *He left all of our bills with me, including a loan that's in my name and his dad's name. The last thing he said before he left was that he'd kill me if I ruined his dad's credit.* Financial needs were generally viewed as a by-product of abuse, much like a black eye; there was little sense that anything could be done to improve the situation.

Closely tied to the financial needs are the following legal issues: legal protection from the abuser (193 instances such as *After I left for good he continued to stalk, assault, and tried to kill me and our children*), child custody/visitation (81 instances such as *No judge is going to take your boys away from you based SOLELY on your going to a shelter*), property/income law (66 instances such as *I left with only my clothes and my laptop*), documenting abuse (36 instances such as *Remember when you go to report an incident sometimes the bruises don't show up for a day, especially ones from being choked or restrained by the arms...go back the next day and have the cops take pictures*), divorce (26 instances such as *When I asked him for a divorce, he put the house on the market the very next day*), and other less common needs. Legal information needs often focused on making the system work or dealing with its failures.

Mental health needs pertained to the survivors themselves (*my deepest depression to date. Pills and the river looked so very inviting*), their children (*it's esp important to treat your son right now so you can help overcome his habits that he's picked up from the father*), and their abusers (*He had never been to serious therapy to deal with his childhood of abuse*). While the value of counseling for survivors was a common theme in discussions of mental health information needs, a great deal of effort was expended in discussing the mental health needs of the abuser, including the possibility of effective "treatment" for DV behavior, as well as addictions which were seen as the root cause of violence. *He said he'd go to anger management and counseling. Where can I seek help for that?*

Domestic violence information needs were less common but quite fundamental to progress. In eleven of the twelve months, a few individuals asked for confirmation of their perception that they were indeed being abused. Without an understanding of that basic fact, they had little chance of moving forward. (*He makes me feel ... no matter what I say or do it is never right. After looking at some of these websites I've realized that maybe this could be a form of abuse but when I talk to him about it he feels that it is not and that since he does not leave any physical bruises on my body that it is not abuse.)* Experienced forum members responded to these information needs with definitions, examples, and clarifications in an effort to demonstrate the fact that abusive behaviors run the gamut from isolation to murder.

Finally, information needs pertaining to the logistics of communication, relocation, employment, and other survival concerns surfaced regularly. People sought and gave advice on postal addresses (*Get a post office box for a forwarding address so you can be untraceable*), phone access (*change your phone number*), safety planning (*secretly pack documents, clothes, money etc so that when you leave you won't be empty handed if you have to go in a hurry*), documentation (*Me and my children have new names and ssn so there is no way to trace us*), and finding local social service agencies (*I have searched for local help but have not found anything*). The cyber-safety concerns often revealed a limited understanding of the degree of privacy available on the Internet (e.g., *My abuser managed to find me via lycos email and yahoo email*).

Information needs started with an understanding of what behaviors constitute abuse and then moved on to understanding the process of growing strong enough to separate. The act of separation included legal protections, property division, child custody, and divorce. The final stage, however, was the most common and difficult, that of staying away from the abuser despite emotional connections, fiscal problems, legal issues, and physical threats; mental health needs characterized this stage. Individuals joined the forum at various stages in the escape/survival process so no single pattern of information needs encompassed all users.

INFORMATION RESOURCES

The array of information resources offered in response to these needs included the Internet, services, and individuals. No single resource or type of resource dominated the postings. Instead, the resources were often described as useful but difficult to obtain in that they required a great deal of emotional energy, planning, and persistence to maximize their effectiveness. This patchwork quilt of information resources was rarely seen as sufficient but a long-term combination of resources could be life-saving.

The most common resource was information-seeking (120 instances); the value of seeking information in general (21) and reading specific self-help books (18) combined with general use of the Internet for information and/or emotional support (81). The act of seeking information was viewed as inherently therapeutic and empowering while the resulting understanding of DV and additional resources were viewed as tools with which to build change.

Formal and informal help systems were often recommended, particularly to those whose abusers isolated them. Counseling (81 instances) was useful throughout the escape process as beyond as survivors dealt with Post-Traumatic Stress Disorder. A shelter or DV service (60) was often recommended as at points of acute need while telling or moving in with someone trustworthy (59) could provide emotional support at any time. Although not universally trusted, the police (55) stood as a bulwark against physical danger.

Various activities designed to distract survivors from their urge to return to their abuser (e.g., taking classes, volunteering) or used in support of their overall healing (e.g., exercising, relaxation breathing) were suggested in 48 postings. Other resources were less commonly mentioned including abortion providers, support groups, the media, lawyers, a dog, a gun, and the ACLU.

Several resources were specifically described as problematic including the police (28), court officials (16), mandatory classes for abusers (8), and shelters/DV services (8). Although details were often lacking, some problem scenarios indicated an inaccurate understanding of what the resource could do, such as expecting police to function as body guards.

In this online community, domestic violence survivors are actively, regularly, and deliberately identifying a wide range of information needs and resources. They share affective concerns, pose cognitive problems, and share tactics on behavioral issues. As might be expected of individuals posting online in times of stress, they value both their online community and related resources, such as web sites. Legal, mental health, and social work resources are called for and recommended extensively. Certainly context-specific recommendations could be constructed from careful data-mining of state, county, and local service resources. Further examination of this type of support network for domestic violence survivors may reveal further commonalities which could serve as the basis of a service template. The complexities of the problem definitely requires such work just as the pain of the problem warrants a viable solution.

REFERENCES

Bowker, L. (1983). *Beating wife beating*. Lexington, MA: Lexington Books.

Centers for Disease Control, 2003. *Costs of intimate partner violence against women in the United States*. Atlanta, GA: U.S. Department of Health and Human Services.

Goelman, D. (2004). Shelter from the storm: Using jurisdictional statutes to protect victims of domestic violence after the Violence Against Women Act of 2000. *Columbia Journal of Gender & Law*, 13, 101-168.

Goodkind, J., Sullivan, C., & Bybee, D. (2004). A contextual analysis of battered women's safety planning. *Violence Against Women*, 10, 514-533.

Grayson, J., & Smith, G. (1981). Marital violence and help-seeking patterns in a metropolitan community. *Victimology*, 6, 188-197.

Harris, R., & Dewdney, P. (1994). *Barriers to information: How formal help systems fail battered women*. Westport, CT: Greenwood Press.

Harris, R. (1988). The information needs of battered women. *RQ*, 28, 62-70.

Harris, R., Stickney, J., & Grasley, C. (2001). Searching for help and information: Abused women speak out. *Library & Information Science Research*, 23, 123-141.

Heise, L., & Garcia-Moreno, C. (2002). Violence by intimate partners. In: Krug, E., Dahlber, L., Mercy, J., Zwi, A., & Lozano, R., editors. *World report on violence and health*. Geneva: World Health Organization, 87-121.

Krippendorff, K. (1980). *Content analysis*. Sage, Beverly Hills.

Miles, M., & Huberman, M. (1984). *Qualitative Data Analysis*, Sage, Newbury Park.

Postmus, J. (2004). Battered and on welfare: The experiences of women with the family violence option. *Journal of Sociology & Social Welfare*. 31, 113-123.

Savolainen, R., & Kari, J. (2004). Conceptions of the Internet in everyday life information seeking. *Journal of Information Science*. 30, 219-226.

Savolainen, R. (1995). Everyday life information seeking. *Library and Information Science Research*. 17, 259-294.

Strauss, A. (1987). *Qualitative Analysis for Social Scientists*. Cambridge University Press, Cambridge.

Wathen, C. & Harris, R. (2006). An examination of the health information seeking experiences of women in rural Ontario, Canada. *Information Research*, 11(4) paper 267. [Available at http://InformationR.net/ir/11-4/paper267.html] Accessed 1/10/07.

Information Systems Internships: Student Perceptions and Outcomes

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INTRODUCTION AND BACKGROUND

It is not difficult to find sources that espouse the virtues of internships (e.g. Anonymous, 2006). However, little valid data can be found to demonstrate the positive outcomes that are generally assumed for internships in any portion of the business curricula. In addition, there is little information available to describe students' perceptions of internships and their decision process associated with making the decision to pursue (or not to pursue) an internship as part of their academic experience.

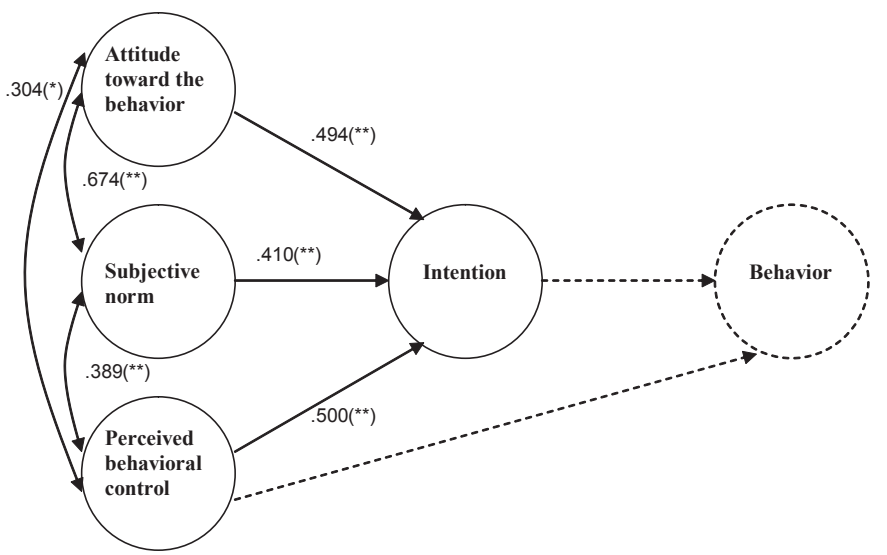
This research is an attempt to illuminate this issue. During the spring and summer of 2006 an online survey was administered to all business students at a large Midwestern university concerning internships. This research focuses on describing information system (IS) students' perceptions and outcomes related to internships. In addition, it will investigate differences in perceptions and outcomes of IS students when compared to their non-IS business student colleagues.

The Theory of Planned Behavior (TPB) (Ajzen, 1991) was determined to be the most appropriate means of modeling the process of students forming the intention to participate in an internship (see Figure 1). The TPB was simplified so that only students who had not yet engaged in the behavior were included in this model and actual behavior was, therefore, not measured. The relationship between intention and future actual behavior is presumed in our analysis. This is well supported by many TPB studies though the conversion rate of intention to behavior varies according to various factors. This conversion rate is unknown and left to future research (this would most likely require a longitudinal study to determine this rate). It is certainly reasonable to suggest that, if one has the goal of increasing the percentage of students who undertake an internship, developing students' intent to engage in internships is a necessary step. However, the need to encourage and facilitate the student in following through on the intent should not be underestimated. Other general questions were also incorporated into the questionnaires to determine what tools students utilize to find internships, where and when they participated in internships, whether they did or will take other coursework during the term of their internship, what skills were most developed, and what the most positive and negative aspects of their internships were, among others. Finally, demographic and employment information were gathered.

METHODOLOGY

Two surveys were designed. The first was designed for those who had not participated in an internship. The second was designed for those who had completed or were currently engaged in an internship. The survey instruments were created by a committee responsible for managing and promoting IS internships at the university. This committee was composed of the faculty internship coordinator, three industry representatives (IS/IT managers), and two members of the university's career services center (placement). This broad set of views created representative instruments that were then validated by presenting the questions to an oversight committee composed of approximately 30 industry and faculty representatives (approximately 70% industry). Valuable suggestions for improvement were gained and used to augment the instruments. Finally, the instruments were pilot tested on a single class of undergraduate students. The pilot test was completed by 27 students. Most of the instruments' constructs were adapted from pre-validated

Figure 1. Theory of planned behavior with bivariate correlations for IS students (n=48)



* *Correlation is significant at the 0.05 level (2-tailed).*

** *Correlation is significant at the 0.01 level (2-tailed).*

Table 1. TPB individual items (1=Very Strongly Agree, 7=Very Strongly Disagree)

IS Students Only (n = 48)

Questions	Mean	Sig. (2-tailed) - that students are *indifferent* (=4.00).
I believe that participating in an internship would be a positive experience. (ATT)	1.646	.000
I believe that participating in an internship would be stressful.	3.417	.000
I believe that participating in an internship would be beneficial to my education. (ATT)	1.563	.000
I believe that participating in an internship would be enjoyable. (ATT)	2.563	.000
I believe that participating in an internship would be challenging.	2.229	.000
I believe that participating in an internship would be beneficial to me in achieving my career aspirations. (ATT)	1.688	.000
Fellow students would encourage me to participate in an internship.	2.917	.000
My instructors would encourage me to participate in an internship. (SN)	2.417	.000
My family and friends would encourage me to participate in an internship.	2.583	.000
People I admire would encourage me to participate in an internship. (SN)	2.500	.000
If I decide I want to participate in an internship I will be able to. (PBC)	2.833	.000
Finding and obtaining an appropriate internship position would be easy. (PBC)	4.125	.322
There are factors beyond my control that could keep me from participating in an internship.	3.833	.415
I intend to participate in an internship. (INT)	2.604	.000
I would participate in an internship if an appropriate opportunity presented itself.	1.875	.000
I intend to actively seek out an internship position. (INT)	2.563	.000

sources (TPB) and the pilot test was used to confirm these measures. The committee review and pilot study demonstrated good face, content, convergent, and discriminant validity.

The data collection was completed via an online web-based survey utilizing email with a link to the survey as the means to solicit responses. This research endeavor received unusual special permission to solicit students via email since experiential learning has been identified as a strategic direction of the university. A total of 387 valid responses were obtained. Of these, 65 responses were from majors or minors enrolled in the information systems (IS) curriculum. The number of responses to the survey for students who had not had an internship were 277 total with 48 IS students. The survey for those who had engaged in internships yielded 110 total and 17 IS students. The sample size for IS students, especially those who had completed internships, does limit the types of analyses that can be performed. However, we believe useful information has been obtained from the available data. The results reported here are only for IS students. Those interested in the full study are referred to Brandyberry (2007).

RESULTS AND ANALYSIS

The TPB items analyzed are from the survey of students who had not completed an internship. The latent variables utilized in the analysis were validated through a confirmatory factor analysis utilizing structural equation modeling (SEM) for the entire sample of business students. Conservative respecification of the model resulted in a good fit (X^2=39.029, DF=31, P≥.152, GFI=.970, CFI=.979, RMSEA=.031) (see Brandyberry, 2007). The results reported for IS students utilized these measures validated for the larger group. A SEM analysis for only IS students was not possible due to sample size limitations, however, bivariate correlations suggest that there are significant positive relationships between the three independent variables (attitude toward the behavior (ATT), the subjective norm (SN), and perceived behavioral control (PBC)) and the dependent variable (intention to pursue an internship (INT)). These correlations are shown in Figure 1.

Table 1 shows the individual items included in the measures as well the results of testing the hypothesis that the students are not indifferent (= 4.00). In addition, the items that were included in the TPB latent variables after model respecification are designated by having the item followed by the latent variable abbreviation. Each of the individual items was also tested for differences between IS students and other business students in the overall sample. The results showed no significant differences between these two groups on any of the variables.

Other selected results from the survey for students who have not had an internship will now be summarized. The students reported preferences for tools that they would use to find an internship. In order of preference these were: the university career services center job postings (64.6%), faculty assistance (60.4%), university sponsored job fair (50.0%), internship or employment websites (45.8%), family/friends (45.8%), and newspapers (22.9%). Students had a strong preference for receiving course credit for their internship in addition to the work experience (75%). Only 6.3% reported no desire for course credit while the remainder was uncertain. Students also thought an internship should be required for the major (47.9% required, 20.8% not required, 31.3% uncertain or not answered). Additionally, students are willing to commute to their internships with 100% reporting they would travel 15 miles and 68.9% reporting they would travel up to 30 miles.

For the students who completed internships selected results will now be summarized. Students used the following tools to locate their internships: internship or employment websites (29.4%), the university career services center job postings (23.5%), faculty assistance (17.6%), family/friends (17.6%), and the university sponsored job fair (5.9%). The majority of students took other courses during the time of their internship (70.6%) and 58.8% received academic credit for their internship.

Students were asked to list up to five skills that their internships helped develop. In rank order of occurrence, these were:

1. Technical/programming skills (82.4%)
2. Ability to work as a contributing/cooperative member of a team (70.6%)

3. Professionalism (58.8%)
4. Oral communication skills (58.8%)
5. Problem solving skills (52.9%)
6. Initiative and self-directed work habits (47.1%)
7. Ability to learn (47.1%)
8. Ability to adapt to organizational rules, policies, and culture (41.2%)
9. Dependability (41.2%)
10. Written communication skills (35.3%)
11. Ability to work accurately and with attention to detail (23.5%)
12. Research abilities (23.5%)
13. Creativity (17.6%)
14. Leadership abilities (11.8%)

DISCUSSION AND CONCLUSION

Some of the most important results of this research could not be reported here due to space limitations. These include the open-ended question results concerning the most positive and negative aspects of their internships as well as what information interested students would like to have available and what the internship program should offer to best serve students. These will be discussed in the associated presentation and are included in the full paper.

The results presented here show that IS students' perceptions and interest in internships is not significantly different from other business students. Modeling the intention to pursue internships with the Theory of Planned Behavior was supported for business students as a whole in a separate related study and correlations from the present study also suggest that TPB would hold for IS students as well. Individual TPB item analysis show that these IS students have positive attitudes towards internships, believe that others are supportive of the value of internships, but are less certain that they have control of whether they can successfully find and acquire an internship. Students that have completed internships report very positive skill sets being developed. In addition to the expected technical skills they also report frequent development of teamwork, communication, professionalism, and problem-solving skills among others.

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Note: This paper is a significantly reduced version of the complete paper due to conference word count restrictions on research-in-progress submissions (2000 words). The complete paper is available from the authors.

REFERENCES

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*, 179-211.

Anonymous (2006). Internships now key to hiring decisions. *USA Today Magazine*, *135*(2734), 9.

Brandyberry, A. (2007). *Business student intentions towards internships: An application of the theory of planned behavior* (working title). Unpublished manuscript.

Enhancing the Effectiveness of Knowledge Management Systems: Using Grounded Models of Knowledge-Intensive Work Processes

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INTRODUCTION

This paper aims to present the author's research interest and plans in relations to his doctoral studies. His research work focuses on the modelling of knowledge-intensive work processes for guiding the design and development of knowledge management systems (KMS) that fit an organization's particular knowledge flow pattern. Research will be undertaken as a multiple case study using knowledge-intensive organizations as an empirical setting.

THE CONTEXT

The changing business environment and the globalization of exchanges have greatly contributed in modifying the economical landscape. Consequently, the way in which organizations operate is becoming an ever-changing process resulting in the emergence of new business models.

Presently, because capital intensive and labour-intensive firms are moving to emerging countries like China, India, and Brazil, western countries are increasingly relying on knowledge-intensive organizations (KIOs) in order to maintain their competitive edge.

In knowledge-intensive organizations (KIO), as opposed to capital intensive and labour-intensive firms, knowledge is more important than other inputs, and exceptional and valuable expertise dominates commonplace knowledge (Starbuck, 1992). KIOs are more likely to be service firms or production firms with a strong service orientation (Roberts, 1999).

Ranging from global consulting firms to technology companies, KIOs are mainly composed of highly qualified experts. The work done by these experts consists primarily in gathering information, know-how, and feedback from three sources: from interpersonal exchanges; from reading, analyzing and applying this knowledge; and in delivering written and oral conclusions to their colleagues and clients (Haas, 2006).

Given the complexity of the projects that they undertake, these experts need to integrate knowledge that comes from either their colleagues or from external sources. To facilitate this integration, KIOs have invested substantial resources in knowledge management initiatives, typically in the development of information systems intended to capture, store and share knowledge about specialized topics (Haas, 2006). The systems that are designed specifically to facilitate the sharing and integration of knowledge are referred to as knowledge management systems (KMS) (Alavi and Leidner, 1999). They usually include the three following components: storage and retrieval, collaboration, and communication technologies.

THE PROBLEM

Despite the massive investments in KMSs, these systems do not always result in project teams performance improvements (Haas, 2006). Because KMSs are just beginning to appear in organizations, little research exists to guide the development and implementation of such systems or to set expectations of the potential benefits of such systems (Alavi and Leidner, 1999).

In fact, KMSs are conceptualized along the traditional information-processing model that promotes knowledge management that emphasizes convergence and compliance in order to achieve pre-specified goals (Malhotra, 2000). However, this model's underlying objective of obtaining greater efficiencies through optimization and routinization of pre-specified goals is increasingly not suitable for organizations that experience discontinuous environmental change, ambiguity, overload and politics (Haas, 2006; Nadler et al., 1995). Thus, KMSs modeled on the information-processing paradigm could be inappropriate for capturing the specificities of knowledge-intensive organizations such as: non-routine work processes, lateral coordination prevalence in work teams, constellations structure of value-creation processes, blurred boundaries determined not by formal structure but by interaction patterns, self-organization, etc.

In addition, systems in the information-processing view are mostly designed around organization information flows. But where teams of knowledge specialists from different disciplines are required to perform non-routine work, the flow and processing of knowledge becomes at least as important as the flow and processing of information (Nissen et Levitt, 2002; Allen et al., 1990). Given that KMSs are systems dedicated specifically to facilitate the sharing and integration of knowledge, it would be better to design them around knowledge flow rather than data flow. Indeed, there are a large number of knowledge management models found in the literature. Each one of them uses its own terms (sharing, transferring, disseminating, etc.) to label knowledge processes. But beyond the diversity of terms used to describe them, these processes all express the idea of knowledge flowing from one entity to another. Consequently, knowledge flow seems to be a pivotal concept to harness different knowledge activities. In other words, in order to design a robust KMS that fits the needs and specificities of knowledge-intensive organizations, we must have a profound understanding of how to represent and simulate knowledge flow processes in modern enterprises (Nissen et Levitt, 2002). The fast emerging knowledge economy provides strong impetus for such an undertaking since knowledge-intensive work now represents the principal means of attaining a competitive advantage across most industries and economic sectors (Drucker, 1995).

However, little is presently known about the phenomenology of knowledge flow. Though many scholars have been interested in studying knowledge-intensive organizations, mainly computational organization theorists, such as the Virtual Design Team (VDT) research group, address the phenomenon of knowledge flow. The VDT research project was launched in the late 1980s with the objective of developing language, theory and tools capable of formalizing work-process modeling. Initially the VDT chose to focus on organizations engaged in routine project oriented task. Research by and Cheng and Levitt (2001) extended the modeling and simulation techniques to address less routine project oriented tasks. Even this extension of VDT has had difficulty in simulating the kind of knowledge-intensive work that is becoming increasingly important in the modern enterprise (Nissen et Levitt, 2002). These last authors, in a collaborative research, built upon the VDT research stream to incorporate emerging work on the phenomenology of knowledge flow using agent-based simulation. Despite the wealth of contribution of these research streams, they do not succeed in capturing the social interactions underlying and shaping knowledge flow patterns. As yet, there is no grounded model of knowledge-intensive work processes that organizations with non-routine work processes can use as a basis to design and implement their KMS. Thus,

we need field research to increase our understanding of how to model the flow and processing of knowledge related to knowledge-intensive work. This new understanding needs to be grounded in data. This is mandatory not only to better design KIOs, but also and particularly to develop and implement robust KMSs that can deliver the tangible benefits expected from them.

RESEARCH GOALS AND QUESTIONS

The general purpose of the research is to describe the knowledge flow patterns associated to the emergent knowledge processes that take place in knowledge-intensive organizations. From this broad purpose are derived the following more specific purposes:

- Understanding the mechanisms underlying the emergence of the observed knowledge flow patterns.
- Modelling different knowledge flow patterns that are typical of complex adaptative processes.
- Developing a KMS design theory, including the formal model, the management philosophy, and the model of organizational relations that define any managerial technique.

In short, the research aims at both describing and understanding the factors that influence the structures of knowledge flow patterns associated with complex adaptive work processes like those that take place in knowledge-intensive organizations.

More precisely, this research plans to address the following questions:

What are the characteristics of the different knowledge flow patterns observed?

What are the environmental, structural, cognitive, political and other factors that shape the knowledge flow pattern observed?

How do these factors interrelate in structuring the flow patterns?

RESEARCH APPROACH AND STRATEGY

Two broad research approaches are generally cited in the litterature: quantitative and qualitative. These approaches include mixed methodologies (Creswell, 1994) and may be conducted under three epistemological assumptions generally named paradigms: positivist, intepretive and critical. Since the goal of this work is to acquire a deep understanding of the phenomenon of knowledge flow in organizations, a qualitative approach will be used. This implies constructing reality through language, cultural location and actions of the people involved. In other words, this work will use a qualitative interpretive approach. Then, the understanding of the phenomenon will be induced from data which are grounded in its context.

RESEARCH DESIGN

In the literature, case study is referred to as a research methodology (Creswell, 1998) or as a research strategy (Yin, 1984; Robson, 1998). A multiple case study in the former sense will be used in this work.

The research design will be twofold.

First, within the multiple case study a grounded theory methodology will be used to identify knowledge flow patterns in at least eight different KIOs, including healthcare organizations, hi-tec organizations, global consulting firms and engineering firms. This will then be followed by an attempt to build a susbstantive theory of knowledge flow in organizations by using multiple stages of data collection through an interactive process of refinement and interrelation of concepts. Doing so, this research will propose grounded models of knowledge flow process, as opposed to those derived from numerical simulation. These grounded models are anticipated to capture the essence of the social interactions governing the knowledge flow patterns. By identifying the contextual factors used to explain the observed knowledge flow patterns, the theory is expected to show sufficient predictive capacity to guide knowlege management systems design and development.

Secondly, considering that the goal of this research is ultimately to guide the design and development of KMSs and that a pure descriptive study would not be sufficient to do so, we will also need to understand how interrelate the different factors that structure the knowledge flow patterns. This implies adopting a systems approach. Moreover, it is worthy to note that KIOs are hybrid systems since they have both bureaucratic and human components. The main characteristic of such hybrid systems is the plurality of viewpoints held by different human components concerning the system's objectives, and even in what the system itself consists of (Lidell and Powell, 2003). Consequently, the systems approach needs to provide not only a practical means of capturing dynamic processes of knowledge flow from data collected in the multiple case study but also needs to inform on the degree to which the actions of the people involved affect the dynamics of the knowledge processes. Thus, to complement the descriptive analysis of the grounded theory, this research plans to use a non-numerical approach of system dynamics known as Qualitative Politicised Influenced Diagrams (QPID) (Powell and Bradford, 1998) .

Systems dynamics use cause-and-effect loops, and influence diagrams to represent processes within a system. By the means of these diagrams, one could visualize the way in which factors or variables affect one another in a dynamic system. These variables need not to be numerical (Powell and Bradford, 1998). Causality is expressed in the form of arrows connecting these factors. Being a non-numerical approach, qualitative system dynamics (QSD) reveals itself to be practical in capturing dynamic processes from responses given in a group environment. «*It avoids the necessity for numerical representation while retaining the causal information contained in influence diagram*» (Liddell and Powell, 2003).

QPID is a recent extension of QSD that works by ascribing agents and actors to the arrows of an influence diagram, allowing the examination of both the roles and motivations in a managed system (ibid). This could be useful not only to understand and predict the dynamic underlying specific knowledge flow patterns but also to put forward effective managerial actions that could enhance the adoption of KMS in the organisations.

SIGNIFICANCE OF THE PROPOSED STUDY

My research will make significant contributions to both theory and practice. First, I expect it will provide the knowledge-based view of organization with models that can help to understand the underlying logic of the dynamic of knowledge-intensive work processes. Second, it will serve as a framework not only for IS designers but also for executive managers to ensure that knowledge management systems they are building suit the needs and the work process nature of their organizations.

Note: The following references are those cited in the text above. For the purpose of this research, we mention that there exists a more comprehensive set of references that covers the different themes that our research touches upon.

REFERENCES

Alavi, M., Leidner, D.E. (1999), Knowledge Management Systems: Issues, Challenges, and Benefits. *Communications of the Association for Information Systems, Vol.1 article 7.*

Allen, T.J., Hauptmann, O. (1990), The Substitution of Communication Technologies for Organizational Structure in R&D, *In Fulk and Steinfeld (Eds.), Organization and Communication Technology, Newbury Park, CA: Sage Publications.*

Cheng, C., Levitt, R. (2001), Contextually changing behaviour in medical organizations. *Proceedings of the 2001 Annual Symposium of the American Medical Informatics Association, Washington, DC.*

Creswell, J.W. (994), Research Design: Qualitative and quantitative approaches. Thousands Oaks, CA: Sage publications.

Creswell, J.W. (1998), Qualitative inquiry and research design: Choosing among five traditions. Thousands Oaks, CA: Sage publications.

Drucker, F.P. (1995), Managing in a Time of Great Change. Tuman Talley: New-York

Haas, M.R (2006), Knowledge Gathering, Team Capabilities, and Project Performance in Challenging Work Environments. *Management Science, Vol.52, No.8.*

Liddell, W., Powell, J.H. (2003), Are you still here: Reconciling patient access and GP effectiveness in the management of a large medical practice: a case study using QPID. *Working Paper series 2003.06, University of Bath School of Management.*

Malhotra, Y. (2000), Knowledge Management and New Organizational forms: A Framework for Business Model Innovation. *Information Resources Management Journal, special Millennium issue on Knowledge Management & New Organization Forms*.

Nadler, D.A., Shaw, R.B. (1995), Change Leadership: Core Competency for the Twenty-First Century In *Nadler, D.A., Shaw, R.B., Walton, A.E. (Eds.) (1995), Discontinuous Change: Leading Organizational Transformation, Jossey-Bass, San Francisco, CA, 1995*.

Nissen, M., Levitt, R. (2002), Toward Simulation Models of Knowledge-Intensive Work Processes. *CIFE Working Paper # 77, Stanford University.*

Powell, J., Bradford, j. (1998), The security-strategy interface: using qualitative process models to relate the security function to business dynamics. *Security Journal, Vol.10.*

Roberts, H. (1999), The control of intangibles in the knowledge intensive firm. 22nd Annual Congress of the European accounting Association in Bordeaux, France, 5-7 May.

Robson, C. (2002), Real World Research, second edition. Blackwell Publishing.

Starbuck, W.H. (1992), Learning by Knowledge-Intensive Firms. Journal of Management Studies 29(6).

Yin, R.K., (1984/1994) Case study research, design and methods. Newbury Park, CA, SAGE 2e edition.

Are Schools Ready to Go Online? A Case Study of Ten Secondary Schools in the Sydney Metropolitan Area

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INTRODUCTION

Much has been written and said about the use of technology to engage students in the learning process. This research is founded on the premise that technology in a school environment is more than just the number of computers in a classroom. According to a recent British Education report (Dfes, 2004), students are manipulating technology and information with dexterity that is not adequately catered for. This research explores the current impact that computer technology has on learning in a secondary school context by examining student and teacher perceptions about the use of computer technology in secondary school including the use of the Internet. The research also collects data about the skill and usage patterns of students and teachers in the use of computers, computer applications and the Internet. The research links these perceptions and usage data to the online presence of each school and examines from 2004 to 2006 the development of learning material posted on the school web pages.

RESEARCH DESIGN AND QUESTIONS

The research design needed to capture the school setting with the various realities of students, teachers and principals. The adoption of a case study approach, utilising quantitative and qualitative methods, provides the necessary liaison between the individual elements as well as capturing the substance of the research. The inclusion of a quantitative analysis allows the researcher to develop a richer understanding of the complexities between student and teacher perceptions, the impact of technological development and the implications for an online presence. The quantitative analysis provides robustness to the results collected from the surveys administered to students and teachers in the survey schools. The analysis is also used to develop a scale of online use. The qualitative analysis provides contextual information as well as a level of perspicuity to the quantitative analysis.

The questions underpinning this research needed to capture school practice, with its underlying pedagogy and individual rationales, along with technical data and use patterns. The eight specific questions that are addressed by this research design are listed below:

1. What is the relationship between teachers' computer skills and the integration of computer technologies into education programs?
2. What infrastructure has been established at schools to assist teachers in (a) increasing their information technology skills and (b) integrating technology into their teaching?
3. If the school has an infrastructure of networked computers, (a) what influences were responsible for its establishment and (b) what goals were serviced by establishing that infrastructure.
4. Does student age or gender have any relation to (a) their level of computer skill or (b) their interest in using computers?
5. Is there a perception amongst (a) students or (b) teachers that computer based programs will improve student achievement and is this view consistent across all schools whether it be single sex, co-educational or lower secondary?
6. What impact, if any, do students perceive that online learning can have on their education?
7. Is there any evidence of an on-line delivery of educational services in schools or a movement towards one?
8. Do schools or the participants surveyed see any advantage in adopting a greater stake in the use of computer technologies in the learning process?

The information needed to provide answers to these questions was gleaned from two questionnaires, one each for the students and teachers, and interviews with the Principals of the participating schools.

METHODOLOGY

Students in two particular year levels and teachers in the ten secondary schools were surveyed. Overall 2023 student and 243 teacher responses were received. Nine principals agreed to be interviewed and the web sites for each school were accessed and evaluated for their learning content for the period 2005 to 2006.

From the student and teacher data, after a factor analysis, six specific scales were formed: computer use, computer application, relevance, positive learning, online readiness and online usefulness. Online readiness and online usefulness were identified as the two dependent variables. In order to evaluate the impact of the dependent variables a linear regression analysis was applied. The linear regression also assisted in curbing the other variables.

The qualitative data from the interviews with principals served two purposes. The principal's specific knowledge of the school operating model was able to add a complementary layer of understanding to the quantitative data for each school. Secondly the principals provided an insight into the particular school's rationale and direction for learning and technology development.

Connecting the six scales to the school's web presence required the learning material on each page to be analysed and an eFactor be calculated. Various models of eLearning exist that do discriminate between the amount of physical presence as well as web interactivity. However the models did not adequately distinguish between the learning purposes of each posting. Using a model developed by the Organisation for Economic Co-operation and Development (OECD, 2005) as a foundation, existing constructs of eLearning were modified and adapted to this particular research. Six constructs of eLearning were defined; supplementary administration, supplementary augmented, supplementary directed, supplementary formative, dependent and mixed modal. Each of the constructs was categorised and weighted according to the following criteria:

- **Learning**
  - **Linked**: A hyperlink or directive to a website or hardcopy material.
  - **Encased**: Structured or staged work usually comprised of a variety of materials and stimuli. This material would be able to replace instructional time in the classroom.
- **Context**
  - **Related**: Material for use by students at their discretion
  - **Additional**: Further pertinent material for the students to use or investigate at their discretion due to the lack of accompanying instruction.
  - **Essential**: Accompanying instruction renders this material a necessary part of the learning sequence and requires the student to interact with the material.
- **Formal Interaction**: Addresses the flow of material that has been documented for each posting. Where there is a lack of documentation, a one way flow has been assumed.

The web presence of each school was then scored according to the categories of the postings, see table 1, school size and the number of teachers posting material.

Table 1. Categorisation of e-learning constructs

Categories	Learning	Context	Formal Interaction
Administration		Related	One Way
Augmented	Linked	Related	One Way
Directed	Linked	Essential	One Way
Formative	Encased	Additional	One Way
Dependent	Encased	Essential	Two Way
Variable	Encased	Essential	Multi

RESULTS

The study provides descriptive data about the access to computers away from school for students and the number of home computers that are connected to the Internet. This dispelled some notions that there were not enough students with computers at home with Internet connections. It also augments available data about student computer use patterns away from and at school, showing that year rather than gender influences the use of some computer applications. The study provides data about the level of a teacher's computer skills and the influence of gender, years of experience and subject background on the data. The study also provides a teacher opinion rating on the use of computer applications as they apply to learning.

This understanding is then matched by the regression analysis to the ways that computers are used at school by teachers. The regression analysis shows the levels of operation and understanding between students and teachers and that the students and teachers are clearly operating from different levels. The teacher linear regression variance for Online Readiness and Online Usefulness was R^2=0.199 and R^2=0.144 respectively whereas for students' the linear regression variance for Online Readiness and Online Usefulness was R^2=0.18 and R^2=0.36. Teachers are waiting to be ready for online use, model 1, whereas the students are past being ready, model 2.

The web site analysis provided some confirmation of the regression analysis as well as giving some insight to the progression by teachers in their use of school website in the following year. The resultant eFactor for the ten schools placed the schools in three distinct groups. The schools in the top category were distinctive not only by the number and interactivity of each posting but the underlying technology philosophy of the school principal. This was despite some of the schools focusing on the technical skills of the teacher and underpinning those skills as part of a total school program.

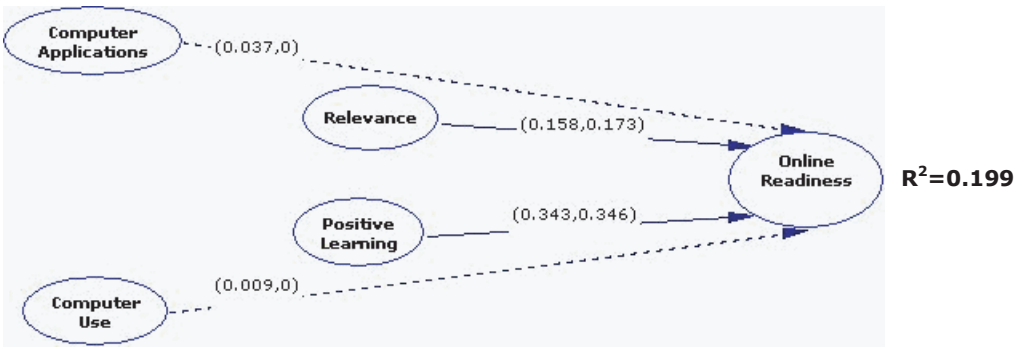
Finally the case study provides on overall perspective as to the understanding by individual leaders as well as educational systems of their commitment to and understanding of technology integration with the learning process. Clear evidence exists to demonstrate that school leaders who have a sound understanding of the benefits of technology coupled with an inspirational learning vision have instituted appropriate school development.

REFERENCES

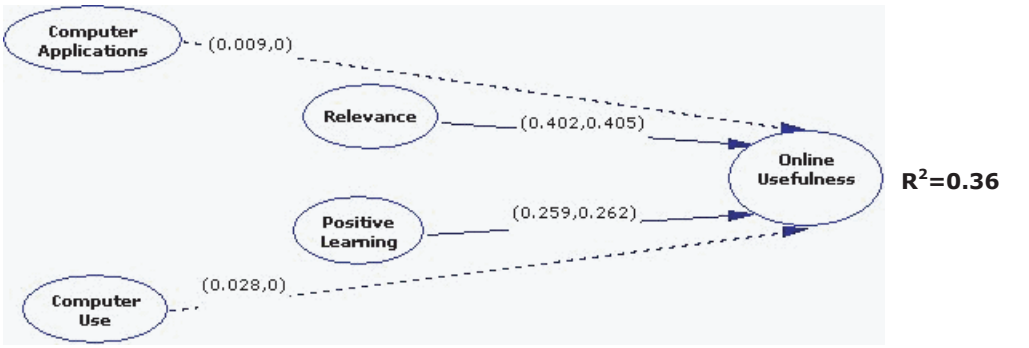
Department for Education and Skills. (2004). *Pedagogy and Practice: Teaching and Learning in Secondary Schools.* Retrieved March 30, 2005 from www.standards.dfes.gov.uk/keystage3/downloads/sec_ppt1043804u15u1sing_ict.pdf

Organisation for Economic Co-operation and Development (OECD). (2005). *E-learning in tertiary education*. Retrieved September 12, 2006 from http://www.oecd.org/dataoecd/55/25/35961132.pdf

Model 1. Linear relationship showing the teacher relationship between the variables of online readiness, relevance and positive learning



Model 2. Linear relationship showing the student relationship between the variables of online usefulness, relevance and positive learning



Organizational Project Management Maturity Model (OPM3): A Case Study

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ABSTRACT

The degree to which an organization practices the project management effectively is referred to as Organizational Project management Maturity (OPM). Organizational project management is defined as the application of knowledge, skills, tools, and techniques to organizational and project activities to achieve the aims of an organization through projects. Effective project management helps organizations to achieve the strategic goals. OPM, by aligning projects to business strategy, fills the gap between organization's strategic planning process and accomplishing successful projects. The objective of this research case is to understand and apply the current OPM framework (OPM3) in context of the company IProcure Systems Inc (ISI).

1. SETTING THE STAGE

IProcure Systems Inc. (ISI), an internet based procurement service provider company, started offering web based procurement services with the vision to host I-Procurement application and offer indirect sourcing services to many small, medium and large companies giving users a self-service purchasing web experience. This strategy intends to offer numerous benefits to many organizations such as standardization of procurement processes, shared technical and functional expertise, and use of common infrastructure, accurate and comprehensive information gathering and reporting. A variety of projects have been executed to bring number of companies on this centralized IProcurement system as well as to introduce efficient processes, which could be used by all companies. This environment is used by number of companies for performing procurement activities using SSP (Self-Service Purchasing) worldwide. ISI continues to provide a very dynamic, innovative and very critical sourcing environment to many companies.

2. CASE DESCRIPTION

Our case will focus on the understanding the OPM3 model and its concepts in ISI organization's functioning, process and environment. The next step was to carry out the assessment of the organization. Two techniques were used to complete the survey - (i) group members individually complete survey independently from his/her operational point of view (ii) discuss the questions and answers of the survey in a group setting and then consolidate the results. The final stage is to generate and analyze results. After feeding answers to the survey questions, OPM3 model returns with the results of the preliminary assessment. It includes total four graphs that visually indicates ISI's organizational project management maturity placement on a continuum of maturity, ISI's attainment of Best Practices against the domains of PPP and the stages of process improvement (SMCI). These results are shown in terms of percentage points. It also identifies the detailed OPM3 components—Best Practices, Capabilities, Outcomes, Key Performance Indicators. The list then generated was analyzed in the areas exposed by the self-assessment as 'Areas requiring improvement'.

Establishing a well-planned project management process, OPM3 demands that projects, programs and Portfolio management processes are controllable. In order to establish a controlled system four steps are meaningful i.e. Standardize, Measure, Control and continuously Improve (SMCI).

3. OPM3

OPM3 is comprised of three, interlocking elements: Knowledge, Assessment and Improvement.

The **Knowledge Element** includes an executive summary, the narrative explanations required for the user to understand organizational project management, its definition and its application toward organizational project management maturity; an explanation of terms specific to the OPM3 Standard; the explanation of the OPM3 steps and an example of application, the appropriate appendices; the OPM3 Glossary; and the OPM3 Index. The **Assessment Element** includes the OPM3 self-assessment, an interactive database application. After completion of the self-assessment, the results include various graphs (spider diagrams) that visually depict an organization's attainment of Best Practices against the domains of Project, Program and Portfolio (PPP) management and the stages of process improvement: Standardize, Measure, Control, and continuously Improve (SMCI). When combined, these values produce a percentage point representative of the organization's organizational project management maturity placement on a continuum of maturity. The OPM3 components—Best Practices, Capabilities, Outcomes, Key Performance Indicators and the relationships across and among Best Practices–are warehoused within a database comprising the **Improvement Element**. This database will include each component's unique identifier, name, and description. Because different organizations might apply OPM3 in differing ways, this database will allow the user to filter specific criteria and parameters important to their organization to obtain various lists of Best Practices and/or Capabilities.

Thus, OPM3 provides answers to very important questions related to the organization's current project management maturity and allow organizations to further improve on the same. OPM3 is a roadmap, a well-structured and detailed guide to the Best Practices that the organization needs to implement to achieve its strategic goals through projects while conserving organizational resources. It promotes organizational maturity awareness among senior management and attributes organizational success to project management.

The detailed aspects and functioning of the company from the subject standpoint, by applying the framework, terminology and concepts used by OPM3 in the company ISI will be discussed at the conference and in our paper which will be submitted to JCIT for possible publication.

4. OTHER MODELS FOR ASSESSING THE PROJECT MATURITY OF A FIRM

Among the project managers, the PMBOK ® Guide [7] is widely accepted as a de-facto standard for PM. In Europe, and more recently in Japan and in US, there are competing standards, showing that there is not established unique standard in PM. The short list of standards in PM is in Table 1., below:

This variety of standards opens the possibilities for development different models for Project Management Maturity apraisals. In this paper, we are examining three other models.

4.1. PMMM

The **Project Management Maturity Online Assessment Survey** is a formal tool developed by PM Solutions and Primavera Systems used to measure an organization's project management maturity. Authors (from PM Solutions) claim that the online model will answer next important questions (PM Solutions (2006)):

1. How well does my organization manage projects?
2. What are the strengths and weaknesses of my organization?
3. How does my organization stand in comparison with others?

Table 1. International PM standards

Standard Name	Country
Open Standards Project Management & Consulting Services	Open standard
A Guide to the Project Management Body of Knowledge(*PMBOK Guide*)	USA
APM Body of Knowledge 5th ed. (*APM - Association for Project Management*)	UK
PRINCE2 (*PRojects IN a Controlled Environment)*	UK – (government sand commerce)
P2M (*A guidebook of Project & Program Management for Enterprise Innovation*)	Japan
V-Modell	Germany
HERMES	Switzerland, Luxembourg

4. What can I do to improve the project management maturity of my organization?

The list of questions for the survey is presented in Appendix 1 (Top 10 CSF (2004)). After taking the survey, PM Solutions offer two-stage pathway using their PMMM (Project Management Maturity model) with 65 questions (Rayner, P. & Reiss G. (2000)), based on Software Engineering Institute Capability Maturity Model's (CMM®) and in compliance with OPM3. Model examines PM maturity level in 5 stages: Initial Process, Structured Process and Standards, Organizational Standards and Institutionalized Process, Managed Process and Optimized Process. User needs to position all PM activities in one of those stages. This extended list of PM activities covers Management of Project Integration, Scope, Time, Cost, Quality, HR, Communications, Risk and Procurement/Vendors.

4.2. $(PM)^2$

The Project Management Process Maturity or $(PM)^2$ maturity model (also known as the Berkley model) is developed by Young Hoon Kwak, Ph.D. and C. William Ibbs, Ph.D., from the Department of Civil Engineering, University of California at Berkeley. This model "measures, locates, and compares an organization's current PM maturity level… The model is continuously being refined to reflect advances in their PM knowledge. Some of the most recent improvements include evaluating replicability of project success" (Kwak, Y.H. William, C. (2000)). This model is in sink with PMI principles and the process is organized in 5 levels (Table 2).

4.3. CMMI

The Capability Maturity Model Integration (CMMI®, CMMI 2006) is developed in 2001 and updated in 2006 by Carnegie Mellon University. The model is based on a premise: " Process, people, and technology are the major determinants of product cost, schedule, and quality". Use CMMI in process improvement activities: as a collection of best practices, framework for organizing and prioritizing activities, support for the coordination of multi-disciplined activities that might be required to successfully build a product, means to emphasize the alignment of the process improvement objectives with organizational business objectives. A CMMI model is not a process, but it describes the characteristics of effective processes. The Standard CMMI Appraisal Method for Process Improvement (SCAMPI) is designed to provide benchmark quality ratings relative to Capability Maturity Model Integration (CMMISM) models. It is applicable to a wide range of appraisal usage modes, including both internal process improvement and external capability determinations (see Appendix 2). Model defines 3 Classes of Appraisal Methods (SCAMPI family): SCAMPI C (provides a wide range of options, including characterization of planned approaches to process implementation according to a scale defined by the user); SCAMPI B (provides options in model scope and organizational scope, but characterization of practices is fixed to one scale and is performed on implemented practices), and SCAMPI A (the most rigorous method, and is the only method that can result in ratings.) The SCAMPI requirements are presented in Table 3.

Table 2. Five levels in the $(PM)^2$ model

Levels		Major characteristics
1	Ad Hoc	Basic PM process
2	Planned	Individual Project Planning
3	Managed	Systematic Project Planning and Control
4	Integrated	Integrated Multi-Project Planning and Control
5	Sustained	Continuous PM Process Improvement

Table 3. SCAMPI requirements

Requirement	**SCAMPI A**	**SCAMPI B**	**SCAMPI C**
Types of Objective Evidence Gathered	Documents and interviews	Documents and interviews	Documents or interviews
Ratings Generated	Goal ratings required	No ratings allowed	No ratings allowed
Organizational Unit Coverage	Required	Not required	Not required
Minimum Team Size Appraisal	4	2	1
Team Leader Requirements	SCAMPI A lead appraiser	SCAMPI B and C team leader	SCAMPI B and C team leader

5. INITIAL CONCLUSIONS AFTER USING THE OPM3 MODEL IN THE COMPANY ISI

In conclusion, applying the OPM3 model, we are able to announce that a percentage point representative of the ISI's organizational project management maturity placement was 68%. Model also provided ISI for the purpose of analysis and focus the improve areas, the list of Best Practices and Capabilities that are currently being observed in ISI and also the ones which need to be focused for further improvement. More details will be available in the JCIT paper.

REFERENCES AND LITERATURE (IN ALPHABETICAL ORDER)

1. Cleland, D.I. and Ireland, L.R. (2002). Project management – strategic design and implementation. McGraw Hill, New York, NY.
2. CMMI (2006) - Sources for documents dealing with CMMI model: http://seir.sei.cmu.edu; http://www.sei.cmu.edu/cmmi; www.sei.cmu.edu/pub/documents/01.reports/pdf/01hb001.pdf
3. Crnkovic J., Ross P., and Desai S., (2007) *Software Support for the Classical, Contemporary and Future Project Management.* SCI Journal (to appear, accepted for publication)
4. Nicholas, J.M.(2001). Project Management for Business and Technology, PrenticeHall, Upper Saddle River, NJ.
5. Kwak, Y.H. William, C. (2000). *The Berkeley project management process maturity model: measuring the value of project management*. Proceedings of the 2000 IEEE Engineering Management Society, Albuquerque, NM. Published on-line in 2002.
6. Olson, D.L. (2004). Information Systems Project Management. McGraw Hill, New York, NY
7. OPM3 Website on PMI URL http://www.pmi.org/info/PP_OPM3.asp
8. OPM3 (2003) Organizational Project Management Maturity Model. Project Management Institute, (www.pmi.com), Newton Square, PA.
9. Rayner, P. & Reiss G. (2000). *The Programme Management Maturity Model.* pmmm_questionnaire_v72.
10. PMBOK ® Guide, published by the Project Management Institute, (www.pmi.com), Newton Square, PA, 2000 and 2003
11. PM Forum web site: www. PMFORUM.org
12. PM Solutions (2006). Web site: www.pmsolutions.com
13. PMI Website URL http://www.pmi.org
14. Primavera web site: www.primavera.com
15. Project Manager Competency Development Framework (2002). Project Management Institute, (www.pmi.com), Newton Square, PA.
16. Schwalbe, K.(2004) Information technology project Management, Thomson, Boston, Ma.
17. Top 10 CSF (2004). Top 10 Critical Success Factors for a Project Management Office, Computerworld, February 16, 2004

APPENDIX 1. TOP 10 CRITICAL SUCCESS FACTORS FOR A PROJECT MANAGEMENT OFFICE (FOR THE ON-LINE PM MATURITY ASSESSMENT)

Rating scale for all questions:	
3 - We've got it covered. 2 - It's OK, but could be better.	1 - Needs some serious improvement. 0 - Couldn't be worse.
Questions	
1. The PMO has senior executive-level support.	6. Training of project managers is competency-based (rather than purely academic).
2. A superior process for selecting project managers and teams has been established.	7. Project management methodologies, tools and templates are standardized.
3. Project teams include participants from multiple business functions and disciplines.	8. A useful knowledge library of best practices is maintained as part of the PMO.
4. A high standard of truthfulness and integrity exists within the PMO.	9. The PMO is involved in all projects from start to finish.
5. The PMO serves as an "ambassador," communicating with all internal and external stakeholders.	10. The organization's project portfolio is managed by the PMO.

APPENDIX 2.

Phases and Processes in SCAMPI appraisal	
Phases	Processes
1: Plan and Prepare for Appraisal	1.1 Analyze Requirements 1.2 Develop Appraisal Plan 1.3 Select and Prepare Team 1.4. Obtain and Analyze Initial Objective Evidence 1.5. Prepare for Collection of Objective Evidence
2: Conduct Appraisal	2.1. Examine Objective Evidence 2.2. Verify and Validate Objective Evidence 2.3. Document Objective Evidence 2.4 Generate Appraisal Results
3. Report Results	3.1 Deliver Appraisal Results 3.2 Package and Archive Appraisal Assets

Diffusion of RFID in Organizations: A Perspective Based on Risk Perception

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ABSTRACT

There are very well known advantages of implementing RFID technology in many industries. For example, if RFID tags are embedded within drugs it becomes very difficult for counterfeit drug makers who will have to replicate the RFID tag as well. However, there are several reasons for lack of adoption, including: rapidly changing technology, high costs, and poor reliability of tags. Even required mandates from partners and senior management may not be sufficient drivers to ensure penetration of RFID technology in other organizations. The "Diffusion of Innovation Theory" or DoI is used to explain the delay in the adoption of the technology in businesses. There has been significant work on computing the ROI for RFID based on technology risks and the cost of technology. The focus in this paper is on the significance of atypical risks in the adoption of RFID technology. This research is using the survey method to reject two suggested hypotheses. The innovative approach is in expanding the DoI in the organization into the process of planning the adoption of RFID technology and to continue using DoI during the implementation process.

INTRODUCTION

Radio Frequency Identifiers (RFIDs) are computer chips that can be tracked from a distance. They are slated to become one of the most significant business innovations in this century with far reaching implications in supply chain management, real-time location monitoring, and asset management. Since RFID allows a product to be tracked without line of sight, a greater level of automation in business processes is possible leading to reduction in labor costs and improved efficiency. In addition, RFID enables improved accuracy and closer integration with business partners. RFID tags are typically affixed onto the goods that they are supposed to track, however, they can also be embedded within the product thereby preventing proliferation of counterfeit goods with fake RFID tags or at least making it much more difficult. For instance, if the RFID tag is embedded within drugs counterfeit drug makers will also have to replicate the RFID tags. There are limitless possibilities for use of RFID tags, however despite all these advantages, their adoption remains painfully slow. There are several reasons for this lack of adoption, including: rapidly changing technology, high costs, and poor reliability of the tags. The infrastructure supported by different vendors is also often incompatible due to conflicting standards, incompatible frequencies, and different power levels for RFID tags and readers. Even required mandates from partners and senior management may not be sufficient drivers to ensure penetration of RFID technology in other organizations. In addition, there are other risks that have not been explored adequately which can skew the ROI equation for the adoption of RFIDs. We examine the risk perception of adopters to determine its impact on the penetration of the technology in organizations. The diffusion of innovation theory is used to explain the delay in the adoption of the technology in businesses. This work builds up on the initial work on RFID risks (Goel & Crnkovic, 2005). There has been significant work on computing the ROI for RFID based on technology risks and the cost of technology. However, there are several factors that have been ignored in this equation which we believe will be the key to the adoption of this technology, including, health, environment, security, privacy, and business uncertainty. The focus if this paper is on the significance of atypical risks in the adoption of RFID technology. Our hypothesis is as follows:

H1: Non-technology perceived risks are a significant factor in adoption decision on the RFID technology in organizations.

H2: Organizations are still mired in the first two stages (relative advantage and compatibility) of the Roger's Diffusion of Innovation Theory (DoI) in RFID adoption.

We use DoI to explain our hypothesis. In addition, we conduct a survey to collect the data to examine the hypothesis. The rest of the paper is organized as follows: Section 2 provides the theoretical foundations of this work; Section 3 presents the data collection methodology and preliminary results, and Section 4 presents conclusions and directions for future work

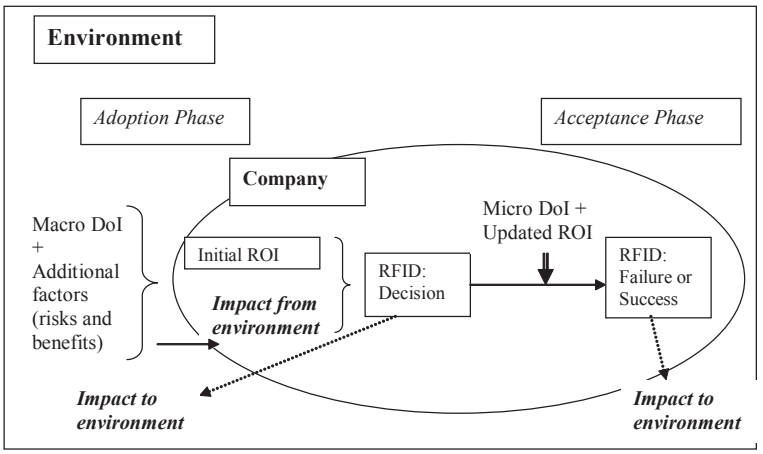
2.0 THEORETICAL FOUNDATIONS

There is often inertia in adoption of innovations by organizations for a variety of reasons such as: lack of clear understanding, aversion to risk, and general apathy to create changes in the organization. In the past, problems of diffusion and adoption of new ideas, processes, and technologies have been studied under the rubric of DoI. Rogers and Shoemaker (1971) have defined diffusion as the process of communication of a new idea to a person, group, or organization. Rogers and Shoemaker (1971) defined the adoption as the process of acceptance of an idea or technology after initially learning about it. The basic tenet of DoI is that innovation is communicated through certain channels over time within an organizational context. Individuals have different degrees of willingness to adopt new ideas or technology and the percentage of individuals adopting innovation is distributed normally over time (Rogers, 1995). The rate of adoption of innovations is impacted by five factors: 1) relative advantage, 2) compatibility, 3) trialability, 4) observability, and 5) complexity. The first four factors are generally positively correlated with rate of adoption while the last factor, complexity, is generally negatively correlated (Rogers, 1995). Mustonen-Ollila & Kalle Lyytinen (2003) in a recent study show that several DOI factors strongly influence adoption of innovations in organizations, however, innovation adoptions follow no discernable pattern.

The rate of adoption is governed by both the rate at which an innovation takes off and the rate of later growth. Low cost innovations may have a rapid take-off provide a quicker breakeven point for investment, while high cost innovations require a larger time to amortize the initial costs. RFID falls in the latter category where the initial investment is very high and the amortization time is fairly long. Given the high degree of uncertainty in the current business environment companies are reluctant to make the huge investments in an unproven technology (Collins, 2004; Schrieber, 2005).

Innovation adoption rates can also be impacted by other phenomena such as civic, social, and ethical concerns of the adopters. Some of the risks are real while others are based on paranoia emanating from lack of knowledge and understanding. The key factors influencing management decisions include health, security, privacy, environment, and business ethics. The key health issue is the possibility of radio frequency waves having carcinogenic effects. However, recent research by the cell phone industry refutes these claims. Current emission levels of WLAN and RFID tags are below RF emission levels from cell phones (CISCO, 2005). In addition, RFID uses low-end of electromagnetic spectrum from which the waves are not dangerous for general public (ILO, 2006). The other areas of legitimate concerns are security (Goel & Crnkovic, 2005) and privacy (EPIC, 2005), are currently being addressed through encryption and other security technologies. There are significant environmental concerns primarily related to disposal of millions of tags including batteries for active RFID tags. However on the other

Figure 1. Model for exploring acceptance of RFID using the DOI model



hand, RFID tags also allow trash to be tagged and tracked, which provides some ecological advantages (Thomas, 2003). A growing concern about adoption of RFID technologies will have huge labor implications (Gonsalves, 2004; Jaques, 2004; ILO, 2006).

This study examines the impact of the factors suggested in the DoI model as well as the civic, social, and ethical concerns of decision makers.

In this research, we are expanding DoI outside from simply organizational settings to discuss the planning of implementing this new technology. There is a very strong network externality associated with the adoption of the new technology since the supply chain can only be automated if all vendors and suppliers in the chain have adopted the technology. However lack of standardization in the technology and protocols associated with RFID mitigates the impact of network externality. Nevertheless, in the current network environment where company supply chains are intricately linked, a group of companies operate as a single organization with adoption decision made at the level organizations in the supply chain. Typically DoI is applied to individual companies where adoption is considered as an individual level. In view of a network environment we extend the DoI theory to a group of firms linked together via a supply chain. We consider the adoption within the organization as micro level diffusion and the adoption by the firm as the macro level diffusion.

Our research model is presented in Figure 1 which shows that DoI is applicable at two levels: 1) the macro level (adoption by multiple companies in a supply chain), and 2) the micro level (acceptance of RFID within a single organization). Our focus in this paper is the adoption of RFID among companies in a supply chain or in other words, at the macro level. To obtain the reasons for adoption it is important to understand the perspectives of the management and we choose to employ the survey methodology as described in Section 3. We attempt to determine the factors preventing the implementation of the technology and to identify the stage of diffusion that organizations are by evaluating their perceptions of the technology.

3.0 DATA COLLECTION METHODOLOGY & PRELIMINARY RESULTS

3.1 Participants

The participants in the study are executives of companies that work full time and attend the Part-time MBA program at the University at Albany, State University of New York. These employees have a diverse background in areas such as engineering, finance, sales, accounting, medicine, and manufacturing. They all have a good understanding of the technology, but differing levels of interest in RFID deployment.

3.2 Procedures, Analysis, and Results

The survey questions were developed for the elements of DoI (relative advantage, compatibility, trialability, observability, and complexity) as well as ethical considerations (health, security, privacy, environment, and business ethics). The initial set of questions was created based on review of previous relevant literature in risk (Armitage et al., 1999; Goodhue & Straub, 1991) and refined via pretest interviews. An initial set of respondents was solicited to further demonstrate content validity and clarify the wording for each item. A pilot study will be conducted with a set of graduate students to ensure the initial reliability of the scales and the general mechanics of the questionnaire, such as instructions, completion time, and wording. The revised questionnaire will be used with the primary pool of respondents that are industry executives participating in the Part-time MBA Program. A small set of demographic questions (Appendix 3) will be used at the aggregated level. One of the authors administeres each of the surveys in person. Participants will be briefed of the study, and informed that participation was voluntary and had nothing to do with their normal MBA course work. In lieu of financial incentives as suggested by Dillman (2000), participants were promised a summary of the study. Data gathered from the pilot study and from completed survey will be examined using traditional statistical methodology. All results from the pilot study will be presented at the conference.

REFERENCES

[1] Rogers, E. M. (1995). Diffusion of Innovations. New York, NY: The Free Press.

[2] Rogers, E. M. & Shoemaker, F. F. (1971). Communication of Innovations: A Cross-Cultural Approach. New York, NY: Free Press.

[3] Moore, G. C. & Benbasat, I. (1991). Development of an instrument to measure the perceptions of adopting an information technology innovation. Information Systems Research, 2(3), 173-191.

[4] Goel, S. & Crnkovic, J. (2005). RFID: Risks to the Supply Chain. Information Resources Management Association (IRMA) 2005 Conference Proceedings, Washington, D.C. IDEA Publishing, Hershey, PA.

[5] EPIC. Radio Frequency Identification (RFID) Systems. Electronic Privacy Information Center (EPIC). Retrieved on November 1, 2006 from http://www.epic.org/privacy/rfid/

[6] Erja Musstonen-Ollila, Kalle Lyytinen (2003). Why organizations adopt IS process innovations: a longitudinal study using DoI theory, Information Systems Journal, 2003, 13, 275-297

[7] Armitage, C. J., M. Conner, J. Loach, D. Willerts. 1999. Different perceptions of control: Applying an extended theory of planned behavior to legal and illegal drug use. Basic and Applied Social Psychology 21 301–316.

[8] Goodhue,D.L.and Straub,D.W,1991.Security concerns of system users: A study of perceptions of the adequacy of security. Information and Management, Vol.20, No.1, 13-27.

[9] Collins, J. (2004). RFID'S ROI Tops User Concerns. RFID Journal, October 2004, www.rfidjournal.com/article
[10] Schrieber, J. (2005). The Analytic Value of RFID. Teradata (NCR), EB-4556, 0905, www.ncr.com/en/solutions
[11] CISCO. (2005). Wireless Systems and RF Safety Issues. Cisco, Aironet 1100 Series, www.cisco.com/en/US/products/hw/wireless/
[12] Thomas, V. (2003). Product Self-Management: Evolution in Recycling and Reuse. Environ. Sci. Technol. 2003, 37, 5297-5302
[13] Dillman, D.A. (2000). Mail and Internet survey: The tailored design method. 2000, New York, NY: John Wiley & Sons
[14] Gonsalves, A. (2004). RFID saves money, displaces workers. EE Times Online, at http://www.eetimes.com
[15] Jaques, R. (2004). RFID to affect four million jobs. At http://www.vnunet.com
[16] ILO (International Labor Organization, 2006). Social and labor implications of the increased use of advanced retail technologies. Geneva, Switzerland, at http://www.ilo.org/public/english/standards/relm/gb/docs/gb297

The Effect of the Combination of Business Characteristic with ERP Implementation Strategies on Firm Performance

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INTRODUCTION

This study focuses on the effect of the combination of business characteristic with ERP implementation strategies on firm performance. Implementing ERP is not simply purchasing software. Each ERP system represents the best practice for business processes selected from the vendor's point of view. Therefore implementing ERP means that the company implementing the system accepts the vendor's assumptions about the business and changes its existing business processes as required by the vendor (Umble, et al. 2003). Accordingly, it is reasonable to assume that business characteristics of a company and the implementation strategies may affect the benefits resulting from the implementation of the systems. To do this, we employ a cluster analysis to identify different group behaviors among companies and examine the differences in performance between the groups of companies. The results of this study show that what kinds of groups exist in terms of the combination between business characteristic with ERP implementation strategies and how their performance differs.

The current study contributes to literature in two ways. First, this research identifies the basic strategies for ERP implementation and their relationship with business characteristic that in turn affects firm performance. Second, this study empirically tests the role of the combination of the business characteristic with ERP implementation strategies in explaining firm performance. In so doing, this study sheds light on the factors that affect the successful implementation of ERP.

BUSINESS CHARACTERISTICS: MAKE-TO-ORDER/MAKE-TO-STOCK

For manufacturing companies, business requirements such as customization, volume flexibilities, production volume, set-up and production schedules, number of suppliers, and labor skills may determine their business orientations (Yen and Sheu 2004). Typically, this orientation is categorized into two continuums: make-to-order (MTO) and make-to-stock (MTS) (Gupta and Benjaafar 2004). Under MTO approach, a production order is released to the manufacturing facility only after a firm demand has been received, while under MTS approach, products are manufactured in anticipation of future orders and stored in the finished goods inventory (Youssef, van Delft, and Dallery 2004). The MTO production method is good for customization and volume flexibilities (Yen and Sheu 2004) when products are low in volume but high in variety. On the other hand, when products are high in volume but low in variety, the MTS strategy is better than MTO. That is, when there are requests for high production volume, long set ups, stable production schedules, relatively small number of suppliers, lower labor skills, and a functional organization, companies need to implement MTS strategy to obtain immediate reactivity to external demands at the cost of inventory holding costs (Yen and Sheu 2004, Youssef, van Delft, and Dallery 2004).

Recently, an increasing variety in production variety with varying logistical demands (e.g., short due dates, specific products) and production characteristics (e.g., capacity usage, set-up) leads to a combined strategy of both MTO and MTS (Gupta and Benjaafar 2004, Soman, van Donk, and Gaalman 2004). One widely used approach to the combination of these two strategies is the assemble-to-order (Lu, Song, and Yao 2003). Under this strategy, the upstream part of the manufacturing system is controlled through MTS, whereas the downstream part of the manufacturing system is controlled via MTO (Youssef, van Delft, and Dallery 2004). This approach is effective when finished products have high variety but components have low variety. This approach enables mass customization and quick response by using advanced information technology (Lu, Song, and Yao 2003). However, It is noteworthy that very different managerial actions than those required in MTO and MTS strategy are necessary in a combined MTO-MTS production situation where important issues need to be addressed such as which products should be manufactured to stock and which ones on order and, how to allocate capacity among various MTO-MTS products (Soman, van Donk, and Gaalman 2004).

Initially the primary benefits of ERP implementation have been expected to be in the production processes (i.e., better inventory management and faster order processing). These benefits are very important factors to run MTS types of organization. However, practitioners and researchers now generally agree that the real benefits of ERP are its ability to standardize business processes, build a clean database and minimize data complexity (Connolly 1999). This will affect the business process of MTO types of organization, increasing the level of communication with their suppliers and partners. Based on ERP's origin, it is a better view how ERP impacts different types of manufacturing firms. ERP only increases business process efficiencies or it boosts other business areas beyond business process efficiencies.

ERP IMPLEMENTATION STRATEGIES

In IT implementation, organizations have to either customize the software packages and/or change their existing business processes (Amrani et al., 2006). This is natural process when organizations implement information systems because different organizations, department, and users require costumed systems based on their needs derived from different approaches to task (Pawlowski et al., 1999). In this study, we use two terms to conceptualize those processes: software customization and process re-configuration. Software customization occurs when an adopting organization will not or cannot change its business process, instead it modifies the application to meet business requirements. On the contrary, business re-configuration is defined as an adoption of business processes embedded in ERP application without modifying the application, which leads to business process reengineering for the adopting organization. An ERP is the enterprise-wise software in which all business functions (such as financial, manufacturing, human resources, distribution, and order management) are tightly integrated into a single system with a shared database. While customization is not impossible, the broad scope and close connectivity of all related functions make customization very costly for any ERP implementation (Davenport 1998, Davis 1998).

The high cost and lengthy implementation process persuade most organizations to align their business processes with the functionality provided by the ERP, rather than customizing the ERP to match their existing processes. According to Forrester Research, only five percent of the Fortune 1000 companies that had purchased an ERP application customized it to match their business processes (Davis 1998). Implementation of an ERP typically entails using the business models included in the ERP software package (Slater 1998). While some companies opt to customize ERP to fit their organizations, the majority of organizations prefer

to install off-the-shelf ERP implementations as a way to avoid customization by altering their business processes. The important fact is that the cost of customization is formidable, and there is a trade-off between convenience/functionality and customization.

Customization and re-configuration are not discrete but on continuum. Thus, organizations, with ERP implementation, have opportunities to define, identify, and improve their business process through business process re-engineering (BPR) approach to enhance business process over different functionalities (Hammer and Champy, 1991).

ERP IMPLEMENTATION APPROACHES

ERP implementation is no easy task. Once started, there is no way of going back due to the considerable expense of ERP implementation (Bingi 1999). Accordingly, companies have developed various approaches to the implementation. Parr and Shanks (2000) categorized ERP implementation approaches based on the number of implemented modules. First, comprehensive implementation, so called 'big bang' approach, refers to a total effort to implement all modules of the ERP package to their organizations with the tremendous efforts targeted for business process reengineering (BPR)." This approach is the option frequently used by multi-national companies. The second approach is called Vanilla. This approach is for less ambitious companies which want less BPR and few ERP functionalities in probably one site only. The last approach is middle-road, which is in-between the comprehensive and vanilla approaches. This approach can be defined as a phased approach (Parr and Shanks 2000). The phased approach can be further divided into two types, one proceeds module-by-module and the other goes site-by-site (Boudreau, 1999). Recently, companies have followed more structured ways of implementing ERP based on their degree of need for integration. This partial implementation is possible due to the modularity of ERP. Companies may decide to adopt financial accounting module without changes in it process but make significant changes in materials management module.

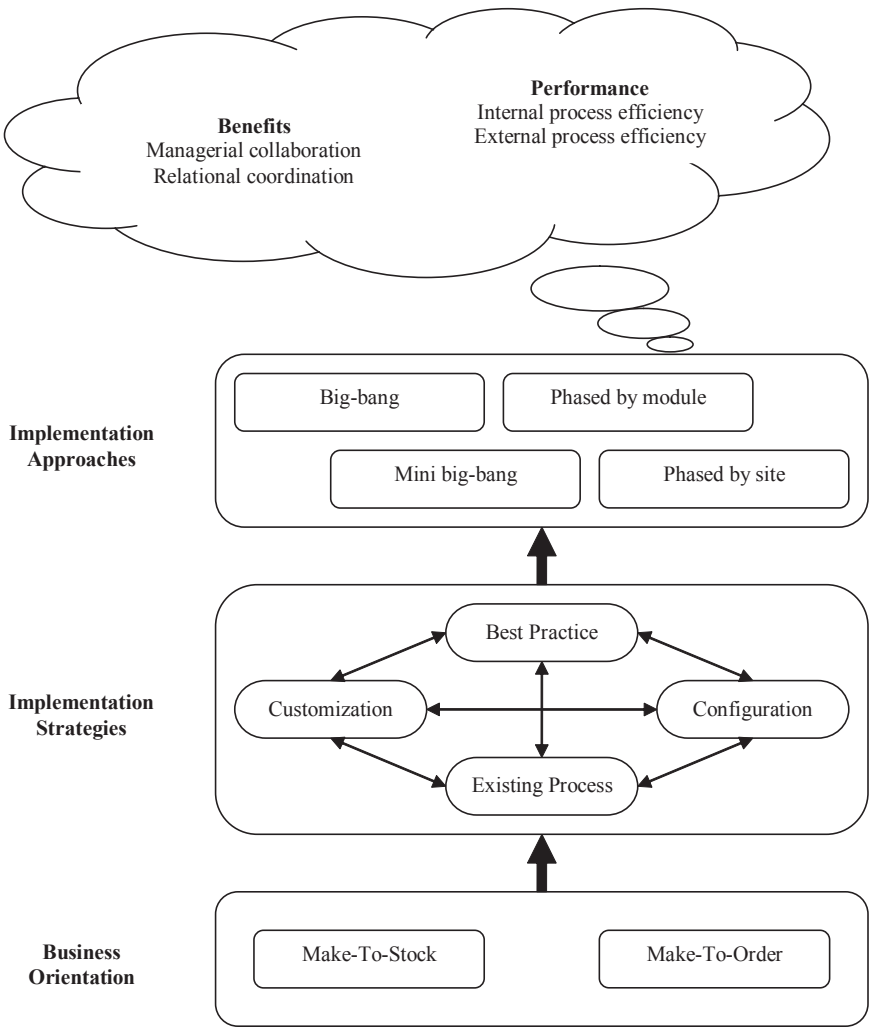
Based on companies' business characteristics and inter-relationship between functions, a variety of mixed implementation approaches can be used together. Companies can take a big bang approach to go live all ERP modules at a single period of time or they can open several modules at different dates, mini big bang. For phased approach, companies can set each phase based on ERP modules or companies' sites.

Figure 1 illustrates the relationship between the production orientation in manufacturing companies, ERP implementation strategies, and implementation approaches. It is assumed in this paper that business orientation affects the selection of ERP implementation strategies which subsequently influence the choice of the implementation approaches. We discuss this relationship in the next section.

RESEARCH HYPOTHESES

In the previous sections, we discussed production orientations in manufacturing companies, ERP implementation strategies and approaches. As discussed earlier, a different business orientation leads to a different resource allocation system

Figure 1. Business orientation, ERP implementation strategies and approaches



and distinctive communication systems to align the downstream, midstream, and upstream processes to customer needs (Prasad, Tata, and Madan 2005). For example, compared to the more traditional MTS orientation, the MTO strategy requires managers to answer for the added complexity resulting from the increased production complexity including product range, more detailed specifications on batch sizes and due dates (Prasad, Tata, and Madan 2005).

As such, the business orientation affects the subsequent implementation strategy of and approach to ERP application. This relationship between the orientation, implementation strategy and approach can be understood in terms of organizational configuration referring to "commonly occurring clusters of attributes of organizational strategies, structures, and processes" (Ketchen, Thomas, and Snow 1993, p. 1278). The basic premise of the configuration theory is that identifying groups different from others but similar within the group allows the better understanding of the relationship between organizational characteristics and performance (Ketchen, Thomas, and Snow 1993). In this study, we define the clusters of the companies based on three configuration variables: business orientation, ERP implementation strategy and implementation approach. We believe that making clusters of companies that have similar business orientation and pursue similar implementation strategy and approach is a better way of understanding the differential effect of ERP implementation on firm performance. That is, if the implementation strategy and approach well fit the business orientation of a company, the company may achieve a better performance.

Therefore, we hypothesize:

Hypothesis 1: The performance of companies pursuing different combination of business orientation, ERP implementation strategy, and implementation approach is significantly different from that of others.

CONCLUDING REMARKS

In this study, we will investigate what kinds of clusters exist in the ERP implementation context and how the clusters affect firm performance. We will do so using cluster analysis and drawing on the concept of the fit between business orientations and ERP Implementation strategy and approach (Ketchen, Thomas, and Snow 1993). The major implication of this study lies in the finding that where there is discrepancy in business orientation, i.e., production strategies, there may be a gap in the firm performance. Another contribution of this study will be the observation made regarding the role of ERP implementation strategy and approach in determining the types of configuration of groups. This observation will allow the understanding what kinds of firms can be classified as a group and what kinds are not.

REFERENCES

Available upon by request.

Conceptualization of a Secure Agent Based Network Management System

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ABSTRACT

As configuration of network services is faced with wide-spread deployment problems requiring considerable human efforts and involvement, Plug-and-Play (PnP) services become a central concern. Moreover, the recent developments in the area of mobile agent based network management and ever improving Java Programming language have provided important tools for designing Secure Mobile Agent based PnP Protocol (SMA-3P). Again, a roaming agent on a network consumes significant network bandwidth which implies that their frequency and number must be regulated. In a sensitive and intelligent network where the PnP behaviour can be altered dynamically during the lifetime, the proposed system must be genuinely secure. So, it is necessary to design secure protocol using the elliptic curve based multi-signcryption for the purpose of efficiency.

Keywords: Mobile Agent, Security, Plug-and-Play, Protocol, Network, Configuration

1.0 INTRODUCTION

The current network is characterized by its increasing distribution, its dynamic nature, and the complexity of its resources, due to the increasing requirement of different services (Yang, 2003). Network management essentially involves monitoring and controlling the devices connected in a network by collecting and analyzing data from the devices (Stallings, 1999).

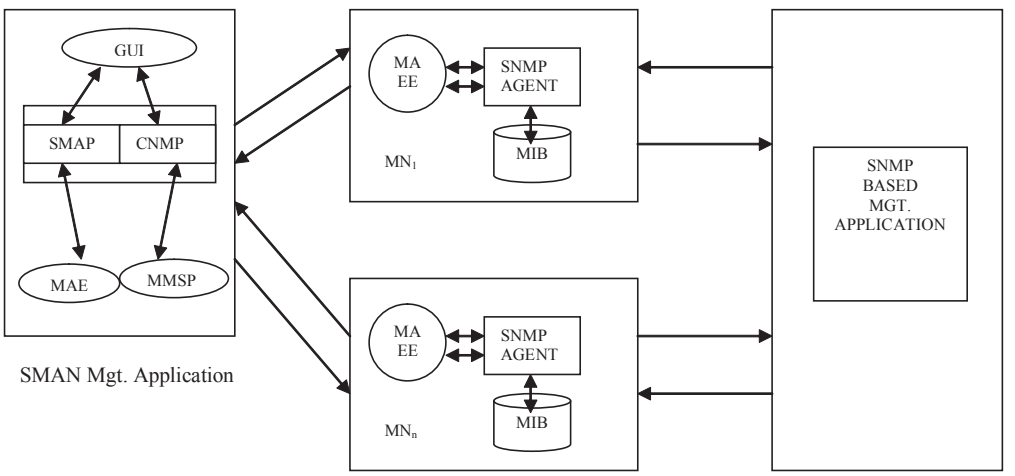
The current trend is to deploy mobile agents to manage large heterogeneous networks. Mobile agents are special software objects that have the unique ability to transport itself from one system in a network to another in the same network (Feng, 2002).

One of the possible approaches is to automate the installation and configuration steps using a mobile-agent based Plug-and-Play (PnP) architecture for service configuration.

2.0 RELATED WORKS

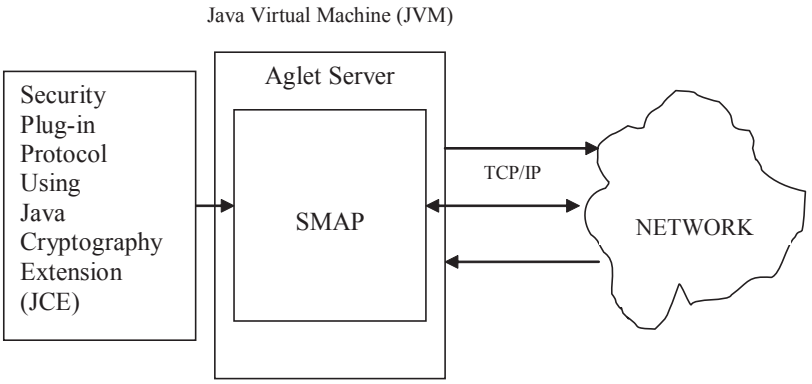
As networks are growing and becoming more distributed, the need for better management through available distributed technologies is being realized. According to Kona (2002), mobile agent technology has long been pursued but its applications in network management are still rudimentary. Bieszczad et al. (1998) described theoretical views on application of mobile agents for network management that lack concrete implementation. Gavalas et al. (2000) presented the application of mobile agents in bulk transfer of network monitoring data, data aggregation and acquiring atomic SNMP table views. They analyzed the usage of mobile agents in network management with regard to the bandwidth utilization. The work addresses the issue of mobile agents for network monitoring, but did not consider provisioning services. Pinheiro et al. described a conceptual model which collects management related data across a changing set of networked components and periodically compute aggregated statistics using mobile agents. More concentrated towards aggregation of network monitoring data and exploring mechanisms for agent adaptation.

Figure 1. Hybrid SMAN model



Keys:
GUI – Graphical user Interface
CNMP – Conventional Network Management Protocol
MIB – Management Information Base
MNi – Managed Nodes where i = 1 to n

Figure 2. SMAN station



3.0 OBJECTIVES

1. To provide a comprehensive review of mobile agent architectures, development tools and emerging agent technologies
2. To develop a prototype application system that will allow the development of the network management system using a secure mobile agent oriented approach
3. To employ the use of discrete logarithm based multi-signcryption for the secure protocol.

4.0 SMAN ARCHITECTURE

SMAN station assumes responsibilities of a client. All managed nodes are servers, which has mobile agent execution environment and respond to SNMP queries from mobile agents when they visit the servers and manipulate data locally. When the client in the SMAN needs access to data in a network-connected device, it does not talk directly to the server over the network but dispatches a mobile agent to the server's machine. On arriving at the servers' machine, the mobile agent makes its request and return to the management station with the results.

The SMAN architecture consists of the following major components:

- Management application (MAP)
- Mobile Agent Execution Environment (MAEE)
- Secure Mobile Agent Producer (SMAP)
- Mobile Agents (MA)
- Modified Multi-signcryption protocol (MMSP)

The mobile agent development environment is the Aglet Software Developer Kit (ASDK), which provides a modular structure, easy-to-use API for programming of mobile agents and excellent documentation.

Figures 1 and 2 show the hybrid model of SMAN and architecture for network management using secure mobile agents. The administrator/manager is given the flexibility of deciding whether to use SNMPv3 or mobile agents.

6.0 CONCLUSION

This paper has demonstrated that it is possible to develop a secure mobile agent network management system using Java components and cryptography. To this end, the paper has presented reasonable detail on design level view.

REFERENCES

Bieszczad, A., Pagurek, B. and White, T. (1998a): Mobile Agents for Network Management. IEEE Communication Survey, Vol. 1 No. 1

Bieszczad, A, Raza, S. K., Pagurek, B. and White, T. (1998b): Agent-based Schemes for Plug-and-Play Network Components. Proceedings of the 3rd International Workshop on Agents in Telecommunication Applications. IATA '98

Feng, X. (2002): "Design and Analysis of Mobile Agent Communication Protocols", Master of Science (M.Sc) paper, Institute of Computer Software, Nanjing University, China

Gavalas, D., Greenwood, D., Ghanbari, M. and Mahogany, M. O. (2000): Advance Network Monitoring Applications based on Mobile Intelligent Agent Technology. Computer Communications.

Kona, M. K. and Xu, C. (2002): "A Framework for Network Management using Mobile Agents", available at http://www.ernie.eng.wayne.edu

Pinheiro, R., Pohylisher, A. and Caldwell, H. (2000): Mobile Agents for Aggregation of Network Management Data, Telecordia Technologies, University of Warwick, Bell South Telecommunications.

Stallings, W. (1999): SNMP, SNMPv2 and RMON: Practical Network Management. Addison-Wesley.

Yang, K., Galis, A., Mota T., and Michalas, A. (2003): "Mobile Agents Security Facility for Safe Configuration of IP Networks" EU IST project MANTMP, funded by commission of EU.

Zheng, Y. (1997): "Digital Signcryption or How to achieve cost (Signature & Encryption) << Cost (Signature) + Cost (Encryption) "Advances in cryptology – crypto '97, Lecture Notes in Computer Science, Vol. 1294 pgs 165-179, Springer-Verlag

The Contagion of Corporate Social Responsibility in Networks: From a Technical Competition to a Social Competition

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Keywords: CSR, contagion, networks, distribution, agent-based model, Corporate Social Responsibility, Transnational Corporations, contagion, drivers.

Corporate Social Responsibility (CSR) combines microeconomic aspects (firm level) and macroeconomic aspects (environment level) and has become a main issue worldwide for well-being. At the micro-level, the social capital can be defined as a set of social norms, and organization behaviours through "trust" that shapes and reshapes the collective and individual production in order to maximize the well-being. At the macro-level, this social capital could be envisioned as a dynamic networks that might accelerate or impede the economic growth.

Within a few years, CSR, which relies on voluntary adoption, has paradoxically become a predominant governance model. Moreover, due to stakeholders' pressure, CSR has also emerged as a societal mode and recently in Europe as a "protectionist" tool to face the Developing Countries Transnational Corporations (DCTNC). The strong emergence of national champions from developing countries, in particular Chinese and Indian with a huge potential economic development has accentuated the technical and economic competition among Western and Developing Countries Transnational Corporations(WCTNC vs. DCTNC). For years the emerging countries have been passives (or not) recipients of technology and knowledge accumulation, and foreign direct investments (FDI). CSR was one of the strong components of these transfers for the last years. Two opposing CSR strategies are in fact at work, and the current CSR contagion observed among the Western-based TNCs may be facing a much stronger resistance than the current literature anticipates. Labor forces or consumers in the developing countries are gradually exposed to CSR and Western-type management via Western-based TNCs. However, at the same time, the Developing Countries TNCs (DCTNCs) are now settling in Western countries, notably by means of corporate acquisitions.

The purpose of this paper is to examine the phenomenon of CSR contagion and to understand the possible implications of strategies of the Western-based TNCs and Developing countries TNCs through competition in the area of CSR through networks. We propose an agent based model (ABM) for CSR contagion through global supply networks based on classic BASS model (Bass 1969) and on the recently emerging Complex Network theory (Newman 2003).

BACKGROUND

Since the early 90s, most Transnational Firms controlled by Western-based parent companies (WTNCs) have modified their development strategies. As markets in developed countries became saturated and less profitable, WTNCs started to target the developing countries, not only as a source of cheap labor and raw materials, but also as an important growing market. For years the emerging countries have been passives (or not) recipients of technology and knowledge accumulation, and Foreign Direct Investments (FDI). CSR was one of the strong components of these transfers for the last years. However, as these WTNCs and their brands became increasingly transnational, so the risk to their reputation increased. It is notably to tackle the growing risk of "reputation" and in accordance to the "Nexus of Stakeholders' pressure," that a number of major Western transnational corporations (WTNCs) have decided to integrate Corporate Social Responsibility (CSR) principle in their operating procedures worldwide. The voluntary adhesion to CSR principles has raised skepticism and criticisms, but the non-adhesion to it is judged even more severely by stakeholders. In spite of controversies about the motives of the firms' adoption, loose self-regulation boundaries and no evidence of its social performance, CSR evolved no longer as marketing tool but it became a growing issue for companies. But CSR became also a social issue in the Western civil society for it has a perspective to relieve the conflict between self interest and atruism. So it has rapidly become a standard model of management by a sort of contagion phenomenon in networks. This evolution seems now beyond the control of the Western transnational corporations (WTNCs) which adopted it through worldwide competition and under the stakeholders' pressure. Most observers considered that this phenomenon is global. At the meso-level the corporations are more and more involved in CSR, and the macro-level (States and international organizations) and micro-level (Stakeholders) claim for the CSR as a social capital and need. It seems that CSR has some drivers in networks worldwide to spread the contagion beyond the WTNCs.

The literature has heavily focused on the Western TNCs strategies and how they approach, and might impose, worldwide, the contested concept of CSR (Moon 2002, Crane et al. 2003, and Davies 2002). But the strong growth of developing countries' TNCs might counterbalance this trend, after a century of domination by Western countries standards. Recently, researchers have turned to the Asian arena to conceptualize and benchmark CSR in corporations in emerging countries. For Blowfield (2004), the success of CSR in Asian corporations will depend on the Asian capacity to manage a global supply-chain. Does it mean that Western global management of CSR is still efficient or shall it fail facing Asian corporations? In addition, if CSR is a model that was designed for industrialized corporations and States (Khanna and Palepu 1997), what should be its global development? So far, what could be the approach of Asian corporations to CSR and where could CSR find growth drivers?

Two opposing CSR strategies are in fact at work, and the current CSR contagion observed among the Western-based TNCs may be facing a much stronger resistance than the current literature anticipates. Labor forces or consumers in the developing countries are gradually exposed to CSR and Western-type management via Western-based TNCs. However, at the same time, the Developing Countries TNCs (DCTNCs) are now settling in Western countries, notably by means of corporate acquisitions.

As globalization creates homogenization, will CSR find out strong new drivers in the Asian corporations or it will experience a severe breakdown? Is CSR today under control or beyond control worldwide? And if CSR is a model designed for industrialized corporations and States (Khanna and Palepu 1997[1]), what its global development could be?

RECENT CHANGES IN THE MARKET DYNAMICS

Until recently, global competition involved mainly WTNCs or TNCs with a western background (from Japan, Korea, Singapour, Hong Kong and Taiwan). However, the rapid and strong growth of TNCs in developing countries (DCTNC[2]), supported

by steady growth rates and by their governments, has generated an unexpected economic and cultural shock. Nowadays, WTNCs are competing with other WTNCs and also with their challengers from developing countries (DCTNCs) to attract consumers, best competitive labour-force and investments drivers.

In the last years and particularly since 2003, market dynamics highlights[3] a heavily underestimated economic strength of the DCTNCs. Several takeovers were carried out in industrialised countries by DCTNCs (in particular Chinese and Indian), as for example IBM's PC division by Lenovo, Thomson by TCL, Teleglobe by Tata, RPG, a branch of Aventis and Ohm Laboratories by Ranbaxy, Bayer's generic medicines branch by UB Group, MG Rover by Nanjing Auto, one Arcelor's plant by Mittal Steel, Marionnaud by Hutchinson Whampoa. These takeovers have been possible and welcome by the governments as these firms were unprofitable or non strategic for the future of the Western corporations and States. However, Mittal Steel's takeover bid on Arcelor and its latest development, or CNOOC's bid on Unocal and the subsequent Western governments intervention are even more representative of the rising economic power of DCTNCs. In order to prevent such takeovers, Western governments focused on the alleged lack of social responsibility of DCTNC in both environmental and social terms. Becoming aware of this phenomenon, the industrialized States and their firms started almost immediately to implement national defense strategies based mainly on "economic patriotism" and underlined corporate social responsibility enhancing, for both WTNCs and DCTNC to redefine their strategies.

The emergence of national champions, in particular Chinese and Indian, has accentuated the competition and the degree of "patriotism" of industrialized countries towards their corporations, claiming the lack of social responsibility of the DCTNCs. They have thus implicitly underlined and reinforced their own CSR. Indeed, since 2000 most WTNCs have introduced Sustainable Development or Corporate Social Responsibility at least as communication, management or strategic tool. Yet, a closer look at the last five years shows that CSR has become a competitive advantage between WTNCs but lately even more strongly between WTNCs and DCTNCs.

THE ASIAN DRIVER

The three main theories explaining the emergence and the development of DCTNCs are the learning cycle theory (Wells 1983[4]), the technological accumulation theory (Lall 1983[5]) and the investment cycle development theory (Dunning 1988 & al 1997[6]). These theories are rooted in the TNCs theories and combine microeconomic aspects related to the firm and macroeconomic aspects related to the environment (Beausang 2003[7]).

FINDINGS

CSR in Perspective Today: A Global Trend Beyond Control?

As we explained, over the last five years, many WTNCs present in industrialized and emerging countries, were particularly exposed to a risk to their reputation. They incorporated elements of corporate social responsibility into their international development strategies, in response to internal or external pressures or stimuli (Ansoff 1979, Agle et al. 1997). Even though their motives continue to fuel criticism and reflection, it seems that they have had a number of consequences.

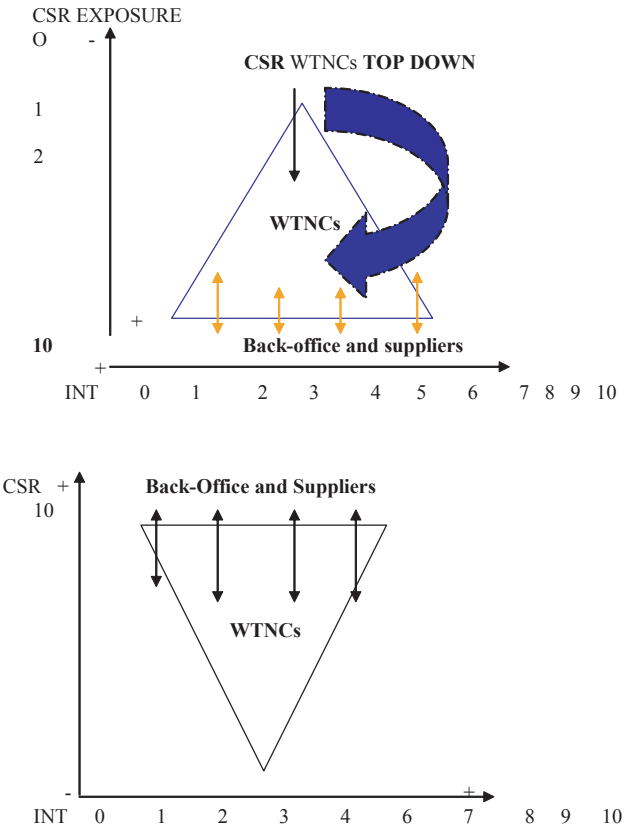
Firstly, they brought to light the corporations seeking to avoid taking a stance on CSR.(need some change) Secondly, they generated the quest for intra- and extra-sector social performance (De Bry 2001) by corporations in industrialized countries. Lastly, they imparted on CSR an internal momentum and maturity via the adoption of CSR in the front office and back-office networks of these corporations in their national territories and in emerging countries (Paone and Mangalagiu 2006). For Abernathy and Clark (1985), anything innovative, at any point in a commercial chain, has repercussions on the entire sector (on the existing technologies and on the players in the sector) and even has voluntary and involuntary repercussions outside the sector. We have seen how over recent years, and particularly since 2000, under the pressure of public opinion, of the financial markets and of insurance companies, furthermore due to the convergence of standards and legislation around the world, some WTNCs adopted CSR as an element of strategic management and as a competitive advantage to be developed and improved.[8]

CSR afford the firms to define their own boundaries of responsibility to maximize the benefits to their stakeholders. Voluntary CSR has led corporations to modify, to a greater or lesser degree, their management, communication, methods, and organization in developing countries. Either they now compete to secure the sources of supply best able to satisfy CSR criteria, or they work together in competition. By working together and pooling their needs in the eyes of their worldwide front office and back-office networks, they harmonize their demands over methods and criteria, reducing the cost of this competition. Whilst the costs generated by the implementation of CSR are easily quantifiable, the costs and losses linked to the risk to reputation are more difficult to estimate.

In order to understand CSR' global contagion from west to east, we have to rank the company's exposure rate by the adoption timing, as we have listed some of them in table**. Here we can see the most exposed sector is the Retailing Sector. It should endure most of the reputation pressure from the stakeholder side in order to compete with other retailers. On the supply side, the retailers have to shape the suppliers' product standard to meet their CSR criteria and this effort spread through the supply chain in a top-down way, as we defined from the most exposed sector to less exposed sector. But is this top-down western mode fit for the eastern emerging market? What is a general mode for the contagion of CSR from regions to regions? We examine this theme in both empirical and computational approaches.

Empirical approach: We have seen that the rationale behind the internationalization of WTNCs and DCTNCs is similar but that the difference resides in their competitive advantages and in the nature of their national markets. Because of the difference in the characteristics of competitive advantages and markets, the emerging market cannot spontaneously appear a top-down CSR adoption, partly for the unawareness of the social issue on the stakeholder side, and partly for the pressure from the economical globalization. More and more companies across western and eastern traded, collaborated and even merged. These intense interactions of western and eastern world truly facilitate the adoption of organization practice, including CSR, through the global supply networks. But in contrast to the Western adoption, most of the companies that adopted CSR early in emerging market are

Figure 1



less exposed DCTNCs. Although they do not have to face the pressure from the retailers or stakeholder in country, they must be aligned with the criteria that casted by WTNCs. So this spread mode is not the top-down pull mode, but a bottom-up push mode. Many data have been collected and some pre-results have shown the trend of this pull mode in contagion of CSR from Western to Eastern.

Computational approach: For confirming this "bottom-up"contagion phenomena, we will model CSR contagion phenomena from WTNC to DCTNC and contrarily the influence of DCTNC to WNTC in an Agent-Based Model for the future work. We combine the classic BASS diffusion model (Bass 1969) with the emerging Complex Networks theory (Newman 2003) into an ABM simulation. We propose the CSR contagion from WTNC to DCTNC through global supply networks, which follows a Scale-Free fashion. Firms in this global supply network have their own decisions on the adoption of CSR, but this decision would be influenced by two factors, the external factors from characteristics of the national environment or pressure of stakeholder side (i.e. mass media, the law) and the internal factors from the transnational supply network ties. The internal factor is given by the local network connectivity. More local firms that have direct transaction relation with the central firm adopt the CSR criterion, more possibility the central firm would adopt it for the higher risk and cost to trade with these CSR firms. And the contagion phenomena exhibits an S shape in the basic model setting, that means if the number of CSR firms gets to a critical mass, the contagion speed would be much more quick than the beginning. More results will be explored in the future work.

ENDNOTE

1 Khanna,T and Palepu, K.(1997), »Why Focused Strategies May be Wrong for Emerging Markets », Harvard Business Review, 75(4),45-51.

2 Developing Country Transnational Firm

3 Unocal, Arcelor were the last controversy on takeover bid by DCTNCs

4 Wells , L.T. (1983), "The Third Word Multinationals", Cambridge, Massachussets,MIT Press.

5 Lall,S. (1983),"The New Multinationals",Paris.

6 Dunning, J.H.(1988),"Explaining International Production",London,Hyman Dunning, J.H. Van Hoesel, R and Narula, R. (1997) "Third Word Multinationals Reinvented:New Devlopments and Theorical Implications"Discussion Papers in International Investment & Management, n° 227, University of Reading.

7 Beausang, F. (2003), "Third World Multinationals :Engine of Competitiveness or New Form of Dependency ? ", Palgrave.Mc Millan.

8 United Nations Global Compact 2000 and Corporate Social Responsibility from European Commission 2001

Table 1. Adapted from F. Beausang 2003

CHARACTERISTICS and MOTIVES	WTNC	DCTNC
Multi-nationalization rationale	Growth achieved at lower cost through fragmentation of labor Search for resources, markets, efficiency and strategic assets. Saturated market Increased cost of competition Eroded margins	Growth Transfer of technologies and accumulation of knowledge Immature domestic markets
Competitive advantages	Internal network External network Monopolistic markets not available to competitors Exclusive intangibles	Small-scale, labor intensive, technologies, Few exclusive intangibles
Host country location	Raw materials, natural resources Size and characteristics of the market Stability of countries	Natural resources Low-cost workforce State owned-firms
Last evolutions	Take-over bids Irregular investments CSR Low production capacity No employment growth Mass layoffs by TNCs Growth of Investments Socially responsible	Capabilities in regular investments Savings Middle-class needs Workforce Huge production capabilities Working on high-technologies local standards

Trust and Leadership in Virtual Teams

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INTRODUCTION

Team activity has long been a core aspect of organizational life. Traditional teams have primarily interacted in a face-to-face setting. However, due to globalization and advances in technology, it is no longer necessary for team members to be located in the same place and meet at the same time in order to perform at a high level. Instead, it is possible for "virtual teams" of people supported by electronic collaboration technologies to meet in a distributed setting and collaborate across distance, time and organizational boundaries (Lipnack & Stamps, 1997). Due to the operational and competitive advantages associated with using virtual teams, the virtual team approach is rapidly being adopted in organizations. For example, high technology companies and consulting firms have relied on virtual teams for several years to reduce costs, reduce project time, and enhance decision making and communication (Duarte & Snyder, 1999; Townsend, DeMarie & Hendrickson, 1998).

The "virtual" environment can impose new types of challenges for the management of virtual teams (Pauleen, 2003-04). The development of trust among virtual team members can be a particularly important factor associated with team performance (Jarvenpaa & Leidner, 1999). While the development of trust in a virtual environment may not be easy, it can be a critical component for virtual team success (Duarte & Snyder, 1999; Handy, 1995; Jarvenpaa, Knoll, & Leidner, 1998; Paul & McDaniel, 2004). One potential way to enhance trust in teams is through effective leadership. Research on effective leadership in traditional, face-to-face teams is voluminous. Recently, however, a model of effective leadership has been proposed by Avolio and colleagues that argues for authentic and transformational leadership as most effective (Avolio, Gardner, Walumbwa, Luthans & May, 2004). They view effective leadership as, among other things, motivational, participative, inspirational, and authentic (Avolio, et al., 2004; Bass & Steidlmeier, 1999).

Leadership in virtual teams requires the ability to inspire and motivate others without face-to-face interaction. Research on virtual team leadership supports the Avolio, et al. (2004) model of an inspirational and understanding leader as most effective in that context (Kahai, Fjermestad, Zhang & Avolio, 2007). For example, in their field study of 13 virtual teams, Kayworth & Leidner (2002) found that the most effective virtual team leaders acted as mentors for other team members, motivating them through a participative and authentic style.

For our "research in progress," we will describe a study in which we investigate the role of emergent leadership on the facilitation of trust in virtual teams. Research questions to be addressed by the study include: Are emergent leaders in virtual teams considered to be more trustworthy?; If so, in what ways? Do trustworthy leaders help to enhance trust within a virtual team? For purposes of this manuscript, the three factors of trustworthiness suggested by Mayer, Davis & Schoorman (1995) – ability, benevolence, and integrity – will be explored using a survey instrument designed by Bigley (1996). The data for the study has been collected and is in the process of being analyzed. The next section provides a brief overview of the study, followed by brief summaries of preliminary results and the potential contributions of the research.

OVERVIEW OF STUDY

Sample: The research study has employed a case study approach to learn more about the perceived characteristics of emergent leaders in virtual teams. Participants in the study included 101 students who were members of a distance-learning executive MBA program operated by a university in the United States. The mean age of the participants was 33 years old and 70% were male. The participants were distributed throughout North America and typically had several years of managerial experience.

Teams and Tasks: The participants were randomly assigned into 26 distributed groups consisting of four members each (three teams had three members). Over the duration of the class term of fifteen weeks, each team performed ten graded team assignments associated with an introductory Information Systems course. To provide each team member with an opportunity to apply and demonstrate leadership skill in a virtual team setting, each member was randomly assigned to serve as the "team leader" for two of the team's assignments. The team leader's role was to oversee the work tasks associated with the team assignment. Team leaders were allowed to implement their own approach and style in leading the team. After each team member had rotated through two stints as a team leader, then the teams were allowed to select a leader for the remaining assignments. (The group size was selected to be four members to allow each to allow each team member to serve as a team leader for at least two of the ten assignments and to allow the teams to have the opportunity to select a leader for the later assignments.) The team tasks included five business case analysis assignments (i.e., Harvard Business School cases) and five "summary paper" assignments involving a report on a technical or managerial topic in information systems. To complete the tasks, the team members communicated via e-mail and phone. Based on the reports of the participants, no team members for any team met face-to-face.

Data Collection: The data collection included weekly self-reported communication behavior logs, a post-study survey questionnaire, and performance evaluations. The communication logs were used to determine the extent to which the team members interacted with one another and the type of communication media used. The survey questionnaire included several items aimed at assessing perceptions of trust. In part, trust was measured using a survey developed by Bigley (1996) based on work by McAllister (1995) and Mayer, et al. (1995). This 18-item instrument was used to measure perceptions regarding three types of trust: role performance trust (based on task performance), affective bond trust (based on close relationships, such as friendship), and ethical integrity trust (based on a belief in the ethical integrity of the individual). Each team member was also asked to assess the other members with respect to perceived leadership effectiveness using a 4-item scale. (Survey instruments used for this study are available upon request.) Ninety of the participants completed the final survey for a response rate of 90%.

PRELIMINARY RESULTS

A regression analysis was conducted to address the research question of whether or not emergent leaders in virtual teams are considered to be more trustworthy. The means, standard deviations, and correlations of the regression variables are shown in Table 1. The scale reliabilities for the measurement scales were good. Although the correlations among variables was high, based on a review of the variance inflation factor (VIF) indices for the regression coefficients (Cohen, Cohen, West, & Aiken, 2003), multicollinearity did not appear to be a problem. A factor analysis of Bigley's (1996) trust survey instrument confirmed that the trust measures clearly loaded as three distinct factors.

Table 2 shows the unstandardized regression coefficients and intercept, the standardized regression coefficients, and R^2 for the regression analysis. The overall R^2 for the regression model was high (0.85). For this model, the significant coefficients corresponded to the role performance and affective bond trust factors, with role performance trust most strongly related to perceived leadership effectiveness. Ethical integrity trust was not significant. Drawing from the preliminary findings of this study, it appears that the ability and benevolence factors of trustworthiness identified by Mayer, et al. (1995) were most strongly tied to perceptions of leadership effectiveness. In particular, those who rated high with respect to the trust that others had in their demonstrated ability to perform were also considered to be effective leaders.

Table 1. Correlations of trust variables with respect to perceived leadership effectiveness

Variables	1	2	3	4
1. Leadership Effectiveness	–			
2. Role Performance Trust	.91 **	–		
3. Affective Bond Trust	.71 **	.68 **	–	
4. Ethical Integrity Trust	.68 **	.72 **	.78 **	–
	1	**2**	**3**	**4**
No. of Items in Scale	4	6	7	5
Scale Reliability	0.90	0.94	0.89	0.85
Mean	2.96	3.13	2.57	3.05
Std Deviation	0.59	0.56	0.46	0.50

Notes:
1. Scale reliability calculated using Cronbach's Alpha.
2. All scale items were on a Likert scale ranging from 0 ("Strongly disagree") to 4 ("Strongly agree"); higher values reflect a more favorable perception.
*3. *p < .01, **p < .001.*
4. N = 90.

Table 2. Regression analysis for variables related to perceived Leadership effectiveness

Variable	B	SE B	β
Constant	-.020	0.16	
Role Performance Trust	0.87	0.07	0.82 **
Affective Bond Trust	0.29	0.09	0.23 *
Ethical Integrity Trust	-0.10	0.09	-0.08
R^2 for total equation (Adjusted R^2)	0.85 (0.84)		
F for total equation	156.2		

Notes*:*
*1. *p < .01 , **p < .001.*
2. N = 90.

POTENTIAL CONTRIBUTIONS

Based on our preliminary results, this study has the potential to contribute to the growing body of research on virtual team effectiveness by enhancing our understanding of the role of leadership in the development of trust for virtual teams. Previous literature suggests that virtual teams with higher trust may perform at a higher level (e.g., Jarvenpaa & Leidner, 1999). The trust relationships in any team are complex and variable. In our study, we found that role performance trust and affective bond trust in the leader were strongly related to perceptions of leadership effectiveness. Through a trustworthy leader, trust in a virtual team might be developed and enhanced. Perhaps virtual teams with lower trust levels would benefit from having a leader who was perceived by the team as more trustworthy. We plan to continue our analysis of the study data to gain more insights into the characteristics and implications associated with trust and leadership in virtual teams.

REFERENCES

Avolio, B.J., Gardner, W., Walumbwa, F.O., Luthans, F., & May, D.R. (2004). Unlocking the mask: A look at the process by which authentic leaders impact follower attitudes and behaviors. *Leadership Quarterly*, 15(6), 801-823.

Bass, B.M. & Avolio, B. (1990). *Transformational leadership development: Manual for the multifactor leadership questionnaire.* Palo Alto, CA: Consulting Psychologists Press.

Bass, B.M. and Avolio, B. (1995). *MLQ: Multifactor leadership questionnaire for research*, Redwood City, CA: Mind Garden.

Bass, B.M. & Steidlmeier, P. (1999). Ethics, character, and authentic transformational leadership behavior. *Leadership Quarterly*, 10(2), 181-217.

Bigley, G. (1996). *Follower trust in the leader at work*. Unpublished doctoral dissertation, UC Irvine.

Cohen, J. , Cohen, P., West, S.G., & Aiken, L.S. (2003). *Applied Multiple Regression/Correlation Analysis for the Behavioral Sciences*, Mahwah, New Jersey: Lawrence Erlbaum Associates.

Duarte, D.L. & Snyder, N.T. (1999). *Mastering virtual teams: Strategies, tools and techniques that succeed.* San Francisco, CA: Jossey-Bass.

Handy, C. (1995). Trust and the virtual organization. *Harvard Business Review*, 73(3), 40-50.

Jarvenpaa, S.L.; Knoll, K., & Leidner, D.E. (1998). Is anybody out there? Antecedents of trust in global virtual teams. *Journal of Management Information Systems,* 14(4), 29-64.

Jarvenpaa, S.L. & Leidner, D.E. (1999). Communication and trust in global virtual teams. *Organization Science,* 10(6), 791-815.

Kahai, S., Fjermestad, J., Zhang, S., & Avolio, B. (2007). Leadership in virtual teams: Past, present and future. *International Journal of e-Collaboration*, 3(1), i-viii.

Lipnack, J. & Stamps, J. (1997). *Virtual teams: Reaching across space, time and organizations with technology.* New York, New York: John Wiley.

Mayer, R.C., Davis, J.H. & Schoorman, F.D. (1995). An integrative model of organizational trust. *Academy of Management Review*, 20(3), 709-734.

McAllister, D.J. (1995). Affect- and cognition-based trust as foundations for interpersonal cooperation in organizations. *Academy of Management Journal*, 38(1), 24-59.

Paul, D.L. & McDaniel, R.R. (2004). A field study of the effects of interpersonal trust on virtual collaborative performance. *Management Information Systems Quarterly*, 28(2), 183-227.

Pauleen, D.J. (2003-04). An inductively derived model of leader-initiated relationship building with virtual team members. *Journal of Management Information Systems*, 20(3), 227-256.

The Disconnected Customer: An Exploratory Study Toward a Model of Call Center Effectiveness

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ABSTRACT

The call center plays a significant role in the development and retention of customer relationships in all industries. Organizations have become more complicated, and the ability to get personal service and satisfaction has become more difficult. Technology and its use in processing a customer phone call to a call center are changing the quality of communication. The customer often experiences a combination of touch- tones, transferred calls and frustration. Loyalty centers on the customer and failure to provide good customer service results in lost revenues and customers. This paper discusses the effectiveness of banking call centers. Several categories affecting call center effectiveness are elaborated; these include automated call handling technologies, corporate cultures and attitudes, management styles and outside forces. Another aspect or factor of customer satisfaction can be extracted from the mission statement. The mission statement of the call center reflects corporate attitudes and perceptions from the company to the customer. These relationships are the heart and soul of every corporation and can be based on future success and failure of a call center and possibly of the corporation.

INTRODUCTION

Framing the Discussion

Cost efficiency over customer service is the main reason for the use of technology in call centers. In order to lower costs and improve profitability and efficiency, customers are forced to interact with automated systems until they are finally given the option to speak with a live representative.

Bank customers tend to be the pickiest and most diverse customer (O'Herron 2004). The call center is one of the most essential tools that banks possess. The strategies used in handling the many thousands of customer calls involve using Interactive Voice Response (IVR) systems (keypad input) and call handling technologies. Interactive Voice Response (IVR) is defined as an automated telephony and computer system that allows customers to interact with the system through touchtone response or voice response. This interaction allows the call center to gather customer information and filter or route calls to the appropriate agent or area (Thomas, 2003; Ammenheuser, 2004). Even with all of the latest technology, the banks interviewed in the above article noted that a live human voice was still the most effective tool. Internal operations provide strong influences on good customer relations and experiences. Attitudes, cultures, perceptions and motivations within the institution can be transferred outward to the customer and directly reflects the internal structure of the organization (Spradley and McCurdy, 1988).

Customer frustration is rapidly turning to anger and is reflected in their loyalties with a bank or company (Clark, 2003). The challenge for banks and corporations is to operate a call center efficiently and at the same time provide superior customer service. The research indicates that reliance on technology is not the answer to customer satisfactions and provides a quick path to customer frustration.

The financial services corporation used for this research displayed a true reflection of satisfactory customer service once a person was reached. The process of getting to a person seemed to cause frustration and poor customer service. Banks and corporations struggle with the balance of providing good customer service and maintaining a cost effective, efficient call center.

For a financial services institution, in order to retain customers and develop ongoing relationships, there must be a balance of good use of technology and human interaction in the call center. Customers have become very impatient with poor service of any kind and will switch loyalties to where they are treated well. An innovative bank or company will understand that customer satisfaction is a key element of their success. The ability to blend the mission statement objectives with the customer expectations should be a standard practice. Adherence to the mission statement and clear communication of its importance provides consistency in customer relationships and good business practices (Bart, 1999).

The three key elements that should be blended to provide a good customer experience are the mission statement, technology, and customer service. By blending these three elements, the barriers between the customer and the call center are lowered and provide the ability for superior customer service (Phillips, 2004). Particularly important is the balance of technology used to direct and filter the incoming customer phone call. Technology in the form of Interactive Voice Response (IVR) systems can be adjusted to be more customer- friendly by enabling the customer to reach an agent in the first menu (Swann, 2003).

The analysis encompasses the role of the call center, corporate perspectives and philosophies detailed in its mission statement, value of the customer, effect of technology on customer relations and effectiveness of the call center. Success and effectiveness of the call center will be determined by the customer response to the call center mission statement. The call center mission statement is an important asset in this analysis because it is used as the basis of determining if corporate perspectives of customer service are reflected to the customer.

CALL CENTERS: THEIR USES AND ABUSES

Why do companies and customers like call centers? They are still the main source of communication between customer and company. Customers get immediate results and resolution to problems when dealing with a person over the phone (Dausilio, 2005).

As companies consolidate and offer more products and services, there is a greater dependency on call centers to provide the complete customer experience. There is the advantage of up- selling products to customers. Companies are constantly searching for ways to increase productivity and reduce costs. There is a cost advantage of using technology when handling inbound customer telephone calls and a slow acceptance that customers have towards automation (Bills, 2004).

In their attempts to cut costs, companies constantly try to improve efficiencies by using new technologies while creating customer dissatisfaction in the process. The installation of trendy technologies is not the best way to keep up with rising customer expectations (Monegain, 2001; O'Herron, 2004).

A TYPICAL EXAMPLE

While conducting this research study, the researcher discovered a distance towards customers that call centers create either through poor use of technology or poorly directed corporate initiatives. Several test calls were made to the bank call center to determine the how easily an agent could be reached. Upon dialing the toll-free number, the main menu was accessed giving five options. The remaining option was a "zero out" option to reach an agent. The menu encompasses the sequence

of prompts as the call travels through the menu. The bank call center does offer the ability to request an agent at the first menu. As with most call centers, the time it takes to actually speak to a person would depend on call volume and time of day.

DISENCHANTMENT

The research details customer distaste for being forced to interact with technology, when the need for human interaction is necessary. People want to interact with other humans and not with an automated response system. Enterprises must provide consistent quality communications at each touch-point (Swanson, 2004).

Customers are revolting against companies and their impersonal approach to customer service. Customers will slowly and silently defect to a competitor and the company loses the opportunity to learn what went wrong. They will not complete surveys after they left and automation cannot detect emotions or frustration of customers (Dawson, 2005).

There is a consumer movement and website named "gethuman.com" headed by Paul English, who seeks to improve the quality of human communication in U.S. call centers (gethuman.com, 2006). This emergence indicates that customers have grown weary of navigating through endless menus while trying to reach a representative. The ratings of company call centers are based on ten standards set to determine overall quality of customer experiences including ease of navigation, ability to reach a human immediately, response to frequent customer service complaints and logical information flow. Currently, there is a list of 500 companies named on the "gethuman500" list (www.gethuman.com, 2006). In a recent article, only 9 out of 500 companies earned a high rating. Some companies included are Hertz, Dillard's, Land's End, and L.L. Bean (Houtz, 2006). The website also displays IVR shortcuts and override codes for a large list of companies.

THE PROBLEM

After nearly 19 years of call center experience, a recurring problem of misuse and overuse of automation seemed to be the main cause of customer complaints and dissatisfaction. Customers are much happier to deal with human interaction on a phone call. In addition, the company may realize additional revenue from opportunities that arise during the conversation. In an ethnography conducted by the researcher, low value and tightly scripted phone conversation, combined with dependency on technology, impairs the communication process in a call center (Rodi, 2004; Monegain, 2001). This research seeks to discover the effectiveness of people, process and technology and discover how customer relationships are impacted. The goal of the research is to explore if mission statements, corporate beliefs and perspectives are channeled through to the customer (Bartkus, et al 2000). This is call center effectiveness. Call center effectiveness is defined as effectively providing good customer service, using efficient, user- friendly technology, and customer relationships and satisfaction. What is the impact of the call center on the customer perceptions and attitudes when forced to interact with automated technologies in comparison to dealing with a live agent? Are call centers channeling corporate perspectives of good customer service through to the customer?

METHODOLOGY

The focus of this exploratory study is represented using qualitative methods, in particular, focus groups. Through the use of focus group discussions, participant observation, and personal experience, ethnographic analysis will be utilized (Morgan, 1997; Morgan and Krueger 1997; Spradley, 1980). Personal experience was used to compare and contrast the researcher's knowledge and experiences with those from the participant group experiences. The focus group discussions seek to reflect customer and corporate attitudes, behaviors, cultures, failures and successes at the customer telephone call level and effectiveness of the call center.

Qualitative research uses thick or rich description where value is placed on deep detail in order to see all possible meanings and to dig deeper in the understanding of things (Geertz, 1973). In a similar case study by Gilmore (2001), participant observation and focus groups were employed as main sources of data collection (Gilmore, 2001).

SOME RESEARCH FINDINGS

The first classification named Getting to a person, reflects the level of frustration that exists throughout the customer base. Each focus group revealed strong emotions towards the issue of speaking with a person. The results of the focus group discussions indicate that customers have lost their patience with banks that do not place importance on customer relationships. These same customers are willing to switch their loyalties to a bank that is more customer- friendly.

The second classification is using a cell phone. The cell phone has become the primary form of communication as a result of our mobile society. Using a cell phone complicates the communication process because of the parameters that exist with cell phone usage. These parameters include peak usage times, weak or lost signals and service, low battery causing disconnected calls that would not normally happen when using traditional telephone communications.

The third classification, Reliance on technology, revealed customer importance with the banks that rely heavily on an Interactive Voice Response (IVR) system to filter or screen their customers away from speaking to a person. The results revealed that customers feel that they are purposely routed through the Interactive Voice Response (IVR) to discourage them from speaking to a person and is used for the bank's convenience. Customers are tired of being routed through endless loops of touchtone and voice responses and feel disconnected from the ability to develop good human communication with a live person. Good customer service means providing satisfaction and the ability to provide user- friendly technology.

Classification four dealt with providing good customer service. The focus group discussions revealed that customers are weary of poor customer service and demand better treatment. People are looking for the personal touch in customer service. When customers do not get treated well for any reason, they will switch to a competitor with no remorse, regardless of their previous relationships with that bank. Like other industries, banking has similar products and what sets them apart is the quality of the service that is provided.

In contrast to reliance on technology, classification five addresses the advantage of using technology. The focus group participants felt that technology has its place and can be beneficial when used to check balances or make simple updates where a live agent is not needed. They felt that a customer needs a choice whether to interact with the Interactive Voice Response (IVR) or to go directly to a person.

As a final classification, adherence to the mission statement proved to be important in the group discussions. The mission statement is the basis of the operation and should be projected to the customer. A consistent response throughout all of the groups was that the participants felt that their bank did not stand out above the other banks with their innovative technology. The participants felt that similar technologies existed and the difference between banks is their approach to the customer.

SUMMING UP THE FINDINGS

An important classification discussed in the research was getting to a person. The call center is usually the first point of contact for many banks and the first impression is developed from this experience. In many cases, the call center is the only point of contact for a customer. The research indicated the customer impatience with call routing technologies and the negative perception of these technologies. When accessing a call center, bank customers generally have a need to speak to a person to resolve an issue. The reliance on automated response systems has created a barrier between the customer and their bank call center (Dawson, 2005). This barrier became apparent during the focus group discussions where customers felt isolated when navigating through the Interactive Voice Response (IVR) systems. The customer perception discovered from the research indicated that the focus of a call center is on saving money and creating efficiency at the cost of good customer service.

Discovered through this research is the fact that banks must be focused on their customers. The products are so similar in banking that the difference between good and bad banks is determined by their focus on the customer. This focus encompasses the call center experience and the ability to provide user-friendly call center initiatives.

CONCLUSION

The goal of this research project is to explore and discover if the call center is meeting its customer's expectations. The impact of technology on customer relationships and adherence to the mission statement plays a key role in operating a successful call center. A good example is L.L. Bean. They are famous for their outstanding customer service and superior call handling in their call

centers (L.L.Bean Company, 2006). This researcher has called L.L. Bean on several occasions and has consistently reached a phone representative on one ring, regardless of the time of day. Running a call center strictly by the numbers creates a distance with customers and limits the ability to build and develop good customer relationships. Good, consistent customer service is what attracts and retains customers. The emergence of websites such as "gethuman.com" proves that call center customers are weary of interacting with technology when their need is to speak with a live person. The goal of a successful company would be to provide choices to interact with technology or to speak with a person. By providing these simple choices to call center customers indicates that they are still important and are valued.

REFERENCES

Ammenheuser, M.K. (2004). Banks Hear Customers Loud and Clear. Bank Systems and Technology. New York: 41(9), 42.

Bart, C.K. (1999). Making Mission Statements Count. Camagazine. March 1999.

Bartkus, B., Glassman, M., McAfee, R.B. (2000). Mission Statements: Are they Smoke and Mirrors? *Business Horizons.* Greenwich.

Bills, S. (2004). Upgrades making voice systems more palatable. American Banker. New York. February 26, 2004:16(38),13.

Clark, S. (2003). There are three critical steps for cultivating top-tier customers. Houston Business Journal. November 7, 2003.

Dausilio, R. (2005). Customer Service and the Human Experience. www.successfuloffice.com. Accessed June 22, 2005.

Dawson, K. (2005). Ignore Dissatisfaction at Your Own Risk. Call Center Magazine. www.callcentermagazine.com/shared/articles/showArticle.jhtml?articleId=165700873.

Geertz, C. (1973). The Interpretation of Cultures. Basic Books. New York, NY.

Gethuman. (2006). Retreived January 8, 2007, from http://gethuman.com.

Gilmore, A. (2001). Call Centre Management: Is Service Quality a Priority? Bedford. Volume 11, Issue 3; pages 153-160.

Hofstede, G. J. (2001). Culture's consequences: comparing values, behaviors, institutions, and organizations across cultures (2nd edition). Thousand Oaks, CA: Sage.

Houtz, J. (2006). Talk to a human? Most firms flunk test. Seattle Times. December 12, 2006.

Levit, M. (2004). Is CRM technology living up to the hype? GoArticles. www.goarticles.com/cgi-bin/showa.cgi?C=29794.

L.L. Bean, Inc. (2006). Freeport, Maine. USA.

Monegain, B. (2001). Do you know what your IVR is doing? CC News. Yarmouth. Dec, 2001: 3(11), 11.

Morgan, D.L. (1997). Focus Groups as Qualitative Research. Sage Publications. Thousand Oaks, CA. Second edition.

Morgan, D.L. and Krueger, R.A. (1997). The Focus Group Kit. Sage Publications. Thousand Oaks, CA.

O'Herron, J. (2004). Answering the call. Bank Systems and Technology. New York. May, 2004: 41(5), 34.

Phillips, J. (2004). What do Customers Really Want? ISeg Technologies. www.customerserviceworld.com.

Rodi, A. (2004). The Verbal Community. Ethnography of a phone culture-The call center. Unpublished manuscript.

Spradley, J.P. (1980). Participant Observation. New York. Holt, Rinehart and Winston.

Spradley, J.P. and McCurdy, D.(1988). The Cultural Experience. *Ethnography in Complex Society.* Waveland Press, Inc.

Swann, J. (2003). Making the Connection. How Technology Integrates Call Centers. Community Banker Magazine. July 2003. Published by America's Community Bankers.

Swanson, R. (2004). Speech Automated Self-Service Solutions: From Sidelines to Primetime. Customer Inter@ctionSolutions. Norwalk: 23(3), 54.

Thomas, D. (2003). Interactive voice response aims to improve call center experience for users. Edinburgh University. Sutton. October 28, 2003, p.32. Retrieved from www.proquest.umi.com

Performance Based Testing: Can a Web-Based, Simulated Environment Assessment Tool Measure Student Ability in Application Software Programs?

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INTRODUCTION

The College of Business Administration (CBA) offers a comprehensive business computer literacy and application software skills course. This MIS 110 course is required for our Business Administration (BBA) degree. The course covers hardware, the information processing cycle, ethical computing practices, and problem solving using popular business application software. The applications covered include Excel, Access, Word, and PowerPoint.

Eighty percent of the course is focused on using the computer as a tool to solve business problems. Developing intermediate-level application software skills is an important course goal for two reasons. First, the course is a prerequisite for other upper-division BBA required courses. As computing topics and software usage in these other courses becomes more extensive and required tasks more complex; a higher prerequisite knowledge and problem-solving skill level is mandatory for success. Second, CBA faculty members believe that businesses hiring BBA graduates place high value on computing skills proficiency.

Our University is an open enrollment institution and MIS 110 faculty members have witnessed increasing diversity of incoming student skill levels. To help identify students needing a more introductory course, we have investigated using simulated environment assessment programs such as SAM, SimNet, and TAIT for course placement purposes.

We believe that to use a tool as a means to measure performance, there must be an established correlation between the tool's outcome, or student score, and actual performance (Witnah, 2004). Performance-based testing (PBT) methods which "show us what you know by showing us what you can do" (Childers, 2000), are how we prefer to approach skills measurement in this course. PBT was originally designed to assess whether students can put knowledge to use, or demonstrate application of knowledge (Vaglio-Laurin, 2006). In other words, according to industrial psychologist Ruth Clark, "To establish that a person can use a procedure, the person must be able to actually perform it." (Stolovitch & Keeps, 1999)

PERFORMANCE-BASED TESTING METHODS

There are two popular methods for testing performance in software: simulation and live application. Each is an alternative to the most authentic means of measuring performance – on-the-job evaluation. (Vaglio-Laurin, 2006)

Simulation

A simulation approximates the live application environment--often by presenting a series of screen captures in response to the student's keystrokes / mouse clicks, thereby giving the appearance of actual interaction with the software. Simulations typically do not approximate the entire functionality of a live application, and required examination tasks are completed *independently* of each other.

Live Application

Live application approaches have students using actual software and/or hardware to perform a series of required tasks. Using the live application method, required tasks are *dependent* upon each other. The correct result of one task is needed for successful completion of subsequent tasks, much like on-the-job situations.

Though the labor and time intensive nature of developing and evaluating our live application examinations may seem excessive, we believe that simulated assessment environments do not adequately measure a student's ability to use these tools in real-world, on-the-job environments. However, resource shortages and an ever-expanding curriculum are forcing us to reconsider using simulated environment assessment tools as not only a placement mechanism, but possibly a way to reduce the time-intensive nature of our current assessment environment. If we can demonstrate that:

1. simulated environment test results are positively correlated with live application project-based test results, and
2. these results measure the learning outcomes we expect from our students, then

simulated environment assessment tools should be included as a part of our course curriculum / delivery and should be used for student performance evaluation.

EXPERIMENT DESIGN AND DATA ANALYSIS

Subjects for this study will be MIS 110 students in spring 2007. Subjects will be freshmen or sophomores and will belong to one of three sections taught by the same instructor. Each section may enroll up to 35 students. In this study phase, we will focus on two applications: Microsoft Excel and Microsoft Access. These two applications are the most important components of MIS 110. The simulated environment tool we will use is TAIT (Train and Assess IT), a Prentice Hall product. The live application examinations (LAE) are developed in-house by experienced instructors. Our formal design with three subject groups combines a factorial design with repeated measures and counterbalancing. Group 1 subjects will take a TAIT examination before taking the LAE examination. Group 2 will take the LAE examination before the TAIT examination. Group 3 is our control group and will take only LAE examinations.

At the beginning of the semester, subjects in all three groups will complete a survey gathering general demographic data such as gender, age range, self-reported current GPA range, level of comfort with Microsoft Excel and Microsoft Access, and years of computing experience.

For Group 1 subjects, after both Excel examinations have been scored and feedback received, a survey gathering feedback on the perceived benefits of completing TAIT prior to the LAE examination will be administered. Group 2 subjects will receive a similar survey gathering feedback on the perceived benefits of taking the LAE examination before the TAIT examination. Group 3 subjects will take only the LAE examinations and will have no exposure to the TAIT environment. This process will be repeated for the Access examinations.

Individual student examination scores will *not* be identifiable. Only categories of students and their score data will be collected, analyzed, and reported on. Score analysis for different tasks in each group will be made to determine whether the TAIT examinations enhanced student performance on LAE examinations, or vice

Table 1. Research activities

		Excel Examinations			Access Examinations		
Group 1	**General Demographic Survey**	**TAIT**	**LAE**	**Excel Perceptions Survey**	**TAIT**	**LAE**	**Access Perceptions Survey**
Group 2	**General Demographic Survey**	**LAE**	**TAIT**	**Excel Perceptions Survey**	**LAE**	**TAIT**	**Access Perceptions Survey**
Group 3	**General Demographic Survey**	**LAE**			**LAE**		

versa. Our data analysis can also be used to test the hypothesis of whether the simulated environment tool – TAIT, can be used as a viable student performance assessment tool. See Appendix A for a comparison of sample TAIT and LAE task instructions.

CONCLUSION

We believe this research will assist us in determining whether simulated environment assessment tool results can provide sufficient evidence of student ability within a live application. Given increasing emphasis on measurement of student learning and attainment of student learning goals, the identification of more efficient, reliable, time-saving, and cost-effective assessment methods will benefit both CBA faculty and students.

REFERENCES

Childers, P. (2002). "Performance-Based Testing: Proving Your Skills." *Certification Magazine*, June 2002.

Stolovitch, H. & Keeps, E., eds. (1999). *Handbook of Human Performance Technology: Improving Individual and Organizational Performance Worldwide,* 2d Ed. San Francisco, CA: Jossey Bass-Pfeiffer.

Vaglio-Laurin, M. (2006). "Don't Just Tell Us –Show Us!: Performance-Based Testing and SAS Certified Professional Program", *Proceedings of SAS Users Group International (SUGI)* 31, March, 2006.

Witnah, D. (2004) "A Practical Guide to Simulation Development." June 2004. Available at: www.performancetest.org/members/files/testdesigndox/backgrounddox/Simulation%20Development.pdf. Note: Access to this document requires registration (www.performancetest.org/register/index.html).

APPENDIX A

Sample of TAIT Examination and LAE Task Instructions

	NOTE: TAIT tasks are *independent* of each other and may be presented to students in random order.	**NOTE**: LAE tasks are *dependent* on each other and it is recommended that students perform each task in the order presented.
Excel Software Function / Task	**TAIT Sample Task Instruction**	**LAE Sample Task Instruction**
Open correct workbook	Open the "Judson Ford Realty.xls" spreadsheet.	Locate the Excel_HO_2_Template.xls file located on the H: drive. Open the workbook.
Merge and center cells	Merge cells A1:D1 and center "Expenses" in the merged cells.	Merge and center the heading in row 1 across columns A through E.
Sorting	Perform a multiple sort on the spreadsheet: first by Description and then by Member Company (both in Ascending order).	Using the appropriate menu command option, sort the list by both Destination (in ascending order) and Trip Cost (in descending order).
AutoFilter	Apply an AutoFilter to this sheet, and show only figures from the year 1850 or later.	Using AutoFilter, display the data for trips with a Trip Length of 7 Nights and a Trip Cost greater than $2,300.
Average function	In cell B20 of the current worksheet, create a function by typing in cell references to display the Average Monthly Sales for the six-month period covering January to June.	In cell E23, determine the average of Trip Cost for the displayed data. Use the appropriate Excel function to accomplish this.

The Influence of Contribution Visibility on Participant Satisfaction in Electronic Brainstorming

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ABSTRACT

Electronic brainstorming (EBS) was developed to overcome limitations of face-to-face brainstorming, and can be particularly useful in distributed idea generation sessions. However, EBS adoption in organizations has been sluggish, and its benefits beyond productivity—such as participant satisfaction—are equivocal. Applying the recently advanced theory of satisfaction attainment by Briggs, Reinig, and deVreede, our research explores if EBS participant satisfaction can be increased by innovative visualization of participants' contributions. This paper outlines our research model, and reports on the pilot deployment of one of our proposed EBS user interfaces.

INTRODUCTION

Idea generation is the process of deriving new concepts that may be useful when addressing a problem or opportunity [20]. Group brainstorming—a key ideation method in organizations—is characterized by deferring judgment, including even wild ideas, striving for quantity, and building on the ideas of others [16]. *Electronic* brainstorming (EBS) was developed to overcome limitations in face-to-face brainstorming, such as delays from taking turns speaking and withholding ideas for fears of a negative reaction. EBS eliminates these limitations by allowing simultaneous and anonymous input of ideas from distributed workstations, especially relevant in today's global teams [6, 18].

Despite the potential of EBS to boost productivity, its adoption in organizations has been sluggish—not unlike other e-collaboration technologies [7, 11]. *LotusNotes*, for instance, was not well accepted in a consultancy, due to lack of incentive to share one's best ideas if they were going to be seen as common property [17]. Other group support systems have left managers emotionally unfulfilled, for lack of that affective atmosphere inherent to some face-to-face meetings [21]. At the design firm IDEO, for instance, brainstorming sessions serve as 'prestige auctions' among employees, whose status is affected by reactions within the group [23]. While such explicit evaluability is not the point of EBS, complete anonymity, on the other hand, has been known to decrease motivation and participant satisfaction [5, 9, 14]. Anonymity may refer to *process* (inability to tell who is contributing) or *content* (inability to associate comments to contributors) [19].

CONTRIBUTION VISIBILITY

A recent EBS study by Jung, Schneider and Valacich [14] took a middle-of-the-road approach to anonymity. Their user interface (UI) included a bar chart that plotted the idea generation rates of each of the five participants, identified by pre-assigned pseudonyms. This treatment increased participants' motivation, compared to the control UI with no such performance feedback. The study, however, did not measure participant satisfaction. In addition, the authors note, some participants had realized the chart was displaying the number of contributions, and so lowered the *quality* of their ideas. Our study fills these gaps by investigating whether higher satisfaction with EBS outcome and process would be reported in conditions of identifiability and contribution visibility.

Only a handful of EBS studies address the issue of information visualization in EBS [8, 12]. Despite the compelling work by Erickson and Kellogg's on social translucence and social proxies in digital systems [10], the value of visualization

Figure 1. Our research model, with an iconic representation of the EBS interface conditions on the left, instantiating three levels of contribution visibility (our independent variable). Perceived goal attainment is the causal construct, while meeting satisfaction is the consequent construct. Dependent variables are reported scores on the various items (shown with the smallest type)

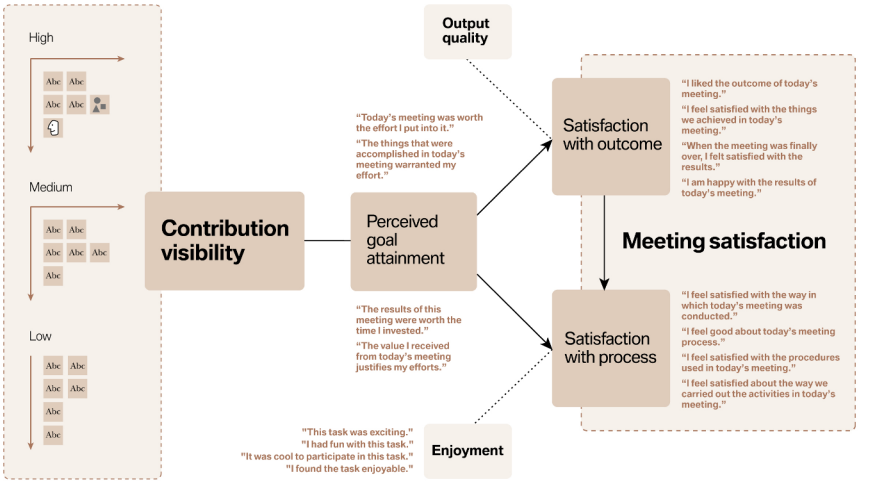

Figure 2. A screenshot taken near the end of the pilot session. Participants have submitted ideas as in a threaded discussion, except that text appears in rectangular cells. New ideas are arranged horizontally. Refinements or elaborations of already generated ideas are arranged top-down

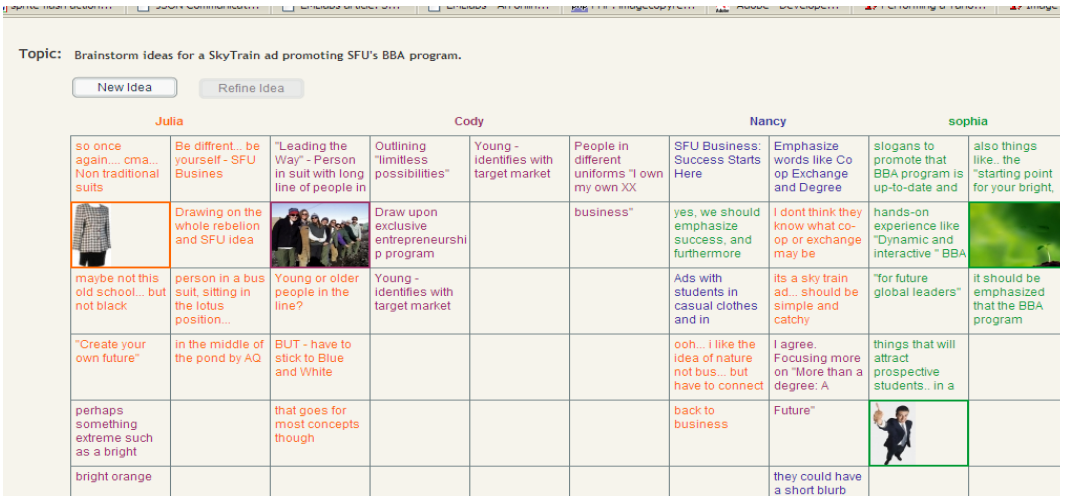

Table 1. Mean responses for each construct from the five participants in the pilot test.

	1 Strongly Disagree	**2** Dis-agree	**3** Some-what Disagree	**4** Neutral	**5** Some-what Agree	**6** Agree	**7** Strongly Agree
Perceived goal attainment					**5.3**		
Satisfaction with outcome					**5**		
Satisfaction with process				**4.85**			
Enjoyment				**4.75**			

for interfaces of collaboration technology has yet to be realized. The most popular system on the market and in the labs, GroupSystems.com, is mostly based on text and tables, and relies on trained facilitators to wield its rich computational functionality. But the scope of our research does not include facilitated meetings. For political and economic reasons, reliance on facilitators in companies has become impractical [3]. Instead, our experimental manipulation is varying the design of our web-based EBS interface.

MEETING SATISFACTION

There is a dearth of research on what causes satisfaction in technology-supported meetings. Yet insufficient satisfaction can undermine the adoption of otherwise productive systems [2, 22]. Briggs and his colleagues observed many instances of users abandoning systems they *judged* to be useful and easy to use, but with which they nonetheless *felt* dissatisfied [2, 21]. These researchers have since then defined meeting satisfaction as an affective arousal with a positive valence on the part of a participant with respect to the outcomes or procedures and tools used in a meeting [2, p. 588]. We apply the validated instrument that stems from this definition, but in addition include items for *enjoyment*, which has influenced technology acceptance in more general IT contexts [24]. Its inclusion will help us better understand the link between extrinsic and intrinsic motivation in EBS.

Effort towards a goal is generally determined by our subjective assessment of its *value* and the *likelihood* of its attainment [2]. Yet this effort is reduced when individuals work collectively and combine their inputs, according to the collective effort model [15]. This reduction is strong when individuals feel unlikely to get credit for their contributions, or when these are not instrumental towards attainment of the group goal. In one study of an online community, for instance, members were reminded of their unique position to rate a specific movie that only they had seen. This intervention increased their participation [1], and similar increases in EBS have been achieved based on social comparison [14, 21]. Indeed most of us compare ourselves to others due to some degree of uncertainly about our abilities, which we seek to resolve through positive confirmations [19, 23]. Uncertainty occurs in EBS given the flurry of incoming ideas, as some participants even confuse their own ideas with those of others [9].

While all hypotheses have yet to be derived, our main expectation is that EBS participants who brainstorm in conditions of high contribution visibility (CV) will report higher meeting satisfaction than participants who brainstorm in the conditions of low CV. Further, since the condition of highest CV supports uploading of image thumbnails alongside text, we expect participants, who do take advantage of this feature, to report the highest levels of satisfaction. This is because—simply put—pictorial representations are more impressive than text [4, 13]. Pictures can also be used as avatars instead of usernames, but this feature was not enabled in our pilot.

METHODOLOGY AND PILOT TEST RESULTS

Consistent with the EBS literature, our methodology is the lab experiment with students. In a between-subjects design, 240 students from a second-year business course will brainstorm on how to advertise the University's undergraduate Business program in the local mass transit. Each participant will receive course credit, and teams with the best ideas will further receive $100 ('best' being determined by independent coding from domain professionals). All 5-person teams will brainstorm for 15 minutes in distributed settings, using one of the three web-based EBS interfaces. The post-experimental questionnaire, with items on a 7-point Likert scale (shown in Figure 1) will be administered at the end online.

A pilot test was already conducted with five participants using the high contribution visibility condition. The quality of participation (Figure 2) and survey responses (Table 1) were promising. Some usability problems that emerged will be fixed for the upcoming main data collection. For instance, participants needed more and wider cells, so an algorithm will rescale and optimize the canvas aspect ratio. The outcome also alleviated our concern whether participants would take the trouble to find and upload pictures with relevant content. All five participants submitted a picture. The elaboration structures were not so clear, unfortunately, but on the plus side, participants reported they found the color-coding meaningful. The next step is conducting a second pilot test for instrument validation and finalizing all three EBS interfaces.

REFERENCES

1. Beenen, G., Ling, K., Wang, X., Chang, K., Frankowski, D., Resnick, P. and Kraut R.E. (2004), "Using social psychology to motivate contributions to online communities*", Proc. CSCW'04*, Nov. 6-10, Chicago, Illinois.
2. Briggs, R.O, Reinig, B.A., and deVreede, G.J. (2006), "Meeting satisfaction for technology-supported groups: An empirical validation of a goal-attainment model", *Small Group Research* 37(6), 585-611.
3. Briggs, R.O., deVreede, G.J. and Nunamaker, J.F. (2003), "Collaboration engineering with thinkLets to pursue sustained success with group support systems", *J. of Management Information Systems* 19(4), 31-64.
4. Burkhard, R. (2005), "Towards a framework and a model for knowledge visualization", in: Tergan, S.O. and Keller, T. (Eds), Knowledge Visualization and Information Visualization–Searching for Synergies, Springer-Verlag: London, 238-255.
5. Connolly, T., Jessup, L.M. and Valacich, J.S. (1990), "Effects of anonymity and evaluative tone on idea generation in computer-mediated groups", *Management Science* 36, 689-703.
6. Dasgupta, S., Granger, M. and McGarry, N. (2002), "User acceptance of e-collaboration technology: An extension of the technology acceptance model", *Group Decision and Negotiation* 11(2), 87-100.
7. Dennis, A. and Reinicke, B. (2004), "Beta versus VHS and acceptance of electronic brainstorming technology", *MIS Quarterly* 28(1), 1-20.
8. Dennis, A., Valacich, J., Carte, T., Garfield, M., Haley, H. and Aronson, J. (1997), "The effectiveness of multiple dialogues in electronic brainstorming", *Information Systems Research* 8(2), 203-211.
9. Dugosh, K.L. and Paulus, P.B. (2005), "Cognitive and social comparison processes in brainstorming," *J. of Experimental Social Psychology* 41, 313-320.
10. Erickson, T. and Kellogg, W. (2002), Social translucence: Using minimalist visualizations of social activity to support collective interaction", in: Höök, K., Benyon, D. and Munroe, A. (Eds), Readings of Social Navigation of Information Space, Springer-Verlag: London.
11. Fjermestad, J., and Hiltz, S.R. (2000), "Group support systems: A descriptive evaluation of case and field studies", *J. of Management Information Systems* 17(3), 113-157.
12. Grise, M.L. and Gallupe, B. (1999-2000), "Information overload: Addressing the productivity paradox in face-to-face electronic meetings", *J. of Management Information Systems* 16(3), 157-185.
13. Ivanov, A. and Cyr, D. (2006), "The concept plot: A concept mapping visualization tool for asynchronous web-based brainstorming sessions", *Information Visualization* 5(3), Palgrave Publishing, 185-191.
14. Jung, J.H., Schneider, C. and Valacich, J.S. (2005), "The influence of real-time identifiability and evaluability performance feedback on group electronic brainstorming performance", *Proc. 38th HICSS.*
15. Karau, S. J. and Williams, K. D. (1993), "Social loafing: A meta-analytic review and theoretical integration", *J. of Personality and Social Psychology* 65, 681-706.
16. McGrath, J. (1984), Groups: Interaction and Performance, Prentice Hall: Englewood Cliffs, NJ.
17. Orlikowski, W. (1992), "Learning from *Notes*: organizational issues in groupware implementation", *Proc. CSCW'92*, Oct. 31-Nov. 4, Toronto, Ontario, 362-369.
18. Paulus, P.B. and Nijstad, B.A. (Eds). Group Creativity: Collaboration through Innovation, Oxford University Press.
19. Pissarra, J. and Jesuino, J.C. (2005), "Idea generation through computer-mediated communication: The effects of anonymity", *J. of Managerial Psychology* 20(3/4), 275-291.
20. Reinig, B. and Briggs, R. (2006), "Measuring the quality of ideation technology and techniques", *Proc. 39th HICSS.*
21. Reinig, B., Briggs, R., Shepherd, M., Yen, J. and Nunamaker, J. (1996), "Affective reward and the adoption of group support systems: Productivity is not always enough", *J. of Management Information Systems* 12(3), 171-185.
22. Shaw, G.J. (1998), "User satisfaction in group support systems research: A meta-analysis of experimental results", *Proc. 31st HICSS.*
23. Sutton, R.I. and Hargadon, A. (1996), "Brainstorming groups in context: Effectiveness in a product design firm", *Administrative Science Quarterly* 41, 685-718.
24. Venkatesh, V. (2000), "Determinants of perceived ease of use: Integrating control, intrinsic motivation, and emotion into the technology acceptance model", *Information Systems Research* 11(4), 342-365.
25. deVreede, G.J., Briggs, R.O., van Duin, R. and Enserink, B. (2000), "Athletics in electronic brainstorming: Asynchronous electronic brainstorming in very large groups", *Proc. 33rd HICSS.*

KM in Higher Education: Modeling Student Help-Avoidance Behaviors and Performance

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ABSTRACT

The application of corporate knowledge management (KM) practices such as customer relationship management (CRM) within the academic environment is considered within the sphere of student relationship management (SRM). By engaging in SRM, key issues such as student help-avoidance behaviors can be proactively addressed to ensure academic achievement and success.

This study describes the development of a structural model to investigate how student help-avoidance is related to perceived academic performance. We based our model on one developed by Butler (1998) which includes autonomous orientation, ability-focused orientation, and expedient orientation as three dimensions of the help-avoidance construct. Preliminary results of a survey of 130 undergraduate students taking an IT course indicate that besides the three dimensions of help-avoidance, students have other student- and instructor-specific perspectives of help-avoidance also exist.

Keywords: Knowledge management, higher education, student help-seeking, help-avoidance, academic performance, student relationship management, structural equation model.

1. INTRODUCTION

Knowledge management (KM) is a relatively new management activity which many companies have embraced in an attempt to meet the challenges of an increasingly global business environment to compete over customers. Even though some have questioned the view that educational institutions can be and indeed are in business (Bishton, 2005), the competitive wave is being experienced in educational institutions. More than ever before, higher educational institutions now have to compete for students. Competition is particularly fierce among those institutions that are moving away from research and putting more emphasis on teaching. For teaching-oriented institutions, the student is the focal entity. While the debate about the view of students -- as customers, products, or partners (Clyason & Heley, 2005; Obermiller, Fleernor, & Raven, 2005) is far from being over, for institutions that consider students as their "raison d'être," the predominant view is that students are their customers.

The view of students as customers brings two expectations. First, students are expected to seek help in the course of their studies to ensure the best academic achievement and success just as customers would seek help in the course of using a product or service for maximum benefit. Second, since the value proposition of KM in the corporate world includes innovation, customer intimacy, and operational excellence (Kindwell, Vander Linde, & Johnson, 2000), teaching-oriented institutions are expected to embrace KM with a vested interest in student intimacy. Student intimacy can be attained through the establishment of student relationship management (SRM) programs just as companies have established various customer relationship management (CRM) programs for the same parallel purpose. The foregoing expectations remain largely unmet. For example, whereas most customers will readily seek help from company help-desks, the same is not true of most students, who do not often approach instructors ("university help-desks") to seek help in the course of their studies. Equally, with every effort is made to recruit and retain students, few or no educational institutions have any SRM programs in place to help understand student help-avoidance or promote help-seeking behavior. SRM will foster help-seeking behaviors of students for two potential benefits -- instructors are able to fill gaps in student knowledge and adapt teaching, both of which should contribute to student achievement and success.

This purpose of this study is develops a structural equation model to delineate factors that account for student help-avoidance behaviors, and subsequently relate it to academic performance. We base our model on a previously developed model to investigate the relationship between help-avoidance and style of help-seeking behavior (Butler, 1998). As we apply the model in the higher educational setting, we attempt to answer the following questions: (1) why do students avoid seeking help when doing their academic assignments?; (2) how does help-seeking behaviors relate to academic performance?

2. LITERATURE REVIEW

KM can be used to learn about students' needs and behaviors just as is done in the corporate world with respect to customers. In this review, we examine the nature of the relationship between students and educational institutions (referred further as universities) as well as discussion on the student help-avoidance and help-seeking behavior.

2.1 Student-University Relationship

The nature of the student-university relationship is highly debated and three orientations of how students should be considered have been discussed in the literature. The first orientation considers students as customers, the second as products, and the third as partners to universities. Many institutions do not explicitly state their orientations of students as customers (Clyason & Heley, 2005). These authors cite evidence that have shown that indeed the customer-oriented view of student implicitly exists in most universities. For example, marketing material for future students resembles marketing material for customers in the corporate world, the urge by university departments to write marketing plans, the requirement for students to complete customer-like surveys about their educational experiences including evaluation of instructors.

In an empirical study involving instructors and students, Obermiller *et al*.(2005) found that instructors preferred referring to students as products while students preferred being referred to as customers. However, both instructors and students "believe the other orientation prevails" (p. 27). In an earlier study students were more deterministic about being called customers, and the researchers concluded that the operation of higher education was consumer-driven (Delucchi & Korgen, 2002). The use of both customer and products orientations has been advocated (Conway & Yorke, 1991). Other think referring to students as customers or products is not appropriate (Franz, 1998; Bay & Daniel, 2001; Bishton, 2005; Clyason & Heley, 2005).

An emerging view of students as partners has been proposed (Bay & Daniel, 2001). Although we support this view, we contend that KM practices associated with CRM can be applied to the partnership under the appellation of SRM as previously discussed.

2.2 Student Help-Avoidance and Styles of Help- Seeking Behaviors

When faced with a problem, between the alternatives of giving up or persisting unsuccessful alone and seeking help, it has been recommended that seeking help is the most valuable thing to do (Newman, 1991). Failure to heed to the foregoing

recommendation may be due to several factors, including consideration that the cost of help-seeking outweighs the benefits of help-avoidance (Nadler, 1997), striving for independent mastery (Butler & Neuman, 1995), culture; where students tend to avoid embarrassment (Hambrecht, 2006), and reward; where high achieving students seek help for personal difficulties related to course work (Taplin, Yum, Jegede *et al.*, 2001).

Other studies have pointed out that seeking or avoiding help, especially in computer mediated environments is dependent on the nature of learner-oriented factors such as help facilities (Bartholome, Stahl, Pierschl *et al.*, 2006). Cognitive tutors have been developed in an attempt to help students learn to seek help (Aleven, McLaren, Roll *et al.*, 2004). Evidence suggests that those who seek help have better learning outcomes, whereas those who really need help are less likely to seek help (Ryan, Gheen, & Midgley, 1998).

Help-avoidance have been characterized as a multidimensional construct and studied in relationship with the style of help-seeking behaviors (Butler, 1998).The help-avoidance construct has three dimensions – autonomous orientation, ability-focused orientation, and expedient orientation. The author defined autonomous help-avoidance orientation as striving for independent mastery; ability-focused as desiring to mask incompetence, and expedient orientation as reluctance to seek help attributed to the perception that asking for help will not expedite the task. The author used the model to investigate the relationship between help-avoidance and styles of help-seeking behaviors (autonomous –first trying to solve a problem before asking for help, executive – request help relatively early, and avoidant-covert – requesting little overt help). In an experimental study in a K-12 environment, it was found that autonomous help-avoiders are likely to engage in autonomous help-seeking style; expedient help-avoiders used the executive help-seeking style; and ability-focused help avoiders used the avoidant-covert help-seeking style (Butler, 1998).

3. HELP-AVOIDANCE AND PERFORMANCE RESEARCH MODEL

We adapted the help-avoidance model proposed by (Butler, 1998) to the context of a university environment and investigated the relationship between the various orientations and perceived academic performance. The research model is shown in figure 1.

4. METHODOLOGY

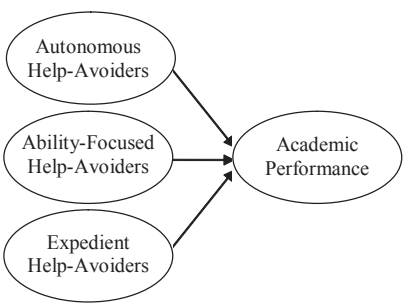
4.1 Instrumentation and Sample

To measure help-avoidance, we used a modified version of the 17-item instrument proposed by Butler (1998). The modified instrument was reviewed by four instructors for clarity and consistency. Perceived academic performance was measured using the six items below. One hundred and thirty students from eight sections of an undergraduate IT course were surveyed to collect data for the study. Each student was asked to rate his/her performance compared to fellow students in the class using a five-point scale (SD –Strongly Disagree, D-Disagree, N-Not Sure, A-Agree, and SA-Strongly Agree):

"Compared to your fellow students taking the course, you: ..."

1. *Have or will have a better grade in the course*
2. *Are more satisfied with the class organization*
3. *Are more satisfied with the course material*
4. *Are more satisfied with the way the course is taught*
5. *Are more satisfied with the course instructor*
6. *Have a higher Grade Point Average (GPA)*

Figure 1. Help-avoidance and performance model



Besides the reasons pointed out in the research instrument, students were asked to identify one other reason why they believe may explain why students do not ask for help. Demographic information was also solicited, including number of credit hours and working status.

5. PRELIMINARY RESULTS AND FUTURE WORK

Preliminary analysis of the responses to the qualitative question requesting students to state one reason they believe students do not ask for help indicate some student-oriented reasons such as students being lazy, students not wanting to learn, not caring if they get it right, scared and preserve self-respect, think attention being bad, and not wanting to slow progress. Instructor-oriented reasons cited include expectation of students to know certain things ahead of time and sometimes, instructor tells everything but the answer to the question asked.

Future work will focus on analyzing the data and examining the results to see if the same three dimensional model of help-avoidance is applicable to higher educational environments. Results from the study would provide management indicators for the establishment of SRM programs geared at understanding and eliminating help-avoidance. SRM will foster help-seeking behaviors of students for two potential benefits -- instructors are able to fill gaps in student knowledge and adapt teaching, both of which should contribute to student achievement and success.

6. REFERENCES

Aleven, V., McLaren, B., Roll, I., & Koedinger, K. (2004). *Toward tutoring help seeking: applying cognitive modeling to meta-cognitive skills.* Paper presented at the Seventh International Conference on Intelligent Tutoring Systems (ITS-2004).

Bartholome, T., Stahl, E., Pierschl, S., & Bromme, R. (2006). What matters in help-seeking? A study of help effectiveness and learner-oriented factors. *Computers in Human Behavior, 22*(2006), 113-129.

Bay, D., & Daniel, H. (2001). The student is not the customer - an alternative perspective. *Journal of Marketing for Higher Education, 11*(1), 1-19.

Bishton, J. (2005). Are universities in business? *IEE Engineering Management*(April/May), 45-46.

Butler, R. (1998). Determinants of Help seeking: relations between perceived reasons for class help-avoidance and help seeking behaviors in an experimental context. *Journal of Educational Psychology, 90*(4), 630-643.

Butler, R., & Neuman, I. (1995). Effects of task and ego achievement goals on self-seeking behaviors and attitudes. *Journal of Educational Psychology, 87*, 261-271.

Clyason, D. E., & Heley, D. A. (2005). Marketing models in education: students as customers, products, or partners. *Marketing Education Review, 15*(1), 1-10.

Conway, A., & Yorke, D. A. (1991). Can the marketing concept be applied to the Polytechnic and College sector of Higher Education? *International Journal of Public Sector Management, 4*(2), 23-35.

Delucchi, M., & Korgen, K. (2002). We're the customer - we pay the tuition: student consumerism among undergraduate sociology majors. *Teaching Sociology, 30*(January), 100-107.

Franz, R. (1998). Whatever you do, don't treat your students like customers! *Journal of Management Education, February*, 63-67.

Hambrecht, M. F. (2006). Help seeking behavior of international students: does culture have an impact? Retrieved Dec. 15, 2006, from http://www.idp.edu.au/aiec/pastpapers/Hambrecht%20(Paper)%20Wed%201520%20MR4.pdf

Kindwell, J. J., Vander Linde, K. M., & Johnson, S. L. (2000). Applying corporate knowledge management practices in Higher Education. *Educause Quarterly, 4*, 28-33.

Nadler, A. (1997). Personality and help-seeking: autonomous versus dependent seeking of help. In G. R. Pierce, B. Lakey, I. G. Sarason & B. R. Sarason (Eds.), *Sourcebook of social support and personality* (pp. 379-407). New York: Plenum Press.

Newman, R. S. (1991). Goals and self-regulated learning: what motivates children to seek academic help? In M. L. Maehr & P. R. Pintrich (Eds.), *Advances in Motivation and Achievement* (Vol. 7, pp. 151-183). Greenwich, CT: JAI Press.

Obermiller, C., Fleernor, P., & Raven, P. (2005). Students as customers or products: perceptions and preferences of faculty and students. *Marketing Education Review, 15*(2), 27-36.

Ryan, A. M., Gheen, M. H., & Midgley, C. (1998). Why do some students avoid asking for help? An examination of the interplay among students' academic efficacy, teachers' social-emotional role, and the classroom goal structure. *Journal of Educational Psychology, 90*(3), 528-535.

Taplin, M., Yum, J. C. K., Jegede, O., Fan, R. Y. K., & Chan, M. S.-c. (2001). Help-seeking strategies used by high-achieving and low-achieving distance education students. *Journal of Distance Education, 16*(1).

Data Mining in Higher Education: Mining Student Data to Predict Academic Persistence

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ABSTRACT

The question of student retention remains one of the main preoccupations of university administrators. As the interplay of several factors often causes students to withdraw from university at various levels, pro-active administrators are in dire need of analytical tools to help predict student academic persistence. By knowing which students are likely not to persist after a given semester, administrators are able to take measures to help reverse the trend.

We report on an on-going data mining project to develop and deploy models to predict student persistence in the first year of undergraduate studies following their participation in a specialized pre-undergraduate program at the Center for Academic Success at Southern Illinois University, Carbondale. Preliminary results from the first run of the models have validated predicted persistence at 75 percent accuracy. These results are very encouraging compared to previous work at this level.

Keywords: higher education, knowledge discovery, data mining, GPA, prediction, academic persistence.

1. INTRODUCTION

Data mining, which has predominantly been carried out by private sector organizations is gradually emerging as a routine endeavor in the academic environment because of its potential benefits of improving the quality of education (Ma, Liu, Wong *et al.*, 2000; Luan, 2002). University administrators, instructors, students, and parents often want to have some idea ahead of time, regarding the performance and persistence of students. Being able to predict performance and persistence offers the opportunity for better planning and better decision-making processes.

This report highlights our current work of applying data mining on academic data and is organized in five sections: background information, research model, methodology, results and discussion, and a conclusion highlighting the limitations of the research, management recommendations and direction for future work.

2. LITERATURE REVIEW

Although data mining is an emerging practice within the academia, it has been used as technique to answer many challenging questions. Mining of student data has been eloquently compared with mining of customer data (Luan, 2002). The author outlines several customer-related data mining questions and provides an analogy for student data-mining. For student data mining, such questions include knowing those students that are unlikely to persist, take many credit hours, or transfer. In a case study of using clustering techniques and neural networks to model academic persistence, an initial prediction accuracy rate of 65% was obtained. Modification of the models resulted in an improvement up to 85% prediction accuracy (Luan, 2002). A system has been developed to identify weak students for remedial classes with 67% accuracy (Liu, Hsu, & Ma, 1998). A more recent system for the same purpose performed at a higher accuracy level (91%) but the task was attainable at 93% accuracy using traditional methods (Ma *et al.*, 2000)).

3. PROJECT BACKGROUND AND RESEARCH QUESTION

The Center for Academic Success (CAS) is a pre-undergraduate preparatory at Southern Illinois University Carbondale (SIUC) that offers target students the opportunity to prepare themselves for better performance in their first year at the university. Procedurally, CAS admits new students during the Fall and Spring semesters, with the greatest number of admissions (300 - 500) in Fall and the least in Spring (typically 20). As these students spend only two semesters at CAS (Fall and Spring or Spring and Summer), their persistence is verified at the end of the second week of their third semester at SIUC, in the academic unit of their choice.

Although the data mining project is geared at providing actionable data for administrative support to address several questions, this first question we are attempting to answer is: who are those CAS students that persist at SIUC after their time at CAS?

4. DATA MINING PROJECT MODEL

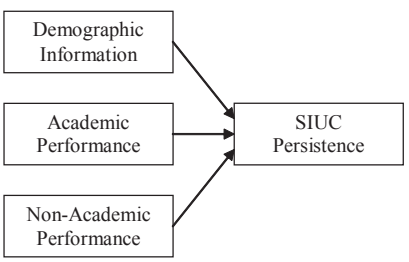
Given the problem at hand, our project uses the predictive data mining approach. Student persistence is a categorical variable with two levels (YES or NO). Therefore, we develop a predicting data mining classification model, i.e. a model that will predict the value of the persistence attribute of a student as either YES or NO, based on a number of input variables. The model being investigated to respond to the research question at this stage of our project is shown in figure 1.

5. METHODOLOGY

5.1 Data Mining Approach

The data mining approach adopted for the project is based on the Cross-Industry standard Process for Data Mining (CRISP-DM) model (Chapman, Clinton, Kerber *et al.*, 2000) which reflects the real-world experience of how data mining should be conducted in a standard and systematic way. We have implemented key elements from all six steps of the CRISP-DM methodology (Business, Understanding, Data Understanding, Data Preparation, Modeling, Evaluation, and Deployment) and obtained a prototype system whose performance is very encouraging.

Figure 1. Persistence research model



5.2 Dataset and Variables

The dataset included demographic, academic, and non-academic information on the students. **Demographic variables** included gender, age, and race. **Academic variables** included *ACT scores*: English, Mathematics, Reading, Science, and Composite; *High School-related*: Rank, Percentile, and High School GPA; *CAS-performance*: Term1 GPA, Term2 GPA, Term1 Standing, Term2 Standing, Year1 GPA; and *SIUC-related*: Term3 Persistence. ***Non-academic variables*** included *CAS-Semester related*: Term1 Semester (e.g. Fall 2004), Term 2 Semester (e.g. Spring 2005), Term 1 Mentoring, Term2 Mentoring, Term1 Tutoring, Term2 Tutoring, Positive Self Appraisal, Positive Self Confidence, Long Range Goals, and Gender Sensitivity.

For the prototype system develop at this point, we have not used non-academic variables since these are not available across the entire dataset. Nine of the other variables were retained for the prediction of Fall 2005 persistence (T3 Persistence). These include five continuous variables: age, ACT composite score, High School GPA, Term1 GPA, and Term2 GPA; and four categorical variables: gender, race, Term1 Standing, and Term2 Standing.

Within the dataset with demographic and academic variables, the data mining dataset was further screened to include only those students who had effectively spent two semesters (Term1 and Term2) at CAS. Given the objective of developing a model to predict Fa2005 persistors, two final datasets were maintained for this stage of the data mining project. The first dataset (**dataset1**) spawns the period of Fall 1998 to Spring 2004 (2279 records) and the second dataset (**dataset2**) included Fall 2004 and Spring 2005 (384 records). We used **dataset1** to train and test the data mining models. The models were then applied to **dataset2**, to predict persistence status for Fall 2005. The data mining project is being carried out using Statistica Data Miner (Statsoft.com).

6. RESULTS AND DISCUSSIONS

6.1 Preliminary Investigations on the Training and Testing Datasets

Preliminary investigations were conducted on the training and testing dataset regarding risk of wrong estimate and standard error. The training set had a risk estimate of 0.15 and a standard error rate of 0.01 and the testing dataset had a risk estimate of 0.13 and standard error rate of 0.02. Given the standard errors for the training and testing datasets, we estimated prediction accuracy to be between 83 and 91 percent at the 95% confidence level. Since the training and testing datasets had different risk estimates and different standard errors, we compared their performance using the approach of comparing supervised models (Roiger & Geatz, 2003). We found that the two models were not significantly different from each other. This alleviated any worries about the accuracy of the final results when persistence was to be predicted using the target sample (**dataset2**). We investigate the relative importance of each predictor variable and found that Term2 GPA was most influential, while gender had the least predictive importance (Table 1).

6.2 Performance of the Data Mining Algorithms/Models

Eight data mining algorithms/models were used, referred to here as CTrees2, CCHAID3, CECHAID4, CBTrees5, Logit6, Probit7, CMLP8, and CRBF9. The performance of an algorithm was judged by examining goodness of fit or misclassification rate, the degree to which predictions disagree with actual cases in the testing dataset. Low percentage disagreement (% Incorrect) of an algorithm meant lower misclassification, and hence better performance in prediction. The performance of each algorithm of incorrectly predicting Term3 Persistence (T3Persist) in the test dataset is shown in Table 2. The percentage disagreement among all eight algorithms of incorrectly predicting Term3 Persistence as either Yes or No is shown in Table 3.

6.3 Fall 2005 Persistors and Non-Persistors Predictions: Vote of Three Best Predicting Models

Three of the 394 records in dataset2 (Fall 2004 and Spring 2005) were deleted because of "excessive" missing values in some of the fields. As a result, 391 records were used in the subsequent analysis. In line with extant research, the results of the eight data mining algorithms were subjected to a vote. However, only the results of the best three performing algorithms were considered in the vote. The results indicate that **48 students** (12% of Fall 2004/Spring 2005 students) **may not** persist while **343 students** (88 %) **may persist** in Fall 2005.

Table 1. Predictor ranking and importance in predicting T3 persistence

Predictor Variable	***Rank***	***Importance***
AGE	25	0.25
ACTCOMP (ACT Composite Score)	27	0.27
HSGPA (High School GPA)	48	0.48
T1GPA (Term1 GPA)	95	0.95
T2GPA (Term2 GPA)	100	1.00
GENDER	8	0.07
RACE	39	0.38
T1STAND (Term1 Standing)	55	0.55
T2STAND (Term2 Standing)	79	0.79

Table 2. Percentage disagreement of individual algorithms in predicting observed persistence

#	*Data Mining Algorithm/Model*	*Fall 2005 Persist* (% Incorrect for Yes and No)	
		Yes	**No**
1	CTrees2	14.30	5.26
2	CCHAID3	13.85	18.88
3	CECHAID4	13.85	18.88
4	Logit6	13.88	12.30
5	Probit7	14.04	11.11
6	CMLP8	11.42	59.76
7	CRBF9	12.64	57.34
8	CBTrees5	12.37	34.76

Table 3. Percentage disagreement among algorithms in predicting observed persistence

#	*Data Mining Algorithm/Model*	*Fall 2005 Persist* (% Incorrect Yes or No)
1	CTrees2	13.27
2	CCHAID3	14.57
3	CECHAID4	14.57
4	Logit6	13.67
5	Probit7	13.67
6	CMLP8	31.86
7	CRBF9	28.74
8	CBTrees5	17.07

Table 4. Fall 2005 persistors and non-persistors

#	Predicting Algorithm/Model	Fall 2005 Persist	
		Yes (%)	No (%)
1	CTrees2	343 (88)	48 (12)
2	CCHAID3	349 (89)	42 (11)
3	CECHAID4	349 (89)	42 (11)
4	Logit6	343 (88)	48 (12)
5	Probit7	343 (88)	48 (12)
6	CMLP8	240 (62)	148 (38)
7	CRBF9	249 (64)	142 (36)
8	CBTrees5	325 (83)	66 (17)
	Best3Voted	343 (88)	48 (12)

6.4 Fall 2005 Persistors and Non-Persistors Predictions: Individual Algorithms/Models

Prediction results of all eight models were compared with that of the vote from the three best models and presented in Table 4. We note that three algorithms (CTrees2, Logit6, and Probit7) won the vote as these three had identical predictions.

6.5 Fall 2005 Persistors and Non-Persistors Actual Persistors

Actual persistence assessed using Fall 2005 data indicated that 294 students persisted (as opposed to 343 predicted) and 97 students were non-persistors (as opposed to 48 predicted). The actual persistence rate obtained is 75% (as opposed to 88% predicted) while the non-persistence rate is 25% (as opposed to 12% predicted).

7. CONCLUSION AND FUTURE WORK

Compared to previous similar work at this level (e.g. Luan (2002) and Liu, Hsu, & Ma (1998)) the results obtained are very acceptable. The 75% prediction accuracy are quite encouraging, giving that this is the first run of the models; and it is our expectation that better results can be obtained with the improvement of the models. Nevertheless, the results are being exploited with caution since most of the parameters have not been incorporated into the models. We found an interesting pattern in the prediction of persistors and non-persistors. The differences in accuracy for both predictions are about the same -13%. This result could be coincidental but it does raise some curiosity which we are exploring, especially because we consider the 13% difference to be very large.

Future work includes drilling down to identify whether individual students predicted to persist indeed were the ones who persisted and vice versa. Subsequently, we will proceed to refine the models

The results of our project will be useful to management as an aid in making decisions regarding resource allocation to accommodate the number of persistent students, i.e. those who will return to continue their undergraduate studies after the pre-undergraduate preparatory year. The results are also useful in exploring different channels to ensure high persistence rates.

8. REFERENCES

Chapman, P., Clinton, J., Kerber, R., Khabaza, T., Reinartz, T., Shearer, C., et al. (2000). CRISP-DM 1.0. Retrieved March 19, 2005, from http://www.crisp-dm.org/CRISPWP-0800.pdf

Liu, B., Hsu, W., & Ma, Y. (1998). *Integrating classification and association rule mining.* Paper presented at the KDD-98.

Luan, J. P. (2002). *Data mining and knowledge management in higher education: potential applications.* Paper presented at the Association of Institutional Research Forum.

Ma, Y., Liu, B., Wong, C. K., Yu, P. S., & Lee, S. M. (2000). *Targeting the right students using data mining.* Paper presented at the Sixth ACM SIGKDD International Conference, Boston, MA (Conference Proceedings; p. 457-464).

Roiger, R. J., & Geatz, M. W. (2003). *Data Mining: A tutorial-based primer*. Boston: Addison Wesley.

Dynamical Enhancement of the Large Scale Remote Sensing Imagery for Decision Support in Environmental Resource Management

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ABSTRACT

In this study, we address a new efficient robust optimization approach to large-scale environmental RSSS reconstruction/enhancement as required for remote sensing imaging with multi-spectral array sensors/SAR. First, the problem-oriented robustification of the previously proposed fused Bayesian-regularization (FBR) enhanced imaging method is performed to alleviate its ill-poseness due to system-level and model-level uncertainties. Second, we incorporate the dynamic filtration paradigm into the overall reconstruction technique to enhance the quality of the imagery as it is required for decision support in environmental resource management with dynamic RSSS behavior.

Keywords: Environmental Remote Sensing, Dynamic Filtration, Resource Management, Decision Support, Regularization.

I. INTRODUCTION

Nonlinear reconstructive processing/enhancement of large-scale environmental imagery provided with modern multi-spectral array sensors/synthesized array sensors/radar (SAR) are extremely computation and time consuming. The crucial aspects here are problem-level and system-level model uncertainties that complicate severely the implementation of any adaptive nonlinear large-scale image enhancement techniques based on descriptive or statistical regularization paradigms [1] - [4]. The aggregated regularization inference-based treatment of the problem was initially undertaken in [3] and developed in recent papers [7], [8] in the scope of the inverse problem methodology for coherent SAR image restoration. Some recent publications in this field use the maximum entropy (ME) approach but again in a context of descriptive regularization that simply alleviates the ill-posed nature of the corresponding scattering pattern estimation or image restoration inverse problems [5].

The key distinguishing feature of the new paradigm considered in the present study is that the inverse problem of estimating the particular remote sensing scene signatures (RSS) from the available measurements of random realizations of the data field is stated and treated in the framework of the robust regularization strategy aggregated with the dynamic filtration. We address a new efficient robust optimization approach to large-scale environmental RSS reconstruction/enhancement as required for remote sensing imaging with multi-spectral array sensors/SAR. First, the problem-oriented robustification of the previously proposed descriptive regularization (DR) enhanced imaging method is performed to alleviate its ill-poseness due to system-level and model-level uncertainties. Second, we incorporate the dynamic filtration paradigm into the overall reconstruction technique to enhance the quality of the imagery as it is required for decision support in environmental resource management with dynamic RSS behavior. The new proposed method is addressed to as the dynamical aggregated robust regularization (DARR) technique. Finally, we report and discuss some simulation results of enhancement of the real-world 1024-by-1024-pixel format 256-scaled environmental RSS indicative of the efficiency of the developed DARR method. In the simulations, the advantage of the RSS reconstruction using the derived DARR-optimal and suboptimal estimators over the case of the conventional matched spatial processing technique [6] based on the use of the matched spatial filtering method is evident. The resolution is substantially improved; regions of interest and distributed object boundaries are much better defined, while ringing effects usually observed with filters based on inverse operations are substantially reduced.

II. PROBLEM PHENOMENOLOGY

According to the mathematical statement [1], [2], [4] to perform the image enhancement via processing the remote sensing data employing the descriptive regularization (DR) approach one have to solve the optimization problem

$$\hat{\mathbf{v}} = \underset{\mathbf{v}}{\operatorname{argmin}}\, E(\mathrm{v}|\lambda) = \underset{\mathbf{v}}{\operatorname{argmin}}\, \{(1/2)\,\lambda_1 J_1(\mathrm{v}) + (1/2)\lambda_2 J_2(\mathrm{v})\} \qquad (1)$$

of minimizing the cost (energy) function $E(\mathrm{v}|\lambda)$ with respect to the desired K-D image vector v for the assigned (or adjusted) values of the regularization parameters $\lambda = (\lambda_1, \lambda_2)^{\mathrm{T}}$. The proper selection of λ is associated with parametrical optimization of the DR process. In (1), $J_1(\mathrm{v}) = \|\mathrm{u} - \mathrm{F}\mathrm{v}\|^2$ represents the error function for corresponding sensing system, and $J_2(\mathrm{v})$ represents the conventional Tikhonov's stabilizer [5].

The data acquisition model is defined, as in [7], by the equation, $\mathrm{u} = \mathrm{F}\mathrm{v} + \mathrm{n}$ where F defines the corresponding system's degradation operator usually referred to as the imaging system point spread functions (PSF) and n represents the noise in the actually acquired image, respectively.

Next, the particular RSS is formed applying corresponding nonlinear signature extraction operator Φ to the enhanced image $\hat{\mathbf{v}}$, i.e.

$$\ddot{\mathbf{E}} = \Phi(\hat{\mathbf{v}}). \qquad (2)$$

Note, that in our particular study of the hydrological RSS, the Φ is specified as corresponding weighted order statistics (WOS) computing operator [1].

It is important to mention that the DR solutions for $\hat{\mathbf{v}}$ and $\ddot{\mathbf{E}}$ exist and are guaranteed to be unique for a given λ because the surfaces of all functions that compose $E(\mathrm{v}|\lambda)$ given by (1) are convex. But one can deduce that in the case of incorporating any additional dynamic information on the evolution of the RSS $\ddot{\mathbf{E}}$ in time, the non-linearity of the aggregated optimization problem (1), (2) will require extremely complex computations and will result in the technically intractable scheme if solve this problem employing the standard direct minimization techniques [1], [3]. For this reason, we propose here to apply the iterative computing paradigm for implementing the proposed DARR method.

III. DYNAMIC RSS RECONSTRUCTION WITH DARR METHOD

The crucial issue in application of the modern dynamic filter theory [1] to the problem of reconstruction of the desired RRS in current time is related to modeling of the RSS as a random field (i.e. spatial map developing in discrete time i) that satisfies the dynamical difference state equation [1]

$$\begin{aligned}\mathbf{z}(i+1) &= \ddot{\mathbf{O}}(i)\mathbf{z}(i) + \tilde{\mathbf{A}}(i)\mathbf{x}(i)\\ \ddot{\mathbf{E}}(i) &= \mathbf{C}(i)\mathbf{z}(i)\end{aligned} \tag{3}$$

specified by the linear dynamic model formation operators (matrices) $\ddot{\mathbf{O}}(i)$, $\tilde{\mathbf{A}}(i)$ and $\mathbf{C}(i)$, respectively. The dynamical estimation strategy for such optimal RSS prediction procedure can now be defined as follows [1]

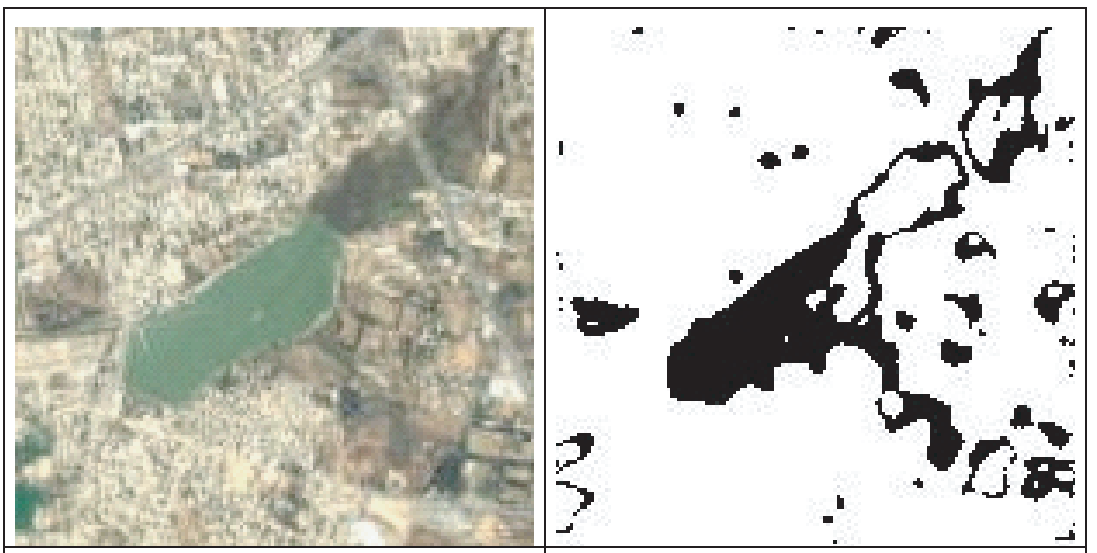
$$\begin{aligned}\hat{\mathbf{z}}(i+1) &= \left\langle \mathbf{z}(i+1) \middle| \hat{\mathbf{z}}(i),\ \hat{\mathbf{v}}(i+1) \right\rangle;\\ \ddot{\mathbf{E}}(i) &= \mathbf{C}(i)\mathbf{z}(i)\end{aligned} \tag{4}$$

Routinely solving the dynamical RSS filtration problem (4) for the current $(i+1)$-st discrete-time prediction-estimation step, we obtain the desired DARR technique

$$\begin{aligned}\hat{\mathbf{z}}(i+1) &= \mathbf{m}_{\mathbf{z}}(i+1) + \acute{\mathbf{O}}(i+1)\left[\hat{\mathbf{v}}(i+1) - \mathbf{H}(i+1)\mathbf{m}_{\mathbf{z}}(i+1)\right];\\ \ddot{\mathbf{E}}(i) &= \mathbf{C}(i)\mathbf{z}(i)\end{aligned} \tag{5}$$

where $\mathbf{m}_{\mathbf{z}}(i+1)$ represents the predicted mean vector and the optimal dynamic filter operator $\acute{\mathbf{O}}(i+1)$ is defined as follows,

Figure 1. Simulation results of hydrologic electronic map (HEM) extraction from the original super-high-resolution image reconstructed with the proposed DARR method.



(a) – Original super-high-resolution image.

(b) – HEM-W extracted from the original scene image reconstructed with the proposed DARR method.

(c) – HEM-WH extracted from the original scene image reconstructed with the proposed DARR method.

(d) – HEM-WHD extracted from the original scene image reconstructed with the proposed DARR method.

$$\begin{aligned}
&\acute{O}(i+1) = \mathbf{K}_{\acute{o}}(i+1)\mathbf{H}^{T}(i+1)\mathbf{P}_{i}^{-1}(i+1)\ ;\\
&\mathbf{K}_{\acute{o}}(i+1) = \left[\emptyset_{\acute{o}}(i+1) + \mathbf{P}_{z}^{-1}(i+1)\right]^{-1}\ ;\\
&\emptyset_{\acute{o}}(i+1) = \mathbf{H}^{T}(i+1)\mathbf{P}_{i}^{-1}(i+1)\mathbf{H}(i+1)\ .
\end{aligned} \tag{6}$$

Last, using the derived filter equations (4), (5), we finally obtain the DARR optimal filtering procedure for dynamic reconstruction of the desired RSS map in the current discrete time $i = 0, 1, \ldots$

$$\ddot{E}(i+1) = \ddot{O}(i)\hat{z}(i) + \acute{O}(i+1)\left[\hat{v}(i+1) - \mathbf{H}(i+1)\ddot{O}(i)\hat{z}(i)\right];\ i = 0, 1, \ldots \tag{7}$$

with the initial condition, $\ddot{E}(0) = \Lambda\{\beta(0)\}$. The crucial issue to note here is related to model uncertainties regarding the particular employed dynamical RSS model (2), hence the corresponding uncertainties regarding the overall dynamically reconstructed RSS (7). These issues require more investigations and are the matter of further studies.

V. SIMULATION EXPERIMENT AND DISCUSSION

The results of the simulation experiment are summarized in Figure 1. The Figure 1.a shows the original super-high-resolution image, displaying the dam named "Las Pintas" in the Metropolitan area of Guadalajara in Mexico.

In Figure 1.b, 1.c and 1.d we present the simulation results of dynamic reconstruction-filtration of a particular RSS that represents the so-called *Hydrologic Electronic Map* (**HEM**) extracted from the reconstructed images $\{\hat{v}\}$. The HEMs are specified as follows:

1. **HEM-W** (Water content) map that represents the water content zones extracted from the original super-high-resolution image reconstructed with the proposed DARR method. The watered zones are shown in black. All white regions represent non-classified zones.
2. **HEM-WH** (Water and humidity content) map that represents the water content zones (black regions) and the humidity content zones (gray region) extracted from the original super-high-resolution image reconstructed with the proposed DARR method. All white regions represent non-classified zones.
3. **HEM-WHD** (Water, humidity and dry content) map that represents the water content (black region), the humidity content zones (gray region) and the dry content zones (gray region) extracted from the original super-high-resolution image reconstructed with the proposed DARR method. All white regions represent non-classified zones.

The purpose of this research was to investigate the possibility to perform the dynamic RSS filtering in the realistic conditions of minimum prior model knowledge regarding the dynamical behavior of the particular RSS. The dynamic HEM information was used iteratively applying the DARR algorithm (5), (6), (7).

The reported results qualitatively demonstrate that with proper adjustment of the degrees of freedom in the general DARR algorithm (5), (6), (7), it is possible to predict the dynamic behaviour of the HEMs. The detailed investigation of application of the developed DARR method to resource management is the matter of the perspective studies.

V. CONCLUDING REMARKS

In this paper, we have presented the dynamical aggregated robust regularization (DARR) approach for solving the nonlinear inverse problems of high-resolution dynamical reconstruction of the SSP and RSS of the remotely sensed scenes via processing the finite-dimensional space-time measurements of the available sensor system signals as it is required, for example, for enhanced RS imaging/scene mapping with imaging radar/SAR. We have developed the dynamical RSS post-processing scheme that reveals some possible approach toward a new dynamic computational paradigm for high-resolution fused numerical reconstruction and filtration of different RSS maps in current time. In future work, we intend to develop a family of such dynamical versions of the DARR-based algorithms for updating the relevant RSS maps in current discrete time.

REFERENCES

[1] H.H. Barret and K.J. Myers, *Foundations of Image Science*, New York: Willey, 2004.

[2] R.N. McDonough, *Nonlinear Methods of Spectral Analysis*, S. Haykin, 1984.

[3] E. Dadgeon and R.M. Mersereau, *Multidimensional Digital Signal Processing*, N.J.: Prentice Hall Inc., 1984.

[4] J. Munier, and G.L. Delisle, "Spatial analysis in passive listening using adaptive techniques", in *Proc. IEEE*, 1987, vol. 75.

[5] D. Ingman and Y. Merlis, "Maximum entropy signal reconstruction with neural networks", *IEEE Trans. Neural Networks*, vol. 3, pp. 195-201, 1992.

[6] Raney R.K., *Principles and Applications of Imaging Radar, Manual of Remote Sensing,* New York: John Wiley & Sons, 1998.

[7] Y. V. Shkvarko, "Unifying regularization and Bayesian estimation methods for enhanced imaging with remotely sensed data Part I: Theory", *IEEE Trans. on Geoscience and Remote Sensing*, pp. 923-931, 2004.

[8] Y. V. Shkvarko, "Unifying regularization and Bayesian estimation methods for enhanced imaging with remotely sensed data Part II: Implementation and performance issues", *IEEE Trans. on Geoscience and Remote Sensing*, pp. 932-940, 2004.

Ensuring Equal Access to Technology: Challenges of Providing Assistive Technology Service for Individuals with Disabilities

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With the passages of landmark laws such as the Americans with Disabilities Act (ADA) and the Individuals with Disabilities Act (IDEA), equal access to technology for all individuals regardless of their abilities or disabilities has been getting increasing attention in the field of education and rehabilitation. The Technology-Related Assistance for Individuals with Disabilities Act (Tech Act, 1988), and the Public Law 105-17 the IDEA amendments of 1997, define assistive technology (AT) device as any item, piece of equipment, or product system that is used to increase, maintain, or improve the functional capabilities of a child with a disability (IDEA 1997). AT devices are typically categorized as no technology, low technology, medium technology, or high technology depending on the existence and level of sophistication in the included electronic components. An AT item can be as low-tech as the Dycem mat, which is a non-slippery material used to prevent objects from tipping or slipping, or as high-tech as the Pathfinder which is a highly sophisticated communication device. AT devices can also be classified into a number of categories based on how they assist individuals in meeting the tasks that are demanded by different environmental settings (i.e., computer access aids, communication aids, daily living aids, education and learning aids).

Considering a continuum of assistive technology items and services for individuals with disabilities is a recommended practice in the field of rehabilitation and education. However, due to the vagueness of the current laws and lack of clear guidelines on how the service should be provided, service providers at education and rehabilitation agencies are faced with challenges of developing effective AT service delivery system on their own. While funds for AT has been decreased, it is still the intent of the laws that school professionals consider AT as an option for students with disabilities. Once professionals identify the needs for the use of any AT item on the Individualized Education Plan (IEP), they must provide the item at no cost to parents (IDEA 1997). School and rehabilitation professionals are faced with additional challenges of evaluating the technological needs of individuals with disabilities and identifying the appropriate AT items that will increase their functional capabilities in the settings of home, school, and community. In other words, AT items can function as an equalizer that will enhance the independence and freedom of individuals with disabilities.

Given the fact that rehabilitation and education agencies attempt to fulfill the intent of the laws regardless of these challenges, the purpose of this case study is to examine how a number of rehabilitation and education agencies provide assistive technology services to individuals with disabilities. An instrumental case study method (Stake, 1995) will be used to examine how AT service delivery system is developed and functions. Case study research method is widely used to investigate a phenomenon in its real-life context (Yin, 1984). Using a purposive sampling method, five to ten agencies in a Midwestern metropolitan city have been identified for the case study. These agencies provide AT services for individuals with disabilities between the ages of birth to 21. A professional who is responsible for coordinating AT service at each agency will be contacted. Data sources include interviews, site visit, and document review. A face to face interview will be conducted using a semi-structured questionnaire that contains items including the population served, funding sources, staffing pattern, evaluation procedure, purchase/lease procedures, technology training, inventory, device/equipment lending policy, and challenges and barriers to providing effective assistive technology services. In addition, documents such as evaluation models and AT inventory will be collected with the consent of each agency. Data will be analyzed using both quantitative and qualitative methods. Findings from this study will shed lights on the development of effective AT teams by education and rehabilitation agencies where the administrators are either in the process of or at the planning stage of developing AT service team. In addition, it is expected that the findings from this study will enable researchers to develop a structured survey for a larger scale research to examine the factors that are associated with effective AT service delivery and utilization.

REFERENCES

Individuals with Disabilities Education Act Amendments of 1997, 20 C.F.R. § 1400 et seq. (1997).

Stake, R.E. (1995). *The art of case study research*. Thousand Oaks, CA:Sage Publishing.

Technology-Related Assistance for Individuals with Disabilities Act (Tech Act), P.L., 100-407 (1988).

Yin, R. (1994). *Case study research: Design and methods* (2nd ed.). Thousand Oaks, CA: Sage Publishing.

MIS Shaped by Business Process Models

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Many of today's dominant global businesses have achieved their successes by being better integrated, better coordinated, better focused than their competitors. Many of their leaders attribute these characteristics to a process orientation; top management explicitly designed an organizational structure reliant upon integrated processes to coordinate the efforts of the organization. That coordination and that process structure are built upon and reliant upon software process models.

Business colleges can ill afford to ignore this growing phenomenon. The integrated business structures and practices should be reflected in an integrated, process focused curriculum. This paper will attempt to justify the business process focus and will then propose a model curriculum based on that process focus.

THE PROCESS FOCUS

During the last decade, management emphasis was directed to adding value (Boulton, Libert, Samek, 2000). Bolstering that emphasis was the relatively recent definition of a business model which included a value proposition, the market segment, the value chain structure, revenue generation, and the position in the value network. This business model, in other words, included a larger process view of business. It forced managers to consider the importance of their relationships with partners, to think about how best to coordinate the whole supply chain process to maximize adding value.

The e-business phenomenon also created an emphasis on business process and on process models. The ideal e-business ventured on being completely automated, e.g., Ditech.com, PriceQuote.com. Web-linked businesses are commonplace; they are now categorized as Business to Business, business to consumer, portals, auction sites, etc. Business authors clearly noted and commented about automated business processes in which : "the systems…don't just track the process, they contain and perform it" (Treacy & Wiersma, 1995). The re-engineering craze brought further notoriety to the process approach—although, in the end, re-engineering quickly faded from the management scene.

The supply chain management process has achieved such prominence that, by itself, it is largely the justification for a process focus. Thanks to publicity from organizations such as AMR research, the benefits of that approach can to be noticed and widely adopted. AMR research annually publishes a list of the "Top 25" businesses using supply chain management software; the criterion for making the list is market performance for that year. For 2005, the top five were Dell, Proctor and Gamble, IBM, Nokia, and Toyota. The list is impressive. Here are some of the reasons why businesses feel it imperative to adopt supply chain management, a process approach to their business:

- The top 10 percent of SCM performers in any industry use half the working capital per unit of sales than their median competitors (Source: University of Maryland Supply Chain Management Center)
- The fraction of U.S. GDP tied up in inventory and SCM costs has dropped by 40 percent (The Economist). The amount tied up in distribution and transportation has halved, from 19% to 9% of GDP.
- "Supply chain excellence" companies use 15% less inventory, have 35% shorter cash-to-cash cycle times and 60% higher margins than the average large firm (AMR Research).

What is distinctive about some of the best businesses in the world is how well coordinated they are. Dell, for example, has excellent synchronization of it supply chain, resulting in the fastest possible inventory turns. Wal-Mart, too, has a tightly integrated supply chain/demand chain that extends from customers back to a multitude of suppliers. Southwest airlines, competing in a horribly unprofitable industry, makes money by its standardization of operations and its highly choreographed processes. All three use information technology to coordinate their operations, culture, and knowledge base; all three are designed to focus every employee on the big coordinative strategy delivery. Finally, Peter Keen emphasizes that all three "have an explicit enterprise coordination design, owned by top management" (Keen, 2004).

AMR is quick to point out, these are more than supply chain models, they are "Demand Driven Supply Networks" (DDSN).(Caruso, Cecere, & O'Marah, 2006) The business process is embedded in the process model software; the model is a network which links the complete flow, from suppliers to customers. "The demand signal, " i.e, customers' demand for new features or products, is monitored with dashboards, scorecards, alerts and reports which are shared with all partners. With these process models companies can influence and shape demand, not just respond to it. Product innovations are based on a deep understanding of the customers; feedback from customers—AMR terms the software a "supply network" to indicate the partners' collaborative efforts to seize market opportunity (Caruso, Cecere, & O'Marah, 2006).

PROCESS MODELS

According to Peter Keen. "A business process is an organizational routine with clearly identified tasks and responsibilities that is: recurrent, replicable, consequential, leveragable, and well coordinated" (Keen, 2004). A process model is a representation of that entire process with its suppliers, producers, distributors, partners, and customers clearly displayed, and with outcomes and costs measured at each step in the workflow. Process models which feature dashboards measuring performance, graphic displays of performance trends are a great help to the process teams and to supporting managers.

The better models include visual displays of parts or all of the model; the lesser models rely on metrics only.

There is a growing body of practitioners, software vendors, and researchers who have created a business cognate area called Business Process Management (BPM). Here is the definition posted at Wikipedia.com:

Business Process Management *(or* **BPM***) refers to activities performed by businesses to improve their processes. While such improvements are hardly new, software tools called business process management systems have made such activities faster and cheaper. BPM systems monitor the execution of the business processes so that managers can analyze and change processes in response to data, rather than just a hunch. BPM differs from business process reengineering, a technique popular in the 1990s, in that it deals not just with one-off changes to the organization, but long-term consequences.*

Note the emphasis that BPM places upon the BPM software which enables the process-focused business. To fill out this coverage of process modeling, here is a description of a leading BPM vendor's software suite. Note that Savvion's software does much more than build process models; it integrates other software, integrates the process workflows, monitors them, controls the process, and provides a platform for improving the process.

A comprehensive Business Process Management platform provides an organization with the ability to collectively define their business processes, deploy those processes as applications accessible via the Web that are integrated with their existing software systems, and then provide managers with the visibility to monitor, analyze, control and improve the execution of those processes in real time. (Savvion's Web Site)

Process Models have become very sophisticated. Software vendors, such as IBM and Savvion, sell process model software that does much more than mirror the process. The best supply chain software models not only monitors the flow of activities, the software "executes" or runs the process, meaning by that the process model orders the supplies (and pays the vendors), schedules production, arranges distribution or shipping, and verifies delivery at the retail outlets. That ability to run the process has been extended to the capability to simulate improvements to the process model—and this is how process innovations can occur. Since both time and cost are measured at each step of the process, trading off resources for time savings can be simulated and decided upon.

Toyota is the most publicized example of a process-based business. Toyota's profits are greater than Ford, GM, and Chryslers' combined income over the previous five years (Liker, 2004). While Toyota's "Lean Manufacturing" is its best known process, it is one of many process models. Toyota is spending an estimated $1 billion to implement a massive information technology system that will model every aspect of the cars' designs, production sequences, just-in-time parts availability, and the distribution to the dealers. This shared process model platform is the foundation for the collaboration and coordination to which Toyota's managers attribute its success. Volkswagen's CIO tells us:" The vehicles and factories are all digital—all based on digital models." (Hoch & Laartz, 2006).

The automotive industry is fully committed to process modeling, indeed manufacturing as a whole has long understood itself as a process. Now most managers understand the message of supply chain management, i.e., that linking suppliers, partners, producers, and customers is the accepted way. But there are many tasks that can be turned into organizational routines and, as they are streamlined and standardized, they become processes. Here are examples: travel and expense reporting and processing, employee benefits management, procurement, any handling of forms or contracts. Defining and modeling these routines, then creating software applications can make them much less bureaucratic, much simpler and faster.

PROPOSING CURRICULA BASED ON A BUSINESS PROCESS APPROACH

Again, the major premise here is that the curriculum should reflect current business practice. And it has been shown that a business process approach is a distinctive competency of many, many excellent businesses. Colleges need to prepare their students for this evolving business context. What follows is a suggested MIS curriculum which could pilot the concept. The training in Web Services, Rules Engines, and Process Design are easily generalizable into many different careers. Should this MIS curriculum become accepted, it could lead to the fully integrated business college curriculum described below. The business accrediting agency, AACSB, has long urged colleges to integrate their functional departments and curricula into a coherent whole. Here is one way.

SAMPLE MIS MAJOR: ARCHITECTING AND DESIGNING A PROCESS-MODEL DRIVEN BUSINESS

1. Overview of business processes, process models, and vendors' suites
2. ERP: Web Services to deploy data from ERPs to new apps
3. Definitions and Design in a process model: XML, SOA, WSDL, Schema building, Ontology
4. Web Services (WSFL) to integrate workflows & design Process Models
5. Designing Processes & building Process Models using donated software
6. Creating Business Rules in a donated "Rules Engine"—Business Decision-making in context.
7. Adding Monitoring tools: metrics, dashboards, alerts
8. Seminar: Strategic directions in MIS enabled businesses

SUGGESTED BUSINESS COLLEGE CORE CURRICULUM

1. Conceptual Bases: Re-engineering, Business Process Management, Demand Driven Supply Networks, Management Innovation(Hamel & Keen), using studies of Toyota, Dell, e-businesses
   a. Strategic Management
   b. Operations Management
   c. Entrepreneurship
   d. Management of Innovations
2. Managing the transition from functional jobs to process teams
   a. Management
   b. Human Resource Management
3. Learning from the models: Building Metrics, dashboards, alerts.
   a. marketing research from the demand signal on price, shaping demand
   b. Accounting studies of trade-offs of cost vs resources, added value
4. The Process Model as a workbench for analyses and simulations
   a. Decision Sciences
   b. Marketing,
   c. Accounting
5. The Rules Engine shapes the process and gives the business its edge
   a. Management and business rules
   b. Decision Sciences
   c. Accounting

REFERENCES

Aronica, Ronald. *Reschooling the Corporation for Business Process Management*. Referenced January 5, 2007 at http://www.greystonegroup.com/Reschooling_the_Corporation_for_BPM.pdf

Burlton, Roger. (2001). *Business Process Management: Profiting From Process*. Indianapolis, Indiana: Sams Publishing.

Caruso, David, & Cecere, Lora, & O'Marah, Kevin. (2004). *Demand-Driven Supply Networks*. Retrieved December 30, 2006 from http://www.amrresearch.com/Content/View.asp?pmillid=17647.

Chesbrough, Henry, & and Rosenbloom, Richard S. (2004). The Role of the Business Model in Capturing Value from Innovation. *Industrial and Corporate Change*, 11 (3), pp529-555. Retrieved December 30, 2006, from icc.oxfordjournals.org/cgi/content/abstract/11/3/529

Collet, Stacy. (2006). *Hot Skills, Cold Skills: The IT worker of 2010 won't be a technology guru but rather a 'versatilist.* Retrieved January 6,.2007 from http://www.computerworld.com/action/article.do?command=viewArticleTOC&specialReportId=9000100&articleId=112360

Gardner, Robert A. (2004). The Process-Focused Organization. Milwaukee, Wisconsin: ASQ Quality Press.

Hamel, Gary. (2006, November). *Continuous Management Innovations*. Speech at the Fortune Innovation Forum, New York, NY.

Hamel, Gary. (2006). The Why, What, and How of Management Innovation. *Harvard Business Review*, *Feb. 1, 2006*, 1-5.

Hoch, Detlev, & Laartz, Jurgen. (2006). How IT can drive business process reorganization. *McKinsey Quarterly:The Online Journal of Mckinsey & Co*. Retrieved January 5, 2007 from http://www.mckinseyquarterly.com/article_page.aspx?ar=1846

Keen, Peter. (2004). *Business Process Management is not Workflow Automation*. Retrieved December 30, 2006 from http://www.peterkeen.com/recent/articles/index.htm.

Keen, Peter.. (2005). *Organizational Transformation Through Business Models*. Retrieved December 30, 2006 from http://www.peterkeen.com/recent/articles/index.htm.

Keen, Peter. (2004). *What exactly is a business process?* Retrieved December 30, 2006 from http://www.peterkeen.com/recent/articles/index.htm.

Liker, Jeffrey K. (2004). *The Toyota Way*. New York: McGraw Hill.

O'Marah, Kevin. (2006). *AMR Research Releases Second Annual Supply Chain Top 25*. Retrieved December 30, 2006 from http://www.amrresearch.com/Content/View.asp?pmillid=18895.

Treacy, Michael, & Wiersema, Fred. (1995). *The Discipline of Market Leaders*. New York: Addison-Wesley Publishing Company.

Smith, Howard, & Fingar, Peter. (2002). *Business Process Management: The Third Wave*. Tampa, Florida: Meghan-Kiffer Press.

Smith, H. (2006). *Process Innovation.* Retrieved December 30, 2006 from http://www.bptrends.com/publicationfiles/02%2D06%20COL%20Proc%20Innovation%20P%DTREZ%20Smith%2Epdf

International Research on Web Accessibility for Persons with Disabilities

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ABSTRACT

The current research establishes a global benchmark for web accessibility by evaluating 8557 higher education home pages and 6872 national government web pages for 181 United Nations member states. Results show that overall, web pages around the globe have room for improvement on all rated dimensions of accessibility. Fewer than half of the items assessed on any criterion received a "pass" rating. There is very little difference overall between education and government pages on accessibility. However, there are significance differences by country. Cluster analyses revealed a group of 39 countries whose web pages are significantly more accessible than others, and a subgroup of ten countries whose pages are especially more accessible. The correlation between web accessibility and demographic variables provides insights into the characteristics of the more accessible countries.

Keywords: Internet, International, Web, accessibility, accessible design

INTERNATIONAL RESEARCH ON WEB ACCESSIBILITY FOR PERSONS WITH DISABILITIES

Researchers undertaking disability-related studies across nations and cultures face fundamental challenges. First, there is no universal concept of disability. Although physical, sensory, cognitive, and psychological impairments occur universally, there are differences in how nations and cultures explain these impairments and respond to them (Ingstad & Whyte, 1995; Retish & Reiter, 1999; Iwakuma & Nussbaum, 2000). Some languages include labels for individual disabilities, but have no single term that encompasses all disabling conditions (Ingstad & Whyte, 1995). World Health Organization (WHO) has created a common cross-cultural classification system that attempts to address this problem by expressing disability in terms of body/impairment-related functions and the effect of social and environmental factors (WHO, 2001). WHO estimates that 10% of the world's population (approximately 600 million people) meets this definition (WHO, n.d. 1).

For cultures that have embraced or are beginning to embrace technologies such as the Internet, the ability of persons with disabilities to participate is significantly impacted by the accessibility of these technologies. Technology is made accessible in part by people with disabilities using assistive technologies—specialized tools that allow people with disabilities to perform functions that they otherwise would be unable to perform at all or without extreme difficulty. Assistive technologies related to computer access include screen-reader software for people who are blind or dyslexic and speech input systems for people who are unable to operate a mouse or keyboard. There are tens of thousands of assistive technologies available (ABLEDATA, n.d.), and those that process language (either as input or output) are available in dozens of languages and dialects. However, there are still significant gaps in availability of assistive technology for poorer nations and in smaller language markets. WHO estimates that only 5-15% of people who require assistive devices and technologies in low- and middle-income countries have access to them (WHO, n.d. 2).

A second requirement for technology accessibility concerns the actual design of the technology device or system. On the Web, visual images are inaccessible to blind users unless the images are encoded with alternate text, which is read by screen readers and Braille output devices; multimedia content is inaccessible to users with hearing impairments unless captioned; and features that require a mouse are inaccessible to users who are unable to use a mouse.

The problem of web accessibility becomes larger as the web itself becomes larger and plays a growing critical role in commerce, education, and the dissemination of information and services worldwide. The Computer Industry Almanac (2006) estimates that over one billion people worldwide use the Internet, expected to top two billion by 2011. At the start of the new century, approximately 50 percent of economic production in Organization for Economic Co-operation and Development (OECD) countries was generated by knowledge-based industries (United National Development Programme, 2001). The Internet also plays a key role in the inter-country transfer of beliefs, knowledge and experiences, including those related to disability (Mitchell, 1999).

The Internet has potential to provide enormous benefits to individuals with disabilities worldwide, allowing them to communicate, learn, work, and participate in society in ways that might otherwise be unavailable. However, it can also become a significant barrier. To address the problem, the World Wide Web Consortium (W3C), an international organization that develops interoperable specifications, guidelines, software, and tools for the web, has developed the Web Content Accessibility Guidelines (WCAG). Version 1.0 of the WCAG (W3C, 1999) provides definitive guidance on how to develop accessible websites, and is comprised of 14 guidelines, each of which is further explained using specific checkpoints. There are a total of 65 checkpoints, with each assigned a priority level of 1, 2, or 3, where Priority 1 checkpoints are the most critical for accessibility. The WCAG provides the basis for many policies, guidelines, and laws related to web accessibility worldwide. The W3C maintains a growing archive of national laws and policies, which as of January, 2007, includes 19 countries/regions (W3C, 2006).

The United Nations has worked for decades to promote accessibility, and has recently extended these efforts to include technology accessibility. On December 13, 2006, the United Nations General Assembly adopted a Convention on the Rights Of Persons With Disabilities (United Nations, 2006), which prohibits discrimination against persons with disabilities in all areas of life. Article 9 of the Convention specifically calls for State Parties to ensure that persons with disabilities have access to information and communications technologies and systems.

Despite the leadership of the United Nations, the availability of international web accessibility standards, and national laws and policies related to web accessibility, published studies have reported widespread inaccessibility of websites across a variety of societal sectors, including postsecondary education institutions in the United States (e.g., Jackson-Sanborn, Odess-Harnish, & Warren, 2002; Odess-Harnish, 2001; Opitz, Savenye, & Rowland, 2003; Walden, Rowland, & Bohman, 2000; Zaphiris & Ellis, 2001; Schmetzke, 2001, 2002a, 2002b, 2002c, 2004; Thompson, Burgstahler & Comden, 2003; Williamson, 2003; Hacket, Parmato, & Zeng, 2003), Australia (Alexander, 2004), the United Kingdom (Kelly, 2002; Witt & McDermott, 2004), and Ireland (McMullin, 2002); as well as government websites in Taiwan (Chen, Chen, & Shao, 2006) and the United States (Hacket, Parmato, & Zeng, 2004); and websites across all sectors in Cyprus (Zaphiris & Zaphiris, 2001).

The United Nations commissioned the first global report on web accessibility (Nomensa, 2006). The survey was "not intended to be exhaustive", and sought to obtain a "snapshot" of global web accessibility from a sample of 100 home pages across 20 countries. Only three of the pages in the sample met all Priority 1 WCAG 1.0 checkpoints, and 93% did not provide adequate text descriptions for graphical content, thereby creating barriers for people using screen reader software. The present study seeks to extend this effort with a more extensive global assessment of web accessibility, focusing specifically on higher education and national/federal government web pages worldwide and identify demographic predictors of web accessibility.

The following specific research questions are addressed in the present study:

1. Are there significant differences in the accessibility of web pages across countries?
2. Are there significant differences between higher education web pages and national/federal government web pages on accessibility?
3. Are there demographic predictors of web accessibility that might help us to understand why some nations are more inclined to address web accessibility than others?

METHOD

Selection of Countries and Web Sites

Countries included in this research represent the 192 member states of the United Nations (United Nations, 2006b). Home page Uniform Resource Locators (URLs) from 8557 universities within 162 of these countries were collected from the website Universities Worldwide (Förster, 2006). Additionally, 6872 national/federal government websites from 181 of these countries were collected from the website Worldwide Governments on the WWW (Anzinger, 2002). Of the 15,429 URLs collected, researchers were able to connect to 12,520 pages—7239 higher education pages (57.8%) and 5281 government pages (42.2%).

Selection of a Method for Evaluating Website Accessibility

Most web accessibility studies have used an automated web accessibility evaluation software tool. A few others (e.g., Thompson, Burgstahler, & Comden, 2003) have used a manual evaluation method for greater detail and accuracy. A manual method was not practical given the sample size in the present study, so researchers used the Functional Accessibility Evaluator (FAE), a tool developed by the University of Illinois at Urbana-Champaign (UIUC, n.d. 1). FAE evaluates web resources for markup that is consistent with Web Accessibility Best Practices identified by UIUC researchers (UIUC, n.d. 2). FAE focuses on functional requirements that improve access to all users, including people with disabilities, rather than limiting its scope to a set of technical accessibility standards. This approach helps to address issues of usability as well as accessibility.

Selection of Demographic Variables

The World Bank (2006) annually publishes 900 World Development Indicators (WDI). For the present research, a subset of 355 indicators was selected that included measures related to economics, health, education, and technology.

Hofstede (2001) has developed five independent dimensions of culture, and has scored 40 countries on each of these dimensions. The dimensions include a Power Distance Index (the degree to which less powerful members of society expect there to be differences in levels of power), Individualism vs. Collectivism, Masculinity vs. Femininity, Uncertainty Avoidance (the extent to which a society attempts to cope with anxiety by minimizing uncertainty), and Long vs. Short Term Orientation.

Procedures

Using FAE, each web page was automatically evaluated on 31 rules across the following five categories:

Navigation and Orientation: Inclusion of structural markup that facilitates navigation and contextual orientation, e.g., including an HTML title element, HTML headers, and appropriate accessible markup on forms and data tables

Text equivalents: Proper use of images for interoperability across web-enabled browsers, platforms, and devices; inclusion of text descriptions of non-text content for accessibility to non-visual users

Scripting: Avoidance of scripting techniques that compromise accessibility and interoperability

Styling: Use of cascading style sheets (CSS) to separate content and structural information from styling and presentation.

HTML standards: Conformance to the W3C HTML specification, to improve interoperability.

For each category, each web page received scores reflecting the percent of rules passed and percent of rules failed. FAE also outputs a third score, reflecting the percent of rules for which accessibility can not be programmatically determined, and therefore requires manual inspection. Since manual inspection was not practical for the present study, these values were not used in analysis.

RESULTS

Overall, web pages worldwide have room for improvement on all rated dimensions of accessibility (see Figure 1). Conformance to HTML Standards is the criterion that received the highest rating overall, but the average proportion of "pass" ratings on this criterion is slightly less than half of items evaluated. The criteria on which web pages rate most poorly are Navigation and Orientation (only about one-quarter of the items assessed on this criterion received a "pass" rating) and Scripting (nearly all of these items failed on accessibility).

A cluster analysis was conducted to explore which countries are more similar in their web accessibility ratings. The analysis produced two clusters, one with 39 members and another with 119 members. Figure 2 shows the average "pass"

Figure 1. Overall level of accessibility

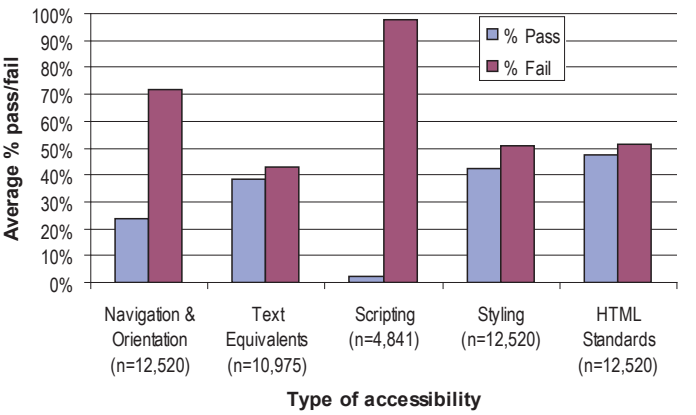

Figure 2. Average "pass" rate on each criterion by cluster group

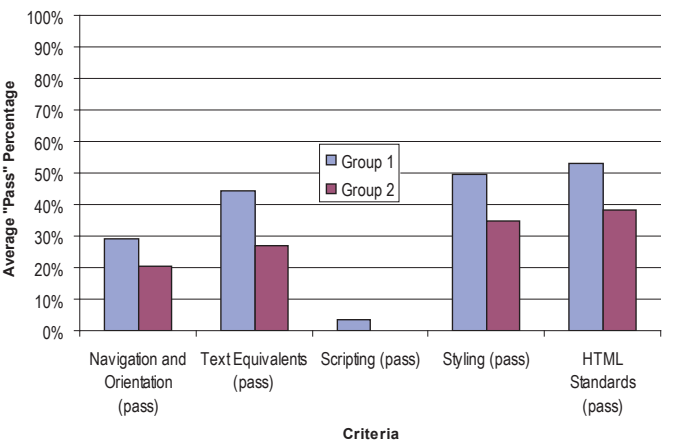

Table 1. Accessibility data for the "Top Ten" group of countries

					% Pass rating				
	# EDU pages	# GOV pages	Total pages	# with Scripting	Nav & Orientation	Text Equivalent	Scripting	Styling	HTML Standards
Australia	50	113	163	53	39%	64%	2%	59%	63%
Czech Republic	24	40	64	13	37%	60%	0%	61%	61%
Congo, Dem.Rep.	3	0	3	2	46%	67%	0%	55%	44%
Ireland	21	78	99	27	31%	51%	22%	48%	60%
Marshall Islands	0	1	1	1	75%	50%	0%	40%	66%
New Zealand	8	84	92	33	46%	62%	0%	53%	64%
Spain	74	70	144	33	34%	52%	8%	64%	59%
Sweden	32	122	154	36	41%	40%	3%	54%	68%
Switzerland	35	65	100	28	41%	44%	5%	54%	65%
United Kingdom	156	290	446	99	43%	64%	11%	57%	71%

rate of the countries in cluster groups 1 and 2 on the criteria used to classify the groups. The group of countries in the first cluster has a higher percentage of "pass" ratings on each of the accessibility measures. Detailed assessment results for each country, including cluster group membership, is available at http://staff.washington.edu/tft/research/international.html.

Additional analysis with country demographic information creates a profile of the countries that have greater accessibility. Group 1 countries, those with more accessible web pages, are countries with more money and with more investment in information and communication technology both publicly and in individual spending. More of the people in Group 1 countries have personal computers and more use the Internet. According to Hofstede's cultural ratings, Group 1 countries have Power Distance Index (PDI) ratings 29% lower than in Group 2, and ratings on Individualism vs. Collectivism (ICI) twice that of those in Group 2. A low PDI rating indicates a strong belief in equal rights held by all members of the society (Group 1 countries also have a higher percentage of women holding a seat in a national parliament). Group 1 countries also have a larger urban population (and a much smaller percentage of the labor force works in agriculture). These countries spend more money on health care and education, and their population lives longer and are more likely to complete school.

A second cluster analysis was performed on Group 1 countries, which further broke this group into two clusters based on web accessibility, revealing a "Top Ten" group of countries which received a higher percentage of "pass" ratings on all accessibility criteria except for scripting. Two of the countries in this group had very low numbers of web pages in the sample. However, the remaining eight countries are the accessibility leaders as measured by this study. Table 1 provides detail on the top ten countries' web accessibility ratings.

Analysis of the demographic factors used above to describe differences between Groups 1 and 2 did not reveal statistically significant differences between the Top Ten and other Group 1 countries in these characteristics. This could reflect the small number of countries included in the analysis, or it could mean that the factors that account for these differences are not embodied in or related to the items included in the analysis. Some factors that could be important but not represented here might include web accessibility initiatives promoted by the national government, or an active organization working to heighten awareness of the needs of people with disabilities, or school curricula that teaches students to consider varying perspectives and varying needs.

Comparison of Higher Education and Government Web Pages

Higher education and government web pages are similar in their accessibility. Government pages performed slightly better in Navigation and Orientation and education pages performed slightly better in HTML Standards. There is little difference in accessibility of Scripting. However, 43% of higher education web pages use scripting, as opposed to only 33% of government pages. This may imply that educational institutions are showing leadership in the adoption of scripting technologies, but without corresponding leadership in accessibility.

Correlations Between Accessibility and Country Demographics

Correlation analysis yields similar results to those attained in the above profile of the Group 1 cluster of countries. A higher "pass" rate across all web accessibility criteria (except in a few cases Scripting, which is suspect because of its poor distribution) is strongly and positively correlated with GDP per capita sales; number of bank branches per 1000 people; value of commercial service imports and exports; both expenditures and receipts on international tourism; per capita expenditure on information and communication technology; per capita health expenditure; female life expectancy; percent of population 65 and above; percent of urban population; use of electricity per capita; number of personal computers, secure Internet servers, and telephone mainlines per 1000 people; number of Internet users; number of mobile phone subscribers; price basket for residential fixed line; and Hofstede's Individual vs. Collective Index (high individualism is associated with greater accessibility). Correlation statistics on these variables range from $r=.29$ to $r=.69$ at $p<.001$. Hofstede's Power Distance Index was strongly negatively associated with web accessibility, which means that more hierarchical countries (less equality) tend to perform more poorly on accessibility (statistics range from $r=-.24$ to $r=-.59$).

Strong and positive correlations were found between secondary and tertiary school enrollment and accessibility. However, surprisingly, few other education demographics correlated significantly with web page accessibility.

DISCUSSION

The correlation findings in the present study suggest that two types of conditions may promote attention to accessibility. One is the level of media use, influenced by the type of commerce important to the country, such as those requiring international communication (tourism, commercial service imports and exports) or by the sheer prevalence of electronic devices among the people. These factors may be related to other correlates of web page accessibility, such as the country's wealth and investment in information and communication technology. The other type of condition these data suggest may promote attention to accessibility is a culture's and government's values regarding individual rights, and the social contract stipulating the relationship between the government and the people. These can be seen in the relationship between Hofstede's PDI and ICI indices and accessibility, as well as the relationship between public health care expenditures and accessibility.

The present study also identifies countries that may employ promising practices. Given the performance of the "Top Ten" countries relative to other countries, a deeper exploration of each of these countries is a logical next step, although even these countries' results show considerable room for improvement.

At least six of these countries (Australia, Ireland, New Zealand, Spain, Switzerland, and the United Kingdom) have laws and/or policies protecting the rights of individuals with disabilities and/or requiring accessibility of electronic communications (W3C, 2006). However, other countries have similar laws, yet did

not perform as well in the current assessment. Further research is required to gain a deeper understanding of the legal, political, social and cultural factors that contribute toward a nation's embracing web accessibility.

This study provides a starting point for understanding the global state of web accessibility. Hopefully a deeper understanding will stimulate dialog and international collaboration, as all nations work toward creating a World Wide Web that is accessible to everyone, including the estimated 600 million people who have disabilities.

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REFERENCES

ABLEDATA (n.d.). *What is ABLEDATA?* Retrieved January 7, 2007 from http://www.abledata.com/abledata.cfm?pageid=19332&ksectionid=19329

Alexander, D. (2004). How accessible are Australian university web sites? *Ariadne, 38*. Retrieved August 22, 2006, from http://www.ariadne.ac.uk/issue38/alexander/intro.html

Anzinger, G. (2002). *Worldwide Governments on the WWW*. Retrieved December 6, 2006 from http://www.gksoft.com/govt/en/world.html.

Chen, Y., Chen, Y, & Shao, M. (2006). 2005 accessibility diagnosis on the government web sites in Taiwan, R.O.C. *ACM International Conference Proceeding Series; 134*, 132-142. Retrieved October 3, 2006 from http://portal.acm.org/citation.cfm?id=1133219.1133243

Computer Industry Almanac (2006). *Worldwide Internet users top 1 billion in 2005*. Retrieved January 7, 2007 from http://www.c-i-a.com/pr0106.htm

Förster, K. (2006). *Universities worldwide*. Retrieved December 6, 2006 from http://univ.cc/

Hackett, S., & Parmato, B. (2005). A longitudinal evaluation of accessibility: Higher education web sites. *Internet Research, Volume 15*(3), 281-294. Retrieved October 2006 from http://www.emeraldinsight.com/Insight/ViewContentServlet?Filename=Published/EmeraldFullTextArticle/Articles/1720150303.html

Hackett, S., Parmato, B., & Zeng, X. (2004). Accessibility of Internet websites through time. *Proceedings of the 6th international ACM SIGACCESS conference on computers and accessibility,* Atlanta GA, No. 18-20, 32 - 39. Retrieved October 2006 from http://portal.acm.org/citation.cfm?id=1028630.1028638

Hofstede, G. (2001). *Culture's consequences, 2nd ed.* Newbury Park, CA: Sage.

Ingstad, B. & Whyte, S. (Eds.). (1995). *Disability and culture.* Berkeley: University of California Press.

Iwakuma, M., & Nussbaum, J. (2000). Intercultural views of people with disabilities in Asia and Africa., in *Handbook of Communication and People with Disabilities*. D. Braithwaite & T. Thompson (Eds.), pp 239 - 255. Mahwah, New Jersey: Lawrence Erlbaum Associates.

Nomensa (2006). *United Nations global audit of web accessibility*. Retrieved January 5, 2007 from http://www.nomensa.com/resources/research/united-nations-global-audit-of-accessibility.html

Jackson-Sanborn, E., Odess-Harnish, K., & Warren, N. (2002). Web site accessibility: A study of six genres. *Library Hi Tech*, *20*(3), 308-317.

Kelly, B. (2002). *An accessibility analysis of UK university entry points*. *Ariadne, 33*. Retrieved February 26, 2003, from http://www.ariadne.ac.uk/issue33/web-watch/

McMullin, B. (2002). *WARP: Web Accessibility Reporting Project Ireland 2002 Baseline Study*. Retrieved February 26, 2003, from http://eaccess.rince.ie/white-papers/2002/warp-2002-00/warp-2002-00.html

Mitchell, D. (1999). Transfer of beliefs, knowledge, and experiences between countries. In Retish, P. & Reiter, S. (Eds), *Adults with Disabilities: International Perspectives in the Community*. Mahwah, NJ: Lawrence Erlbaum Associates.

Opitz, C., Savenye, W., & Rowland, C. (2003). Accessibility of State Department of Education home pages and special education pages. *Journal of Special Education Technology, 18*(1), 17-27.

Reiter, S. (1999). Conclusion: Cross-Cultural Perspectives - Diversity and Universalism. In Retish, P. & Reiter, S. (eds), *Adults with Disabilities: International Perspectives in the Community*. Mahwah, NJ: Lawrence Erlbaum Associates.

Retish, P. & Reiter, S. (Eds). (1999). *Adults with disabilities: International perspectives in the community*. Mahwah, NJ: Lawrence Erlbaum Associates.

Schmetzke, A. (2001). *Accessibility of the homepages of the nation's community colleges*. Retrieved September 19, 2002 from http://library.uwsp.edu/aschmetz/Accessible/nationwide/CC_Survey2001/summary_CCC.htm

Schmetzke, A. (2002a). *Web accessibility survey home page*. Retrieved September 19, 2002, from http://library.uwsp.edu/aschmetz/Accessible/websurveys.htm

Schmetzke, A. (2002b). *Web page accessibility on University of Wisconsin campuses: 2002 survey data*. Retrieved September 19, 2002, from http://library.uwsp.edu/aschmetz/Accessible/UW Campuses/Survey2002/contents2002.htm

Schmetzke, A. (2002c). *Web site accessibility at 56 North American universities: 2002 survey data on libraries and library schools*. Retrieved September 19, 2002, from http://library.uwsp.edu/aschmetz/Accessible/nationwide/Survey2002/contents2002.htm

Schmetzke, A. (2004). *Web page accessibility on University of Wisconsin campuses: 2004 survey and six-year trend data*. Madison, WI: University of Wisconsin. Retrieved January 1, 2006, at http://library.uwsp.edu/aschmetz/Accessible/UW-Campuses/Sursvey2004/contents2004.htm

Thompson, T., Burgstahler, S., & Comden, D. (2003). Research on web accessibility in higher education. *Journal of Information Technology and Disabilities*, 9(2). Retrieved December 5, 2005 from http://www.rit.edu/%7Eeasi/itd/itdv09n2/thompson.htm

United Nations (2006). *Convention on the rights of persons with disabilities*. United Nations General Assembly. Sixty-first session, Item 67(b). Retrieved January 7, 2007 from http://www.un.org/esa/socdev/enable/rights/convtexte.htm

United Nations (2006b). *List of member states*. Retrieved December 6, 2006 from http://www.un.org/Overview/unmember.html

United National Development Programme (2001). *Human development report*. New York: Oxford University Press.

University of Illinois at Urbana-Champaign (UIUC). (n.d. 1). *Functional Accessibility Evaluator*. Retrieved January 7, 2007 from http://fae.cita.uiuc.edu

UIUC (n.d. 2). *Web accessibility best practices*. Retrieved January 7, 2007 from http://www.cita.uiuc.edu/html-best-practices/

Williamson, D. (2003). Web accessibility - Where do we currently stand? In P. Kommers & G. Richards (Eds.), *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2003* (pp. 3291-3295).

Witt, N. & McDermott, A. (2004). Web site accessibility: What logo will we use today? *British Journal of Educational Technology*. 35(1), 45-56.

World Bank (2006). *Development data & statistics: World development indicators*. Retrieved January 7, 2007 from http://www.worldbank.org/data

World Health Organization (WHO). (n.d. 1), *Concept paper: World report on disability and rehabilitation*. Retrieved January 7, 2007 from http://www.who.int/disabilities/publications/dar_world_report_concept_note.pdf.

WHO (n.d. 2). *Assistive devices/technologies*, Retrieved January 7, 2007 from http://www.who.int/disabilities/technology/en/index.html)

WHO (2001). *ICF: Introduction*. Retrieved January 7, 2007 from http://www3.who.int/icf/intros/ICF-Eng-Intro.pdf

World Wide Web Consortium (W3C). (1999). *Web content accessibility guidelines 1.0*. Retrieved May 16, 2003 from http://www.w3.org/TR/WCAG

W3C (2006). *Policies relating to web accessibility*. Retrieved January 7, 2007 from http://www.w3.org/WAI/Policy/

Zaphiris, P. & Ellis, R.D. (2001). Website usability and content accessibility of the top USA universities. *Proceedings of WebNet 2001*, Orlando, FL, USA.

Zaphiris, P. & Zacharia, G. (2001). Website content accessibility of 30,000 Cypriot web sites" In *Proceedings of the 8th Panhellenic Conference on Informatics*, November 8-10. Nicosia, Cyprus. Retrieved October 3, 2006 from http://scholar.google.com/url?sa=U&q=http://agrino.org/pzaphiri/Papers/accessibility-panhellenic_final.pdf

Antecedents of Online Trust and Acceptance of E-Commerce

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INTRODUCTION

The impact of computer technology has transformed business practices and creation of e-commerce, such as online retailers. However, consumers tend to be reluctant to provide personal information to Web sites because they are unsure if they can fully trust online merchants. Consumer tends to feel uncomfortable engaging in a transaction over the internet with unfamiliar vendors (Gefen and Straub 2002). Previous research has also found that 95% of the consumers have declined to provide personal information to websites because of the lack of trust on those collecting the data (Hoffman at al. 1999, p. 82). McKnight et al. (2002) assert that there is another perception of technology beyond the widely accepted technology acceptance model (TAM). Hence, the trust issue is rooted in security and privacy which has been labeled a key concern of e-commerce by consumers (Miyazaki and Fernadez, 2000). In this study, we build upon the research proposed by McKnight et al. (2002) on understanding the antecedents of trust. We explore factors such as consumers' perceptions of information security, privacy, trust, and their acceptance of e-commerce. Specifically, we are examining the effects of having a third party organization/web seal, and also privacy and security statements on the adoption behavior of electronic commerce.

THEORETICAL BACKGROUND

Trust, according to Pavlou (2001), in electronic transactions context is defined as the subjective probability that customers believe an organization's technology infrastructure and control mechanisms are capable of carrying out transactions that are meeting customers' expectations. Other researchers have included trust as an additional construct in TAM and their findings demonstrated the relationship between trust and adoption intention (McCloskey, 2006; Dahlberg, Mallat, & Oorni, 2003; Pavlou, 2003; Suh & Han, 2003; Keat & Mohan, 2004). McKnight et al. (2002) discusses various forms of trust issues e.g. initial trust, institutional-based trust, trust-related behaviors including trusting intentions and trusting beliefs. Trusting beliefs is defined as the confidence perception that a vendor has attributes that are beneficial to the consumer. These beliefs are competence, benevolence and integrity (Battacherjee 2002, Gefen 1997, Mayer et al. 1995). Trusting intention on the other hand, refers to the willingness to depend on the vendor. There is an element of "volitional preparedness" to make a consumer vulnerable to the vendor (McKnight et al. 2002).

The objective of e-commerce security is information assurance, which means to maintain confidentiality (privacy), integrity, and availability of information resources for authorized organizations and users (Warkentin, Davis, & Bekkering, 2004). Ensuring security and confidentiality are the fundamental prerequisites before any electronic transactions involving sensitive information can take place (Jayawardhena and Foley, 2000). Many researchers have discussed the element of e-commerce security control requirements (Hutchinson & Warren, 2003; Suh & Han, 2003; Kesh and Ramanujan, 2004). These security elements can be summarized in five categories. They are: authentication, non-repudiation, data integrity, confidentiality, and privacy protection.

Researchers have also found that stable situation-specific personal characteristics such as personal innovativeness in information technology (Agarwal and Prasad, 1998) and risk tolerance such as perceived risk (Lu, Hsu, and Hsu, 2005) influence how individuals perceive information technology. Agarwal and Prasad (1998) define personal innovativeness in the domain of information technology (PIIT) as the "willingness of an individual to try out any new information technology." (p.206). They argue that inclusion of personal innovativeness with respect to information technology acceptance model would help to further understand how perceptions are formed and the subsequent role they play in the formation of usage intentions.

Another personality characteristic, perceived risk has been described as comprising the subjective perception of two components: (1) the amount at stake and (2) the degree of certainty about possible negative consequences. Perceived risks can take many forms, depending on the product and consumer characteristics. Lu, Hsu, and Hsu (2005) incorporated perceived risk in their study about intention to use online applications and concluded that perceived risk plays the key factor in influencing the determinants of online applications adoption.

CONCEPTUAL DEVELOPMENT

Figure 1 shows the proposed research model. We are examining the effects of perceived security, the use of privacy and security statements and third part organization seal while controlling the effects of personal characteristics and organization characteristics on trusting beliefs. Then, we study how these trusting beliefs will affect consumers in engaging e-commerce transactions.

Third Party Organization/Web Seal

To address issues of privacy and trust related to on-line transactions, e-commerce assurance services were created in the 1990s (Wakefield & Whitten, 2006). Third party organizations such as Better Business Bureau®, TRUSTe®, and VeriSign ® are organized to promote trust in e-commerce. Studies found that third party web seal promotes consumers feelings of trust (Palmer, Bailey, & Faraj, 2000; Schneiderman, 2000; Wakefield & Whitten, 2006) and confidence in their e-commerce transactions. Thus, the following hypothesis is proposed:

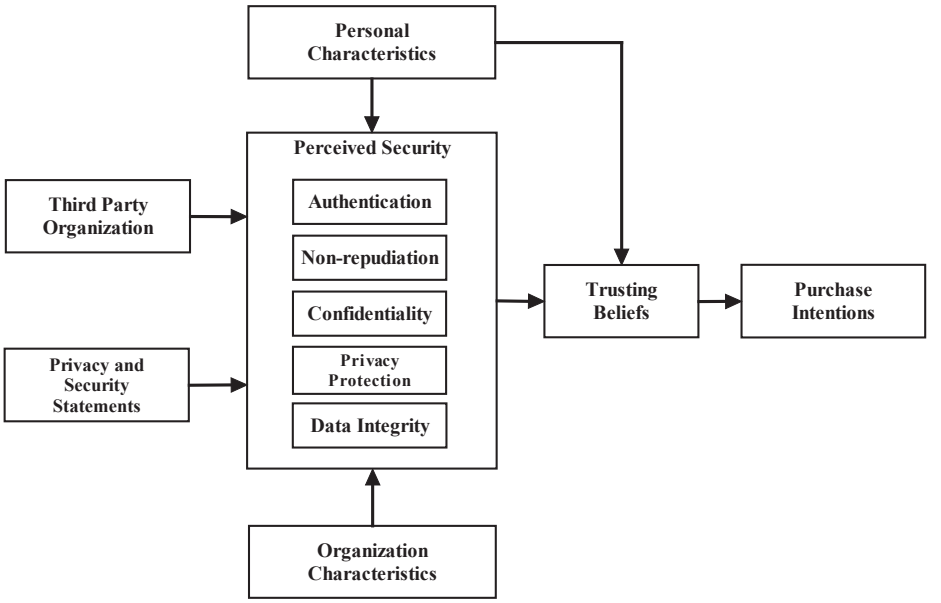
H1: The presence of third party web seal logo has a positive effect on consumers' trust in e-retailer.

Privacy and Security Statements

The ability to monitor and record Internet users' personal information has raised fears about online privacy. According to Federal Trade Commission (FTC) 2000 survey about online privacy, the survey result indicates that 97% of the random sample websites and 99% of the most popular websites collect an e-mail address or some other type of personal information (Federal Trade Commission, 2000). Companies have the ability to collect and follow users' every movement on the Internet by using "cookies" and advanced browser technology. Consumers are concerned about the type of information that is gathered and how this information is being used, and by whom.

Unlike the European countries, where there are laws governing and protecting consumers from being victims of privacy-violating businesses, the United States advocated self-regulation for the Internet. It suggested that businesses should develop and post clearly written policies that inform consumers about who is collecting their personal information and the intended purpose for the collected information. Businesses should also provide consumers with a readily available, simple, and affordable option for exercising their choices with respect to whether and how their personal information is used (Privacy in electronic communications, 1998). Thus, the following hypothesis is proposed for investigation:

Figure 1. Proposed research model



H2: Displaying a privacy and security link on an on-line retailer's home page has a positive effect on consumers' trust in e-retailer.

Perceived Security

Kesh et al. (2002) and Gupta et al. (2004) describe the need of authentication is to "ensure that the origin of an electronic message is correctly identified" (p. 150). The essence of authentication is to make sure the sender of the message or originator of the transaction is the person who he/she claims to be. Authentication reduces the risk of identity theft and fraudulent activities. Non-repudiation refers to the need to ensure that the customers can be certain that they are communicating with the genuine merchant, or vice versa, and each party involved in a transaction will not later falsely deny the transaction (Gupta et al., 2004; Hutchinson & Warren, 2003). Data integrity ensures that only authorized individuals can make changes to the documents transmitted over the network. Integrity ensures the content of the sent message or transaction is the same message or transaction when it is received. Information confidentiality refers to protecting customers' private and personal information to ensure the information is secured and hidden wherever the information is stored, as well as in transit through the Internet. Thus, the following hypotheses are proposed for investigation:

H3: Perceived strength of security has a positive effect on consumers' trust in e-retailer.

Methodology

Instrument Development

Data was collected using a self-administrated questionnaire. Each item presented a statement to which respondents were asked to weigh their level of agreement. All items were measured on a seven-point Likert scale. The measurement items used in this study were derived from validated scales found in previous extant literature, with modified wording to be specific to this study.

Measures for the sub-dimensions of perceived security (SECURITY) were taken from Suh and Han (2003) with modified wordings to adapt the items to the current topic. Measures for antecedents to perceived security were built upon relevant literature. Perceived reputation (PREP) and firm size (PSZE) were derived from Jarvenpaa and Tractinsky (1999). Third-party seal (PTP) and privacy statement perception (GPSS) were modified from Wakefield and Whitten (2006), the privacy statement availability (PPSS) was newly developed items. We differentiated the two based on perception of importance of privacy statement and the availability and presence of such statements. Computer self-efficacy (SEFF), or the confidence and capability of the respondent to use the Internet to make a purchase, was derived from Taylor and Todd (1995). Personal Internet innovativeness (PINN), or the level of respondents' enthusiastic trying out new information technologies and Internet features, was originated from Agarwal and Prasad (1998). Perceived risk (PRSK) was assessed with four items following Jarvenpaa, Tractinsky, and Vitale (1999). These items measured the respondents' perception of there being risk in participating in using online website to make purchase. The measures for trust (TRUST) were based on Pavlou and Gefen (2004). The measures for purchase intention (PINT) sub-dimensions were borrowed and modified from Schlosser, White and Lloyd's (2006) research about online purchase intention.

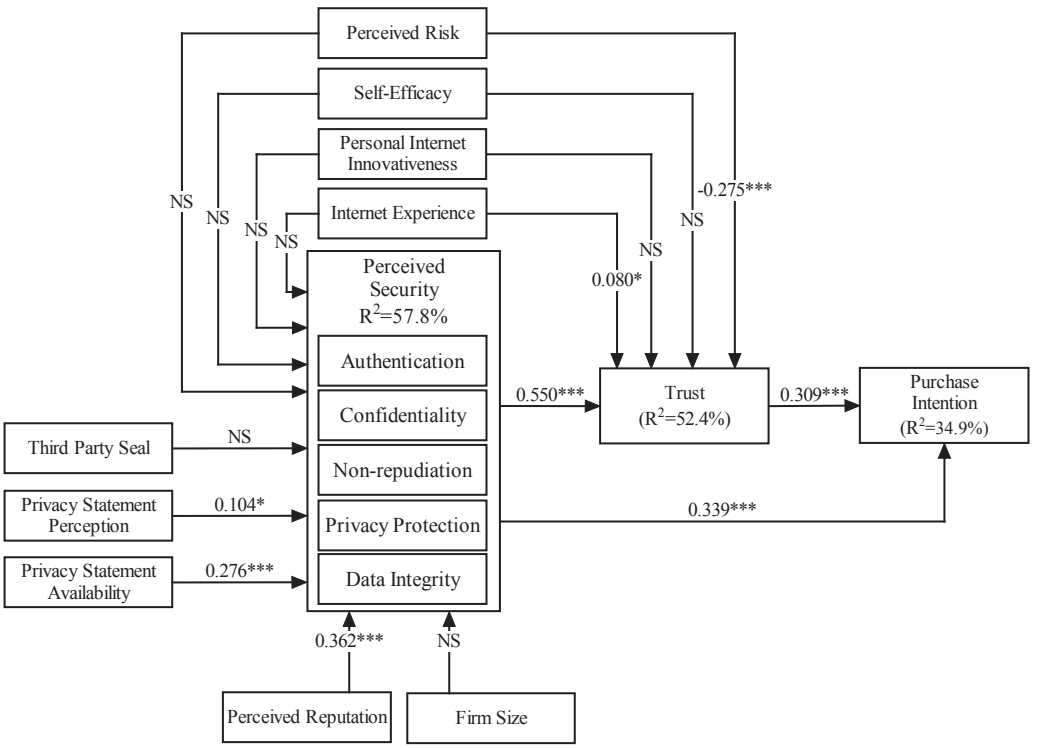
Data Collection

The pool of respondents came from a panel maintained by an online marketing research firm. Invitations were sent out to 4000 panel members. The survey first asked participants to enter the names of three online retailing websites from which they have made a purchase in the past. We randomly picked one entered website and asked participants to answer a series of questions about their impressions of that website. The survey was left open for 14 days. After removing incomplete surveys and surveys that were completed at impossible speed (< 5 minutes), 330 responses were deemed usable giving 8.25% effective response rate. One possible explanation for the low response rate was that there was no reminder e-mail send out to the panel members to remind them to complete the survey. Overall demographic profile of usable respondents: 56% are male with average income of $48,000.

DATA ANALYSIS

From the path model shown in Figure 2, we were able to show strong significance of the availability and presence privacy statements in the perception of security. McKnight et al. (2002) refers to this perception as institutional based trust. Moderate significance was found instead for the perceptions of the importance of these statements. This implies that even though consumers indicate that privacy statements were fairly important, their actions were otherwise, i.e. given the presence

Figure 2. Integrated results of path model



and easily available statements on privacy, it affected their security perception. Perceived reputation is found to be significant in affecting the respondents' perception of perceived security while the presence of third party seal did not influence in their perceptions. The combination of the reputation and third party seal lead us to believe that it is still very important for new websites to develop their reputation and simply putting "artifacts" such as third party seal will not increase the perception of security.

In examining the antecedents for TRUST (Trust in retail website), it is interesting to note that personal characteristics such as innovativeness and self efficacy do not affect TRUST while SECURITY was found to be strongly related to TRUST. In examining the antecedents of purchase intention (PINT), we found significance of both TRUST and SECURITY.

We were able to use Baron and Kenney (1986) method in examining mediating effects. We found that personal characteristics such as perceived risk and internet experience are both mediated by TRUST in purchase intention. Furthermore, we found that signals of privacy statements (GPSS, PPSS) are also mediated by SECURITY to TRUST.

CONCLUSIONS

Based on the data that we analyzed, our research improves on the model suggested by McKnight et al. (2002). We show the antecedents to the institutional based trust model represented by perceived security. We are also able to show the mediating effects of both perceived security and trust for personal characteristics and privacy signals in explaining purchase intention.

REFERENCES

References and working paper is available from terence.ow@marquette.edu

Table 1. Regression model for perceived security

Variables	Unstandardized Coefficients		Standardized Coefficients	t-stats	Significance	VIF
	B	Std. Error	Beta			
PTP	.261	.208	.059	1.251	.212	1.697
GPSS	.475	.220	.104	2.161	.031	1.772
PPSS	1.384	.251	.276	5.513	.000	1.906
PINN	.237	.220	.054	1.079	.282	1.907
SEFF	.266	.213	.060	1.248	.213	1.781
PRSK	-.224	.140	-.065	-1.606	.109	1.229
PREP	1.441	.225	.362	6.412	.000	2.416
PSZE	.278	.252	.056	1.106	.270	1.978
IEXP	-.307	.593	-.019	-.517	.605	1.068

E-Commerce and Health Care Web Site Quality: Comparing and Contrasting End-User Perspectives

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ABSTRACT

In this study, we explore and compare the importance of various quality dimensions for health care and e-commerce web sites and to identify drivers (e.g. features) of health care web sites that managers can use as levers to improve their web sites. The results show that the importance of various quality drivers for all except two of ten quality dimensions studied differ between health care and e-commerce web sites and that in general, the call for quality among the dimensions studies is higher in health care web sites. On-going work will identify feature and operational drivers associated with customer ratings of e-commerce and health care site quality ratings and illuminate difference in identified drivers between each type of web site.

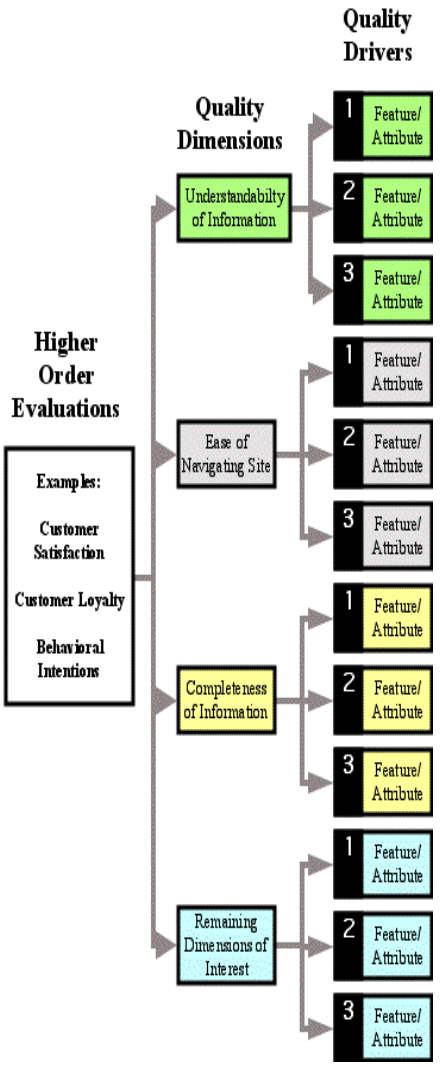
INTRODUCTION

Eysenbach and Kohler (2003) estimated that approximately 4.5% of all search queries submitted to Web search engines are health-related, which is equivalent to a global minimum of 6.75 million health-related searches on the Web every day. With medical professionals referring patients to health care web sites and health organizations initiating the development and management of these sites, some understanding of consumer perceptions of how consumers evaluate the overall quality of such sites is relevant and necessary. Web site designers are traditionally grown from technology fields, such as information systems and are often seasoned in e-commerce environments. Such developers may miss potential nuances in consumer quality perceptions in transporting their skills to new contexts.

Health care site sponsors and developers are increasingly challenged to ensure high quality and good design in their electronic services with tangible guidelines and processes. Research does not seem to provide needed guidance. Piccoli, et al. (Piccoli, et al., 2004 p. 423) lamented the "dearth of research-based insights and guidelines concerning the roles, functionalities, and effective design of Web sites". Zeithaml, Parasuraman, and Malhotra (2002) suggested future research in e-service quality should focus on "… investigat[ing] questions about the importance of different dimensions and perceptual attributes to overall electronic service quality and its consequences" and "… understand[ing] which dimensions are most responsible for driving electronic service quality". Though many researchers have studied how perceptions of individual quality dimensions (e.g., ease of navigation) relate to perceptions of higher order evaluations of overall web site quality (e.g., customer satisfaction), few have studied which features of a web site drive these common quality dimensions (see Figure 1).

Wolfinbarger and Gilly (2003 p. 21) recognize the need to consider site context when they state, "future research should investigate how characteristics of various product categories may affect the importance of the four factors [in their eTail Quality measure] in predicting quality." Research in marketing and information systems (IS) literature on web site quality (e.g. WebQual) does address consumer preferences, but has not typically included application to health care web sites. Existing studies of web site design and quality in the medical literature do focus on health care web sites, but rarely use end-consumers to investigate health care web site quality and often rely on the perceptions of seasoned medical professionals. In summary, current literature does not seem to provide insight on the perceptions of consumers in specifying health care web site quality and attempts to reconcile, bridge, and extend the two literatures is needed.

Figure 1. Web site quality hierarchical model



The overall goal of this study is to understand and improve the design and acceptance of health care web sites based upon consumer perceptions of quality. The study uses e-commerce web sites as a point of comparison. To address this goal, we attempt to (i) determine the priority of various quality dimensions of web site quality for e-commerce and health care web sites (ii) identify specific attributes (drivers) that affect e-service quality dimensions, thereby identifying potential levers for improving web site quality and (iii) examine significant differences between e-commerce and health care sites both in terms of quality dimension ratings and quality attributes identified for each quality dimension.

METHODOLOGY

This study employs quantitative and qualitative methods. Attributes of interest were determined through three group interviews (approximately ten students per interview) with upper division and graduate students in response to the question, "What quality dimensions a health care or e-commerce web site would lead to (visitor satisfaction/promoting desired behaviors by the site sponsors/ consumer site loyalty)." Interviewees were then asked to comment on potential attributes found in the literature that were not included in their responses. The final attribute list was a cross section of the attributes identified by all three groups (see Table 2).

A quality assessment exercise was developed with a focus on the attributes identified. 116 upper division and graduate students in colleges of business, allied health, and public health at two universities completed the exercise. Participants rated the general importance of the ten quality attributes for health care and e-commerce web sites on a low importance to high importance scale of 1 to 5 with 5 anchored as, "*This characteristic is very important to my assessment of this type of web site*". Participants then visited two web sites of each genre and rated the respective web sites according to the ten importance dimensions to provide a focus on context. After rating a quality dimension, participants answered the question, "What would cause you to rate an *e-commerce/health care* site with a high score of 5 for *name of quality dimension* (may be either something present or missing from the site)?

The research team used basic statistics (e.g., means and standard deviations to compare importance ratings of quality dimension) for each type of web site and ANOVA to compare ratings of importance criteria among the web site types. Qualitative open-ended coding procedures to identify drivers (e.g., specific features) that support the quality attributes under study for each type of web site through participant's open-ended commentary is underway. In addition, the team plans to use basic statistical procedures (i.e., means, percentages) to report responses within each group and overall responses evaluating each web site visited and for general insight.

RESULTS AND DISCUSSION

We first identify, compare, and contrast the importance of nine common quality dimensions consumers use to evaluate the quality of web sites applied to both health care and e-commerce sites. An assessment of consumer rankings of these attributes for each type of site is provided in Tables 1 and 2.

The most important dimensions noted for the health care web sites were content related, namely participants want complete, understandable, and relevant information with sufficient detail. On the e-commerce side, consumers seem to want complete and understandable information, but also look to ease of navigation and site reputation as key indicators of site quality. It is interesting that aesthetic aspects of the site (e.g., visual appeal) were among the lower scoring of our ten key attributes, though sensitivity to consumer feelings was more important for the health care site as demonstrated by the .80 statistically significant difference in mean scores.

The range of means across dimensions for health care web sites was generally higher than that of e-commerce web sites perhaps indicating that designers may have a greater call to quality for such sites. Ease of navigating the site and visual appeal of the site showed no significant differences between the genres. However, the mean importance scores for the health care sites were statistically higher than the e-commerce site for all other quality dimensions.

Qualitative analysis is in process. Early results indicate unique aspects of feature drivers for each type of site. For example, for completeness of information, links (to product information, other parts of the site, other items in the general category of goods) was frequently mentioned as a driver for e-commerce sites. In contrast, links were not mentioned as a quality attribute for completeness of information for health care sites. Instead, participants indicated they look for comprehensive, topical article that included information from many sources. Completeness was defined by one participant as, "all a person should know without going to a doctor" which may include the following content mentioned by participants: symptoms, procedures, diagnosis, prevention and treatment content.

In looking at the sensitivity to consumer feelings dimension, e-commerce site drivers included comments such as "geared to all levels of customers", whereas health care site comments indicated they should be "direct, simple to understand term, geared to nonprofessional visitor" and include message boards and live events. With respect to graphics, multiple comments for sensitivity in e-commerce sites indicated e-commerce designers should include pictures of "real members" of the target audience using products. Comments about health care site graphic content, with respect to sensitivity, indicated sites should show photos should represent a target audience, but also be "non-offensive, non-discriminating, non-personal, and non-judgmental." Our final results will further identify feature drivers associated with consumer ratings of e-commerce and health care site quality ratings.

Table 1. Importance ratings of e-commerce and health care quality dimensions in order of highest rating

E-Commerce	Mean	Std. Deviation	Health	Mean	Std. Deviation
Understandability of Information	4.57	±0.514	Completeness of Information	4.90	±0.295
Ease of navigating Site	4.50	±0.640	Understandability of Information	4.85	±0.380
Completeness of Information	4.37	±0.655	Relevancy of Information	4.59	±0.661
Site Reputation	4.04	±0.921	Level of Information Detail	4.51	±0.691
Relevancy of Information	4.03	±0.811	Reputation of Authority Sponsoring Site	4.35	±0.946
Reputation of Authority Sponsoring Site	3.87	±1.022	Ease of navigating Site	4.30	±0.700
Level of Information Detail	3.87	±0.770	Site Reputation	4.27	±0.744
Visual Appeal of Site	3.70	±0.944	Adequacy of References provided by Site	4.25	±0.771
Adequacy of References provided by Site	3.26	±1.085	Sensitivity to consumer feelings	3.97	±0.941
Sensitivity to consumer feelings	3.17	±1.084	Visual Appeal of Site	3.40	±1.019

Table 2. Comparison of importance ratings of e-commerce and health care quality dimensions

One-Way Anova Comparing Importance Ratings Between Health Care and E-commerce Sites	
Quality of Attributes	Sig
Completeness of Information	**0.000
Sensitivity to consumer feelings	**0.000
Adequacy of Reference provided by Site	**0.000
Relevancy of Information	**0.000
Understandability of Information	**0.000
Level of Information Detail	**0.000
Reputation of Authority Sponsoring Site	**0.000
Site Reputation	*0.046
Ease of Navigating Site	0.022
Visual Appeal of Site	0.024
***Significant at p<.01* ****Significant at p<.05*	

CONCLUSION

The overall goal of this study is to understand and improve the design and acceptance of health care web sites based upon consumer perceptions of quality. We provide guidance for the development and assessment of quality e-commerce and health care web sites by highlighting differences in the importance of key quality dimensions for each type of site showing. In fact, results show that there are statistically significant differences in mean score ratings of the importance of eight of the ten quality dimensions studied, with health care web sites having a higher call to quality for all dimensions except site reputation. In addition, on-going analysis of qualitative data indicates difference in the feature set (i.e., attribute) leading to these quality drivers.

Contributions from this study will help decision-makers design and evaluate health care (and e-commerce) web sites with a better understanding of the ultimate consumer and context. On-going work to expand this study will identify features (attributes) that drive each of these dimensions of interest in both health care and e-commerce contexts that can be used as levers to improve web site quality in both contexts to complete the theoretical model.

REFERENCES

Eysenbach G, K. "What is the prevalence of health-related searches on the World Wide Web? Qualitative and Quantitative Analysis of Search Engine Queries on the Internet," Washington D.C.), 2003,

Piccoli, G., Brohman, M.K., Watson, R. and Parasuraman, A. "Net-Based Customer Service Systems: Evolution and Revolution in Website Functionalities " *Decision Sciences Journal* (35:3), 2004, pp. 423-455.

Wolfinbarger, M. and Gilly, M.C. " eTailQ: Dimensionalizing, Measuring and Predicting etail Quality," *Journal of Retailing* (79), 2003, pp. 183-198.

Zeithaml, V.A., Parasuraman, A. and Malhotra, A. "Service Quality Delivery Through Web Sites: A Critical Review of Extant Knowledge " *Journal of the Academic of Marketing Science* (30:4), 2002, pp. 362-375.

Meta-Process Used for Production Process Modeling of a Software Factory: The Unitech Case

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ABSTRACT

This paper proposes the utilization software meta-process theory in a factory context. A case study verifying the adherence of the proposal to the factory in operation also is presented.

1. INTRODUCTION

Brazilian software industry has been constantly working for increasing its quality and productivity. This information can be verified by analyzing the incentive programs promoted by Science and Technology Ministry (MCT) in which Brazilian government established that software is a priority (Software, Semiconductors and Industry). One of these programs is the SOFTEX (Society for Promotion of the Excellency of Brazilian Software). The objectives of SOFTEX are: to place Brazil into the top 5 biggest world software exporters and producers and to reach international standard of quality and productivity in this sector.

Beyond of those programs, the Ministry develops, periodically, a research to verify quality and productivity attributes of Brazilian software development sector. In Brazil exists about eleven thousand companies with activities related to the development and commercialization of software, employing about 160.000 workers, 25% of these companies have a quality program defined, and other 26% feels the need to establish this kind of program. This fact shows that Brazil is conscious about the need of improving the quality of its products in IT sector, in this case, the software sector. (www.mct.gov.br/sepin - November, 2006).

Parallel to the these facts, COSTA (2003) presents a research involving the 31 most significant companies, which work at Brazilian market using the Software Factory model. From these, only 41% apply a software development complete cycle; 45% apply proper methodology; 16% use projects control tools; 14% possess CMMI certification; 13% use CASE tools and 10% apply quality metrics.

Based on the context presented above, it is possible to affirm that to reach the objectives traced by SOFTEX, it is necessary an effort of the UNIVERSITIES, COMPANIES and of the GOVERNMENT with the intention of becoming aware of the market about the existence of the quality and productivity models for the theme software factory.

So, the objective of this paper is to propose a meta-process for the production of a software process. The meta-process will be used in the modeling of the process of UNITECH[1] Software Factory.

2. THEORY ABOUT META-PROCESS

Sommerville (2003) defines that a software process has activities, methods, practices and transformations set which, partially, reach a determined objective.

Reis (2002) indicates that the meta-process provides the development of executable processes for the software production.

Feiler and Humphrey (1993) propose a group of activities to configure the basic structure of a meta-process:

- Analysis of process requirements: social and technological aspects of a certain environment configure the process requirements.
- Process modeling: results in a process abstract model that should be materialized by a process modeling language (PML).
- Instantiation: in that meta-activity the process engine is configured. That engine should act, directly, into the software process and it has the following functions:
  - to support and to monitor the cooperative development of the stakeholders in the process;
  - to register data generated during the execution process;
  - to guarantee the composition of the defined activities in the process;
  - to manage the versions of the information generated by the process;
  - to collect, automatically, the metrics generated with the process execution;
  - to make possible the process changing during its execution and;
  - to manage the resources allocation inside the process.
- Simulation: allows to foresee the problem and to esteem the process duration when it is under production. If problems are detected in that activity, the process planner should return to the previous phases so that fittings can be done.
- Execution: a real project is executed with the process created.

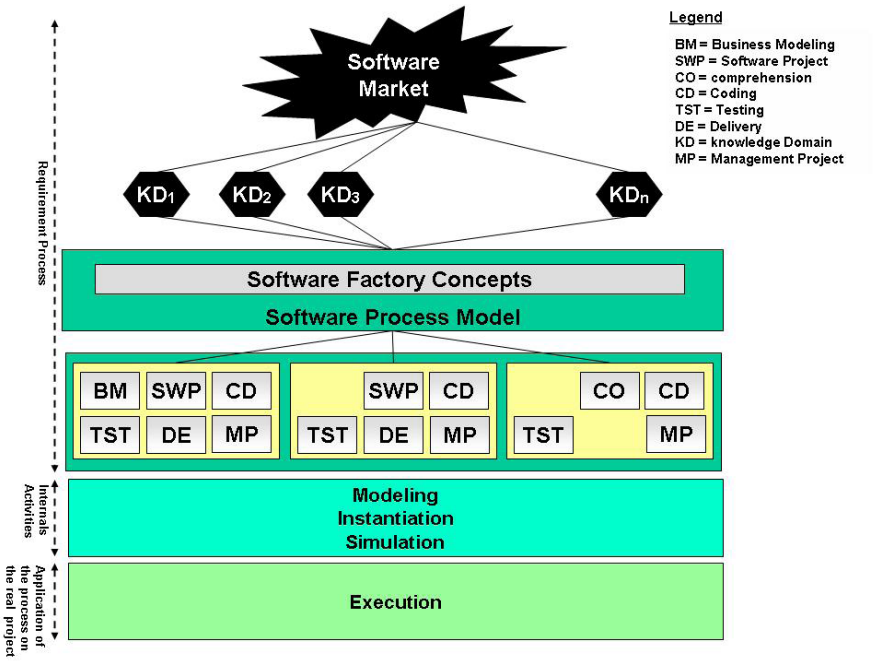
3. THE META-PROCESS PROPOSAL

The meta-process proposed by this paper is divided into five meta-activities: requirements, modeling, instantiation, simulation and execution.

In the requirement meta-activity it is necessary to define:

- Production cycle: The cycle presents the type of products generated by the factory. It can be classified as:
  - Long: The software factories which are framed in this concept should accomplish the business modeling, software project, coding, testing (modular or unitary, integration), project management and, finally, the software delivery (installation and training, for example). The long cycle factories should have a strong standardization to the activities of business modeling and software project. It is important to point out that activities depend on the creativity of system analyst and software architect.
  - Medium: The software factories which are on this cycle do not care about the business modeling; the responsibility of the factory begins with the execution of the activities of software project. It also accomplishes code, tests and project management.
  - Short: The software factories which are on this cycle make the activities of comprehension (the comprehension has the objective to verify if the

Figure 1. Structure of the meta-process proposal



project specifications is correct, consistent and intelligible, in order to reduce the stop risks in the production or the breaks of productivity), coding, testing (component and integrated) and project management. The business modeling, the software project, should be accomplished by long cycle software factory.

- Knowledge domain in which the factory will operate: the definition of domain is, specifically, the line products concept. Which products will the factory produce? This question should be answered.
- Process model (waterfall, incremental) that the factory will operate: The definition of the model will influence the dynamic behavior of the software process, knowing that the model defines the activities relations about the temporary optics.

The modeling, instantiation, simulation and execution activities are described on Section 2.

Figure 2 represents the meta-process used in the modeling of a software process. The figure shows the software development market divided into several segments (knowledge domains), the cycles (long, medium, short) and the conceptual aspects about software factory which are used taking into consideration the chosen model. The modeling, instantiation, simulation and execution activities, also, are contemplated in the figure.

4. ADHERENCE OF THE META-PROCESS TO THE SOFTWARE FACTORY: THE UNITECH CASE

The information presented in this section has been based in a case study realized in the UNITECH Software Factory.

Figure 2. UNITECH process modeling: PML used: IDEF-0 notation

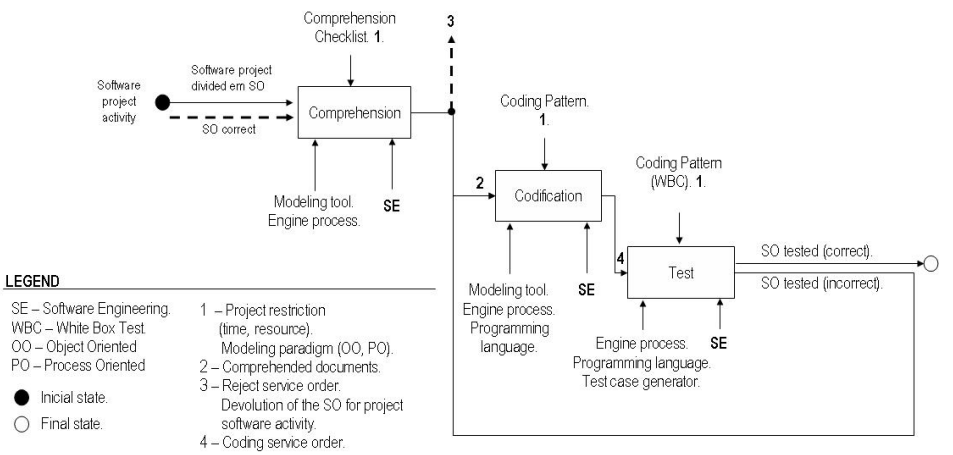
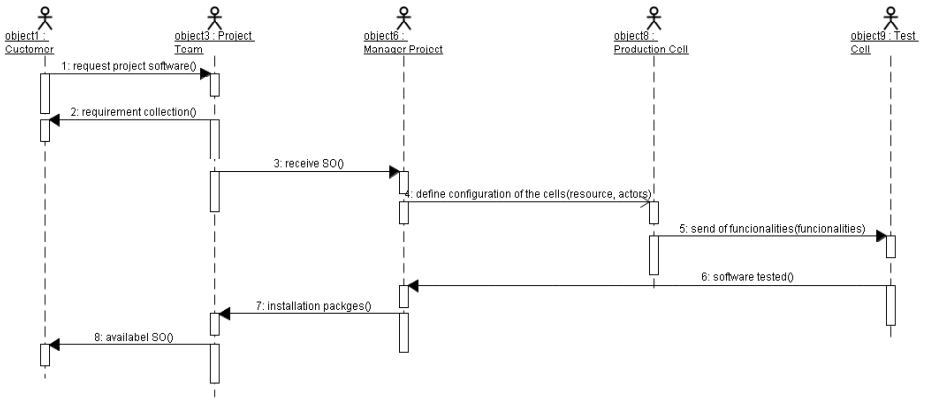


Figure 3. An instance of the real execution of the UNITECH process



The UNITECH was created in 1995 and, nowadays, has about 1266 professionals. In 2002, the company had 584 employees and annual revenue of 18 million dollars. The forecast for 2007 is to reach the 1500 employees with revenue of 50 million dollars. The UNITECH growth rate has been maintained in the last years around 25%. In relation to the quality certification, UNITECH got CMMI level 3.

The company produces software for the following segments: telecommunications, administration of engineering companies, customer relationship management (CRM) and tributary administration for municipal districts.

The process model used by the company is characterized as incremental. The software factory production cycle of UNITECH is defined as short, which is, the comprehension, coding, and testing activities are executed.

After the process requirements are defined, the next activities of the meta-process are modeling and instantiation. The first of them can be verified in Figure 2.

The instantiation demands the configuration of the process engine. In UNITECH such machine has these following functionalities:

- To maintain[2] the production process activities;
- To maintain the service orders, derived from the software project;
- To maintain the stakeholders of the software process;
- To maintain the customers and their software projects;
- To maintain the developed products, which are related to the services orders;
- To store the stakeholders, errors and the development time for each product in each version;
- To relate the products developed to the customers' projects.

Finally, it is important to point out that the UNITECH software process is already under execution, and so, it is not possible to execute a meta-activity simulation. An instance of the real execution of the process is presented in Figure 3, (in case of multiple instances, this is necessary to develop new diagrams). Through the illustration, we can observe that a **Customer** requests a software project to the **Project Team**. This **Team** begins the collection and analysis of the requirements, as well as logical and physical project. The **Project Manager** verifies if the Software Factory has conditions, specially, in relation to time and technology, to produce the requested software.

At this moment, the production cycle of the factory begins. The **Project Manager** receives the SO and defines the configuration of the **Project Team**. The specification comprehension is led; the software production begins and the functionalities implemented are sent to the tests activity. Tests are executed and, if there are no errors, the SO is liberated for delivery to the customer. The **Project Manager** packs such SO, sending it to the **Project Team**. Finally, the Project Team delivery the product requested in the SO to the customer.

5. CONCLUSIONS

This paper presented the possibility of using the meta-process theory for the definition of a software process.

We could verify that the requirements meta-activity has a great importance to the process definition, because it is where is defined the knowledge domain, production cycle and process model.

In the modeling meta-activity was used like PML, the notation derived of the technique IDEF-0, it is important to point out the efficiency of this notation for the modeling process.

The instantiation and simulation meta-activities were not verified, because UNITECH already has a software process implanted.

Finally, as future work authors intends to verify the meta-process under the view point of new cases.

REFERENCES

Costa, Ivanir; *Contribuição para o aumento da qualidade e produtividade de uma fábrica de software através da padronização do processo de recebimento de serviços de construção de softwares* - 174 pag.; Tese (Doutorado) Apresentada ao Departamento de Engenharia de Produção da Universidade de São Paulo; São Paulo: PoliUSP, 2003.

CUSUMANO. M. A. *Japan's Softwares Factories*. New York: Oxford University Press. 1991.

Feiler, P.; Humphrey, W. Software Process Development and Enactment: Concepts and Definitions. In: *International Conference on the Software Process, ICSP Proceedings*. Berlin, Germany: IEEE Computer Society Press, 1993.

REIS, R. Q. APSEE: *Um Meta-Modelo para Apoiar a Reutilização de Processo de Software*. Tese de doutorado apresentada ao Instituto de Informática da Universidade Federal do Rio Grande do Sul. 2002.

Schaefer, Wilhelm; Fuggetta, Alfonse; Gobart Claude, Jahnke Jens. Architectural Views and Alternatives. *Lecture Notes in Computer Science. Software Process: Principles, Methdology, and Techonology*. Derniame, Jean-Claude; Kaba, Badara Ali; Wastell David Eds. Vol. 1500.. ISBN. 3-540-65516-6. Pages 95-116. Springer-Verlag. 1999.

Sommerville Ian; *Engenharia de Software* – 6a. Ed.; Addison Wesley, 2003.

ENDNOTE

1 The UNITECH is a Brazilian company certified CMMI level 3.

2 In this paper the word maintain translates the idea of storing, deleting e consulting such data.

The Use of the IDEF-0 to Model the Process in a Software Factory

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ABSTRACT

This paper presents the use of IDEF-0 in the modeling of a production process of a Brazilian software factory. The information used in the modeling were captured through a case study.

1. INTRODUCTION

The development of the Brazilian software market is constantly searching for quality and productivity. This information can be verified analyzing the incentive programs promoted by Science and Technology Ministry (MCT) which the government established software is priority (Software, Semiconductors and Industry). One of these programs is SOFTEX (Society to promote excellence of Brazilian software). The objectives of SOFTEX are: to ranking Brazil between the 5 biggest software exporters and producers of the world and to reach international standard of quality and productivity in this sector.

Beyond of those programs, the Ministry develops, periodically, research to verify quality and productivity attributes of Brazilian software development sector. In Brazil exist near 11.000 companies with activities related to the development and commercialization of software, those companies hire 160.000 employees, which 25% of them own a quality program defined, and other 26% fell necessity to establish this type of program. This fact shows Brazil is conscious of the necessity of improving its products quality in the IT area, software sector, in this case. (www.mct.gov.br/sepin - November, 2006).

Parallel to these facts, COSTA (2003) presents a research involving 31 most significant companies, which act in Brazilian market using the Software Factory model. Only 41% of these companies apply a complete cycle software development; 45% apply its own methodology; 16% use projects control tools; 14% own CMMI certification; 13% use CASE tools and 10% apply quality metrics.

Based in the presented context, we can affirm: to reach SOFTEX objectives is necessary an effort of Brazilian UNIVERSITIES, COMPANIES and GOVERNMENT, with the intention of becoming aware the market about the existence of quality and productivity models to software factory. In this point of view, this paper has objectives: 1) To present the use of IDEF-0 in the software process modeling of a Brazilian software factory, showing it is perfectly possible to work with production scale in this sector. 2) To verify the adherence of this notation in the software process modeling in a factory context.

2. BIBLIOGRAPHIC REFERENTIAL USED FOR THE DEVELOPMENT OF THIS PAPER

This section presents software factory and IDEF-0 concepts, witch are the base of this paper.

2.1 Definitions about Software Factory

Cusumano (1991) tells: the term software factory was used on the first time in 1960 at Japan. Even so, several companies associate the term software factory with the software development. However the software company witch doesn't assist characteristics of the software production in mass and in wide scale and doesn't own tasks and control standardization, work division, mechanization and automation can't be considered a software factory. For Cusumano the software factory development implies in the good practices of the software engineering systematically applied.

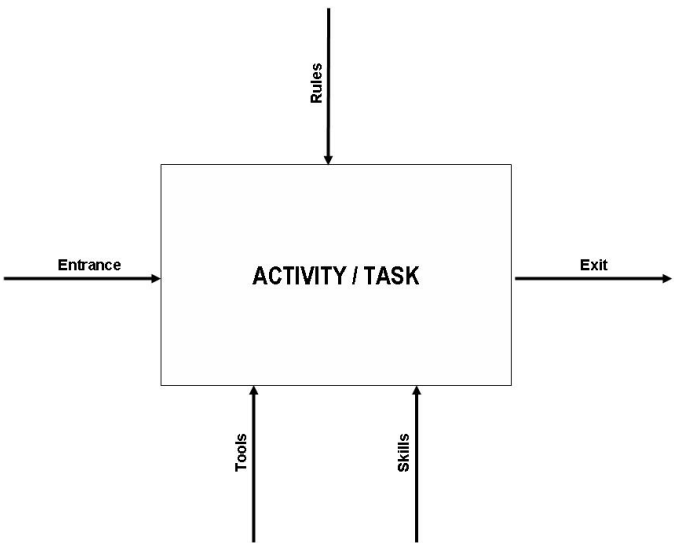
Fabri et. al. (2004) show that is possible to understand a software factory like a structured organization, gone back to software production totally building on the engineering and with strong features of work organization, to capacity modular components and to product in high scale. Software factory may have project management environment and tools, standard process, metrics to estimate cost, term and staff size and quality product guarantee policy.

2.2 Definitions about IDEF-0

The IDEF-0 was developed by American Air Force. In 1972 the SADT (Structered Analysis and Design Technique) was developed by Douglas T. Ross of SoftTech. The SADT was used in AFCAM (Air Forces Computer Aided Manufacturing) project, witch resulted on ICAM I (Integrated Computer-Aided Manufacturing I). The second version of ICAM was developed, documented and renamed as IDEF-0.

The IDEF-0 is a collection of activities, represent by ICOMs (Input Control Output Mechanism). An ICOM doesn't include only data and information but also everything that can be described about the process (scheme, estimate, regulations, products, etc). The ICOM in Figure 1 is a graphic representation of a task or a tasks group witch have "terminals". The terminals feed or are fed by an ICOM. An ICOM has raw material (entrances); rules and restrictions; people/skill; tools/mechanism

Figure 1. An ICOM representation



and products (exit). The entrance receives the data to be converted by an activity (or process), the rules and restrictions present how and when the entrance should be processed and executed, the mechanisms/tools represents who should execute this activity (can be an equipment, machine or others organizations) and the exit presents the result of as the entrance was processed (a product).

3. THE SOFTWARE PROCESS IDEF-0 MODELING A BRAZILIAN SOFTWARE FACTORY

The information presented in this section is configured through of a case study made at a Brazilian software organization with production characterized as factory. To organize this study, the authors used the bibliographical referential proposed by YIN (2005). (Note: the organization is certified with the quality model CMMI level 2). The authors of this work doesn't possess a formal authorization to publish the name of the company, this fact took them to denominate it as FÁBRICA BR.

FÁBRICA BR was founded in 1996 and provides IT solutions on data communications, internet and business process consulting areas. Nowadays, FÁBRICA BR has 600 collaborators on highlight areas.

Inside its production process, FÁBRICA BR does requirement mapping activities, business modeling, software project, comprehension (the comprehension objectives to verify if the project specifications are correct, consistent and intelligible, in order to reduce stop risks production or productivity breaks), codification, test (unitary and integrated), delivery and maintenance. Figure 2 presents the relationship among the software process activities of FÁBRICA BR. Note: process activities won't be detailed in this paper.

Analyzing Figure 2 is possible to verify the presence of process activities, rules and mechanisms that execute it, and two production units: the projects and the software factories. The first one is responsible to execute activities of requirements mapping, business modeling, project and software implantation. The comprehension, codification and tests activities are under the software factory responsibility. In the production process representation is possible to verify the process engine (characterized as a tool) is related with all activities.

Schaefer et. al. (1999), affirm the process engine can be classified as software with the objective of aiding in the communication and coordination of activities accomplished by process involved. One of the process engine objectives is to control the documents production (for example: requirement document), from requirements till delivery activities. FÁBRICA BR process engine possesses the follow functionalities:

- To maintain[1] production process activities;
- To maintain service orders, derived from software project;

Figure 2. FABRICA BR Process Modeling used IDEF-0

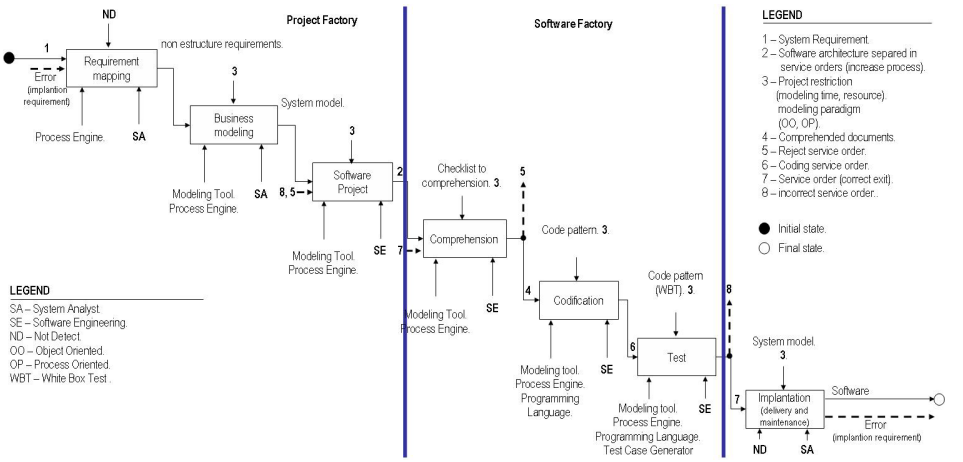


Table 1. Information produced with process engine

FÁBRICA BR Process Engine Production Control				
Client – Company XYZ				
Project – ABC				
Service Order: Date Code 00/00/00	Order: 1	Product – 1.1 St: OK	Actors: John (Leader) Mark	Activity: Codification: Started: 00/00/00 Finished: 00/00/00 t: 3/4 Testing: Started: 00/00/00 Finished: 00/00/00 t: 1/2
		Product – 1.2	Actors: Mary Peter	Errors: Err A Err B
	Order: 2			
	Order: 3			
Legend: St: Product State = In development or OK t: n/n1 = t – development time: n forecast, n1 accomplish.				

- To maintain involved with the software process;
- To maintain customers and theirs software projects;
- To maintain developed products, these related to services orders;
- To store involved, errors and development time for each product in each version;
- To relate developed products to the customers' projects;

With functionalities listed, the management information presented at Table 1, it can be inferred with process engine.

It is perceptible that project manager of factory receive a productivity estimate of each project and management reports. These reports are also supplied by process engine.

FABRICA BR software process possesses an incremental systematic because the inherent functionalities to software architecture document are separated in service orders (these orders aggregate one or more functionalities). The orders are understand, codified and tested by software factory and implanted by projects factory, one by one.

4. CONCLUSIONS

This paper presented the IDEF-0 software process model of a Brazilian software factory. The modeling notation used details the process in following aspects: process activities; activities information flow; rule and tool (the paper emphasize the process engine) applied to activities and to software process actors.

The process theory establishes the process modeling should assist some visions, among them: workflow; skill; tools; dataflow and rule.

The notation IDEF-0 used on process modeling (Figure 2) assists all the visions presented, this fact proves her efficiency.

Finally, as future work, the authors intend details about production process present in this paper, using IDEF-0 as a modeling technique.

REFERENCES

Costa, Ivanir; *Contribuição para o aumento da qualidade e produtividade de uma fábrica de software através da padronização do processo de recebimento de serviços de construção de softwares* - 174 pag.; Doctorate thesis presented to Production Engineering Department of Politécnica School from São Paulo University; São Paulo: PoliUSP, 2003.

Cusumano. M. A. *Japan's Softwares Factories*. New York: Oxford University Press. 1991.

Fabri, J. A.; Trindade, A. L. P.; Begosso, L. R.; L'Erário, A.; Silveira, F. L. F.; Pessôa, M.o S. de P.; Techniques for the Development of a Software Factory: Case CEPEIN-FEMA; in: *Annals of 17th International Conference Software & Systems Engineering and their Applications*; Paris: CNAM, December 3, 2004.

IDEF0. Draft Federal Information Processing Standards Publication 183 1993 December 21 Announcing the Standard for INTEGRATION DEFINITION FOR FUNCTION MODELING. IDEF0 (1993).

Schaefer, Wilhelm; Fuggetta, Alfonse; Gobart Claude, Jahnke Jens. Architectural Views and Alternatives. "*Lecture Notes in Computer Science. Software Process: Principles, Methdology, and Techonology*". Derniame, Jean-Claude; Kaba, Badara Ali; Wastell David Eds. Vol. 1500.. ISBN. 3-540-65516-6. Pages 95-116. Springer-Verlag. 1999.

Yin, Robert K. *Estudo de Caso: Planejamento e Método*. 3rd edition; Bookman. Porto Alegre. 2005.

ENDNOTE

[1] In this paper the word maintain translates the idea of the storing, deleting e consulting of a determined data.

Social Networking in Web-Enhanced Courses

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INTRODUCTION

The use of the Internet for delivering courses has become a pervasive influence on undergraduate and graduate curricula. Current figures indicate that fully 12% of Internet users in the United States use the Internet to take an online course for credit toward a degree of some kind (Pew/Internet, 2006). That number is indicative of the rapid proliferation of online courses over the past several years.

Classifying web courses becomes problematic because the web-enhanced course is a blend with the components of the traditional class and course management software, a course listserver, instructor-student e-mail, collaborative activities using RSS feeds and related technologies.

Navarro (2000) suggests that faculty are far more likely to start by incorporating Internet components into a traditional course rather than directly offering web-based courses. These web-enhanced courses might be considered the transition phase to the new paradigm of Internet-based courses. Rich learning environments are being created, with a shift from single tools to the use of multiple online tools, both to enhance traditional courses and to better facilitate online courses (Teles, 2002).

Lee Rainie, Director of the Pew Internet and American Life Project notes that the role of experts, such as teachers, has changed. The Internet has empowered amateurs. New teaching models and methods have developed as educators try to adjust to changing student attitudes (Rainie, 2006). The new educational model becomes "the net-savvy, well-connected, teacher-independent end-user" (Castells, 2000).

Approximately 96% of undergraduate students at a midwestern, public university come to school equipped with at least one computer with university-supplied high speed Internet access. (Nantz, unpublished research, 2006). Researchers at Ball State University found that 30% of a waking day is spent with media as the sole activity with an additional 39% spent with media combined with some other activity. Part of the expectation of the current college population is that two-way technologies are the norm (instant messaging, weblogs, and online journaling, for example) and that online communities provide a rich environment for information sharing ("Average Person", 2006). According to Pew data, almost half of Internet users access list servs, RSS feeds and bulletin boards to stay engaged.

Clearly, there are many compelling reasons to use web-based resources in a course, including greater efficiency in the delivery of materials, providing up-to-the-minute content, enhanced status for the course and faculty, fostering student-to-student collaboration, and the use of technologies with which the students are increasingly familiar and comfortable.

RESEARCH VALIDATION

We have implemented the learning community paradigm in a variety of classes using several RSS technologies (RSS feeds, blogs, and wikis). Anecdotal evidence suggests that this approach enhances the instructional experience for students and exposes them to a wider variety of ideas than is possible with only the instructor as a source.

The learning community is, essentially, a social network. Social networks are based upon network theory, which focuses on the connections in the network. Any given social network has n(n-1) connections possible, where *n* is the number of nodes in the network. In a classroom, that includes all students plus the instructor and any other relevant individuals (graduate assistants, etc.). That is not to say that all connections will be used in any network. This is just the number of possible connections. In reality, each potential connection may be used in one of four ways:

- No connection exists
- Unidirectional connection, with interaction flowing primarily from node A to node B
- Unidirectional connection, with interaction flowing primarily from node B to node A
- Bidirectional connection, with interaction flowing in both directions

For example, the relationship between a teacher node, X, and a student node, Y, might be primarily unidirectional, from X to Y. A relationship between a student Y, and another student, Z, might be bidirectional.

Further, there is the strength of the connection to consider. It is likely that the strength of the connection between an instructor and a student will be high. The strength of a connection between students will likely vary greatly.

To analyze the efficacy of peer-driven learning communities in the classroom, it is necessary to examine the social networks that result from such communities and to compare them with the social networks that exist in classes wherein the learning

Figure 1. Instructional communication matrix

	Non-interactive	***Interactive***
Synchronous	Lecture Webcasts Videos	Discussion Managed Meetings IRC Chat Internet Messaging (IM) Webinars
Asynchronous	Podcasts / Vodcasts Webcasts Wikis	Discussion Boards Weblogs RSS Feeds / Syndication Cellular Text Messaging (SMS)

community has not been formally established, or is operating on an ad-hoc basis. To do this, a network diagram must be established for both the control and the experimental groups. In order to do this, we intend to establish network maps for each class, both for those participating as experimental groups and for those not participating (controls) by asking students about their learning relationships with other students and instructors in the class. In so doing we will establish:

1. The number of potential connections actually in use in the network
2. The nature of those connections
3. The strength of the connections that are in use

We will undertake a statistical analysis of the differences between the control and experimental networks to see if the difference is significant and if the resulting experimental network can, indeed, be enhanced by stronger and more plentiful peer-to-peer interaction.

Finally, the authors will discuss using synchronous and asynchronous communication with both non-interactive and interactive components as indicated in Figure 1 (Garrett, 2006). This model can enhance web-delivered instruction and meet student expectations for two-way communication and online communities.

REFERENCES

"*Average Person Spends More Time Using Media Than Anything Else." (2005)*. Ball State University News Center. Retrieved July 10, 2006 from http://www.bsu.edu/news/article/0,1370,7273-850-36658,00.htm.

Castells, M. (2000). *The Rise of the Network Society.* Malden, MA: Blackwell Publishers.

Garrett, N. A. (2006, May, 2006). *Setting Up and Using Collaborative Learning Communities Using RSS Technologies.* Paper presented at the Faculty Summer Institute, 2006, University of Illinois at Urbana-Champaign.

Nantz, K. (2006). *Fall 2006 BUS 1950 Pre-Assessment Survey Results*. Unpublished research.

Navarro, P. (2000). Economics in the Cyberclassroom. *Journal of Economic Perspectives, 14:2*(Spring 2000), 119-132.

Pew / Internet. (2006). Internet Activities. Retrieved July 20, 2006, from http://www.pewinternet.org/trends/Internet_Activities_7.19.06.htm.

Rainie, L. (2006). *How the Internet is Changing Consumer Behavior and Expectations.* Retrieved July 15, 2006 from http://www.pewinternet.org/PPF/164/presentation-display.asp.

Teles, L. (2002). The Use of Web Instructional Tools By Online Instructors [Electronic Version]. *The Technology Source Archives*. Retrieved July 20, 2006 from http://technologysource.org/article/use_of_web_instructional_tools_by_online_instructors/.

E-Diabetes: A Low Cost Approach to Diabetes Care in India

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ABSTRACT

As a result of our R&D efforts, we have developed an integrated telemedicine application "e-Diabetes" in accordance with the vision of Govt. of India to provide multi-specialty healthcare to all at an affordable cost. Its primary aim is to develop a world-class telemedicine technology solution for providing health care to all at affordable cost. This paper describes the potential benefits made available by this technology in diabetes care, and how this new E-Diabetes solution complements the daily care of diabetic patients. This Telemedicine Diabetes Application will deliver diabetic care to the patients of under-served rural areas of India at very low cost.

Keywords: E-Diabetes, Tele-Radiology, Tele-Cardiology, Tele-Pathology, Internet Information Services (IIS), Electronic Medical Recorder (EMR)

I. INTRODUCTION

Diabetes in India is increasing in prevalence, and now considered an epidemic. The World Health Organization (WHO) has concluded that India, which has the largest number of diabetic patients (32 million in 2000), is expected to have nearly 80 million patients by 2030. E-Diabetes is an emerging technology for the delivery of patient care in diabetes through telemedicine. Telemedicine has the potential to improve the delivery of health care in India by bringing a wider range of services such as radiology, pathology, cardiology, mental health services and dermatology to underserved communities and individuals in both urban and rural areas. At present, the position of diabetes care in the rural areas of India is not good. The number of primary health care centers in the State is less and thus vital medical facilities necessary for the population are not provided.

In rural areas of Northern India there is a high prevalence of curable diabetes disease, which remains untreated due to lack of resources. E-Diabetes can help the population of Northern India by providing specialized medical care, services and treatment to the patients in the far flung, remote and inaccessible areas from the specialty hospitals. Thus to provide effective solution to such an increasing number of diabetes cases, Center for Development of Advanced Computing (C-DAC), Mohali, India has taken an initiative in designing a web based E-Diabetes solution.

Deployment of "e-Diabetes" will help the poor and needy sitting at remote and rural places where specialized treatment is not available. With this the poor can easily have the advice of the specialists and suffer less.

II. VISION

I. Primary Stage

The purpose of this research work was to design and implement a Web-based e-Diabetes system tailored to provide an expert advice in the intake of insulin dose.

Initially following design goals were set:

1. The system should be tailored to support the workflow of the developed store-and-forward telemedicine software 'Sanjeevani'.
2. The system should be Web-based for true Internet operation.
3. The system should be built upon Open Source components and support multiple platforms for the ease of adoption.
4. The system must be secure and user friendly.

II. C-DAC & Telemedicine

Centre for Development of Advanced Computing (C-DAC), Mohali (Erstwhile CEDTI) is a premier Institute of Ministry of Communications & Information Technology, Govt. of India. CDAC is working in the field of Telemedicine since 1998 and has successfully developed state of the art telemedicine application packages namely, Sanjeevani and e-Sanjeevani that complies with the International telemedicine Standards.

We have established telemedicine sites at various locations in India. Our first endeavor was establishing telemedicine sites at AIIMS, New Delhi, PGIMER, Chandigarh, and PGI Lucknow. We expanded it in the second phase to connect three more medical colleges namely, IGMC, Shimla, Medical College in Rohtak and Cuttack.

Our second effort is to establish telemedicine sites at different states of Himachal Pradesh, and in rural areas of Punjab.

III. Objectives

E-Diabetes is a web-based application and its beta version is hosted on a central server for trial purposes at present. It can be opened with common Internet browser being bundled with any operating system software installed on the computer. The most sophisticated technology on date for developing web based solutions, namely ASP.Net has been used.

By integrating e-Diabetes with our existing Telemedicine software we hope to prevent diseases related to diabetes like cataract, kidney failure, Heart attack, BP, Neuropathy in those areas of Northern India where basic health amenities are not available.

The telemedicine diabetes care procedure aims:

1. To make available the expertise of the specialists at institutes like PGI Chandigarh, to common people at remote places.
2. To improve communication of the patient with the hospital-based diabetologist, in between the patient's visits to the specialized clinics.
3. To allow doctors to assess the patient's condition on a frequent basis.
4. No need to move the diabetic patient from remote areas to specialty hospital at far away places unnecessarily.

IV. Features of E-Diabetes

1. User-friendly interface facilitating doctors to navigate through the database.
2. Comprehensive Electronic Medical Recorder (EMR) with unique patient ID.
3. Structured investigation using clinical reports.
4. Secured environment through encryption and hashing algorithms.
5. Standard communication protocols.
6. Single point entry for operation through user name and password.

7. Multi-point, Multi-referral access to a number of Tertiary Institutes.
8. Central repository to keep the large patient data for backup.
9. Cost effective as no system softwares are required.
10. The application is designed for supporting client server Internet environment.

This e-Diabetes application uses forms authentication for the purpose of security. Every hospital that intends to use this application is provided with an administrative level user name and password. The administrator need not be a computer knowledgeable individual. Their duty is confined to creation of user names and passwords for the doctors employed in their hospital. Only the administrator is allowed to create accounts for doctors for security reasons. The user information passwords have been stored in encrypted form in the database table carrying users' information.

Other than e-Diabetes following modules are also part of E-Sanjeevani application software. Provision of inclusion of other modules is also there which can be implemented as per the requirement of the site.

1. Tele-Radiology
2. Tele-Cardiology
3. Tele-Pathology
4. Nephrology

III. WORKING MODEL

The system's architecture comprises of following main components: the Medical equipment, Workstation, Application software, Video-Conferencing to be used by rural based physicians and nurses at Health Centre in rural areas, and a telemedicine workstation, Multi-Videoconferencing Kit used to provide consultation to multi hospitals at same time at specialist centres in urban areas.

A dedicated internet website, allows the physician to monitor daily blood glucose information of the patient, and allows the patient to access his own blood glucose patterns. With the use of the developed e-diabetes software the doctor or other paramedic staff present at remote area health centers will enter the patient's diabetes data. Then the expertise doctors at institutes like PGI Chandigarh, will provide consultation to the common people at remote places. In the Software, analysis of Diabetes values can be made on daily, weekly or monthly basis by these expert doctors to provide feedback on the amount of insulin intake.

The basic functions of e-Diabetes application software include:

- Telemonitoring of patient's blood glucose data.
- Self-management actions, and
- Remote care from doctors to diabetic patients.

The developed software can handle up to four of 16 possible insulin types. Patient details like Carbs intake, Blood sugar, Protein, Cholesterol, Calories and weight values are filled in his EPR (Electronic Patient Record). The daily Average Line and Bar Graph of all these test figures is available to the doctor present in remote area as well as to the specialists in the urban area hospitals, which helps them to provide an expeditious care to the diabetic patient. Line graphs (Fig 1) and Bar chart graphs and the Print Colors option added to the Graph provides a visual effect to the readings and thus helps in better analysis of the patient data.

The telemedicine diabetes care procedure aims:

1. To make available the expertise of the specialists at institutes like PGI Chandigarh India, to the common people at remote places
2. To improve communication of the patient with the hospital-based diabetologist, in between the patient's visits to the clinic
3. To allow doctors to assess the patient's condition on a frequent basis
4. No need to move the diabetic patient from remote areas to specialty hospital at far away places unnecessarily.

Through consultation between two or more geographically separated physicians and with the availability of accurate and updated patient's diabetes data, an improved patients' glycemic control is achieved. Hence the use of telemedicine diabetes will allow diabetes case management of patients at remote distance and in those cases, where an in-person case management visit is not available or not feasible.

Work flow of the e-Diabetes solution once it is implemented at Health centers of rural areas in Northern India is as shown in Fig.2

Figure 1. Line graph using dummy diabetes values

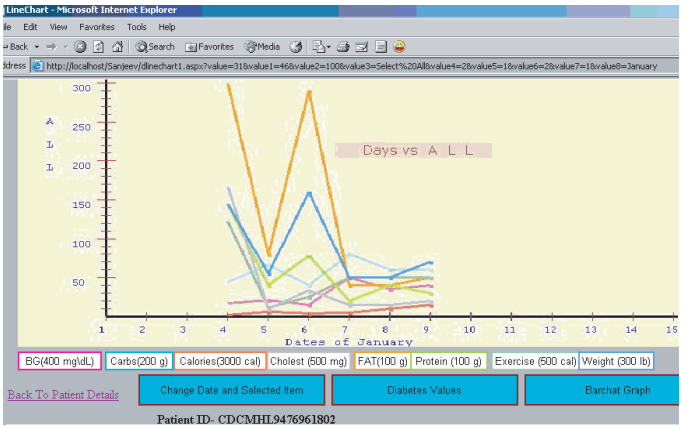
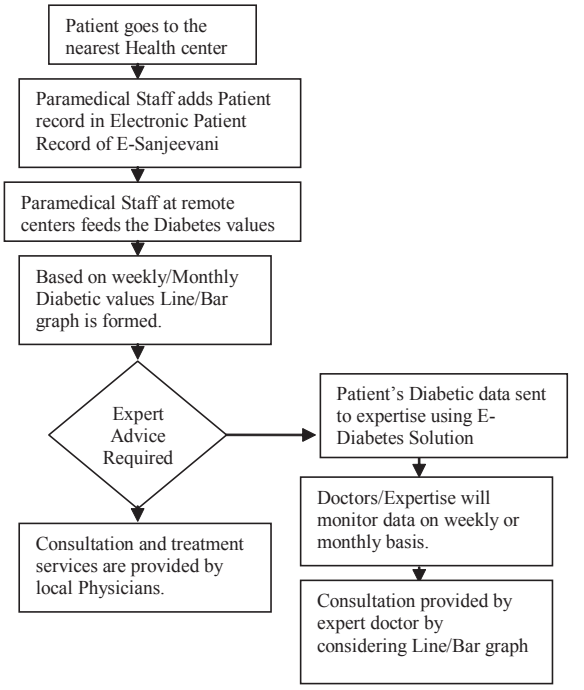


Figure 2. Work flow of e-diabetes



IV. APPLICATION ARCHITECTURE

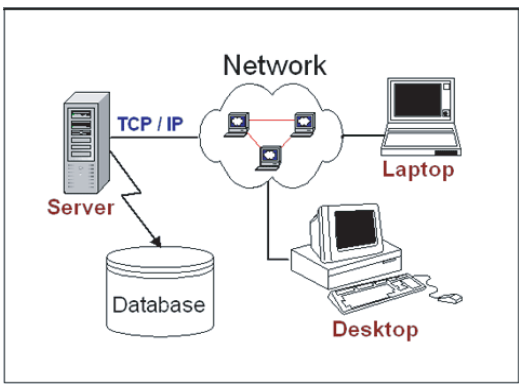
Web applications use client/server architecture. The Web application resides on a server and responds to requests from multiple clients over the Internet, as shown in Figure 3.

I. Client/Server Interaction in a Web Application

The Web application composes responses to requests from resources found on the server. On the client side, a browser hosts the Web application. The application's user interface takes the form of HTML pages that are interpreted and displayed by the client's browser.

On the server side, the Web application runs under Microsoft Internet Information Services (IIS).

Figure 3. Web application architecture



IIS manages the application, passes requests from clients to the application, and returns the application's responses to the client. These requests and responses are passed across the Internet using Hyper Text Transport Protocol (HTTP).

Web applications are much like traditional Web sites, except that the content presented to the user is actually composed dynamically by executable, rather than being served from a static page stored on the server.

The executable portion of the Web application enables you to do many things that you can't do with a static Web site, such as:

1. Collect information from the user and store that information on the server
2. Perform tasks for the user such as placing an order for a product, performing complex calculations, or retrieving information from a database
3. Identify a specific user and present an interface that is customized for that user
4. Present content that is highly volatile, such as inventory,

pending order, and shipment information

What makes a Web application special is that the client/server interaction takes place over the Internet.

II. Platform Chosen

ASP.NET is the platform that we have chosen to create Web applications that run under IIS. ASP.NET provides a high level of consistency, easy to create, debug, and deploy across Web application development.

V. CONCLUSION

During the ongoing trial period, large set of feedback records from the expert doctors and effect of remote Doctors and patients will be studied to develop novel measures of diabetes control in Northern India. Simultaneously many more specific measures will now be considered to update the presently developed beta version of e-Diabetes.

Thus this paper describes the potential benefits made available by this technology in diabetes care, and how this new e-diabetes solution complements the daily care of diabetic patients. This telemedicine diabetes application will deliver diabetic care to the patients of under-served rural areas of India at very low cost.

REFERENCES

[1] JS Bhatia & Sagri Sharma: 'Telemedicine odyssey- Customized Telemedicine solution for rural and remote areas in India' "The Leading International Event in Medicine and Care", 2006 WFCC, Netherlands ICMCC Event 2006
[2] S Grover, A Avasthi et al., "Cost of ambulatory care of diabetes mellitus: a study from North India". Postgraduate Medical Journal 2005;81:391-395
[3] Shobhana R, Rama PR, Lavanya A, et al. Costs incurred by families having type 1 diabetes in a developing country—a study from southern India. Diabet Res Clin Pract 2002;55:45–8
[4] Gomez EJ,del Pozo F, Hernando ME. 'Telemedicine for diabetes care: the DIABTel approach towards diabetes telecare'. Med Inform (Lond). 1996 Oct-Dec;21(4):283-95.
[5] Internet helps diabetics monitor blood sugar. http://www.nlm.nih.gov/medlineplus/
[6] Diabetes and telemedicine: Diabetes Care, Volume 26, Number 5, may 2003
[7] Telemedicine Improves Diabetes Care. May 24, 2004. I Health beat: Reporting internet's impact on Health care
[8] Diabetes Telemedicine Project. Clinical Trial Diabetes Telemedicine Project. htm. http://www.nlm.nih.gov/
[9] Telemedicine as an educational Tool. Journal of Diabetes Nursing may, 2003. http://www.findarticles.com/p/articles/mi_m0MDR
[10] Steven M Edwothy, 'Telemedicine in Developing countries', BMJ 2001; 323,p 524-525.
[11] Deodhar J. Telemedicine by email – Experience in neonatal care at a primary care facility in rural India. J Telemed Telecare 2002; 8:20-1
[12] Engelmann U, Schroter A, Schwab M, Meinzer H. reality and perspectives in teleradiology: a personal view based on personal experiences. Int J Med Inf 2001; 64:449-59
[13] Wells CA and C Sowter. Telepathology: A diagnostic Tool for the Millennium? Journal of Pathology 200; 191:1-7
[14] Shanit D, Cheg A, Greenbaum RA. Telecardiology: supporting the decision making process in general practice. J Telemed Telecare 1996; 2:7-23
[15] Programming Microsoft ASP.NET-Dino Esposito
[16] http://www.cdacmohali.in
[17] http://www.esanjeevani.in

Effects of Color and Gender on the Perceived Attractiveness of Websites

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INTRODUCTION

As the World Wide Web continues to grow in popularity, currently estimated to exceed 1.2 billion users (Nielsen 2005), websites have become core extensions of a business practice rather than a consideration of a new channel (Ravi 2005). Companies seek new insights on how to create more effective websites and entice online customers. Extensive literature exists on the acceptance of a new technology, but the former has centered on utility-related dimensions that drive this acceptance. Limited research exists on the hedonic dimensions of HCI and their relevance to usability and an even smaller set of this research is empirical in nature (Zhang and Li 2005). Furthermore, it appears that there are gender differences regarding perceptions of attractiveness, usability, and the consequent affective state of satisfaction, in website design. However, more research is needed to understand the nature of such differences as in most past studies there were many confounded design variables. Thus, this research-in-progress aims to address the above gap by studying the effects of color and gender on the perceived attractiveness of websites.

LITERATURE REVIEW

Hedonic Effects of Color

Hedonic, derived from Greek where "hedonism" means pleasure, dimensions include factors such as color, graphics, animation and other design elements that either implicitly or explicitly cause an affective state of pleasure. Zhang and Li (2005) argue that the more pleasing or attractive a website is, the easier it will be for the individual to learn how to use it and the more likely that this individual will continue to use it. Past studies have primarily looked at website design as the aggregate product of these hedonic dimensions and the users' consequent affect. However, a closer look at the impact of each hedonic dimension on affect is warranted.

Empirical studies on the impact of color on the perceived attractiveness and usability of websites are extremely limited. Most studies focus on the role that aesthetics play in usability and treat color in an overly subjective and qualitative manner. However, based on the limited number of empirical studies on the subject, it appears that color (and more specifically color combinations and schemes) have a significant effect on the perceived attractiveness and aesthetic appeal of a website. Brady and Philips (2003) suggested that users found a site with a Triadic color scheme more usable and more aesthetically pleasing than a site with a non-standard color scheme. Their study was limited by its design in that it did not differentiate the users' perceptions of usability and attractiveness between the variables of color and balance, both of which make up *visual balance*. Papachristos et al. (2005) suggested that color combinations and schemes resonate with users in a particularly emotional manner. Their research shows that user's tend to predictably attach specific emotional descriptors, such as fresh, modern, friendly, and aggressive, to specific color schemes and color combinations. Results of their research further suggested that the design attribute with the strongest effect on the website's perceived attractiveness is the *brightness* of the dominant color, followed by the *brightness* of the secondary color and its type (warm or cold), the *number of colors*, and the *contrast* between hues.

Based on the limited past empirical research, it is plausible to suggest that color, color schemes, and color combinations are variables dependant on other areas of design such as balance and contrast. It is also possible to suggest, based on the work by Papachristos et al. (2005) that the perceived "temperature" of a color impacts a website's perceived usability and aesthetics. Thus, the following hypothesis is proposed for this study:

H1. There will be differences between designs in relation to users' perceptions of the website attractiveness for each color combination.

Gender Differences in Hedonic Effects

Effects of web design on affect have also been studied in the context of the users' gender. While most studies explored gender differences for credibility, trust, and satisfaction with websites, a few studies focused on the relationship between gender and perceived attractiveness of websites. In the realm of visual design, men had more favorable impressions of how product information was presented. Women were more attracted by the colors on the site, and men by animations and the interactive, 'flashy' aspects of the site (Cyr & Bonanni, 2005). Simon (2001) found that women preferred sites that were less cluttered, having few graphics, as well as sites that avoid multiple levels of sub-pages to drill through. Men liked sites that used extensive graphics and animation. Additionally, in a study of gender and Web usage among college students, significant gender differences emerged with respect to evaluative criteria and use patterns, with men liking some of the "bells and whistles" and women using academic Web sites more (Mitra et. al, 2005).

It appears that there are gender differences regarding perceptions of attractiveness, usability, and the consequent affective state of satisfaction, in website design, but more research is needed to understand the nature of such differences. As with past studies on hedonic dimensions and usability/acceptance, gender differences were explored in terms of website designs as an aggregate of multiple design elements instead of a more controlled design regarding these aesthetic factors. Thus, the following hypothesis is proposed for this study:

H2. There will be differences between men and women in relation to their perceptions of website attractiveness for each color combination

METHODOLOGY

This study employs a 2 x 2 research design, where color is manipulated on two levels: warmth and scheme. Specifically, two sets of colors are selected from the color wheel, each being categorized as either "warm" or "cold." Color scheme indicates whether a warm color, for instance, is selected as the primary or secondary color choice for the particular website design. Implementation of this design resulted in the following four treatments or color combinations for the test website: i) Warm Primary – Warm Secondary (i.e. Red – Orange); ii) Warm Primary – Cold Secondary (i.e. Red – Light Blue); iii) Cold Primary – Warm Secondary (i.e. Blue – Orange); and iv) Cold Primary – Cold Secondary (i.e. Blue – Light Blue). All other design elements (e.g. text, images, background) were held constant across the four designs.

Tasks invoked participants to browse through the website in search of specific information. Participants were informed that the tasks were only meant to offer them an opportunity to explore the website and its design, instead of measuring their performance with it. Having evaluated the website design randomly assigned to them, participants were then asked to rank four different website designs in terms of perceived attractiveness.

A Structural Equations Modeling (SEM) technique, Partial Least Squares (PLS), is used in testing the validity of both the structural and measurement model. Data analysis will speak to the two aforementioned hypotheses, but also on any interaction effects between color and gender on the perceived attractiveness of websites.

A total of 130 subjects were recruited for this web-based voluntary study via email announcements on various databases and listserv. All participants used the same website, but each treatment involved the use of a discriminant color design described above. The minimum sample size for the selected method, PLS, is 10 times the number of the most complex construct. In this study endogenous constructs consist of five items, thus our sample size far exceeded the needed 50 cases. The sample exhibited an even split between males and females, an average age of 39, was entirely college-educated, 84% described themselves as Caucasian/White, and had an average experience of 18 years with computers and 11 years with the World Wide Web respectively. ANOVA tests found no significant differences for subjects in the various treatment groups in terms of these control variables, thereby ensuring the successful randomization of assignment across groups.

Two scales developed by Lavie and Tractinsky (2000) were used to measure the users' perceived attractiveness of websites through assessments of "classical aesthetics" and "expressive aesthetics." These 7-point Likert scales (anchored "Strongly Disagree/Agree") measured responses to the shared question "My perception of this website is that it is…" for each of the following items: Clean, Clear, Symmetric, Aesthetic, and Pleasant for "Classical Aesthetics", and Original, Creative, Fascinating, Sophisticated, and Uses Special Effects for "Expressive Aesthetics".

RESULTS

An item is significant if its factor loading is greater than 0.5 to ensure construct validity. Adherence to this criterion required the modification of the Classical Aesthetics scale by removing two items (i.e. Clear and Symmetrical). Each item was then re-validated by testing its item-to-total correlation measure, where all items had higher measures than the 0.35 threshold and finally reported in Table 1. It should be noted that the loading for Clean was 0.673 before the removal of the other items.

Results of tests for convergent, discriminant, and construct validity can be found in Table 2. Both constructs had adequate reliability and internal consistency well above the 0.7 threshold. Cronbach α-values were satisfactory for our two constructs and constructs' AVE exceeded the 0.5 benchmark for convergent validity. The square root of the variance shared between a construct and its items was greater than the correlations between the construct and any other construct in the model suggesting discriminant validity. Discriminant validity was confirmed by verifying that all items load highly on their corresponding factors and load lowly on other factors.

The structural model tested using PLS demonstrated mixed explanatory power for perceived attractiveness of websites. With an R-square of 0.43, 43% of the variance in Expressive Aesthetics was explained by the color manipulation in this study. Only 3.2% of the variance for Classical Aesthetics was explained by this manipulation, suggesting that there are other dimensions not captured by the scale (in part explained after the removal of two items) and/or by the exogenous construct's effects.

From the two hypotheses, only the effects of color manipulation were supported. Both paths from Site Design to Classical Aesthetics and Expressive Aesthetics were significant to the 0.05 level (t=2.149 and t=2.484 respectively). Gender was not shown to have a significant effect on either Aesthetic construct.

The last measurement pertains to the ranking of the different website designs. Regardless of which website a participant was first exposed to, the ranking was not significantly affected. Rankings were significantly different (one-sample T-test) suggesting a preference for "blues" or the cold-cold color design (see Table 3).

DISCUSSION

The findings of the present study support and extend prior research regarding the effect of color combinations on aesthetics (Brady and Philips, 2003; Papachristos

Table 2. Validity test results

ITEMS	**Classical Aesthetics**	**Expressive Aesthetics**
Clean	**0.590**	-0.036
Aesthetic	**0.887**	0.025
Pleasant	**0.914**	-0.003
Original	-0.026	**0.834**
Sophisticated	0.094	**0.829**
Fascinating	0.010	**0.875**
Creative	-0.029	**0.857**
Uses special effects	-0.081	**0.738**
CORRELATIONS		
Classical Aesthetics	1	
Expressive Aesthetics	0.629	1
Internal Consistency	0.976	0.995
AVE - Convergent Validity	0.932	0.974
Discriminant Validity	0.966	0.987

Table 1. Item and construct statistics

	Mean	**Std. Dev**	**Loading**	**Error**	**Item-Total Correlation**	**Alpha**	**Alpha if Item deleted**
Classical Aesthetics	5.490	1.403				0.731	0.726
Clean	5.880	1.076	0.590	0.060	0.350		0.852
Aesthetic	5.200	1.308	0.887	0.043	0.625		0.555
Pleasant	5.380	1.157	0.914	0.041	0.729		
Expressive Aesthetics	3.082	2.003				0.885	0.885
Original	3.180	1.451	0.834	0.018	0.731		0.858
Sophisticated	3.830	1.490	0.829	0.020	0.698		0.866
Fascinating	2.850	1.393	0.875	0.017	0.789		0.844
Creative	3.200	1.422	0.857	0.018	0.771		0.848
Uses special effects	2.34	1.315	0.738	0.020	0.625		0.881

Table 3. Site rankings and one-sample comparison of means

Site Design Primary-Secondary	N	Mean	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
Warm-Warm	130	3.35	1.041	0.091	36.74308	129	3.42268E-70
Warm-Cold	130	2.62	0.848	0.074	35.16415	129	5.93432E-68
Cold-Warm	130	2.41	0.912	0.08	30.08714	129	3.66714E-60
Cold-Cold	130	1.68	0.998	0.088	19.16219	129	1.49208E-39

et al., 2005). The triadic color schemes that utilized a cold primary color (blue) for the top or global part of the page and then used either another cold color (medium blue) or a warm color (orange) for the secondary page components provided the balance that users found most aesthetically pleasing. In contrast, the site that combined both a warm primary color (red) and a warm secondary color (orange) was the least preferred site, likely because the color pairing did not balance out the rest of the page. Additionally, research has shown that the cool blue color schemes are associated with higher perceived credibility and trust levels, which would be important for a travel booking website (Fogg et. al, 2001; Lee & See, 2004; Zhang & Li, 2005). The current results suggest that designers need to carefully consider color choice as the combinations will convey information about the quality of the site that may not be intended.

While other research has found gender effects in several computer-related contexts (Cyr & Bonanni, 2005; Simon, 2001), the current study did not indicate that gender impacted perceived website attractiveness. However, the small sample size may have been a factor, and the effect may be revealed as more responses are obtained. Similarly, women tend to employ more exhaustive information processing strategies than men do, which means that gender differences may have been masked by the lack of detailed content in the prototype website; the content was not as extensive as users expected from a travel website. We plan to expand and hone the website content to create a more realistic level of detail on each page, as well as having more content pages, which would enable users to better assess perceived usability within the context of the multiple color schemes. Additionally, future research efforts will seek to broaden the focus to assess the influence of culture on perceived website attractiveness and usability through a global multi-country study.

REFERENCES

Brady, L. and Phillips, C. (2003). Aesthetics and usability: A look at color and balance. *Usability News, 5.1. http://psychology.wichita.edu/surl/usabilitynews/51/aesthetics.htm*

Cyr, D., and Bonanni, C. (2005). Gender and website design in e-business. *International Journal of Electronic Business*, *3*(6), 565–582.

Fogg, B. J., Marshall, J., Laraki, O., Osipovich, A., Varma, C., Fang, N., Paul, J., Rangnenkar, A., Shon, J., Swani, P., and Treinen, M. (2001). What makes web sties credible? A report on a large quantitative study. SIGCHI'01, 3(1), 61-68.

Heijden, H.v.d. (2003). Factors influencing the usage of websites: The case of a generic portal in the Netherlands. Information and Management, 40, 6.

Lavie, T. and Tractinsky, N. (2004). Assessing Dimensions of Perceived Visual Aesthetics of Web Sites. International Journal of Human-Computer Studies, 60(3), 269-298.

Lee, J. D., and See, K. A. (2004). Trust in automation: Designing for appropriate reliance, *Human Factors*, 46(1).

Mitra, A., Willyard, J., Platt, C., and Parsons, M. (2005). Exploring web usage and selection criteria among male and female students. *Journal of Computer-Mediated Communication, 10*(3), article 10. http://jcmc.indiana.edu/vol10/issue3/mitra.html

Nielsen, J. (2005). One billion Internet users. *Jakob Nielsen's Alertbox,* December 19, 2005. http://www.useit.com/alertbox/internet_growth.html

Papachristos, E., Tselios, N., and Avouris, N. (2005). Inferring relations between color and emotional dimensions of a Web site using Bayesian Networks. *Proceedings of Interact 2005*.

Seethamraju, R. (2005). Relative importance of Web quality dimensions. *Proceedings of AMCIS 2005*.

Simon, S. (2001, Winter). The impact of culture and gender on Web sites: An empirical study. *The DATA BASE for Advances in Information Systems*, *32*(1), 18-37.

Zhang, P. and Li, N. (2005). The importance of affective quality. *Communications of the ACM, 48, 9*, September 2005, 105-108.

Virtual Learning Evaluation for the Development of Core Competences in Integrated Management of the Chemical Industry

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INTRODUCTION AND OBJECTIVE

The challenge of the companies to get economy of large scale production has taken the integration and development with the companies that follow the productive supply chain by means of management and technological innovation.

The integration of the productive supply chain is an important conquest for a competitive differential. This integration will be able to happen of diverse forms, since the upright of the activities, how to the acquisition of companies throughout the even though competing supply chain, or still, alliances and partnerships with customers and suppliers.

So that this possible integration either, the best experience and dissemination practical accumulated throughout the time are necessary, for the accomplishment of the critical processes, either by means of knowledge of its collaborators either by means of explicit organizational learning.

The advances of the technological innovation and the models of management have allowed successive profits in the productivity of the companies through reductions of costs and improvement of performance of the processes, products and services offered for its force of work.

This search of alternatives leaves to have an isolated focus and starts to have a vision extended of all the productive supply chain by means of resources renewed. The productive supply chain of the petrochemical sector exactly represents a significant parcel of the Brazilian internal production with 23,1% of the BIP (Brazilian Internal Production), producing raw material for other productive sectors, as for example, automobile, electro-electronic, packing and the textile sector, having that to face diverse factors that increase the production costs and hinder one better performance of the productive supply chain.

Amongst the factors that make it difficult the improvement of the productive supply chain could be: the sprayed productive structure, not existing supplements integrated, distant supply chain of the polar regions of production and the biggest consuming markets, the bad quality of the logistic infrastructure, high tax burden, high raw material costs, high capital costs and of the energy used in the sector, raising the production costs (NAKANO, 2006).

Although the essential importance of this productive supply chain, this one has a critical disadvantage that is the dependence of source non-sustainable. In this direction, it is each more frequently the resources of renewable fuels sources.

As alternative for this study, the sugar and alcohol productive supply chain was chosen, that inside represents an importance of the Brazilian potential, in special, for increasing attendance of the energy demand fuel. The challenge is in the generation of bigger combustible alcohol production to replace the gasoline, which is proceeding from the petrochemical sector (OLIVERIO, 2004).

Nevertheless, this productive chain can manufacture fuel from agricultural sources sustainable, as ethanol, which Brazil is world-wide the producing greater with the lowest cost of alcohol production from the sugar cane-of-sugar. To illustrate this competitive advantage, for example, in terms of costs, one liter of ethanol manufactured from the sugar cane costs $ 33 cents against $ 43 cents equivalent made of corn.

The alcohol production in Brazil was of approximately 16 billion liters in 2005, counting on 335 plants and the estimate is of 36.8 billion liters for 2015, being that more 89 plants are currently in project or construction, conducted for operation in 2012, representing an investment of 12 million dollar. Another important factor is that almost whole 335 plants in the country generate the proper energy from the burning of the residue of the proper consumed sugar cane, generating 1.642 megawatts (MW) of electricity from agricultural source sustainable, enough to supply an area with 3.2 million inhabitants, equivalent to the population of Uruguay, generating except for sales (VEJA MAGAZINE, 2006).

This work has the objective to understand the advances of the technological innovation and its impacts in the management of the inserted companies in the sugar and alcohol productive supply chain evaluating the essential abilities for improvement of its competitiveness in the market.

METHOD AND RESULTS EXPECTED

In this study it will be used a specific software for survey and management of the competences, the e-HCDM software, in a virtual learning, the TelEduc, as facilitator of the evaluation process and development of the essential competences. The chosen environment was the TelEduc, environment for distance education, developed for the Nucleus of Computer Science Applied to Education (NIED) of the State University of Campinas. This software is of public domain, being able to be redistributed and/or to be modified under the terms of General GNU Public License version 2 (Free Foundation Software).

For the survey of the data the models of management as ROSS (1997) that it contains four periods of training of management of the productive chain and the classification of the abilities (business, technician-professional and social).

The competences found will be classified as ZARIFIAN methodology (1999) *apud* FLEURY and FLEURY (2001) in abilities of the business, in which will have the strategic vision of the organization inserted in its strategic planning.

Employees must have to know about the external and internal environment for identification of the chances and threats. In this context, they have the knowledge of corporative values and objectives as well as its planning adjusted for the necessary changes.

The technique-professional abilities must have to the specific knowledge in the business core area for the performance in the activities inherent.

The social abilities involve abilities to communicate, negotiation and work in a team which its will allow that the organization can express and transmit ideas and direction with synergy for the employees get the corporative objectives.

For the accomplishment of the competences survey, the e-H-CDM software in the TelEduc will be carried through a diagnosis in the critical processes for evaluation front to the competences, relating the abilities necessary for the development. The competences will be compared with a model of competitive performance of the companies in the productive supply chains and would be to frontier for the learning development of core competences management.

Table 1. Diagnosis of the performance of productive supply chain

Diagnoses	Productive Supply Chain Sugar and Alcohol
Organizational Model	Not yet structuralized; few special companies in this market, functioning as buffer for companies that act in other chains
Requirements of competitiveness of the productive supply chain	Knowledge about the market, design, quality, price, gradual increase of importance of the innovation.
Critical factors of successes of the companies	Technological qualification, qualification for negotiation, prospecting of markets, development of products/systems, fast engineering of processes, answers to the market and search of information to make possible production

Table 2. Core competences for the productive supply chain

Core competences	**Objetive:** Increase of the capacity of sugar cane processing
business	management of the performance of the manufacture processes
Technician-professional	equipment development and engineering of processes
Social	multifunctional, work team and collaborative

An example of the application is shown in the Tables 1 and 2 where the diagnosis of the performance competitive and the essential abilities for the productive chain according to FLEURY and FLEURY (2001).

The analysis of this survey company it will be able to reach its corporative objectives, elaborating a plan for the development and acquisition of abilities improving performance and competitive advantages.

THE FINAL CONSIDERATIONS

The evaluation of the essential abilities of a company by means of a virtual environment of learning will allow, beyond a plan for the development of the abilities, to direct resources for to enrich of the company being considered its competitiveness. A time known to the deficiencies and the competitive advantages, the management front to the strong points of the company will have to be potential and of the neutralized weak points.

It can still, to be fortified and integrated other methods of management, in the search of competitive advantages. From this knowledge, a plan for the development of these abilities could be created, being visualized, of individual and systemic form, by means of reports and pointers in a repository of information for the management of the development of these abilities.

This repository of information will be available in the virtual environment of learning, which will facilitate the integrated management of the chosen productive chain, allowing the improvement of the demand forecast, reduction of costs of supplies and the productivity throughout the supply chain.

REFERENCES

FLEURY, A. & FLEURY, M. T. L.(2001). Enterprise strategies and competences formation - a puzzle of the Brazilian industry; São Paulo: Atlas.

NAKANO, D.(2007). Study of petrochemical sector – final report; FINEP, Retrieved January 6, 2007 from http://www.finep.gov.br/PortalDPP.

OLIVERIO, J. L. (2004). Sugar and Alcohol / Industrial goods – The technological evolution in the vision of the equipment industry, Brazil: Leaders Fórum, 7 (11), 16-18.

VEJA MAGAZINE. (2006, December 20), Energy, São Paulo: Ed. Abril, 39 (50), 165-170.

ROSS, D. F.(1997). Competing through supply chain management: creating market – winning strategies through supply chain partnerships; The Chapman & Hall materials management/logistics series.

ZARIFIAN, P.(2001). Objectif compétence; Paris: Liaisons, 1999 apud FLEURY, A & FLEURY, M. T. L.; Enterprise strategies and competences formation - a puzzle of the Brazilian industry; São Paulo: Atlas.

Virtual Negotiations: Intended and Unintended Interactions with Incentive Schemes

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ABSTRACT

Despite a substantial literature concerning the impact of computer-mediated communication (CMC) on decision-making, the potential interaction with an organization's management control system has received little attention. In this study, we use social presence, media richness and media naturalness theories to develop hypotheses concerning the interactions of communication medium with the incentive schemes, a ubiquitous aspect of management control systems. Hypotheses concerning the intended interaction of increased profit and unintended interaction of reduced cooperation will be presented. The results of a laboratory experiment examining the effects of using face-to-face negotiations versus virtual negotiations where buyer-seller dyads determine the price and quantity of transferred goods will be presented. Preliminary results indicate that there is a significant interaction between communication medium and incentive scheme on the measured outcomes.

Keywords: Computer-mediated communication, virtual negotiations, transfer pricing.

OVERVIEW

New communication technologies are offering options that are impacting many aspects of intra-organizational communication. As organizations rely more heavily on virtual interactions, it is important to more fully understand the interactions between virtual communication and the management control system. The purpose of this study is to compare the outcomes of face-to-face negotiations with the outcomes of computer-mediated communication (virtual) negotiations in an intra-organizational transfer pricing scenario.

TRANSFER PRICING

Transfer pricing negotiations for the price and quantity of an intermediate good are a particularly interesting form of negotiation because they contain aspects from both ends of this spectrum. The larger the **quantity** of goods transferred, the larger the profit to be divided between divisions. This aspect could lead to cooperative behavior from the negotiators. But the transfer **price** determines the portion of the profit that goes to each division, which could lead to competitive behavior. Organizations have a stake in the quantity transferred since it determines the profit to the organization. Negotiators have a stake in both the quantity (larger pie to be divided) and the price (size of the slice). Therefore, negotiated transfer pricing is considered to be a mixed-motive situation.

COMPUTER-MEDIATED COMMUNICATION

The computer-mediated communication literature draws on theories that are concerned with social aspects of communication, e.g., social influence (Fulk, et al., 1990), on theories that are concerned with technology, e.g., task-technology fit (Zigurs and Buckland, 1998), and on theories that integrate both aspects, e.g. media naturalness (Kock, 2004, 2005). Social presence theory (Short et al., 1976) predicts that communication is more effective when the medium has the appropriate level of social presence for the level of interpersonal involvement necessary for the task. Media richness theory (Daft and Lengel, 1986), which extends social presence theory, classifies communication media according to its ability to convey nonverbal cues, immediate feedback, personality traits, and natural language. Under media richness theory, the criterion for matching the media to the collaborative task is based on the need to reduce uncertainty. Face-to-face communication is the richest medium. Most intranet- and internet-based media are near the other end of the spectrum and are classified as lean. These theories emphasize using the appropriate medium for the task at hand.

The media naturalness theory (Kock, 2004) proposes that there is a negative causal link between the "naturalness" of a computer-mediated communication medium, which is the similarity of the medium to the face-to-face medium, and the cognitive effort required for an individual using the medium for knowledge transfer. This theory is integrative in that it encompasses previous theories, and it examines the *reasons* why face-to-face and CMC can lead to different outcomes. The task is an aspect of this theory, but the focus is on the cognitive effort required by the difference between 'natural' medium (face to face) and lean CMC mediums.

INCENTIVES

Cooperation and competition can refer to the interdependence between goals. In cooperative situations, the achievement of one person's goals is positively related to the achievement of another person's goals (one person's movement toward their goal facilitates the other person's movement towards their goal). In competitive situations, the achievement of one person's goals is negatively related to the achievement of another person's goals (one person's movement toward their goal interferes with the other person's movement towards their goal). Perceived interdependence of goals can affect group productivity and problem solving ability. One way to create cooperative or competitive situations is through the incentive scheme. Ferrin and Dirks (2003) found competitive versus cooperative reward structures influence actions (e.g., information sharing) and perceptions (e.g., perceived motives and perceived performance of others). Negotiation situations are of special interest because they can vary in the same manner as incentive schemes, from cooperative (win-win, also called integrative) to competitive (win-lose).

HYPOTHESES

Our hypotheses are concerned with the interaction of communication medium with the incentive scheme. Three outcomes are measured and tested, organizational profit, efficiency of the negotiations, and the negotiators' attitudes.

PRELIMINARY RESULTS

Preliminary results indicate that there is a significant interaction between communication medium and incentive scheme on the measured outcomes.

REFERENCES

Daft, R. L., and R. H. Lengel. 1984. Information richness: A new approach to managerial behavior and organization design. Research in Organizational Behavior 6: 191-233.

Daft, R. L., and R. H. Lengel. 1986. Organizational information requirements, media richness and structural design. Management Science 32: 554-571.

Deutsch, M. A. 1949a. A theory of cooperation and competition. Human Relations 2: 129-151.

Ferrin, D. L., & Dirks, K. T. (2003). The use of rewards to increase and decrease trust: Mediating processes and differential effects. *Organization Science,* 14 (1), 18-31.

Kock, N. (2004).The psychobiological model: Towards a new theory of computer-mediate communication based on Darwinian evolution. *Organization Science,* **15**(3), 327-348.

Short, J., Williams, E., & Christie, B., (1976). *The Social Psychology of Telecommunications,* London, England: John Wiley.

Project Portfolio Management: An Analysis in the Brazilian Market

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ABSTRACT

The definition of portfolio for project management states that portfolio is a collection of projects and or program and other work that are grouped together to facility the effective management of that work to meet strategic business objectives (PMI, 2006). It is necessary to select the right projects to be conducted; otherwise too much effort and money will be invested in wrong projects. The main objective of this paper is to analyze the theory of portfolio management for projects and check its applications in the Brazilian market. Three companies in the Brazilian market were studied, an international bank, a Brazilian public company in the transportation market and a multinational electric manufacturer.

INTRODUCTION

The modern portfolio theory was first described by the Nobel Prize in economics Harry Markowitz in 1952. In brief, it describes how, for a given risk level, there is a specific mix of investments that will achieve an optimal return (LEVINE, 2005). Portfolio management is formally defined as a dynamic decision process, whereby a business list of active new product (and development) projects is constantly updated and revised (COOPER et al., 1997). In this process, new projects are evaluated, selected, and prioritized; existing projects may be accelerated, killed, or reprioritized; and resources are allocated and reallocated to active projects.

The portfolio concept applied to projects comes from economics and management. Some research has been developed in the last years about project portfolio, as the integrated framework for project portfolio selection proposed by Archer & Ghasemzadeh (1999) that states that the task of selecting project portfolios is an important and recurring activity in many organizations and proposes a framework that may be implemented in the form of a decision support system and a prototype system to support the decision making activities.

Portfolio for project management is a collection of projects and/or program and other work that are grouped together to be managed in an easily manner. Morris and Jamieson (2004) arguments that project and program management are widely used as a means of implementing corporate and business strategy and that strategies should be aligned and moved from the corporate level through portfolios, programs and projects in a systematic and hierarchical manner.

The main objective of this paper is to analyze the theory of portfolio management for projects and check its applications in the Brazilian market. The research is basically structured in two parts: project and portfolio management theory and practical application of portfolio management including three case studies.

PROJECT MANAGEMENT

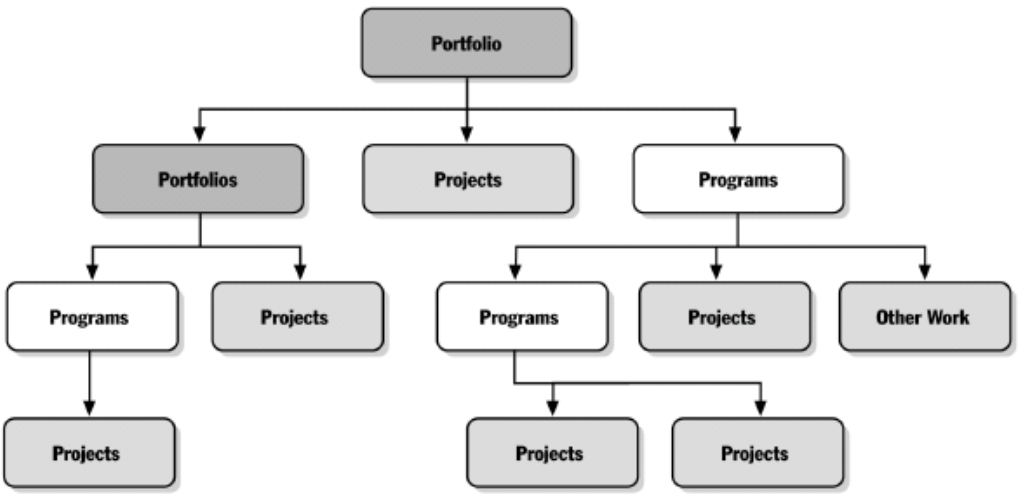
The project management was developed as a leadership concept of interdisciplinary activities with the objective to solve a temporary problem. This characteristic permits the project management to reach a high degree of innovation in the presented solutions to more complex's works (LITKE, 1995).

In the most significant areas of application, new products and services are created through projects, what could be demonstrated by the increasing number of companies that are adopting the project management methodology (KERZNER, 2001).

According to the PMI (2004) a project could be defined as a temporary endeavour to create a unique product or service and project management could be defined as the art of coordinating activities with the objective to reach the stakeholders expectations.

Rabechini Jr and Carvalho (2003) argue that in all the project definitions it is possible to realize two intrinsic concepts: temporality and uniqueness. The temporality

Figure 1. Portfolio and its components (PMI, 2006)



means that all projects have a well-defined beginning and end. The uniqueness or singularity means that the product or service created by a project is different from all the others already made.

PORTFOLIO MANAGEMENT

The portfolio concept applied to projects comes from economics and management. But just recently a standard was properly defined for project management. The definition of portfolio for project management states that portfolio is a collection of projects and/or program and other work that are grouped together to facility the effective management of that work to meet strategic business objectives (PMI, 2006). In the same way, PMI (2006) defines portfolio management for projects as the centralized management of one or more portfolios, which includes identifying, prioritizing, authorizing, managing, and controlling projects, programs, and other related work, to achieve specific strategic business objectives.

Figure 2. Portfolio process (PMI, 2006)

The Figure 1 presents an example of a portfolio and its components.

All of the components of a portfolio present some common characteristics:

- They are investments made or planned by an organization;
- They are aligned with the goals and strategic objectives of the organizations;
- Typically they present some specific characteristics that allows an organization group them in order to a more effective management;
- The components of a portfolio are quantifiable, that means, they can be measured, ranked and prioritized.

The portfolio should also be aligned with the strategy of the company. It should be the way the strategy is implemented by the company. It components must come from the strategic objectives and goals of the company. The output of the portfolio must increase the project and program activities authorized by the company. This process is presented in the Figure 2.

PMI (2006) also presents the phases of the portfolio management. They are organized in two groups:

1. Aligning Process Group:
   - Identification;
   - Categorization;
   - Evaluation;
   - Selection;
   - Prioritization;
   - Portfolio Balancing;
   - Authorization.
2. Monitoring & Controlling Process Group:
   - Portfolio Review and Reporting;
   - Strategic change.

Figure 3 presents the phases of the portfolio management.

There are lots of tools that the theory presents to evaluate and manage the portfolio. One of the most used is the bubble chart. The Figure 5 presents one example.

BRAZILIAN PROJECT MARKET

The Brazilian market for projects could be defined as a big one, considering the number of big projects in the ongoing phase and the value of each one, and all of

Figure 3. Detailed phases of the portfolio process (PMI, 2006)

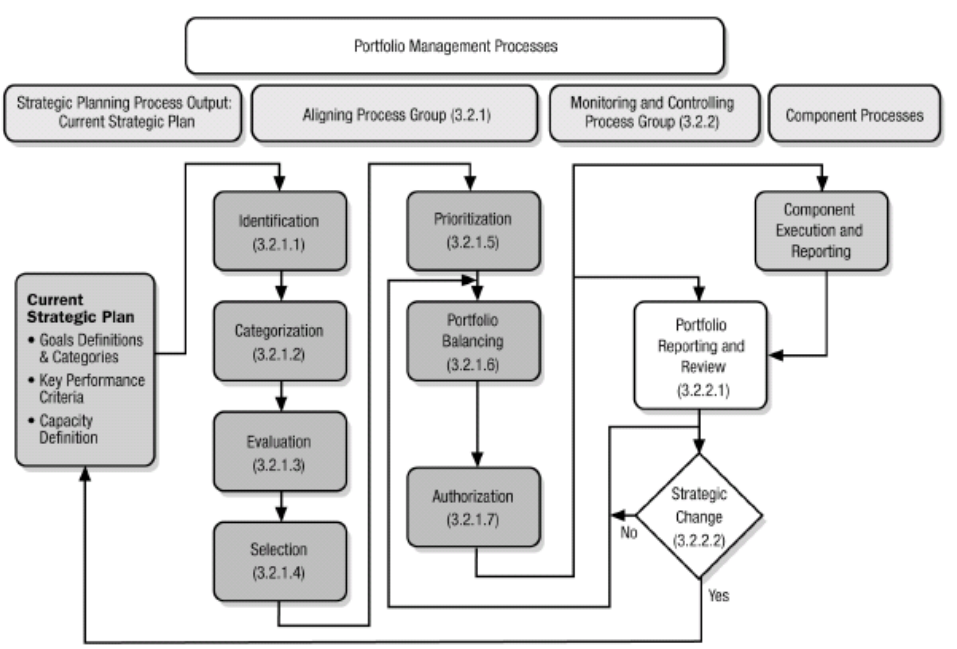


Figure 4. Bubble chart (PMI, 2006)

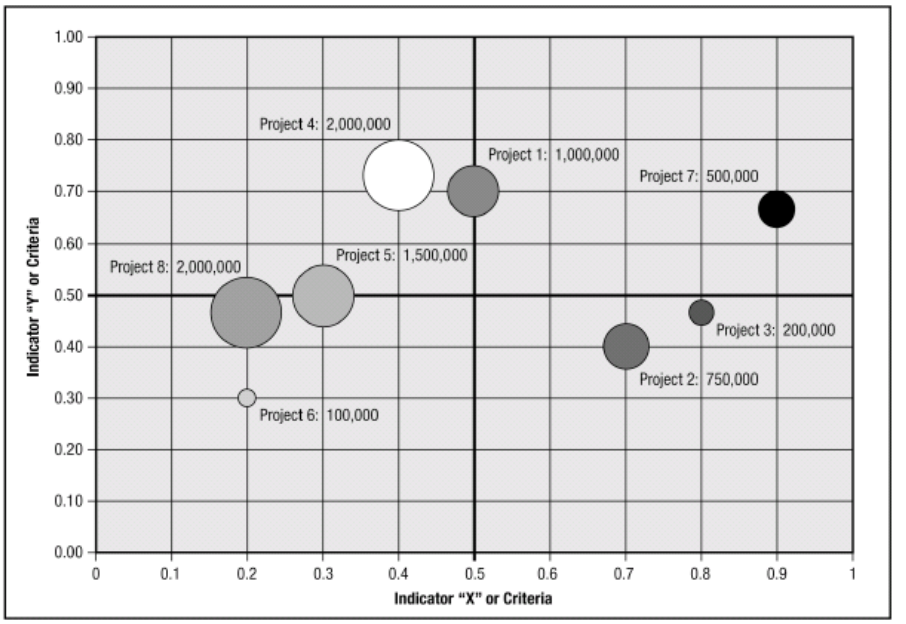


Table 1. Brazilian project market (EXAME, 2005 and EXAME, 2006)

	2005	2006
Total Number of Projects	403	707
Total Value of Projects (millions of US$)	83,574	99,600
Avarege Value of Projects (millions of US$)	207	141

Table 2. Tool for evaluation of projects from a bank

Criteria	Project 1	Project 2
	Grade	Grade
Revenue	5	2
Cost	5	5
Importance	2	1
Final Results	12	8

them. The market is also increasing. In the last year, the total value of the projects increased in 19%, from US$ 83.6 billion to US$ 99.6 billion, as presented in the table below.

The data presented below represent the following economy sectors:

- Energy;
- Oil and gas;
- Water;
- Telephone;
- Transportation.

METHODOLOGY

For the analysis of the practical application of portfolio management, three case studies were selected. For the cases studies, three companies in the Brazilian market were studied, an international bank, a Brazilian public company in the transportation market and a multinational electric manufacturer. The cases were selected to compound a multi-varied scenario were the portfolio management could be evaluated.

CASE STUDIES

International Bank

The analyzed bank has more than 170 years and started its operations in Brazil in the beginning of the last century. The main area that uses project management in the bank is the information technology. This area owns 95% of the projects of the bank.

The method used to select the projects for the portfolio of this company is based in spreadsheets with three defined criteria: revenue to be obtained after the implementation of the project, cost of the project and strategic importance. For each criteria there is a grade related to some specific values defined by the top management. Table 2 presents a simple example of two projects evaluation.

Brazilian Public Company in the Transportation Market

The public transportation company analyzed in this study works simultaneously in three metropolitan regions, which includes 67 cities and a population of 23 millions of inhabitants. It attends 1.5 millions of passengers per day.

It portfolio includes 12 projects and totalize US$ 383 millions. The tool used by the company to select the projects and control the portfolio is the bubble chart as presented in the Figure 5.

Multinational Electric Manufacturer

The electric manufacturer is a Europe based company, with more than 150 years, with 400,000 workers, placed in almost 200 countries. The company produces and installs a great variety of electrical and electronic equipments, in the great majority delivered to customers through specific projects adapted to the necessities of each one. The products innovation tax is extremely high and the products actually sold were developed maximal three years ago. Basically the company sells customized solutions to their customers.

Figure 5. Portfolio of a public transportation company

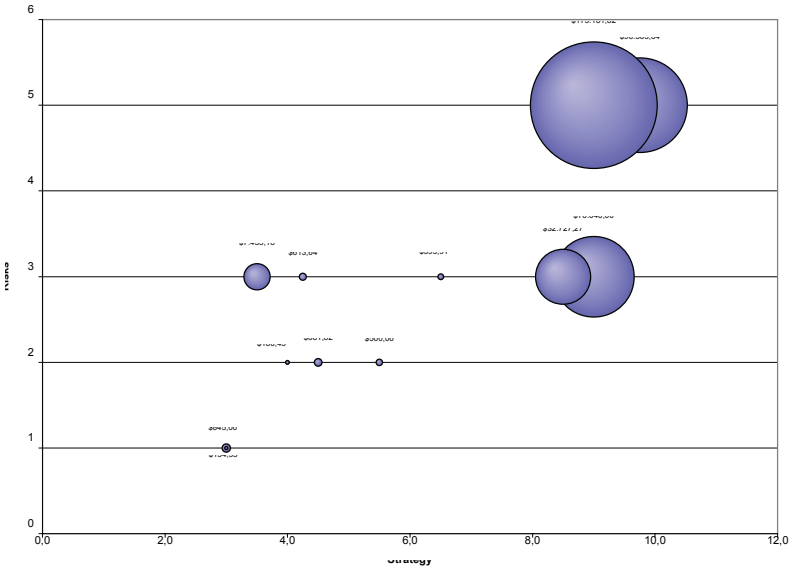
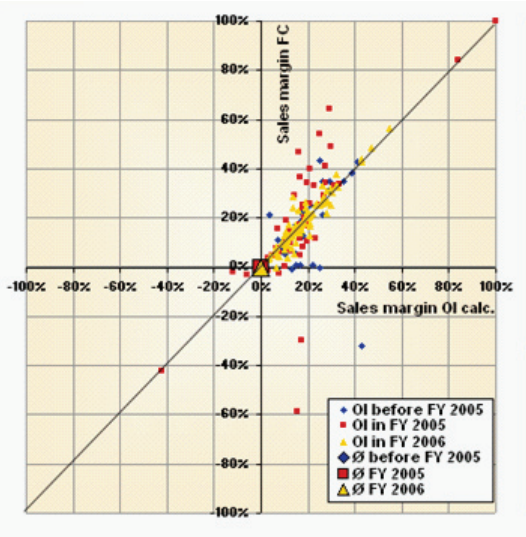


Figure 6. Portfolio of an electric manufacturer



In Brazil more than 50% of its gross sales are managed as projects. In the fiscal year of 2005/2006 this represents almost US$ 1.2 billion. This demonstrates the importance of a good project management for this company. The tool used by the company relates the margin of the projects in the beginning of them and the margin in the closing of the project. This information is crossed in a graph as presented in the Figure 6, where the 220 major projects of the company are placed.

CONCLUSIONS

The conclusions obtained from this study could be grouped in two sections: adoption of portfolio management and tools used by the companies.

- The companies realized the importance of the portfolio management for projects and programs and are starting initiatives in order to implement methodologies to administrate the portfolio;
- There is not a standard tool used by the companies and the tools used by them are made inside the companies and not developed by a specific software provider.

Although the companies in Brazil are realizing the importance of portfolio management in the management of their business, there is some room of improvement for them in the portfolio management topic, for example, the selection methods are not as objective and systematic as presented in the theory.

The great challenge for the companies in general is to do more, better and faster, always with less. To achieve these objectives, the companies must be able to measure what they do, and how well they do. And it is here that portfolio management could help the companies.

BIBLIOGRAPHY

Archer, N. P.; Ghasemzadeh, F. An integrated framework for project portfolio selection. International Journal of Project Management Vol. 17, No. 4, pp. 207-216, 1999.

Cooper, R. G., Edgett, S. J. & Kleinschmidt, E. J. R&D Portfolio Management Best Practices Study, Industrial Research Institute, Washington D. C.: Industrial Research Institute, 1997.

Exame. Anuário de Infra-Estrutura 2004-2005. São Paulo: Abril, 2005.

Exame. Anuário de Infra-Estrutura 2006-2007. São Paulo: Abril, 2006.

Kerzner, H. Project Management – A Systems Approach to Planning, Scheduling, and Controlling. Nova York: John Wiley & Sons, 2001.

Levine, H. A. Project Portfolio Management. San Francisco: John Wiley & Sons, 2005.

Litke, H.D. Projekt-management: Methoden, Techniken, Verhaltensweisen. München und Wien: Carl Hansen: 1995.

Morris, P.W.G. and Jamieson, H.A. Translating Corporate Strategy into Project Strategy, 2004.

PMI, PROJECT MANAGEMENT INSTITUTE. A Guide to the Project Management Body of Knowledge (PMBok). Four Campus Boulevard, Newton Square: Project Management Institute, 2004.

PMI, Project Management Institute. The Standard of Portfolio Management. Four Campus Boulevard, Newton Square: Project Management Institute, 2006.

Rabechini, R. J. & Carvalho, M. M. Perfil das Competências em Equipes de Projetos. RAE-Eletrônica, vol. 2, n. 1, São Paulo. FGV, 2003.

Adaptive E-Learning Using METOD

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ABSTRACT
MetaTool for educational platform design (METOD) is a general computer supported educational development paradigm comprising special framework and flexible tools combined in MetaTool that enables even non-skilled ICT users to develop or adapt educational platforms that suit their needs. In METOD several learning theories and contemporary intelligent system design are integrated to introduce innovative educational methods and to improve the quality and accessibility of training and educational processes.

Keywords: *e-learning, adaptive learning*

1. INTRODUCTION
The rapid advancement in ICT enabled the development of computer supported educational platforms (CSET) which can improve the quality, user friendliness and accessibility of training, education and lifelong learning. Computer supported platforms are the basis for supporting or even developing new innovative types of learning, like problem based learning and evidence based learning [1].

However, literature overview and recent research results and results of some pre-studies [2, 3, 4] have shown that there are various disadvantages of current CSETs,: (i) that after the novelty effect of drill and practice wears off the motivational power is lost, (ii) the platforms are static - the educators or trainees can not adapt them to specific environments (e.g. people with special needs), changed educational requirements, new educational programmes and (iii) normally the educators or trainees can not develop such platforms by themselves.

We identified increasing demand for open and all-accessible training and learning and the need for prospective platforms enabling teachers, trainers, educators and even parents to build their own ICT educational platforms without ICT development and design knowledge. These initiatives led to the development of a special paradigm and development framework – MetaTool for Educational platform Design (METOD) within the Leonardo da Vinci Programme[5].

2. THE METOD PARADIGM AND METATOOL
The METOD paradigm is a collection of theoretical and practical findings and the repository of: various training environments, description of trainees' characteristics, possible pedagogical goals, different pedagogical and communication strategies and learning materials (implemented in MetaTool). It comprises numerous learning theories like adaptive learning, adaptive testing, and item response theory and contemporary intelligent system design [6]. The METOD paradigm concepts are implemented in MetaTool and specialized plug-in for learning management system.

MetaTool enables professional and non-professional educators (parents and other family members) to create e-learning platforms which can be imported into METOD-compatible viewer, e.g. Moodle [7], an open source content learning management system (CMS). After importing e-learning platform student can access materials and exercises of available courses. Each student has a different learning path, which is a sequence of materials and exercises that are displayed. The learning path is defined by student type and learning style of the student and it is adapted to if student type or learning style changes.

3. METOD EVALUATION
The evaluation for e-learning is very important. It includes user evaluation, which is divided into evaluation of the instruction and learning environment and evaluation of learning materials, and the evaluation from the developers of e-learning materials which includes evaluation of the instruction and learning environment. Several evaluation studies have been performed in order to get a real feedback about MetaTool and it's applicability in practice.

3.1 Test Site Evaluation Study: Faculty of Electrical Engineering and Computer Science)
The first testing of the users (trainees) response to the e-learning with Metod enhanced Moodle was performed on Faculty of Electrical Engineering and Computer Science, University of Maribor. E-materials for studying Checkland's soft system approach were prepared. The materials were imported in ordinary Moodle. The same materials were also imported in MetaTool and a Metod project was created. The Metod project was imported into Metod enhanced Moodle. From this small experiment we can conclude that e-learning with Metod enhancements in Moodle contributes to the learning ability but the results would be probably better when blended learning would be used.

3.2 Test Site Evaluation: University College of Nursing Studies
The efficiency of learning with e-learning materials can be tested when prior-knowledge and the knowledge after taking an e-learning course are compared. The difference in successfulness of solving pre-exam and post-exam shows the gain in trainee's knowledge.

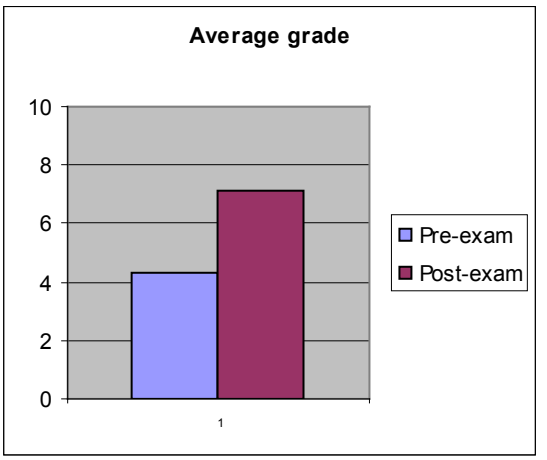
In this study students were using the e-learning materials created with MetaTool during classroom lectures. Before taking an e-learning course in Metod enhanced Moodle they performed a pre-test for evaluating their prior-knowledge. After learning they performed a post-test to establish how much they learned with e-course. The results showed that e-learning was successful.

3.3 Test Site Evaluation: E-Course on Learning Computer Skills
In this study students were using Moodle platform with Metod extensions. E-learning materials for learning basic computer skills were created with MetaTool. The following content was covered: Information Network Services, Basic Concepts of IT, Using a Computer and Managing Files and Word Processing.

The people with special need were also included. The e-learning materials were adapted for them in the following way: (i) the e-learning materials for heard of hearing people and deaf included video with the interpreter and (ii) weak-sighted people had the possibility to use software magnifiers. We tested the efficiency of learning and the trainees satisfaction with e-learning materials and platform.

3.4 Pilot Sites Evaluation
Pilot sites were included in the project with the purpose of testing the MetaTool. The teachers in the schools that were included as pilot sites prepared e-learning materials using MetaTool and they used the materials with their students in their classes. The studies showed that the creation of e-courses with MetaTool is not too demanding. The course creators were satisfied with the help from import and export wizards; however some minor flaws had to be fixed.

Graph 1. The results of test site evaluation at the School of Nursing



The trainees found learning with e-courses very interesting. Their response to e-courses and platform was mostly positive. However, we have to aware that e-learning is not suitable for everyone. The Metod enhanced platform was also tested with people with special needs. The survey results show that deaf and heard of hearing people learned a lot in adapted e-courses. They were satisfied with the courses but since their prior knowledge was generally lower compared to other trainees, they had to spend more time for learning how to manage the course.

4. RESULTS

Because of the space limit we can not present all the results so we will describe only the results for Evaluation study no. 2: Test site evaluation: University College of Nursing Studies.

Fifty-three students at the University College of Nursing Studies were involved into the study. As we mentioned above, the pre-exam and post-exam method was used to evaluate their knowledge. The results showed that e-learning was successful since the average gain in student performance was 27.9% (Graph 1).

At the end of course the students filed out the questionnaire for evaluation of e-course and e-materials. The results are presented below:

- **Question 1**: What is your learning style [8]?
  Most of the students (50%) involved in the survey think that they learn most through seeing. Others learn most with listening (30%) or if they are actively integrated in the process of learning (20%).
- **Question 2**: Were the materials in the course well adapted to your learning style?
  Most of the students have the opinion that their learning style is well represented in learning materials (around 90%).
- **Question 3**: Are you satisfied with the comprehensibility of the text in e-learning materials?
  Most of the students think that the text in e-learning materials is simple and understandable (around 80%).
- **Question 4**: Are you satisfied with the number of practical examples in e-learning materials?
  All except one of the students think that e-learning materials include enough practical examples.
- **Question 5**: Are you satisfied with the number of visual materials?
  E-learning materials should include more visual materials by the opinion of most of the students (55%). Others think that there was sufficient number of visual materials.
- **Question 6**: Are you fond of e-learning and would you like to try it again?
  The analysis showed that more than 50% of students were fond of e-learning and would like to try it again.

From the results of the questionnaire we can conclude that students were generally satisfied with e-course and that all learning styles and learning types were well represented in e-course. The Metod enhancements were well accepted by students.

5. DISCUSSION AND CONCLUSION

Several evaluation studies have been performed in order to get a real feedback about MetaTool and it's applicability in practice. The studies showed that the creation of e-courses with MetaTool is not too demanding. The course creators were satisfied with the help from import and export wizards; however some minor flaws had to be fixed. The trainees found learning with e-courses very interesting. Their response to e-courses and platform was mostly positive. However, we have to aware that e-learning is not suitable for everyone. The MetaTool and Metod enhanced Moodle proved to be very useful for trainees of different ages and also for trainees with special needs. However, the tool will be extended and updates (according to the practical needs) will be available on the project web page in the future.

REFERENCES

[1] Ellis, A., Carswell, L., Bernat, A., Deveaux, D., Frison, P., Meisalo, V., Meyer, J., Nulden, U., Rugelj, J., and Tarhio, J. (1998). Resources, tools, and techniques for problem based learning in computing. SIGCUE Outlook 26, 4 (Oct. 1998),p. 41-56.

[2] Kim, K., Bonk, C. J., and Zeng, T. (2005) Surveying the future of workplace e-learning: the rise of blending, interactivity, and authentic learning. eLearn 2005, 6 (Jun. 2005), 2.

[3] Zhang, D. Zhao, J. L., Zhou, L., Nunamaker Jr., J.F. (2004). Can e-learning replace classroom learning?, Communications of the ACM, Volume 47, Number 5 (2004), p. 75-79

[4] Bielanski, L. (2003). Blended eLearning. Amherst: HRD Press -deCorte, E. (Ed.). (2003). Powerful learning environments. Amsterdam: Pergamon Press. –Issing.

[5] Leonardo da Vinci Programme. Web address: http://www.leonardo.org.uk/

[6] Brusilovsky P., Maybury M. T. (2002): From adaptive hypermedia to the adaptive Web. In: Communications of the ACM, Vol. 45, Number 5 (2002), p. 30-33

[7] Moodle – course management system: http://moodle.org/

[8] Schmeck, R.P. (Ed.). (1988). Learning strategies and learning styles. New York: Plenum.

Performance and IT Implementation Effects of Process Innovation: Does IT Effect Exist?

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ABSTRACT

This study is to investigate the process of innovation capability effects on both technological innovation adoption and firm performance directly and examine the intermediate effect of technology implementation process model and its impact on firm performance.

1. INSTRUCTION

Senior managers have paid attention to focus on whether the process of innovation can directly influences firm performance and implements IT properly in organization. The innovation studies have studied the relationship between nature, type, and process of innovation in organization and its innovative adoption and performance effect. However, in spite of a variety of innovation researches have been carried on, this mainstream of innovation has been little research on the process of innovation capability how this method affects technological innovation (Benner and Tushman, 2002; Edmondson et al., 2001), in turn, whether the technological innovation leads firm performance (Garvin, 1995; Harrington and Mathers, 1997; Harry and Schroeder, 2000). The objective of this study is to investigate the process of innovation capability effects on both technological innovation adoption and firm performance directly and examine the intermediate effect of technology implementation process model and its impact on firm performance.

2. LITERATURE REVIEW

The Process of Innovation Capabilities

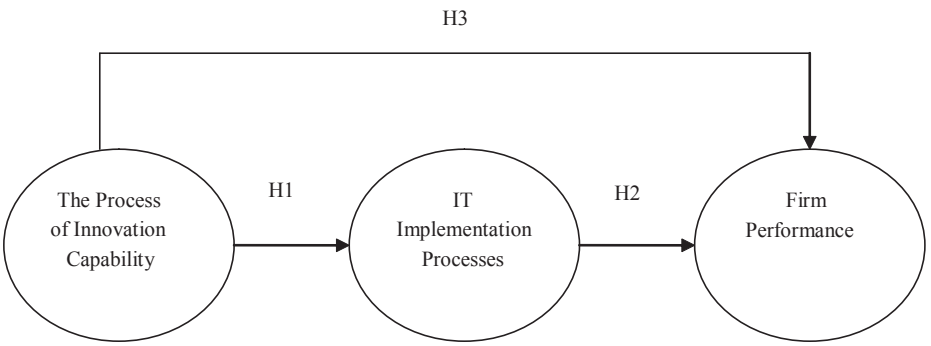
The process of innovation is occurred through fourth phases: idea generation, problem solving, response and implementation. (1) organization-wide generation of technical, product, process, and administrative kinds of innovative idea toward current and future organization need (Van de ven 1986). Ideas are generated by monitoring activities such as political, social, competitive and cultural elements that influence the needs and preference of its organization. (2) Organization-wide dissemination is the innovation into organizations by pushing and leading over time (Van de ven 1986). Rogers (1985) argues that an innovation mainly occurred through communication channels and messages through near peers, salespersons or advertising. Interfunctional coordination gives a chance to communicate or exchange regarding new idea. (3) Organization-wide responsiveness. Decision process can formulate positive attitude or negative attitude the innovation and lead directly a possible choice of adoption or rejection. (4) Organization-wide application actual usage, which means practically flow the innovation into physically implementation.

A Model of the IT Implementation Process

The IT implementation process is developed by Zmud and Apple (1989) and examined empirically by Cooper and Zmud (1990). The IT implementation process proceeds as follows:

- Initiation process: Search or scan problems or opportunities in organization and suggest IT solution. Initiate technology innovation from the organizational needs and wants.
- Adoption process: Implement IT application by political and rational negotiation entailing organizational support and assistance.
- Adaptation process: Developed, installed, test, and maintained the IT application. Revised organizational procedures and re-developed with the IT application. Then, train employees for the procedures and the IT application.
- Acceptance process: Employees accept the IT application and use it
- Routinization process: The IT application is used as a normal base.
- Infusion process: Organizational process effectiveness is achieved by the IT application usage.

Figure 1. Research model



3. RESEARCH MODEL AND HYPOTHSES

Based on the process of innovation theory, we suggest the process of innovation capability model shown in Figure 1.

Process of Innovation Capability and IT implementation Processes

The process of innovation capability helps firms to explore and recognize the significant of external innovation (Iansiti and Clark, 1994), subsequently, lead new technology adoption (Cohen and Levinthal, 1990; Edmondson et al., 2001). Several studies have found the positive relationship between innovation characteristics and implementation processes (Cooper and Zmud, 1990, Premkumar et al., 1994). Therefore, we assume that the process of innovation capability positively influences the IT implementation processes. Thus, we hypothesize as follow:

H1: The process of innovation capability will positively influence the IT implementation processes.

IT Implementation Processes and Firm Performance

Hitt and Brynjolfsson (1994) also found a mixed result of IT investment. Firm sales are positively related to the IT investment, whereas the total shareholder return, ROA, and ROE is not found any significance level. Controversially, Several studies have found that IT investments and firm profitability appear mixed results in IS literatures (Alpar and Kim, 1990; Barua et al., 1995; Bharadwaj et al., 1999, Cron and Sobol, 1983, Weill, 1992). In this study, again, we investigate the relationship between IT implementation processes and firm performance. Hence, we hypothesize as follow:

H2: IT implementation processes will positively influence firm performance.

The Process of Innovation Capability and Firm Performance

Benner and Tushman (2003) stressed the importance of process management and activities of process are positively related to organizational effectiveness in their conceptual paper. Ittner and Larcher (1997) found that process management is positively related to the firm performance in automotive industry. Thus, the process of innovation including organization learning, process management, and market orientation appears to be robust into firm performance. Therefore, we provide the following hypothesis:

H3: The process of innovation capability will positively influence firm performance directly.

4. RESEARCH METHODOLOGY

Sample and Data Collection

We collected data using survey questionnaire for a wide range of firm and industries from South Korea. We took three months for gathering data based on Web survey and paid 1, 500 U.S dollars for the collection. A total of 160 useable surveys were collected, and a response rate is 16 percent.

Analysis

We will analyze this data by structural equations methodology. We will check for the presence of a mediating effect, first, the direct relationship between process of innovation and firm performance, second, the process of innovation and IT implementation process, third, IT implementation process and firm performance. IT implementation will be a mediator between the process of innovation and firm performance.

5. EXPECTED RESULTS

Our study has focused on the process of innovation toward IT implementation and firm performance. We expect the capability of innovation lead IT innovation as well as firm performance. Most importantly, IT implementation by the process of innovation will affect positively firm performance.

REFERENCES

* References will be provided by request.

Evaluating Usability Factors in Three Brazilian Portals

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ABSTRACT

The usability of a system is a concept that relates to the quality of the interaction of systems with the users and depends on many aspects. The objective of this article is to carry through an evaluation of usability in three of the biggest portals of information and service of Brazil. A usability test was carried out to reach this objective. It was used users with and without experience in computer science, for the development of specific tasks to test the efficiency of the portals analyzed. The evaluation was made through standards of usability described for Nielsen.

1. INTRODUCTION

The importance of the interfaces of computational applications has been increasing in the last few decades. Thus the necessity to interact with computers is more present in the life of all. The innovation in the field of the Information Technology (IT) has caused changes in the form of living of people that must adjust themselves to this reality. For this reason it is necessary easy information systems that allow to get and to supply information to the users in easy and intuitive way.

Hence, the usability acts to stand out the importance of thinking ahead about the people who are in the other side of the video, and the reaction of them about the use of the computers, systems and interfaces. According to Leite (1998), the usability of a system is a concept that relates to the quality of the systems interaction with the users and depends on many aspects.

At a time where it verifies the emergency of terms as interactivity and usability, it is well-known the function each more critical played by IT, being distinguished the Internet. In this environment, each second worth a lot in the time to conquer users or to offer services. Therefore, the interfaces of the websites must be friendly and easy of use. This account so much to whom uses the Internet for the most different ends.

IT has proportionate a variety of new resources for the development of interfaces with the user. The adequate use of these resources becomes the websites sufficiently friendly and attractive, making with that the access to the information and the resources are efficient and pleasant for the user. It doesn't matter the great resources spend in technology if the user satisfaction isn't reached.

Portals of information and service are used in day-by-day of the Brazilians, since the former supplies notice and information of the most varied types and updated every second. So, the objective of this study is to evaluate the usability factors in three of the biggest portals of information and service of Brazil.

2. METHODOLOGY

This research used a usability test as form to evaluate the usability factors of the three portals. A usability test is a process in which representative participant evaluate the degree that a product is in relation to the specific criteria of usability (Rubin, 1994).

The evaluation of usability of the interfaces was carried out in three of the biggest portals of information and service of Brazil. According to Folha Online (2006), the three portals more cited by internet users were: UOL with 21% of the interviewed ones, whereas Terra and IG (Internet Group) were with 10% and 9% respectively.

The usability test used 12 users for the development of specific tasks to test the efficiency of the portals analyzed, being that nine work with computer science and the other three use the Internet only in the day by day.

The test used standards of usability described for Nielsen (2000), and that they focus the following aspects:

- Design of the page: Land of the screen, Time of reply, and Links;
- Design of the content: Adequate formatting of the texts;
- Design of the site: Metaphor and Navigation.

3. DATA ANALYSIS

3.1 Design of the Page

The first factor to be analyzed is the Design of the Page, divided in three items: Land of the screen, Time of reply, and Links.

3.1.1 Land of the Screen

In the first question related to the land of the screen, 66.67% of the users affirmed that the available space to the content is fine. However, with respect to priority given to the comparative content to the use of the land of the screen to show other resources or services, the analyzed portals still need to improve in this aspect.

It was verified in the second question referring to the land of the screen, that 80.56% of the users said that the spaces blank in the screen of the portals are few, showing that they are using appropriately the available spaces in the screen for the content, navigation or other resources well.

The question of number three asked to the users about if the announcements and propagandas are taking too much space in the portals. According to 52.78% of the respondents, they consider that the announcements are in excesses and confuse the visualization of the site. In such a way, the portals would have to diminish the amount of advertising in their sites, thus it makes possible a better usability for the user.

3.1.2 Time of Reply

As for the reply time, the evaluated portals demonstrated a good performance. Only 5.56% of the users answered that the site did not react fast to the commands, and 36.11% of those found that the time of reply of the portals is enough. The others 58.33% affirmed that the time of reply of the portals is satisfactory.

With regard to the time of download of file of the portals, for 33,33% of the users these portals almost never inform the size of downloads. Only 16,67% said that the portals always inform the size of downloads. Therefore, these portals need to inform to the user the size of the file, and then one can decide if will download it at that moment or not.

3.1.3 Links

The research verified if the portals offered a resource that showed one brief explanation of link before the user clicks on it. The results show that 38.89% affirmed never the portals show the headings of links to facilitate the navigation of the users, and only 22.22% of the respondents answered that always the portals inform the heading of links. Thus, it expects that these portals always inform some information about the link before the user clicks on it.

3.2 Design of the Content

For 55.55% of the users, the content available for the portals is satisfying the necessity of them with regard to the quality and brevity of the texts. The others

44.45% were indifferent as regards to the adequate formatting of the texts in the site. Therefore, as the result was not satisfactory for the great majority of the respondents, it is expected that the portals try to develop more objective contents, dividing the subjects in topics, facilitating and providing to the user a clearer and direct reading.

3.3 Design of the Site

In respect of the use of metaphors in portals, 47.22% of the users demonstrated indifference to this aspect, affirming that the use of metaphors does not harm and nor contributes for a good navigation. No informer answered that the metaphors helped a lot in the navigation, and 38.89% said to be satisfactory the use of metaphors in the portals.

In the aspect of the navigation, referring to the identification of where the user is in the site, 61.11% of the users said that is satisfactory or very satisfactory the navigation of these portals. This information proves that the portals are informing the localization of the users whenever possible, facilitating to get the information in any place of the site, and not leaving them to lose during the navigation.

4. CONCLUSION

The results in general showed that the users have a good impression as regards to the usability of the portals. The purpose of this research was exactly to show the reality of the main Brazilian portals since all internet users currently access theses sites at least once per day. In such a way, verifying the usability of these portals and identifying possible deficiencies in them, it can solve them, and consequently to facilitate the access of the information for any type of user, from the least to the most experienced in the Internet.

The majority of the developers and Brazilian companies still invest very little in usability, and usability tests still are something rare. Therefore, it must be had in mind that the elaboration and accomplishment of tests to evaluate the usability, applied to a product, as it was the focus of this work, is a good pointer to display problems in potential. This sufficiently minimizes the risk of offering an unstable product and of difficult learning in the market.

This work did not intend to analyze all the existing problems with the usability of these portals since the research would be much more ample. As recommendation for future research aiming at practical results, it is suggested a work deepened in this subject using more professional without experience in computer science, in order to get a set of suggestions for the improvement of the usability in the sites of the Web. This set of suggestions can be carried through one checklist or developing a method of evaluation for portals of information and service.

REFERENCES

Folha Online. (2006). "Folha iBrands: Universo Online é o Top do top da internet". Accessed October 03, 2006 from http://www1.folha.uol.com.br/folha/informatica/ult124u8053. shtml

Leite, J. C. (1998). "Modelo e formalismo para a engenharia semiótica de interfaces de usuário". PhD Thesis. Rio de Janeiro: Pontificia Universidade Católica – PUC.

Nielsen, J. (2000). "Designing web usability". New York: New Riders Publishing.

Rubin, J. (1994). "Handbook of usability testing: how to plan, design and conduct effective tests." New York: John Wiley & Sons.

The Role of ICT in Organizational Knowledge Sharing Processes: An Exploratory Study

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In modern societies knowledge is considered to be an important factor to stimulate organizational development [4,5,7]. Scholars suggest that information and communication technology (ICT) tools such as email and intranet, in which telecommunication and information technology are integrated [1,8,14] support knowledge sharing and thereby enhance organizational development [2,5,7]. However, in several empirical studies, organization managers often complain that the opportunities for knowledge sharing provided by ICT tools are underutilized, or even ignored [3]. Accordingly, the question arises how knowledge sharing processes take place and which role ICT tools have in these processes. The purpose of this study is to examine the role of ICT tools in everyday knowledge sharing processes related to the primary process in organizational teams.

Knowledge sharing is often described as an interaction between individuals in which they mutually exchange knowledge used in their jobs [2,5,11]. This characterization of knowledge sharing implies that a knowledge sharing process consists of both donating and receiving knowledge. Three types of knowledge sharing are discerned: knowledge storage, knowledge retrieval and knowledge exchange [4,5]. In this study, the role of ICT in the sharing of knowledge in (small) teams is examined. We registered and interpreted all communication acts in which we assume knowledge to be shared.

The role of ICT tools in knowledge sharing processes is assumed to be different under various conditions [13]. Based on previous research [6], we expect ICT use to be more prominent in knowledge sharing processes in relatively large, dispersed teams than in relatively small, collocated teams.

METHODS

In an exploratory case study (study 1) and a comparative study of three cases (study 2), we assessed knowledge sharing processes under varying conditions. Each case represents a project team involved in knowledge intensive work. The critical project team size was eight to ten persons [12]. Geographical dispersion was measured by the presence of other team members in their environment [10]. All teams were selected from large, knowledge intensive organizations in both profit as well as non-profit branches. As Table 1 shows, we expected ICT use to be more prominent in knowledge sharing processes in relatively large, dispersed teams (case 2) than in smaller, less dispersed teams (other cases). Moreover, we assumed that ICT tools have a more important role in small, dispersed teams (case 3) and medium sized, less dispersed teams (case 4) than in medium sized, collocated teams (case 1).

STUDY 1: EXPLORATORY STUDY

In study 1 we examined ICT use in knowledge sharing processes by means of diaries in which team members recorded their communication activities during two days (n = 12). In addition, we carried out follow-up interviews with project team members (n = 5) in order to furnish contextual information about the registered communication acts and to check the representativeness of the registered communication acts in their daily work.

To examine knowledge sharing processes, we observed the topic and persons involved in a communication act. In addition, for the use of ICT tools and other communication channels we looked at the use of communication channels and persons involved in a communication act.

Analysis was focused on describing the nature of knowledge sharing processes. While analyzing the communication acts, we found that different forms and subforms of knowledge sharing could be distinguished. These forms were found by observing the topic and persons involved in a communication act in the context of the other communication acts.

STUDY 2: COMPARATIVE STUDY

In study 2 we examined whether the forms and subforms of knowledge sharing distinguished in study 1 could be identified in the other cases as well. Data were

Table 1. Conditions of cases and expectations regarding ICT use

	Size (number of members)	Geopgraphical dispersion	Expectations regarding ICT use
Case 1 (exploratory)	12	--	-
Case 2	45	++	++
Case 3	6	+	+
Case 4	12	-	+

Note. Differences in 'geographical dispersion' and 'expectations regarding ICT use' between cases are relative and range from '--.'(collocated respectively low on ICT use) to '++' (dispersed respectively high on ICT use).

obtained through diaries (n = 27) and interviews (n = 10) in the same way as in study 1. In order to examine forms of knowledge sharing, communication acts were categorized in clusters, such as communication activities around meetings, or a couple of days of work. Furthermore, in the interviews we presented the team members with a list and asked them to indicate which forms and subforms of knowledge sharing they used. In addition, we asked for a ranking of the prominence of communication channels.

Accordingly, we analyzed the diaries and interviews. Analysis was focused on describing forms of knowledge sharing and the use of ICT tools and other communication channels in clusters of communications activities. Comparisons between cases were made in order to formulate generalizations on the role of ICT tools.

RESULTS

Study 1: Exploratory Study

Firstly, we discovered that communication activities could be distinguished into three different forms of knowledge sharing: donating, acquiring, and exchanging knowledge. If a communication act carried out in the context of an interaction, knowledge was exchanged, otherwise knowledge was donated or acquired. These forms seemed to be interesting because they shed light on the nature of knowledge sharing processes and stand for ways in which knowledge could be shared. As knowledge sharing is often described as an interaction between individuals, we would expect that knowledge is mainly exchanged in two-sided, mutual interactions. However, one-sided processes could be identified too. Secondly, zooming in on these forms of knowledge sharing, various subforms of knowledge sharing could be discerned. Examples are brainstorming, giving advise, or receiving an answer. Thirdly, ICT tools did not have a prominent role in knowledge sharing processes of the team. They were mainly used in one-sided activities like donating or acquiring knowledge. Face to face communication was the most prominent channel for the exchange of knowledge.

Study 2: Comparative Study

Firstly, three forms of knowledge sharing distinguished in study 1, donating, acquiring and exchanging knowledge, were recognized in study 2 as well. Secondly, in addition to study 1, six new subforms of knowledge sharing were disclosed, adding up to a total of 23 subforms (see Table 2).

Some of these subforms seem to contribute to the development of knowledge, for instance giving advise or brainstorming. Other subforms seem to deal with information, like giving a remark or spreading information.

Thirdly, we examined how various ICT tools are used in donating, acquiring respectively exchanging knowledge (see Table 3 for summary).

In general, Table 3 shows that email is the most important ICT tool, except for case 4. However, email is not the most prominent tool for exchanging knowledge. Face to face communication plays an important role as well; in case 1 and 3 face to face communication is the most important communication channel.

Table 2. Forms of knowledge sharing

Forms of knowledge sharing		
Donating knowledge	Acquiring knowledge	Exchanging knowledge
making information available	*inquiring information*	*exchanging information*
making mentions available	*inquiring mentions*	*fine tuning*
spreading information	*acquiring information*	*brainstorm*
giving advise	*acquiring mentions*	*evaluation/reflection*
giving an answer	*acquiring advise*	*monitoring*
making mention of things	*receiving an answer*	*exchanging experiences*
giving a remark	*receiving a remark*	
asking a question	*receiving a question*	
writing down information		

Table 3. ICT tools and face to face communication channels used in knowledge sharing processes in teams

Forms of knowledge sharing	Case 1	Case 2	Case 3	Case 4
Donating	**email** shared drive virtual work space face to face	**email** virtual work space	email shared drive intranet face to face	email **workflow system** face to face
Acquiring	**email** shared drive virtual work space face to face	**email** intranet knowledge base virtual work space	**email** shared drive intranet face to face	email intranet **knowledge base** **workflow system** face to face
Exchanging	**face to face**	**email** **phone** conference calls face to face	**phone** **face to face**	face to face

Note. Prominent ICT tools and face to face communication channels are in bold.

Regarding the conditions, knowledge exchange through ICT tools could be identified in dispersed teams (case 2 and 3). In collocated teams knowledge exchange through ICT tools was not identified. Furthermore, ICT tools are used in large teams (case 2) in order to exchange knowledge. However in small teams (case 3) the phone is also used in order to exchange knowledge. Accordingly, dispersion seems to be the most important condition for exchanging knowledge by means of ICT tools. Concerning donating and acquiring knowledge the conditions seem not to matter. Knowledge is donated and acquired through ICT tools in all cases.

Furthermore, the results show that in teams high on ICT use (case 2 and 4) different forms of knowledge sharing are dominant. The team's task seems to offer an explanation for this. In teams involved in developing products or services (case 2), exchanging knowledge through ICT tools was dominant, whereas in teams applying rules (case 4) donating and acquiring knowledge was dominant. In development teams low on ICT use (case 1 and 3), ICT tools are used for donating and acquiring separately.

DISCUSSION

In this study, different forms and subforms of knowledge sharing were empirically derived from organisational teams that differed according to size and geographical dispersion. As knowledge sharing is often described in terms of an interaction between individuals [2,5,11], we would expect that knowledge is mainly exchanged in two-sided, mutual interactions. However, one-sided processes, i.e. donating and acquiring knowledge, could be identified too. Accordingly, in addition to the characteristics mentioned in literature [2,5,11], knowledge sharing is not only characterized by two-sided interactions, but one-sided processes as well.

The starting-point of this study was to empirically examine knowledge sharing processes through observing communication activities. Accordingly, we registered and interpreted all communication acts in which we assume knowledge to be shared and focussed on the process of knowledge sharing. However, there are indications that knowledge is not shared in all communication activities. Some subforms seem to deal with knowledge, whereas other subforms seem to deal with information. With regard to the types of knowledge sharing discerned in literature [4, 5], subforms dealing with information seem to be related to knowledge storage and knowledge retrieval, whereas subforms dealing with knowledge are related to knowledge exchange. We will further investigate when knowledge is shared in communication activities.

Moreover, regarding the subforms, we have to mention that they are not mutually exclusive. Further research into the distinctions between subforms is needed.

With regard to ICT tools, in previous research [6], ICT use seemed to play a more dominant role in relatively large, dispersed teams. Since in our study relatively small teams had a high score on ICT use too, size seems not always to be a critical condition for ICT use. Moreover, in literature it is assumed that ICT could play a dominant role in knowledge sharing [9]. However, this study shows that face to face communication seems most important.

REFERENCES

[1] Bouwman, H. & Van Dijk, J.; Van den Hoof, B. & Van de Wijngaert, L. (2005). *Information and Communication Technology in Organizations: adoption, implementation, use and effects.* Sage: London.

[2] Büchel, B. S. T. (2001). *Using communication technology. Creating knowledge organizations.* Basingstoke: Palgrave.

[3] Edwards, J. S.; Shaw, D. & Collier, P. M. (2005). Knowledge management systems: finding a way with technology. *Journal of Knowledge Management*, *9*(1), 113-125.

[4] Hansen, M. T.; Nohria, N. & Tierney, T. (1999). What's your strategy for managing knowledge? *Harvard Business Review*, *78*(1), 106-116.

[5] Huysman, M. & De Wit, D. (2003). A Critical Evaluation of Knowledge Management Practices. In. M. S. Ackerman, V. Pipek & V. Wulf, *Sharing expertise. Beyond Knowledge Management* (pp. 27-55).

[6] Martins, L. L.; Gilson, L. L. & Maynard, M. T. (2004). Virtual teams: What do we know and where do we go from here? *Journal of Management*, *30*(6), 805-835.

[7] Nonaka, I. & Takeuchi, H. (1995). *The knowledge creating company: how Japanese companies create the dynamics of innovation.* New York: Oxford University Press.

[8] Rice, R. E. & Gattiker, U. E. (2001). New Media and Organizational Structuring. In F. M. Jablin & L. L. Putnam (Eds.) *The New Handbook of Organizational Communication. Advances in Theory, Research and Methods* (pp. 544-581). Thousand Oaks: Sage.

[9] Ruggles, R. (1998). The state of the notion: knowledge management in practice. *Calfifornia Management Review*, *40*(3), 80-89.

[10] Simons, M. (2004). *Wired attraction. Effects of ICT use on Social Cohesion in Organizational Groups.* Doctoral dissertation, University of Amsterdam, Amsterdam.

[11] Ruuska, I. & Vartiainen, M. (2005). Characteristics of knowledge sharing communities in project organizations. *International Journal of Project Management, 23*(5), 374-379.

[12] Valacich, J. S.; Dennis, A. R. & Connolly, T. (1994) Idea generation in computer-based groups: a new ending to an old story. *Organizational Behavior and Human Decision Processes, 57,* 448-467.

[13] Van den Hooff, B.; Groot, J. & De Jonge, S. (2005). Situational influences on the use of communication technologies. *Journal of Business Communication, 42*(1), 4-27.

[14] Van Dijk, J. (2006). *The Networked Society* (L. Spoorenberg, Trans.). London: Sage.

Missed Call Use Across Cultures

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ABSTRACT

With the ubiquitous use of mobile phones everywhere, mobile phone users constantly invent new ways to use their mobile phones to satisfy their communication needs. An example of how technology sometimes is used in a way that was not anticipated is the use of "the missed call". The missed call is an intentional action whereby a person places a call and disconnects the call before the recipient on the other end answers the call. Despite the popularity of the missed call, to date the missed call as a form of communication has not been considered in mobile phone design. Therefore, the aim of this research is to propose a solution that employs an icon-based missed call service (IBMCS) to help users interpret the different meanings of the missed calls. Two contrasting cultures were selected for this study; the UK as a representative for the mature mobile technology market and the Sudan as an emerging market for mobile devices. The results from the study indicated that the IBMCS allows for better interpretation of the missed calls. The Sudanese had more positive attitude towards the developed service than the British participants. However, the British deemed that the icons were self explanatory and more informative and expressive than the old missed call service. The Sudanese were satisfied with the new IBMCS but they suggested adding more icons to the IBMCS. .

INTRODUCTION

The use of the missed call is grown popular especially in Africa. Samuel, Shah and Hadingham (2005) observed missed calls or *beeping* among users in Tanzania and South Africa. Gamos consultancy (2003) found that 38% of participants used payphones and telecentres in Uganda, Botswana, and Ghana to beep mobile phone users.

Donner (2005c) found that users in sub-Saharan have produced elaborated codes and social messages to be exchanged over the network without bearing any cost or at least not from those who are in a less secure financial position. Donner (2005c) found that the missed call/beeps is used mainly to mean 'call me back'; where the caller's intention is to request the recipient to bear the cost of the call. Missed call is also used as 'instrumental message', or 'relational sign' such as "pick me up now", "I am thinking of you" respectively

Chakraborty (2004) observed the missed call phenomena in Sitakund, Bangladesh. Here, users invented ways to communicate through the network without paying for the call. An example for the missed call code is: one ring = 'I am at home, where are you?' two rings = 'I'm at your house, where are you?'

Understanding the intended meaning of the missed call is a challenge that faces missed call users. To eliminate the ambiguity related to the interpretation of the missed calls an icon-based missed call service (IBMCS) was developed.

AIMS OF THE STUDY

- To investigate whether an IBMCS will clarify the meaning of the missed call in comparison to the traditional missed call system
- To investigate the impact of culture on users' perception of an IBMCS.

PARTICIPANTS

Eighty participants took part in this study. 35 British (16 male, 19 females) and 45 Sudanese (18 males and 27 females) ranging in age from 13-34 years old, with the average of 20 years old. All participants were mobile phone users. Experience of mobile phone use for the Sudanese participants ranged from 2-5 years whereas the British participants had used mobile phones for 4-12 years.

DATA COLLECTION

A Likert-type scale (Likert, 1932) was used to ascertain people's perception of using the IBMCS. The questionnaire was a fully revised version of the Computer System Usability Questionnaire developed for IBM by (Lewis, 1995) the scale had a 7 point format with responses ranging from strongly disagree to strongly agree with a neutral mid point. An example of the format is given below in Figure 1.

In addition to the Likert scales, a semi-structured interview was completed to get richer data about the users' perception of the IBMCS.

PROTOTYPE

Flash 8 Macromedia was used to create the prototype used in this study. The prototype consists of set of screens that enable the user to place/receive an icon-based missed call. Figure 2 shows an example of the missed call icon based service.

PROCEDURE

Participants were briefed about the purpose of the experiment and provided with the task instructions.. Examples of typical tasks participants were asked to complete is given below:

- Place a missed call that means "Reminder for prior arrangement"
- Place a missed call that means "After sending sms"

Following this, participants were asked to complete the Likert questionnaire statements. Finally, participants were interviewed for one hour regarding their experience of using the service.

QUESTIONNAIRE RESULTS

A Mann Whittney test indicated that significant differences were found between the British and the Sudanese in relation to the sending and receiving missed calls using the IBMCS.

For sending, Sudanese participants showed a more positive attitude in all measures in comparison to the British. For example the likeability and the overall satisfaction of using the service to send missed calls measures indicated the Sudanese willingness to use the service in comparison to the British ($U= .000, p<0.001$), ($U=.008, p<0.01$).

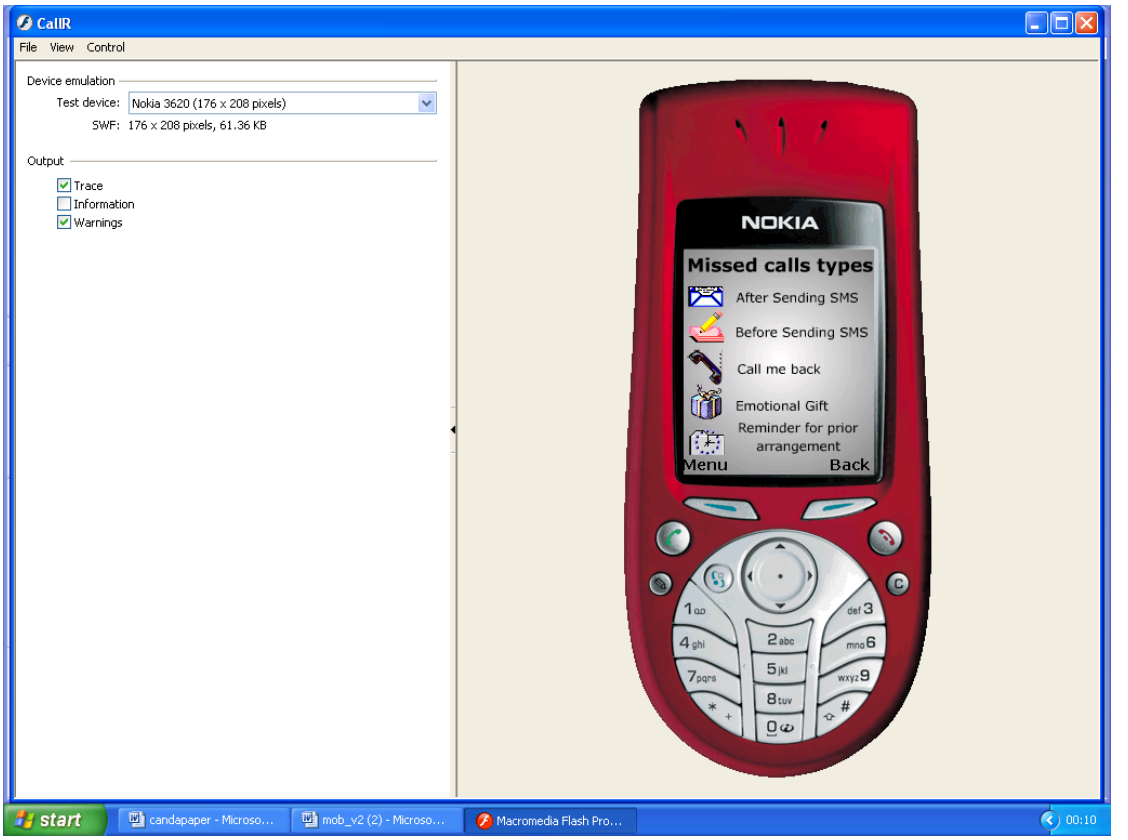
For receiving, again the British were less enthusiastic about using the IBMCS to receive missed calls. For example the enjoyability measure and the ease of use

Figure 1. Example of attitude statement used in the study

It was easy to learn how to send a missed call using the IBMCS.

Strongly disagree	Slightly disagree	Disagree	Neutral	Agree	Slightly agree	Strongly agree

Figure 2. Shows an example of the missed call icon based service



both indicated the Sudanese positive attitude (U=.001, p<0.001), U=002, p<0.001). Please see Table 1 for a summary of the main results.

INTERVIEW RESULTS

The interview results also reflected the Sudanese positive attitude towards the developed service in comparison to their British counterparts. Participants from both cultures appreciated the ability of the new service in conveying missed call messages in a quick and clear way as one of the British interviewee commented:

"I like the new missed call service, on the old system it was tricky to figure out the meaning of the missed call sent."

The British and the Sudanese differentiated between the sms and the IBMCS. The cost element was the main theme that was highlighted by the British and the Sudanese. They believed that using the IBMCS to convey social messages is more cost effective than using sms. The IBMCS enable users to scan and understand the message quicker than the sms message where the user needs to read through the whole text to perceive the intended meaning. As one of the interviewee commented:

"You need to read the entire text to understand the meaning of the message where with the missed call just one quick scan at the icon will explain the message"

DISCUSSION

The results on this study highlighted the importance of missed call rituals as a developed mode of communication that facilitates social interaction. The IBMCS seems to offer users a unique form of mobile phone interaction possibly that is not offered by phone calls or text messages.

The Sudanese were found to be more positive about enjoying and using the new service than the UK participants. Measuring these results against Hofstede's typology (1980) the enthusiasm of the Sudanese towards the IBMCS can be viewed through their collectivistic way of living, where they expected to look after each other, care for others social interests and stay connected. Apparently the IBMCS enable users to fulfil their social commitment with less effort, time and cost.

Both the British and the Sudanese identified differences between the sms and the new missed call. The Sudanese appreciated the ability of the new missed call service in conveying social meanings using the icons. The Sudanese also perceived the IBMCS as a better channel of communication in comparison with the sms in terms of cost, time and effort. One justification for the Sudanese attitude might be related to the difficulty they experience when using sms. For example, the maximum limit of the sms is 160 characters but in Arabic it is only equivalent to around 78 characters. Therefore, a single message might need to be written in 2-3 different sms. Some of the Sudanese mobile phones do not have comprehensive support for Arabic language or the Arabic alphabet may be absent on the key board, as a result, writing an sms may require memorization or a workaround texting and thus they perceive the IBMCS as more of a simple and clear way of communication.

CONCLUSION

The rationale for using the missed call has unmistaken economic and financial connotations. However, diversity in the users' perception of the IBMCS between the two cultures implies that the conventions of the missed call perhaps are shaped by cultural differences. For example, the British perceived the IBMCS as an entertaining mode of communication to fill empty times, whereas the Sudanese

Table 1. Users' attitudes towards the new missed call service in the UK and Sudan

Theme	Country	N	Mean Rank	Asymp sig 2 tailed	Sig level
It was easy to use the IBMCS to send a missed call.	Sudan	45	45.20	.031	*
	UK	35	34.46		
	Total	80			
I enjoyed sending missed calls using the IBMCS.	Sudan	45	47.87	.001	**
	UK	35	31.03		
	Total	80			
During sending of a missed call if I made a mistake I recovered quickly	Sudan	45	38.64	.408	
	UK	35	42.89		
	Total	80			
On the IBMCS, the organization of information on the screen is clear.	Sudan	45	44.60	.055	*
	UK	35	35.23		
	Total	80			
I liked using the IBMCS to place missed calls (very similar wording to one above)	Sudan	45	48.16	.000	***
	UK	35	30.66		
	Total	80			
The IBMCS has all the functions I expect.	Sudan	45	45.69	.018	*
	UK	35	33.83		
	Total	80			
Overall I am satisfied with IBMCS in relation to placing a missed call	Sudan	45	45.73	.008	**
	UK	35	33.77		
	Total	80			
It was easy to use the (IBMCS) to receive a missed call.	Sudan	45	47.01	.002	**
	UK	35	32.13		
	Total	80			
I enjoyed receiving missed calls using the IBMCS.	Sudan	45	47.17	.001	**
	UK	35	31.93		
	Total	80			
When receiving a missed call if I made a mistake I recovered quickly	Sudan	45	43.60	.166	
	UK	35	36.51		
	Total	80			
On the IBMCS the organization of information on the screen is clear.	Sudan	45	43.68	.145	
	UK	35	36.41		
	Total	80			
I like using the IBMCS to receive missed calls	Sudan	45	47.04	.001	**
	UK	35	32.09		
	Total	80			
The IBMCS has all the functions I expect.	Sudan	45	42.77	.300	
	UK	35	37.59		
	Total	80			
Overall I am satisfied with the IBMCCS in relation to receiving a missed call	Sudan	45	47.76	.00	***
	UK	35	31.17		
	Total	80			

**P<0.05, **P<0.01, ***P<0.001*

with their limited financial resources tied with their social and cultural obligation has made the new missed call service an appealing channel of communication that supports their personal and business communication. The Sudanese actually sought further solutions to maximize their communication opportunities and to develop a sophisticated missed call service that satisfies more personal communication needs.

REFERENCES

Charkraborty, D. (2004)The case of mobile phones in Sitakund. Retrieved April 21, 2005, from http://www.i4donline.net/issue/may04/sitakund_full.htm

Ciborowski, T.J. (1979). Cross-Cultural aspects of Cognitive Functioning: Culture and Knowledge. In A.J. Marsella,R.G. Tharp, and T.J. Ciborowski (Eds), *Perspectives on Cross-Cultural Psychology*. New York, NY: Academic Press Inc.

De. Mooij,M (2003) *Consumer Behavior and Culture. Consequences for Global Marketing and Advertising*, Thousand Oaks, CA: Sage Publications Inc. *Eurobarometer 55 and The Young Europeans* (2001) Brussels: European Commission Directorate.

De Mooij, M. and Hofstede, G. (2002). Convergence and divergence in consumer behavior: implications for international retailing. *Journal of Retailing*, 78, 61-69.

Donner, J. (2005c) *The Rules of Beeping: Exchanging Messages using Missed Calls on Mobile Phones in Sub-Saharan Africa.* Paper presented at the 55th Annual Conference of the International Communication Association: Questioning the Dialogue, New York. GOFFMAN E. 1963 *Behaviour in Public Places. Notes on the Social Organization of Gatherings*, Free Press.

Evers, V. and Day, D. (1997). The Role of Culture in Interface Acceptance. In Mende S. Howard, J. Hammond and G.Lindgaard, Proceedings of the Human Computer Interaction INTERACT'97 Conference (pp 260 – 267).Sydney: Chapman and Hall.

Gamos. (2003). *Innovative demand models for telecommunications services*. Retrieved December 23, 2004, from www.teafrica.org

Hofstede, G. (1980). 'Culture's Consequences: International Differences in Work-Related Values'.Beverly Hills, California: SAGE Publications.

Honold, Pia, (1999) "Learning How to Use a Cellular Phone: Comparison Between German and Chinese Users," *Jour* Soc. Tech. Comm., Vol. 46, No. 2, May 1999, pp. 196-205.

Kasesniemi, E. and Rautianen, P. (2002) 'Mobile Culture of Children and Teenagers in Finland', in Katz, J. and Aakhus, R. (eds) *Perpetual Contact: Mobile Communication, Private Talk, Public Performance*, Cambridge University Press, Cambridge

Lewis, J. R. (1995) *IBM Computer Usability Satisfaction Questionnaires: Psychometric Evaluation and Instructions for Use.* **International Journal of Human-Computer Interaction**, 7:1, 57-78.

Likert, R. (1932) A technique for the measurement of attitudes. *Archives of Psychology*, No. 140.

Love, S. (2005) Understanding Mobile Human-Computer interaction. Elesvier Blueworth Heinemann, London.

Samuel, J., Shah, N., & Hadingham, W. (2005). *Mobile communications in South Africa,*

Tanzania, and Egypt: Results from community and business surveys. Retrieved March 9, 2005, from http://www.vodafone.com/assets/files/en/AIMP_09032005.pdf

Smith A., Dunckley, L., French, T., Minocha, S. and Chang, Y. (2004). A Process Model for Developing Usable Cross-Cultural Websites. *Interacting with Computers*, 16: 63–91.

Smith, A., French, T., Chang, Y. & McNeill, M. (2001). 'eCulture: A comparative study of eFinance web site usability for Chinese and British users'. Designing for global markets. Conference (6th. 2001). Proceedings of the third international workshop on internationalisation of products and systems. Edited by D. Day & L. Duckley. Buckinghamshire: The Open University. p.87-100.

Sun, H. (2003) Exploring Cultural Usability: A Localization Study of Mobile Text Messaging Use. Paper presented at the CHI 2003, Ft. Lauderdale, FL.

The Japan Times Online. (2002). *Laws urged to curb mobile phone scams, spam*. Retrieved March 1, 2005, from http://www.japantimes.co.jp/cgi-bin/getarticle.pl5?nn20021226b6.htm

Dealing with Data Warehouse Transaction Processing Truncated Data: Case Study of SQL Server 2000

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ABSTRACT

In this paper, the cause of truncated data in the transaction processing will be discussed. Specifically, the main goal of this paper is to demonstrate the function of recovery model in the SQL Server 2000. In the paragraphs to come, we will discuss in a little more detail, the truncated data that can take place, along with the importance of data integrity. Afterwards, we will discuss two scenarios cases to implement the recovery model. In the case, we will begin by discussing the transaction processing in between data warehouse. Afterwards, we will discuss the potential causes of truncated data. The last part of this case details configuration of each recovery model; more specifically what types of functions are available in this particular setting, what requirements those functions place on to deal with specific problems and few of the benefits that come with having experience. This paper has the potential to provide the recovery model needs to database administrator to do advanced support task.

Keywords: CIS majors, math course, course design.

INTRODUCTION

Transaction management is one of the most crucial requirements for enterprise application development. Most of the large enterprise applications in the domains of finance, banking and electronic commerce rely on transaction processing for delivering their business functionality. Given the complexity of today's business requirements, transaction processing occupies one of the most complex segments of enterprise level distributed applications to build, deploy and maintain.

Enterprise data warehouse often require concurrent access to distributed data shared amongst multiple components, to perform operations on data. Such applications should maintain integrity of data (as defined by the business rules of the application) under the following circumstances:

1. Distributed access to a single resource of data, and
2. Access to distributed resources from a single application component.

In such cases, it may be required that a group of operations on (distributed) resources be treated as one unit of work. In a unit of work, all the participating operations should either succeed or fail and recover together. This problem is more complicated when a unit of work is implemented across a group of distributed components operating on data from multiple resources, and/or the participating operations are executed sequentially or in parallel threads requiring coordination and/or synchronization. Truncated data would be easy to be occurring in the process in either case. It is required that success or failure of a unit of work be maintained by the application. In case of a failure, all the resources should bring back the state of the data to the previous state (i.e., the state prior to the commencement of the unit of work).

In this paper, the cause of truncated data in the transaction processing will be discussed. Specifically, the main goal of this paper is to demonstrate the function of recovery model in the SQL Server 2000. In the paragraphs to come, we will discuss in a little more detail, the truncated data that can take place, along with the importance of data integrity. Afterwards, we will discuss two scenarios cases to implement the recovery model. In the case, we will begin by discussing the transaction processing in between data warehouse. Afterwards, we will discuss the potential causes of truncated data. The last part of this case details configuration of each recovery model; more specifically what types of functions are available in this particular setting, what requirements those functions place on to deal with specific problems and few of the benefits that come with having experience. This paper has the potential to provide the recovery model needs to database administrator to do advanced support task.

DATA WAREHOUSE AND TRANSACTION MANAGEMENT

Every operation involves data occurs within a transaction. The way in which a database handles transactions is a critical to the database industry as the aerodynamic curve of a wing is to the aircraft industry (Nielsen, 2003). Transaction processing is a reliable and efficient of large volumes of repetitive work. Database management systems ensure that simultaneous users do not interfere with each other and that failures do not cause lost work. There are three problems that can result because of simultaneous access to a database: [1] lost update, [2] uncommitted dependency, and [3] inconsistent retrieval (Mannino, 2004).

Data warehouse is a central repository for summarized and integrated data from operational databases and external data sources. In a data warehouse, data must be organized for rapid access to information for analysis and reporting, as this is the purpose of the data warehouse. Data integrity and performance of transaction processing requires that operational database be highly normalized. In contrast, data warehouses are usually demoralized from Normal Form to reduce the effort to join large tables. Most data warehouse processing involves retrievals and periodic insertions of new data. Because of difference processing requirements, different data models have been developed for operational data warehouse database. In general, the different processing may cause the truncated data.

DATA WAREHOUSE IMPLEMENTATION

Dimensional modeling is used in the design of data warehouse database to organize data efficiency of queries that analyze and summarize large volumes of data. The data warehouse schema is usually much simpler than the schema of an OLTP (On-Line Transaction Processing) system designed using entity-relation modeling. The verification tables used in OLTP systems that are used to validate data entry transactions are not necessary in the data warehouse database because the data warehouse data has been verified before it was posted to the data warehouse database and the data is not expected to change frequently once it is in the data warehouse (Agosta, 2000). Backup and restore strategies also differ in a data warehouse from those necessary fro an OLTP system. Much of the data in a data warehouse is unchanging and does not need repetitive backup. Backup of new data can be accomplished at the time of update, and in some situations it is feasible to do these backups from the data preparation database to minimize performance impact on the data warehouse database.

Data to be used in the data warehouse must be extracted from the data sources, cleaned and formatted for consistency, and transformed into the data warehouse schema. The data preparation area is a relational database into which data is extracted from the data sources, transformed into common formats, checked for

consistency and referential integrity, and made ready for loading into the data warehouse database. Performing the preparation operations in source database is not an option because of the diversity of data sources and the processing load that data preparation can impose on online transaction processing systems. Furthermore, attempting to transform data in the data source systems can interfere with online transaction processing (OLTP) performance, and the reconciliation of inconsistencies in data extracted from various sources cannot be accomplished until the data is collected in a common database, at which time data integrity errors can more easily be identified and recited. The data preparation area is a relational database that serves as a general work area for the data preparation operations. It contains tables that relate source sat keys to surrogate keys used in the data warehouse, tables of transformation data, and many temporary tables. It also contains the processes and procedures that extract data from source data systems.

The data preparation area should also contain the processes that are used to extract the data from the data sources, the processes that transform and cleanse the data, and the processes that load the data to the data warehouse. The processes may be in the form of SQL quires, stored procedures, DTS packages, or documents of manual instructions. As in the development of any database system, the objective is to automate as much of the process as possible and to mange and maintain the automated tools developed. Storing and maintaining the transformation processes in the data preparation area permits the use of standard database backup and restore mechanisms to preserve them. The database schema must support complex data representations. Database must contain data that are aggregated and summarized.

CASE STUDY OF SQL SERVER 2000

Scenario

As an administrator of a SQL Server 2000 computer, the job responsibility is to create a database to use an intermediate data store for a data warehouse. Each night the administrator must import daily sales data into the database from SQL Server 2000 computers in 120 locations. After the data is moved into the data warehouse, the tables are truncated. The database schema is shown in the Figure 1. For the purpose of minimizing the time to import the sales data and administering the database, there are several procedures for an administrator to configure the data import processes.

Implementation

We want to optimize or speed and at the same time keep administration down. We accomplish this by

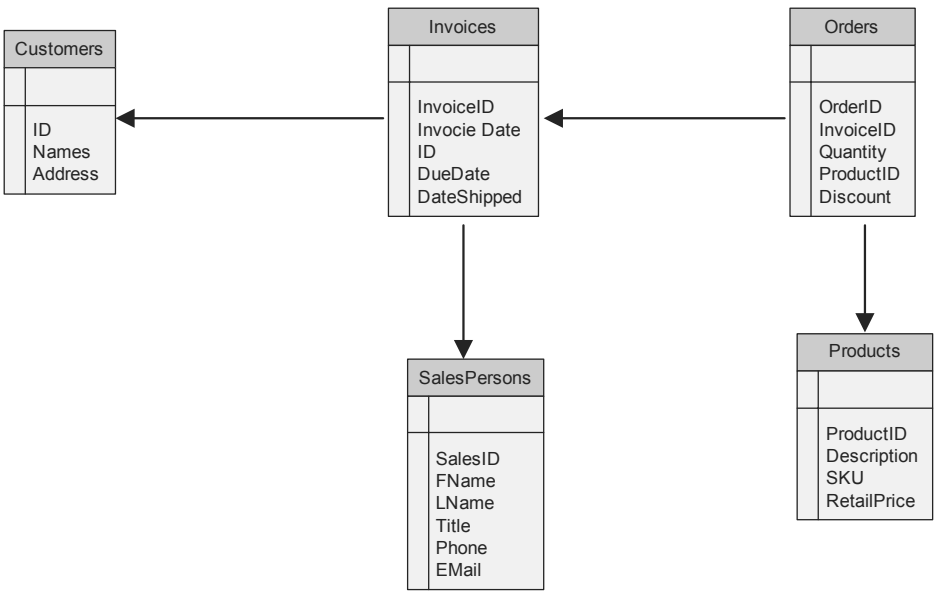
1. Use the simple recovery model and the FOR LOAD option to create the database. Use the simple recovery model. It will avoid logging of the bulk import process. This will increase speed.
2. Create a Data Transformation Services package that uses the BULK INSERT statement to copy the sales Data. Create a DTS package with BULK INSERT to copy sales data. BUL INTERT is fast way to import data and a DTS package can be reused and requires little administration.

A SQL Server 2000 provides three recovery models that can be used to recover database data in case of hardware failure or other eventualities that may compromise data integrity. These recovery models are: the Simple Recovery model, the Full Recovery model and Bulk-Logged Recovery model. With the Simple Recovery model, the database can be recovered to the point of the last backup but not to the point of failure or to a specific point in time. To do that, choose either the Full Recovery or Bulk-Logged Recovery model. Furthermore, the FOR LOAD clauses of the CREAT DATABASE statement are used for compatibility with earlier versions of SQL Server. The database is created with the dbo use only database option turned on, and the status is set to loading. The simple recovery model fits this scenario well since the tables are truncated every night.

REFERENCES

1. Agosta, L. (2000). The essential guide to data warehousing. New York: Prentice Hall.
2. Barquin, R. & Edelstein, H. (1997). Planning and designing the data warehouse. New York: Prentice Hall.
3. Bock, B. (2004). SQL for SQL Server. New York: Prentice Hall.
4. Chaffin, M., Knight, B. & Robinson, T. (2003). Professional SQL Server 2000 DTS. New York: Wiley Publishing.
5. Connolly, T. & Carolyn, B. (2005). Database systems: a practical approach to design, implementation, and management. New York: Addison-Wesley.
6. Mannino, M. (2004). Database: desing, application development, and administration. 2nd Ed. New York: McGraw-Hill.
7. Maraks, G. (2003). Modern data warehousing, mining, and visualization. New York: Prentice Hall.
8. Nielsen, P. (2003). Microsoft SQL Server 2000 Bible. New York: Wiley Publishing.
9. O'Brien, J. A. & Maraks, G. (2007). Management information systems 8th Ed. New York: Irwin/McGraw Hill.
10. Post, G. (2005). Database management systems. New York: McGraw-Hill.
11. Raftree, M. F. (2002). SQL Server 2000 Administration. Boston: Course Technology.

Figure 1. Database schema



12. Rob, P. & Coronel, C. (1995). Database systems: design, implementation, and management. Danvers: Boyd & Fraser Publishing.
13. Turban, E., Leidner, D., & McLean, E. R. (2006). Information Technology for Management. Edison: John Wiley & Sons.
14. Zachman, J. A. & Alexander, T. (1997). Data warehouse: practical advice from the expert. New York: Prentice Hall.

An Overview of the Role of Math Courses for CIS Majors

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ABSTRACT

In this paper, an overview of the math course contents, knowledge and skills and trends should be required for CIS majors will be presented. A variety of math course developments will be discussed. Appropriate math course development provides a systematic, problem-solving approach to planning and designing learning experiences for CIS majors. It is imperative to explain the benefits that result from mathematics, discuss how its practitioners work, and present the rationale for CIS majors.

Keywords: CIS majors, math course, course design.

INTRODUCTION

Since late 1970s and early 1980s, personal computer goes into individual working settings and family life. Computer utilization and operation has no longer for computer professional only. Since then, a sub-division of compute sciences (CS) department, called computer information systems (CIS), has been growing to be an individual academic unit. The computer information technology major is designed to combine the benefits of a traditional college education with the benefits of hands-on training in state-of-the-art computer technology. Students become technically competent, but also learn to write well-organized and clear memoranda and reports. The computer information technology curriculum integrates technical skill with communication skills, superior general education requirements, and breadth of knowledge in the computer information technology field. In other words, from teaching and research standpoints, computer information systems education focuses on more the design for product-oriented and market trends. Computer science education is the discipline that seeks to build a scientific foundation for providing the underpinnings for today's computer applications as well as the foundations for tomorrow's applications. To this extent, computer science requires strong math disciplines and foundations. Computer information systems program only requires minimum math education. Computer information systems majors may not need as many math courses as computer science students need. Mathematics is the language of technology. It is used to formulate, interpret, and solve problems. It is the bedrock for the computer revolution. Mathematics provides us with powerful theoretical and computational techniques to advance our understanding of the modern world and societal problems and to develop and manage the technology industries that are the backbone of our economy.

Mathematics is a living discipline. Some traditional subjects in pure mathematics have been studied for hundreds of years; other topics, developed during the last few decades from the study of industrial issues, form a body of applied mathematics closely tied to the understanding of practical problems and basic phenomena. There is remarkable synergy between these seemingly disparate fields of study; the abstract nature of mathematics supports important applications in an ever-growing number of areas. However, how much knowledge is need for CIS students? How many math courses should be required for CIS students? What math course contents are needs for CIS students?

MATHEMATICS

Mathematics is an abstract science concerned with level and structure. It is best seen as a highly interrelated set of abstract systems, the structure of which is well understood. As such, it is perhaps the most advanced science. Other sciences use the concepts and structures of mathematics as tools to study real world problems. By mapping real world systems into abstract mathematical systems, the researcher facilitates the application of powerful mathematical results and methods. The broader our understanding of different mathematical structures, the better we are able to select appropriate models to study information systems phenomena.

In addition to the fact that mathematics is the most highly developed and powerful science, there are two other characteristics which recommend it to the study of information systems. As noted above, all disciplines contributing to information systems research use mathematics to some extent. It thus provides a common language for cross-disciplinary communication. Finally, the clarity, precision, and conciseness afforded by quantification are essential to the study of complex phenomena like information systems. Whitehead, in regard to mathematics, notes that a good notation spares us the painful necessity of thinking; notation itself may generate ideas. Mathematics has the most highly developed systems of notation of any science.

Mathematics tends to be viewed in a limited and distorted way by non-mathematicians. There is therefore a need to first outline the field of mathematics. Information systems researchers tend to identify mathematics which statistics. Statistics is just one of nine major branches of mathematics (Table 1). Although this may be the only branch of mathematics to which information systems researches are exposed, it is certainly not the only branch of potential use to information systems researchers. The over-emphasis upon statistics in the training of information systems researchers has resulted in a corresponding over-emphasis upon hypothesis testing and inductive methods in information systems research, almost to the exclusion of modeling and deductive approaches. Content analysis of the information systems research literature bears this out (Van Doren and Heit, 1973; Smale, 1981).

The range of potential applications of each of these nine branches of mathematics is limited only by our understanding of these areas of knowledge and out imagination. While each branch of mathematics includes very complex concepts and structures, each also includes quite simple and basic concepts that are within the grasp of virtually any information systems researchers. A good example is set theory's Venn diagram methods, now taught to grade scholars. A more recent development is set theory is the concept of "fuzzy set" (Zadeh, 1973), which offers methods of dealing with the many "fuzzy concepts" in information systems and leisure. Matrix algebra is important in solving systems of equations and provides the basic structure for many applied models, such as linear programming, input-output, and Markov chains.

Table 1. Areas of mathematics

1.	Logic and Set Theory
2.	Algebra, Group Theory, Matrix Algebra
3.	Geometry, Topology, Network and Graph Theory
4.	Differential Calculus
5.	Integral Calculus
6.	Real and Complex Analysis
7.	Probability, Game Theory
8.	Statistics
9.	Numerical Analysis

The mathematics of spatial structure including network and graph theory has many applications to transportation and communication flows, two very important dimensions of information systems. The calculus is one of the most powerful inventions of mathematics. It is difficult for me to envision anyone studying change without an elementary understanding of differential calculus. I would liken it to studying movement without having heard of the wheel.

Stephen Smith reminds me that probability is one branch of mathematics that has its roots in play behavior, and yet most information systems researchers pass all too quickly over probability to statistics, only to learn too late that one cannot fully understand statistics without first mastering the basic laws of probability. Probability and game theory have been applied extensively to management and decision making (Von Neumann and Morgenstern, 1953). Numerical analysis includes many techniques for approximation and estimation that will become increasingly useful to information systems researchers as quantification progresses.

While it may be impossible for a creation researcher to master all of these branches of mathematics in a single lifetime, an exposure broader than statistics is surely needed. We especially need to train future information systems researchers more fully in mathematics. I would recommend the following as a minimum for undergraduate programs in information systems:

1. A course in logic, perhaps in conjunction with philosophy of science.
2. A course in finite mathematics. This would include introductions to logic, set theory, matrix algebra, and probability with applications to linear programming, Markov chains, and the theory of games and decisions. Such courses are offered at most universities at the freshman level, and are required in most business programs.
3. One course in calculus
4. One course in statistics

I must emphasize that this should be a minimum for anyone training for a position in information systems management, administration, planning, or research. Quantitative skills will not be learned on the job, and when neglected in undergraduate education usually results in a lifetime of inadequacy and fear of mathematics. I do not believe there is a single information systems program in North America that meets this minimum requirement. Until we raise our standards in the quantitative area, our graduates will operate under a serious handicap, especially if they must compete with management and business graduates. Few will be adequately prepared to begin graduate programs or understand research.

Second courses in calculus and statistics are desirable, along with a course in mathematical modeling. Operations research, management science, and systems courses at this point in time can fill modeling needs until information systems-related modeling courses are developed. I suggest introducing these at the graduate level.

MODELING

This concludes a brief overview of mathematics. I will now move on to quantitative techniques in general. There is one important area of quantitative applications in information systems: modeling.

The term "model" is synonymous with the term "theory." In use, "model" is generally applied to mathematical models, while "theory" is reserved for more conceptual models in logical or verbal form. A model is simply a representation within abstract mathematical systems, basically mappings from the real-world system to the mathematical system. To be useful, a model must be less complex than the real system and must abstract its essential features. Achieving these two goals is the art and science of model building.

There are four important aspects of modeling that information system researchers need to understand:

1. How does one develop and test a model?
2. What are the different types of models?
3. For which kinds of problems is each model best suited?
4. What roles does modeling serve in information systems research?

Table 2. Classification of abstract models by attributes

1. Treatment of Time	: Static, Comprehensive Status, Dynamic
2. Treatment of Space	: Point, Area
3. Measurement Scales	: Discrete, Continuous
4. Recognition of Uncertainty	: Deterministic, Stochastic
5. Aggregation Level	: Micro, Macro
6. Form of Equation(s)	: Linear, Non-Linear, Systems
7. Inclusiveness	: Open, Closed
8. Flexibility	: Canned, Custom Built
9. Best Solution?	: Non-Optimizing, Optimizing

There are a variety of different types of models, including verbal, physical, graphical, and mathematical models. Mathematical models may be classified along nine distinct dimensions (Table 2). Models that have been applied in information systems tend to be (1) static, (2) linear, (3) deterministic, and (4) "canned." Since most of the phenomena that we study are dynamic, non-linear, and stochastic there is a need to develop more custom-built models to better suit our needs. It is particularly important that we recognize the dynamic and probabilistic nature of the objects of our study and use methods more suited to these properties. Our static, linear, deterministic view of the world is reinforced by the lack of time series data or longitudinal research, and ignorance of non-linear, probabilistic, and dynamic models.

CONCLUSION

As view of information systems research as processes will require all learner to take a broader historical perspective on the field, to develop new measures that better lend themselves to a process approach, to look more to mathematics, modeling and theory, and to take a longer range perspective on information systems research. It is necessary to spend more time and effort integrating what has been learned and making information research a cumulative process. Mathematics and quantification more generally, can help CIS move in these directions.

REFERENCES

1. Abney, D. H., Rubin, L., & Sibrel D. W. (1985). Computer mathematics for programmers. London: Academic Press.
2. Eggenschwiler, D, & (2007). http://www.schoolinfosystem.org/archives/curriculum_-_math/index.php
3. Etzioni, A. (1970). Fact, crazy, theory shy? Science, 170(3956):2.
4. Johnsonbaugh, R. (2001). Discrete Mathematics. New York: Prentice Hall.
5. Kuhn, T. S. (1970). The structure of scientific revolutions, 2nd Ed., University of Chicago Press, Chicago
6. O'Brien, J. A. (2006). Management Information Systems. New York: Irwin/McGraw Hill.
7. Turban, E., Leidner, D., & McLean, E. R. (2006). Information Technology for Management. Edison: John Wiley & Sons.
8. Umble, J. E., Haft, R. R., & Umble, M. M. (2003). Enterprise resource planning: Implementation procedures and critical success factors. European Journal of Operational Research, 146, 241-257.
9. Van Doren, C. S. & Heit, M. J. (1973). Where It's At: a content analysis and appraisal of the Journal of Leisure Research, Journal of Leisure Research, 5(1), 67-75.
10. Von Neumann, J. & Morgenstern, O. (1953). Theory of Games and Economic Behavior. Princeton University Press, Princeton, New Jersey.
11. Zadeh, L. A. (1973). Outline of a new Approach to the analysis of complex systems and decision processes, IEEE Transactions, SMC-3(1), 28-44.

Business and Technological Perspectives About Mobile Commerce

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ABSTRACT

This paper presents a research in process about the privacy and security issues regarding m-commerce (mobile commerce). In this research, privacy issues are viewed as the business perspectives and security issues are viewed as the technological perspectives. M-commerce is an alternative way for customers to be reached. The questions are: is customer privacy acceptable in the m-commerce environment? and is security (reliability and trustfulness of the mobile systems) acceptable in the m-commerce environment? A pilot study was conducted to University students to observe their opinion regarding those questions. The intention of this research is to conduct a formal survey that present possible strategic solutions to improve m-commerce environment. Findings from the pilot study suggests that students would like to be informed about the lowest prices of their favorite products and services and that actual stability of the system is acceptable.

1. INTRODUCTION

About 1.7 billion people in the world own a mobile telephone (Momo, 2005). This is approximately how big mobile commerce market can become. M-commerce (mobile commerce) is an extended branch of electronic commerce, indeed users interact in wireless environment, in which time and space issues are overcome (Coursaris, Hassanein, Head, 2003).

2. LITERATURE

M-commerce is an extended branch of electronic commerce (Coursaris, Hassanein, Head, 2003). Its user interaction is done wireless. This atmosphere provides information about time and space to facilitate the location of potential customers. Privacy and security in the wireless environment are still main issues since technology is continuously improving. Business and technological aspects of m-commerce are analyzed.

2.1 M-Commerce from the Business Side

The business perspective provides an inside about the utility and profitability of m-commerce. Gilbert and Kendall (2003) present that many users of mobile devices carry it wherever they go and are more careful about its incoming stream of calls and text messages. Definitely, this new channel to reach customers closely represents an opportunity of great value to businesses.

Strader, Tarasewich, and Nickerson (2004) emphasize on the relationship between quality of service perceived by customers and the quality of service that was really delivered by service providers in the m-commerce environment. Another issue that they mention that have an impact on the business standpoint is the experience and compatibility among different mobile devices technologies.

New business models need to be developed for the proper m-commerce integration in the market. Gjerde, Venturin, and Stordahl (2005) highlight that the new strategy should take into account the fact that time and content (location, terminal capabilities, personal preferences) are factors known by the provider for the focus of the business campaign.

2.2 M-Commerce from the Technical Side

M-commerce depends on its technical support. Zheng, Chan and Ngai (2006) point out that data should adapt in the highly dynamic wireless environment called adaptive system. An adaptive system consists of presenting real images and text in the m-commerce device by location, awareness or transparency, dynamic reconfiguration, compositions, mechanism, and description. They use a Java platform to promote maximum interoperability across the systems. Even though their system is highly efficient, scalability, security and heterogeneity are important areas to explore.

A centralized database model is proposed by Hu and Meng, B. (2005). Their system uses a database for saving computing time when the mobile equipment is watched and controlled at anytime/anywhere environment. This database is controlled by authorized personnel. This system is like an adaptive system that uses a centralized database. They state that this system is a viable and effective way of saving computing time.

Kato, Yamamoto, Hirota, and Mizuyama (2006) present a Linux based mobile phone to approach some issues in the m-commerce system. Those issues are memory size, stability, boot time/ response time, real time, and power consumption of the mobile device. However, Linux has more processing overhead than what a mobile phone requires. They explain that additional technical innovations should address the configuration of memory size, the stability, which ensures security, and the boot time (to reduce the startup time).

2.3 Summary

Given the current technological advances in m-commerce, business can take advantage of this opportunity by providing the perfect market campaign according to when and where potential customers are. However, customers' invasion of privacy can be adversely affected. Future research would be relevant in the area of privacy and security awareness in the m-commerce environment.

3. THEORETICAL FRAMEWORK

3.1 Research Design

The survey for the pilot study was conducted at the University of Puerto Rico in Aguadilla, and the sample consisted of students taking information systems courses with Dr. Sanchez. Forty-three pilot study surveys were completed. Students were chosen for the study because most of them own a mobile phone, they are typically more receptive to innovations (considering m-commerce as an innovation), and they were the most accessible sample.

3.2 Limitations

There are limitations to the reliability and validity of the data collection instrument and study design common to cross-sectional studies (Bourque & Fielder, 2003). Since the selection of the sample was not randomly selected, the external validity of this study was affected. The survey for the pilot study was not randomly selected for a target population of 200 students registered in information systems courses in the Department of Business Administration. The sample selected was convenience sample of only 43 students. Therefore, generalization of the findings of this study to the target population should be made with caution.

4. IMPORTANCE OF THE STUDY

This study is relevant to the emerging mobile commerce market, which offers a new media to reach for customers. The intention of this study is to present possible strategic solutions to improve m-commerce environment. This particular paper presents the results of pilot study survey that is expected to contribute to the enhancement of the real study that will eventually be conducted.

5. RESEARCH FINDINGS OF THE PILOT STUDY

Forty-three pilot study surveys were completed by students, with no missing values. Those were analyzed in order to develop an improved survey instrument for the real study. According to the pilot study findings, a new survey instrument will be developed. The Statistical Package for the Social Sciences, version 11.0 was used to conduct all data analysis.

5.1 Descriptive Statistics

The variables that have the lowest standard deviation (with less than .73) are "Lowest prices about favorite products and services" and "Feel well if receive unsolicited services no matter the location".

The variables that have the highest standard deviation (with more than .97) are "Carry a mobile phone everyday" and "Customer privacy is accepted".

5.2 Regression

Multiple regression was used to predict customer privacy and security issues regarding m-commerce.

HYPOTHESIS 1

Null Hypothesis: The linear combination of independent variables ("Nearest favorite business location", "Promotions based on time and location", "Lowest prices about favorite products and services", "Feel well if companies know where you are", "Feel well if receive unsolicited services at a specific moment", "Feel well if receive unsolicited services at a specific location", "Feel well if receive unsolicited services no matter the location") does not predict the variation in the dependent variable ("Customer privacy accepted").

Alternative Hypothesis: The linear combination of independent variables (mentioned in the null hypothesis) does predict the variation in the dependent variable ("Customer privacy accepted").

Table 1 shows that the most important predictor in the model is "Lowest prices about favorite products and services" with $\beta = .388$ ($t = 2.065$, $p = .046$).

The ANOVA for the regression model using the stepwise method, $F(7, 35) = 1.43$, $p < .225$, suggests that the linear combination of variables does not explain a significant amount of variation in the dependent variable "Customer privacy is accepted". Therefore, the null hypothesis is accepted. This is maybe due to the sample size.

HYPOTHESIS 2

Null Hypothesis: The linear combination of independent variables ("Stability or good reception of the system is accepted", "Power consumption or battery life is accepted") does not predict the variation in the dependent variable ("Security issues are accepted").

Alternative Hypothesis: The linear combination of independent variables (mentioned in the null hypothesis) does predict the variation in the dependent variable ("Security issues are accepted").

Table 2 shows that the most important predictor in the model is "Stability or good reception is accepted" with $\beta = .301$ ($t = 1.839$, $p = .073$).

The ANOVA for the regression model using the stepwise method, $F(2, 40) = 4.735$, $p < .014$, suggests that the linear combination of variables does not explain a significant amount of variation in the dependent variable "Security issues are accepted". Therefore, the null hypothesis is accepted. This is maybe due to the sample size.

Table 1

Coefficients[a]

Model		Standardized Coefficients Beta	t	Sig.
1	(Constant)		2.953	.006
	Nearest favorite business location	-.065	-.409	.685
	Promotions based on time and location	-.090	-.489	.628
	Lowest prices about favorite products and services	.388	2.065	.046
	Feel well if companies know where you are	.094	.588	.560
	Feel well if receive unsolicited services at a especific moment	-.302	-1.423	.164
	Feel well if receive unsolicited services at a especific location	.083	.361	.720
	Feel well if receive unsolicited services no matter the location	-.058	-.271	.788

a. Dependent Variable: Customer privacy is accepted

Table 2

Coefficients[a]

Model		Standardized Coefficients Beta	t	Sig.
1	(Constant)		3.488	.001
	Stability issue (good reception) is accepted	.301	1.839	.073
	Power consuption (battery life) is accepted	.202	1.237	.223

a. Dependent Variable: Security issues are accepted

6. DISCUSSION OF FINDINGS OF THE PILOT STUDY

Results show that "Lowest prices about favorite products and services" and "Feel well if receive unsolicited services no matter the location" are strong variables. This means that most students were in agreement with those items. Although, none of these variables refer to the m-commerce scenario in which the customer can be reached according to the time and location.

Next, "Carry a mobile phone everyday" and "Customer privacy is accepted" are weak variables since variation in the answers were very high ranging from strongly disagree to strongly agree.

In addition, "Lowest prices about favorite products and services" was the only variable that try to predict better the dependent variable "Customer privacy is accepted" for hypothesis 1. However, "Lowest prices about favorite products and services" is not a variable clearly related to the m-commerce environment.

Lastly, "Stability or good reception is accepted" was the variable that tries to predict better the dependent variable "Security issues are accepted". May be technological issues are not affecting students in the m-commerce environment.

7. CONCLUSIONS

This research in process presents a pilot study that is relevant to improve a complete study about m-commerce and its customer perceptions regarding privacy and security issues. The intention of this research is to conduct a formal survey that present possible strategic solutions to improve m-commerce environment. The lessons learned from this pilot study to apply to future research are very relevant. First, some questions in the survey should be rephrased to emphasize on the m-commerce perspective. Second, more questions concerning security (technical) issues to should be added. More literature review in this area is needed, as well. Third, improvement in the selection and size of the sample is important. This study can provide important implications to m-commerce, if the factors arise from the pilot study are taken into consideration.

REFERENCES

[1] Bourque, L. B. & Fielder, E. P. (2nd Eds.) (2003). *How to conduct self-administered and mail surveys.* Thousand Oaks, CA: Sage Publications.

[2] Coursaris, C., Hassanein, K., Head, M. (2003). M-commerce in Canada: An interaction framework for wireless privacy. *Canadian Journal of Administrative Sciences, 20(1).*54-74.

[3] Gilbert, A. L., Kendall, J. D. (2003). A marketing model for mobile wireless services. *Systems Sciences, 2003, Proceedings of the 36 th Annual Hawaii International Conference,* 9-19.

[4] Gjerde, I. G., Venturin, R., Stordahl, K. (2005). Forecasting mobile market development. *Telecommunications, 2005, 8th Internacional Conference,* 219-224.

[5] Hu, W., Meng, B. (2005). Mobile server: an efficient mobile computing platform based agent. *Wireless Communication, Networking, and Mobile Computing 2005 International Conference,* 1339-1342.

[6] Kato, K., Yamamoto, T., Hirota, T., Mizuyama, M. (2006). Embedded Linux Technologies to develop mobile phones for the mainstream market. *Consumer Communications and Networking Conference 2006,#rd IEEE,* 1073-1077.

[7] Lee, T. (2005). The impact of perceptions of interactivity on customer trust and transaction intentions in mobile commerce. *Journal of Electronic Commerce Research, 6(3).*

[8] Momo, C. (2005). Wireless in Africa: insights into mobile markets. *ITProfessional, 7(3).* 34-38.

[9] SPSS (2001). SPSS Graduate Pack for Windows (Version 11.0) [Computer software]. CD-ROM edition.

[10] Strader, T. J., Tarasewich, P., Nickerson, R. C. (2004). The state of wireless information systems and mobile commerce research. *Information Systems and eBusiness Management, 2,* 287-292.

[11] Zheng, Y., Chan, A., Ngai, G. (2006). Applying coordination for service adaption in mobile commerce. *Internet Computing, IEEE, 10(5).*

The Information Steering in Government: Information Resource Managed by Administration in Welfare Sector

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INTRODUCTION

In government, the impact of information on organizations and humans has been under increasing scientific interest (e.g. Jones, Boushey & Workman 2006). Information can indeed generate fundamental changes both to the structure, processes and management of inter-government collaboration and to the choices of public policy. As research has been done about information processing, usage and sharing, however, there has not been enough research neither about the role of information as a steering method in governmental organizations nor about its effectiveness. In current study, the information is seen like a valuable asset and resource for the inter-government collaboration that the government must power as a public trust on behalf of local public organizations.

The questions rise about the instrumental roles of information (e.g. Sbragia 2000). Hence, it can be asked how the steering strategies and the forms of steering are build up or could be structured in order to coordinate quasiautonomous public organizations? Also, what is the effect of information when used as a steering mechanism? As a result, the information steering is seen as an approach to manage with the information resource. Information steering has an effect to the actor's behavior by sharing or transmitting the information (Stenvall & Syväjärvi 2006). In addition, the information management is seen as interdisciplinary procedures designed to provide, create, transmit and improve appropriate information systems and resources (Soeparman & Wagenaar 2006).

An information organization (e.g. Webster 1995) can be respectively recognized as a society of separate public unions either supported or not by the information. The organizations in public administration confront many challenges due to the information and technology. Information has indeed a direct effect on organizational behavior. Public organizations have to realize the role of information, for example, in the relation to other steering methods. In addition to information steering, there is steering by resources and steering by norms recognized in public sector (Stenvall & Syväjärvi 2006). Thus, information modifies or even challenges traditional organizational practices and further activates to scrutinize organizational processes (Syväjärvi & Stenvall 2006). The suitability of information steering is based on view that organizations operate at least partly according to the information. The success in information usage influences on organizational decision making and coordination (rf. Casson 2001; Adams 2004).

AIMS AND OBJECTIVES

This research aims to build up a theoretical framework or model for a successful information steering. In addition, the effectiveness of information steering is under investigation. The research has focus on the role of Central government as it carries out the information steering. More precisely, the research considers steering of the Ministry of Education and the Ministry of Social Affairs and Health in Finland. The purpose of steering, which coordinates the production of public welfare services, is to power local public organizations. The main research tasks can be set as follows

How information steering can be modeled from the perspective of inter-governmental collaboration?

How effective is information as a steering instrument and how it could be developed?

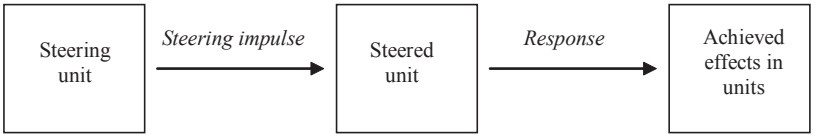
The research considers information as an instrument from the theoretical point of view, models information as a collaborative steering method, but also includes an assessment on the effectiveness of information steering. A comprehensive approach is needed when establishing information steering among inter-governmental organizations. This is partly because the autonomy and control of the public sector organizations affect the choice of coordination methods. We argue that information steering should be approached from the perspectives of traditional steering theory, communication theory, and knowledge and information management theory.

PERSPECTIVE OF STEERING THEORY

Steering is an inherent part in the implementation of public policies. It can be seen as a part of political processes. After a democratic decision-making processes, the steering can be used to direct administration in order to execute the public policy. *Steering power* means the right, power based on status or an expertise to influence on the behavior of another operating unit. Correspondingly a *steering impulse* means incentives or means, such as information, that the steering unit sends to the steered unit in order to produce desired behavior. (Oulasvirta, Ohtonen & Stenvall 2002, 16-21.)

The objective of information steering is to provide information that helps service producers to develop their own operations. Other objectives may be to increase expertise, to provide more general information, and to ensure the implementation of norm and resource steering and, more extensively, the public policy.

Figure 1. Components of steering



Research is indicating that information steering can produce effects, but often these effects on the behavior of the object remain with respect to the expectations minor or deviate from the objectives (e.g. Vedung 1998, 117-118). In addition, the effects of information steering may be difficult to detect. It is also possible that a steering impulse is lost or remains completely unnoticed by the steered unit. In conjunction to steering impulses we can talk about noise (i.e. organization or information noise), which means factors that weaken or prevent the free transfer of information. These factors have a distorting or disturbing effect on interactive operation, flow of information and confidential observations (Zaheer et al 1998; Ivancevich & Matteson 1999).

PERSPECTIVE OF COMMUNICATION

Communication has traditionally been considered to deal with the sending and receiving of messages. Typical communication research objectives include the question how people understand communicated messages, verbal and non-verbal communication as operating modes, and the study of changes in the contents when people exchange messages. Information steering is, indeed, quite naturally understandable and analyzable as a matter of communication. From the system perspective and combined with traditional steering ideas, the communication is a tool for management for achieving its objectives. From the viewpoint of objectives it is possible to set four different tasks to information steering: public information, promotion of objectives, bi-directional asymmetric communication, and bi-directional, symmetric communication.

Besides system perspective, the communication can be approached from a number of other directions that help in studying the success and nature of information steering. These are for example, the organizational communication (Craig 1999), the linguistic approach (Hood 1983, 38), the semiotic approach (e.g. Vedung 1998, 107-114; Oulasvirta et al. 2002, 29), and the approach of social psychology and sociology (e.g. Gibson et al 2003).

The communication principle means a process where information steering includes exchange of information. For instance, the actors in the central administration and at the local level take turns as equal senders and recipients. It should be noted now that the function and approval of information transfer and the related interactive nature seem to depend on the situation. Alternatively in long-term development operations communication and information should preferably have more bi-directional and dialogical nature (Waterhouse & Lewis 2004).

PERSPECTIVES OF KNOWLEDGE AND INFORMATION MANAGEMENT

Information steering is connected to the idea that organizations are increasingly dependent on knowledge and information. This has been studied in organization and management theories within the areas of information management, knowledge management as well as the management of so called expert organizations. Information can be loosely defined in public administration as knowledge of the facts, values, and ideas that help in the implementation of things. Some researchers (e.g. Adams 2004, 30) also include in information the separate information element of public politics, such as political programs. Information steering can, indeed, be used for strengthening organizations. Thus organizations can combine understanding, generate information, and develop decision-making.

Many questions that have been analyzed include the different elements of information and their relations to each other (e.g. data, information, knowledge, wisdom). The more advanced information steering is the more it has been developed in the direction of knowledge and wisdom, and the more the organizations also resemble information organizations that are able to comprehensively utilize the information potential. In this conjunction we also talk about information management, which means the overall management of information, operating processes, and information technology (rf. Sena & Shani 1999; Syväjärvi & Stenvall 2006).

It is essential that the conveyed information is true and accurate. Thus, the effective information must be reliable (Pfeffer & Sutton 2006). In this case attention is paid on, for instance, the fact whether the information also contains other factors than just those corresponding to the desired political will. One consideration of information quality is also the extent of its contents. Information is often conveyed solely on what should be done. Another, wider view is also that information steering should tell how things should be implemented. (Gelders 2005, 377)

METHODOLOGY

Both methodological and data source triangulation principles were applied (Patton 2002). More precisely, the research data was collected by interviews and by focus group meetings (Barbour & Kitzinger 1999). Totally 14 high-position officials from Central government were interviewed and eight experts attended to the focus group. All these were directed to people in Central government. In addition, a questionnaire (n=360) was implemented in local governments and a focus group meeting was arranged to eight managers representing Municipalities. The response rate was 45%.

MAIN RESULTS

Only the key results are shortly presented. Results are comparable throughout the public welfare sector. The findings also allow structuring a preliminary model of the information steering. It was found from strategic perspective of the central government that the information steering is not well organized. This viewpoint was shared by all stakeholders of the inter-governmental cooperation. Although the information steering was not found to be in a crisis, it needs development as it can be an effective method.

Firstly, the information steering was observed in relation to other traditional steering mechanisms like steering by norms and funds. It was showed that the information steering has not a clear or independent role as a governmental steering method. The information steering executed by the central government was indeed diverse and uncoordinated. The main reason for the abovementioned is probably in the implementation processes. It seemed that the information steering consists of a bunch of variable steering elements and it is not a single manner to steer as itself.

Secondly, there was a need for more suitable, functional and practical information steering. Local governments were after more coordinated and compacted steering as otherwise all the representatives of Central government were steering without clear goals. At the same time, the Local governments attempted to gain a more simplified and clarified information steering. This was required in order to get better usability for the general information resource. The lacks of interactive and communicative procedures were immense.

Thirdly, in Local government level as well as in Central government level people were after efficient public information management. As the information steering seems to be diverse and unorganized in many ways, it is obvious that its effects are quite modest. In welfare sector, the inefficient information management was manifested as large difficulties (or lack) with future visualization, coordination and implementation, as mistrust between inter-governmental operators, and finally as a lack of change pressure that emphasize the importance of information steering in inter-governmental collaboration.

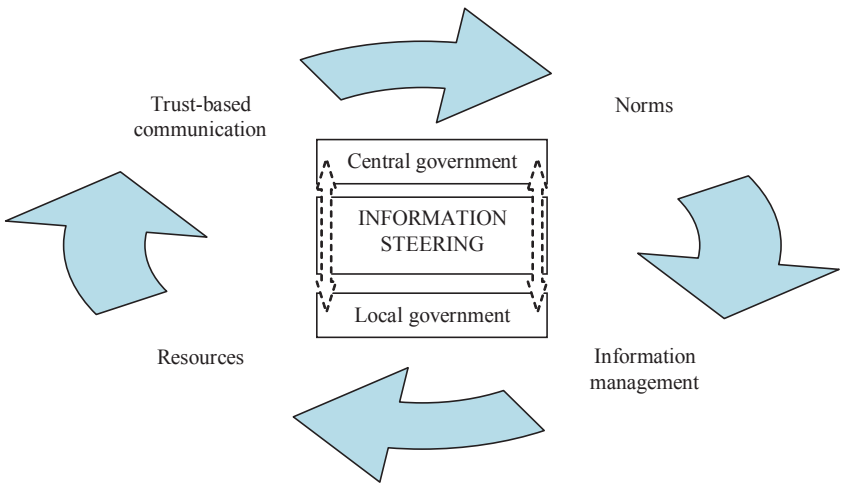
Fourthly, it was found that there are no systematic evaluations done about the effects of information steering. Awareness about the effectiveness of information steering was inaccurate as information steering has not had any stabilized models or perspectives. Steering has been executed by means of various evaluations, verifications and recommendations, which have not had any concrete position. It was recognized that huge information flows are produced, but usually those will not lead to parallel activity. However, the information steering has functioned finest in a quality-based local government work as it has assisted: to both recognize development challenges in Local governments, to increase the transparency of Central government activities and finally, to create knowledge about funding possibilities and norms.

CONCLUSIONS

In information steering, as respectively in other organizational activities, justified and meaningful procedures are needed in relation to what is attempted to accomplish. Research literature has quite well introduced the criteria and ideas of collaborative steering. These are, for example, clear and steady goals, capability to measure execution and results, and finally enough time for implementation (Gelders 2005). It seems evident that more interaction among steering participants and the viewpoints of effectiveness and productiveness should be emphasized in public policy.

Information steering requires communication that serves mutual trust. Trust is needed as an inter-governmental and interpersonal element for communication, but also as a feature of information quality (e.g. Harisalo, Stenvall & Syväjärvi 2006). The results indicate that in inter-governmental collaboration the trust capital

Figure 2. The information steering model in public inter-governmental collaboration



is not well taken care. Elements inducing trust and mistrust will reinforce each other. The information steering can be seen, together with its deepest goals, as an element to develop more interactive inter-governmental collaboration. The quality of information is also one critical factor. Sanderson (2002) has pointed out that a problem in public administration is the lack of information quality about social conditions in where the information will be applied.

The effectiveness of information steering in somewhat blurred as steering does not have a collaborative and strategy-based logic. The outcome is thus uncoordinated, unbalanced and unfiltered. In current research a challenge is to model information steering from the perspective of inter-governmental collaboration. The shaded arrows indicate how information steering consists of four major elements that interact and are in relation to each other. In addition, the dashed arrows indicate how information steering challenges to effective inter-governmental collaboration between the Central and Local governments.

Hence, the information steering can be developed and modeled by the means of information management, trust-based communication, and also in good synchronization to traditional steering methods like norms and a mixture of resources. Information as an instrument requires overall competence with information management (rf. Soeparman & Wagenaar 2006), it requires careful planning and action with two-way communication (Waterhouse & Lewis 2004), it requires the notion of trust and mistrust (Zaheer et al. 1998; Harisalo et al. 2006), and finally it requires well coordinated harmony that takes into account the deep nature and needs of various other steering methods (Sbragia 2000).

It was noticed that the information steering without logic and systematic is not very powerful approach. The information steering seems to have significance for two different levels of information processing that are individual and organizational levels. In order to gain the information steering as a useful part of public policy information processing should be modeled one way or another. In parallel to previous arguments Jones et al. (2006) have showed the information-processing approach of policy making, which focus on both complex environment of policy-makers and on their cognitive capacities.

Finally, organizations are always operating with more or less deficient information. This was noticed already in 1940 by Herbert Simon (1977) as he introduced the bounded rationality. Due to a number of situational factors, such as limited time or intelligence, it is not realistic to assume that any operation could be based on complete information. Information steering is thus inevitably accompanied by a shortage of information between the conveyed information and the demand. This argument is supported by the thematic of information and organization noise presented in conjunction to the theoretical framework.

REFERENCES

Adams, D. (2004). Usable Knowledge in Public Policy. *Australian Journal of Public Administration*, 1/2004, pp. 29-42.

Barbour, R.S. & Kitzinger, J. eds. (1999). *Developing Focus Group Research: Politics, Theory, Practice*. SAGE Publications, London.

Casson, M. (2001). *Information and Organization. A new perspective on the Theory of the Firm*. Oxford University Press. United States.

Gelders, D. (2005). Public Information Problems in the Implementation of Public Policy: The Long Road of the Reflecting License Plate in Belgium. *Government Information Quarterly*, (22) 2995, pp. 374-388.

Gibson, J.L., Ivancevich, J.M., Donelly, J.H. & Konopaske, R. (2003). Organizations: Behavior, structure, processes. Eleventh edition. McGraw-Hill, New York.

Harisalo, R., Stenvall, J. & Syväjärvi, A. (2006). *Factors Inducing Mistrust in Local Board's Decision Making*. In Papadopoulos, N. & Veloutsou, C. (eds.) Marketing from the Trenches: Perspectives on the Road Ahead. ATINER Publishing, pp. 269–289.

Hood, C. (1983). The Tools of Government. MacMillan Press, London.

Ivancevich, J.M; Matteson, M.T (1999). *Organizational behaviour and management*. Fifth edition. McGraw-Hill International Editions, Singapore.

Jones, B.D., Boushey, G. & Workman, S. (2006). *Behavioral Rationality and the Policy Processes: Toward a New Model of Organizational Information Processing*. In Peters, G. and Pierre, J. (eds.) Handbook of Public Policy. SAGE Publications. pp. 49-74.

Oulasvirta, L., Ohtonen, J. & Stenvall, J. (2002). *Kuntien sosiaali- ja terveydenhuollon ohjaus. Tasapainoista ratkaisua etsimässä*. STM-julkaisuja 2002:19, Helsinki.

Patton, M.Q. (2002). *Qualitative Evaluation and Research Methods*. Third edition. Thousand Oaks, CA: SAGE Publications, Inc.

Pfeffer, J. & Sutton, R.I. (2006). Hard Facts, Dangerous Half-Truths and Total Nonsense: Profiting From Evidence-Based Management. Harvard Business School Press, USA.

Sanderson, E (2002). Evaluation, policy learning and evidence based policy making. *Public administration* 1/2002, s. 1-22.

Sbragia, A. (2000). *The European Union as Coxswain: Governance by Steering*. In Pierre, J. (ed.) Debating Governance – Authority, Steering and Democracy. pp. 219-240.

Sena, J.A. & Shani, A.B. (1999). *Intellectual capital and knowledge creation: Toward an alternative framework*. In Liebowitz, J. (ed.): Knowledge management handbook. CRC Press London.

Simon, H. (1977). The new science of management decisions. Revised edition. Englewood Cliffs, New Jersey: Prentice-Hall.

Soeparman, S. & Wagenaar, P. (2006). *Concern-Wide Information Management with the Dutch Police*. In Anttiroiko, A-V. and Mälkiä, M. (eds.) Encyclopedia of Digital Government. Idea Group Publishing Inc., USA. pp. 215-219.

Stenvall, J. & Syväjärvi, A. (2006). Having information? Information Steering by the Central Administration in Welfare Services. Edita Prima Inc., Helsinki. (in Finnish)

Syväjärvi, A. & Stenvall, J. (2006). *The Core Governmental Perspectives of eHealth*. In Anttiroiko, A-V. and Mälkiä, M. (eds.) Encyclopedia of Digital Government. Idea Group Publishing Inc., USA. pp. 244-250.

Vedung, R (1998). *Public Policy and Program Evaluation. Transaction Publishers*. New Brunswick.

Waterhouse, J. & Lewis, D. (2004). Communicating Culture Change: HRM implications for Public Sector Organization. *Public Management Review*, 3/2004, pp. 353-376.

Webster, F. (1995). *Theories of the Information Society*. London: Routledge.

Zaheer, A., McEvily, B. & Perrone, V. (1998). Exploring the Effects of Interorganizational and Interpersonal Trust on Performance. *Organizational Science*, 9, pp. 141-159.

Making E-Business Customer Focused: A Fuzzy Approach

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ABSTRACT

In this paper a methodology has been introduced to make the e-business more customers focused by obtaining the preference ranking of the products as per the buyers' choice. The methodology takes into account the multiplicity of the product attributes and works in an integrated approach of fuzzy logic and Ordered Weighted Average Operator (OWA). The concept of OWA is used here to measure the optimism level of the customers in the given e-business system. This is most valuable information to make the e-business customer focused. Further, the OWA is applied here to articulate the targeted customers thereby making the e-business more customers' orientation.

1. INTRODUCTION

In any business whether it is online or traditional, a customer evaluates all available products as a whole before ranking them according to his or her own preferences. The ranking is specific to a particular customer and it normally depends on the number of products available to the customer in the market and how the product features satisfy to his/her likings. A customer's preferences for the products and hence their rankings are implicit in his/her mind and are difficult to express explicitly.

No doubt that each customer likes to have the fullest satisfaction on all the desired attributes of the products. However, the product attributes are in general conflicting, non-commensurable and fuzzy in nature and it is very difficult to satisfy all of them simultaneously. In this situation, a customer makes effort to satisfy most of the attributes rather than all of them. By the process, the customer is attaching some weights to the product attributes. These underlying weights are implicit in customers' mind. Articulation of these hidden weights will not only make the business more customers focused but also will help the business in analyzing the need of the customers in terms of the product requirements. The enunciation of these weights is a very complex and difficult task. In traditional markets, a sales person can assess these weights to some extent while interacting with the customers and through their body language. However, in e-business where no direct interaction takes place amongst the business partners, the identification of these weights is next to impossible. This problem becomes further complicated when the customers' requirements regarding the product specifications are imprecise or fuzzy in nature. In our paper we have introduced a methodology based on fuzzy sets to handle this problem in the e-business system.

In the literature, several papers refer to e-business sites. Jango and "Deal Time" (www.dealtime.com) are the earlier e-business market places. These sites collect information regarding the customers about their product preferences along with their prices and futures from the internet, and based on the information collected, suggest suitable products to the customers. However, it is difficult for the buyers to decide about an appropriate product in the vast Internet market. The agents such as "decision guide" by www.ActiveBuyersGuide.com assist the customers in identifying a suitable product. This e-business site requires the data from the buyers: the importance of the attributes numerically or in a range. The "decision guide" hardly accepts customer's fuzzily defined product specifications. These characteristics of www.ActiveBuyers.com fail to attract the customers.

A product classification problem in e-market is given in [5] and the classification of the products was based on their attributes. This procedure searches for a suitable product in the Internet, based on the customers' attribute wise requirements and if a product is found, the search ends. In case of non-availability, the procedure chooses a next available product closest to the targeted product. The drawback in the work [5] is the term attribute flexibility which was defined subjectively. The concept of attribute flexibility helps in classifying different products having different attribute values into the same preference group. The procedure given in [4] extends the idea of [5]. In [5], the subjective assumptions of the attribute flexibility are replaced by their objective counter parts. In [5], the available products in the e-business site are hierarchically classified based on their attribute values in a sequential manner. For example, in a CAR purchasing problem the possible attributes may be cost, maintenance-cost, and mileage. First the Cars are selected with respect to cost, then with respect to maintenance-cost, from the selected ones through cost attribute and finally by mileage from the Cars passed through the test of maintenance-cost. However, the deficiency of this approach is that the order in which the attributes are used to screen the products is arbitrary and does not reflect customers' anticipated priority about the attributes while making the final choice.

The present work addresses this problem by calculating the overall assessment of the products by using linguistic quantifiers [3] and OWA (Ordered Weighted Average) operators [6]. The procedure presented in this paper also helps to find the level of optimism of the customers and also the targeted customers. These are important aspect of e-business to make it more customers' focused. Optimism level of customers gives e-business companies become aware of the extent to which it is customer focused. On the other hand, the targeted customer determination helps the e-business system to focus on the valuable customers.

2. FUZZY CONCEPTS IN PRODUCT ATTRIBUTES

In any product purchase, normally a customer expresses his/her desire in multiple product attributes, which in general are fuzzy. For example in a car purchasing problem, the attributes may be price, re-sale value, mileage, maintenance etc. Very often a customer views these attributes fuzzily as shown in the italic words below:

Price should be *around US$ 2000*
The re-sale value should be *OK*
Mileage should be *normal*
Maintenance cost should not be *very high*.

We can define the above fuzzily defined terms as fuzzy numbers [1, 2, 4]. For example, the terms "*around US$ 20000*" and "*normal*" can be represented as fuzzy numbers as shown in figures 1 and 2 below.

Figure 1

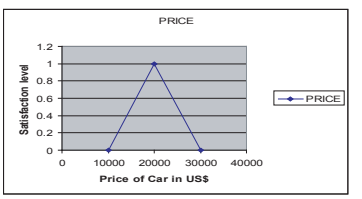
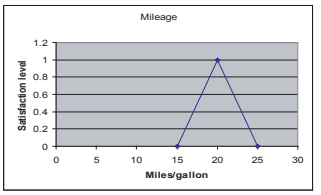


Figure 2



3. OWA OPERATORS IN E-BUSINESS

We have used OWA here to measure how far an e-business system is customer focused under a given product profile and what strategies are needed to improve the same. This is done by determining the preference ranking of the products as per the buyers' choice, optimism level of the buyers and through the identification of the targeted customers.

3.1 OWA Operator

An OWA operator of dimension n is a mapping f: $R^n \rightarrow R$ that has an associated *n* vector $(w_1, w_2 ..., w_n)^T$ such that $w_i \varepsilon [0,1]$ and $\sum w_i = 1$.

If $a_1, a_2 .., a_n$ are the elements to be aggregated (here they refer to product attribute levels) their aggregated value through OWA operator is:

$$f(a_1, a_2, ..., a_n) = \sum_j w_j b_j \quad \ldots \quad (3.1)$$

Where b_j is the jth largest amongst a_j.

The OWA operator uses the linguistic quantifier from the customers to derive the weights for the OWA operator. We consider the linguistic quantifier "most" following the [3] as follows.

$$\mu_{most}(x) = \begin{cases} 1 & x \geq 0.8 \\ \dfrac{(x-0.3)}{0.5} & 0.3 \leq x \leq 0.8 \\ 0 & x \leq 0.3 \end{cases} \quad \ldots. \quad (3.2)$$

The weights for the OWA can be obtained through the following equation [6].

$$w_i = Q\,(i/n) - Q\,((i-1)/n) \qquad \text{for } i = 1, 2, \ldots n \quad (3.3)$$

3.2 Product Ranking

Let us assume that K products (P_1, $P_2 \ldots P_K$) are available on the Internet. Let each product Pi (i =1, 2 …, K) has *m* attributes (A_{ij}) (i = 1, 2… K and j = 1, 2… m). A_{ij} represents the j^{th} attribute of the i^{th} product. Let $s_1, s_2 \ldots, s_m$ represent the customer's attribute-wise requirements in the form of fuzzy sets as:

$\{(s_1, \mu_{s1})\}, \{(s_2, \mu_{s2})\} \ldots, \{(s_m, \mu_{sm})\}$

Where μ_{sj} (j =1, 2, 3 …, m) represents the membership value of the customer's specifications on the attribute *j*.

Initially the e-business system presents the available products to the customers. After evaluating the products, generally customers form an overall opinion about the products fuzzily through linguistic quantifiers such as; mostly, more or less etc. The product rating of the product P_i can be derived through the OWA operator as given below.

$$F_Q(\mu_{s1}(A_{i1}), \mu_{s2}(A_{i2}) \ldots, \mu_{sm}(A_{im})) = \sum_i w_i b_j = R(P_i)\ i = 1,2, \ \ldots \ K \quad \ldots.(3.4)$$

where b_j is the j_{th} largest of the $\mu_{si}(A_{ij})$. The weights in the above equation are determined using equation (3.3).The value $R(P_i)$ is the rating of the product P_i.

Since these values are numerical numbers, they can be ranked from the best preferred product to the least preferred one. Note that the products are ranked here as per the buyer's choice.

3.3 Optimism Level of the Customers

The concepts of OWA operator and the weights therein provide a measure of or-ness [6] (optimism) and it is defined by the equation (3.5) below.

$$\text{Or-ness } (W) = \frac{1}{m-1} \sum_{i=1}^{m} (m-i) w_i) \quad (3.5)$$

The or-ness measure helps the e-business companies become aware of the extent to which it is customer focused in a given product profile. If the customers are absolutely optimistic we have

$$F_Q^*(\mu_{s1}(A_{i1}), \mu_{s2}(A_{i2}), \ldots \mu_{sm}(A_{im})) = Max(\mu_{s1}(A_{i1}), \mu_{s2}(A_{i2}), \ldots, \mu_{sm}(A_{im})) \quad (3.6)$$

The weights are here (0, 0, 0 …1).

Similarly if the customers are pessimistic about the products we have

$$F_{Q*}(\mu_{s1}(A_{i1}), \mu_{s2}(A_{i2}), \ldots, \mu_{sm}(A_{im})) = Min[\mu_{s1}(A_{i1}), \mu_{s2}(A_{i2}), \ldots, \mu_{sm}(A_{im})] \quad (3.7)$$

The weights are as (1, 0, 0 ….0).

3.3 The Targeted Customer Identification

It is very important for a business to identify its most valuable customers in totality. In the context of e-business, however, it is difficult to identify them. In the event of high demand and low stock level, it is an important issue. The purpose of this paper is to find strategies for the selection of these targeted customers under limited products. The procedure first evaluates different customers' ratings of the desired products. Then the customer corresponding to the maximum rating is selected as the targeted customer. The next higher rating determines the second-best targeted customer and so on. This methodology is explained in the following steps.

Step.1 If there are p numbers of customers, $C_2 \ldots, C_p$ and they require the products as follows (P=3, say) we have:

C_1: P_i, P_j, P_k

C_2: $3P_i$, P_j, P_r

C_3: $2P_i$, P_r, P_u, P_t

(The coefficient 3 for C_2 indicates the number of the product P_i as required by C_2)

Step.2 Take their attribute-wise satisfaction levels.

For C_1:

P_i $[(A_{i1}, \mu_{s1}(A_{i1})), (A_{i2}, \mu_{s2}(A_{i2})), \ldots, (A_{im}, \mu_{sm}(A_{im}))]$
P_j $[(A_{j1}, \mu_{s1}(A_{j1})), (A_{j2}, \mu_{s2}(A_{j2})), \ldots, (A_{jm}, \mu_{sm}(A_{jm}))]$
P_k $[(A_{k1}, \mu_{s1}(A_{k1})), (A_{k2}, \mu_{s2}(A_{k2})), \ldots, (A_{km}, \mu_{sm}(A_{km}))]$ (3.8)

For C_2:

$3P_i$ $[(A_{i1}, \mu_{s1}(A_{i1})), (A_{i2}, \mu_{s2}(A_{i2})), \ldots, (A_{im}, \mu_{sm}(A_{im}))]$
P_j $[(A_{j1}, \mu_{s1}(A_{j1})), (A_{j2}, \mu_{s2}(A_{j2})), \ldots, (A_{jm}, \mu_{sm}(A_{jm}))]$
P_r $[(A_{r1}, \mu_{s1}(A_{r1})), (A_{r2}, \mu_{s2}(A_{r2})), \ldots, (A_{rm}, \mu_{sm}(A_{rm}))]$ (3.9)

For C_3:

$2P_j$ $[(A_{j1}, \mu_{s1}(A_{j1})), (A_{j2}, \mu_{s2}(A_{j2})), \ldots, (A_{jm}, \mu_{sm}(A_{jm}))]$

P_r $[(A_{r1}, \mu_{s1}(A_{r1})), (A_{r2}, \mu_{s2}(A_{r2})), \ldots, (A_{rm}, \mu_{sm}(A_{rm}))]$

P_u $[(A_{u1}, \mu_{s1}(A_{u1})), (A_{u2}, \mu_{s2}(A_{u2})), \ldots, (A_{um}, \mu_{sm}(A_{um}))]$

P_t $[(A_{t1}, \mu_{s1}(A_{t1})), (A_{t2}, \mu_{s2}(A_{t2})), \ldots, (A_{tm}, \mu_{sm}(A_{tm}))]$ (3.10)

Step 3. For each customer add the attribute totals of every attribute. For customer C_1 we have the total attributes for the ith, jth and the kth products are as follows:

$$C_1(A_z) = \frac{1}{3}(m_i(A_i) + m_j(A_j) + m_k(A_k)) \qquad z = 1, 2 \ldots m \qquad (3.11)$$

The index z represents the z^{th} attribute. Similarly we can have $C_2(A_z)$ and $C_3(A_z)$ for the 2nd and 3rd customer.

Step.4 Use the aggregated weights from equation (3.4) and apply the OWA operator to $C_1(A_z)$ (z =1, 2… m); the product rating of customer C_1 is

$$R(C_1) = \sum_{z=1}^{m} w_z q_z \qquad (3.12)$$

Where q_z is the j_{th} largest among $C_1(A_z)$. Similarly, product ratings of second and third customers can be obtained as $R(C_2)$ and $R(C_3)$ respectively. Since these product ratings of the individual customers are numerical quantities, they can be ordered. In this approach the customer with the highest rating is considered to be the best customer in the customers' hierarchy. The next best customer in the hierarchy is accorded the second highest rating and so on.

4. NUMERICAL EXAMPLE

Let us assume that the customer's requirements for a product (e.g., a car) are expressed in terms of attributes cost, maintenance-cost (monthly) and mileage (miles/gallon). The attributes are in the form of fuzzy sets as shown below.

Cost = {0/10,000, 0.8/15,000, 1.0/20,000, 0.8/25,000, 0.6/30,000, 0.4/40,000, 0.1/50,000, 0/60,000}

Maintenance = {0/40, 0.4/50, 0.63/100, 0.65/150, 1.0/200,0.8/300, 0.4/400, 0.2/500}

Mileage = {0/9, 0.1/10, 0.4/12, 0.5/15, 0.6/16, 0.73/17, 0.8/19, 1.0/20, 0.9/21, 0.8/22, 0.72/25, 0.7/26}

Let us assume that there are eight types of cars available on the Internet. The data regarding these cars are given in Table 1.

Product Ranking

Using equations (3.2) and (3.3) the aggregated weights to the attributes are:

$w_1 = Q(1/3) - Q(0/3) = Q(0.33) - Q(0) = \mu_{most}(0.33) - 0 = 0.06$. Similarly, $w_2 = 0.66$ and $w_3 = 0.28$.

Now by using equation (3.4) we can get the product ratings are: $R(P_1) = FQ(0.6, 0.63, 0.8) = 0.632$.

Similarly, $R(P_2) = 0.419$, $R(P_3) = 0.792$, $R(P_4) = 0.492$, $R(P_5) = 0.5$, $R(P_6) = 0.7$, $R(P_7) = 0.368$ and $R(P_8) = 0.812$. From the above it can be determined that the customers' preference ranking of the products can be ordered as:

P_8, P_3, P_6, P_1, P_5, P_4, P_2 and P_7.

Level of Optimism

From equation (3.5) with aggregated weights as $w_1 = 0.06$, $w_2 = 0.66$ and $w_3 = 0.28$; $m = 3$, the or-ness or degree of optimism of the customers is:

1/2([(3-1)0.06 + (3-2)0.66+ (3-3)0.28] = 0.39

This demonstrates that the customers' level of optimism at the present system is approximately 40%.

Targeted Customers

Assume there are three customers who would like to purchase the products as given below

C_1: P_1, $2P_2$, P_3

C_2: P_1, P_3, P_5

C_3: $2P_1$, P_3, P_2

Let the company has one product each of type P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8. Now the question is how to choose the customers. First consider customer C_1. Using equation (3.11) the attribute totals of customer C_1 are

$C_1(A_1) = 1/3[0.6+0.4+1] = 0.67$

Note that for P_2 the second attribute's satisfaction has been added once, because the company does not have two P_2s.

$C_1(A_2) = 1/3[0.63+0.4+0.8] = 0.61$

Table 1. Sample data for products

Car type	Cost in US$	μ_{cost}	Maintenance Cost in US$	$\mu_{maintenance}$	Mileage in (miles/gal)	$\mu_{mileage}$
P_1	30,000	0.6	100	0.63	19	0.8
P_2	40,000	0.4	50	0.4	25	0.72
P_3	20,000	1.0	300	0.8	17	0.73
P_4	50,000	0.1	100	0.63	22	0.8
P_5	50,000	0.1	150	0.65	25	0.72
P_6	40,000	0.4	200	1	22	0.8
P_7	15,000	0.8	500	0.2	12	0.4
P_8	25,000	0.8	300	0.8	20	1.0

$C_1(A_3) = 1/3[0.8+0.72+0.73] = 0.75$

Based on the product requirements and the availability, we can obtain the customer's aggregated rating for the products can be obtained following the equation (3.17) as: $R(C_1) = 0.06(0.75)+0.66(0.67)+0.28(0.61) =0.658$. Similarly we have $R(C_2) = 0.66$ and $R(C_3) = 0.658$. This indicates that an e-business system should target the C_2 first and then C_1 and C_3 equally.

5. CONCLUSION

In this research, customers' imprecise judgments are treated in terms of fuzzy logic and their compromising attitudes are handled by linguistic quantifiers Then, OWA operators are used as excellent tools for producing an overall ranking of products in a fuzzy e-business environment. Such applications of these recently developed techniques are lacking in the literature. It has been demonstrated that this approach makes it possible to calculate levels of customer optimism or pessimism. Businesses on the Internet are expected to benefit from such a measure as it will help them become more customer-focused and gain competitive advantage.

REFERENCES

[1] D.Dubois and H.Prade, Addition of interactive fuzzy numbers, IEEE Trans. Automat. Control AC-26(1981) pp 926-936.

[2] D.Dubois and H.Prade, Operations on fuzzy numbers, Int. J. Syst. Science. 9(1978) pp 613-626.

[3] J.Kacprzyk and R.R.Yager, Linguistic quantifier and belief qualifications in fuzzy multi-criteria and multi-stage decision making, Control & Cybernetics, 13(1984) pp 155-173.

[4] B.K.Mohanty and B.Bhasker, Product classification in the Internet business-a fuzzy approach, Decision Support Systems, 38(2005) pp 61-619.

[5] Y.U.Ryu, A hierarchical constraint satisfaction approach to product selection for electronic shopping support, IEEE Trans. Syst. Man Cybernetics, Part A, Syst. Humans 29(1999) pp 525-532.

[6] R.R.Yager, Families of OWA operators, Fuzzy Sets and Systems, 59(1993) pp 125–148.

A Marketing Model for Innovative Software Products (MISP): Research in Progress

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ABSTRACT

In this 'this research in progress' paper a model for marketing innovative software products is presented. This model, which has evolved from Moore's (2002) 'crossing the chasm' metaphor, is discussed. A case study method has been adopted to apply this model to a small innovative software organization in New Zealand.

Keywords: Marketing, Innovation, Software Products

INTRODUCTION

In this research project a model that has evolved from Moore's (2002) 'crossing the chasm' metaphor is used as an appropriate tool with which to identify catalysts required to move from: innovators to early adopters; and early adopters to early majority. The research questions asked are: what are the main factors that impact on marketing new innovative software products; and what are the interrelations among these factors. Applying the model developed suggests that these two sets of marketing catalysts (innovators to early adopters, and early adopters to early majority) may be different.

First the MISP model (Marketing Innovative Software Products) (Figure 1) is outlined. This is followed by a brief review of the literature on marketing strategies for innovative software products. The case study research method to apply this model to a small innovative software organization in New Zealand is then described. Significant findings that are expected to emerge are discussed.

The paper concludes with suggestions for future research and for implications for innovative software organizations.

THE MISP MODEL

Key to the adaptation of Moore's (2002) 'crossing the chasm' metaphor is the identification of catalysts required to cross the divide between different adopter groups. Catalysts are considered to be any factors that influence the uptake of an innovative software product in the case being studied. These catalysts are influenced by both the marketing context of the firm and the firm's characteristics that inform an appropriate marketing mix. Marketing plays a key part in realizing both transitions from invention to innovation and from innovation across the chasm to a commercial product by identifying and implementing catalysts. The MISP model extends Moore's (2002) model by providing a theoretical mechanism for identify marketing catalysts to cross the chasm.

LITERATURE REVIEW

Successful innovations require successful marketing. A marketing concept "holds that the key to achieving organisational goals consists in determining the needs and wants of target markets and delivering desired satisfaction more effectively and efficiently that your competitors " (Dalgic & Leeuw, 2006, p. 12).

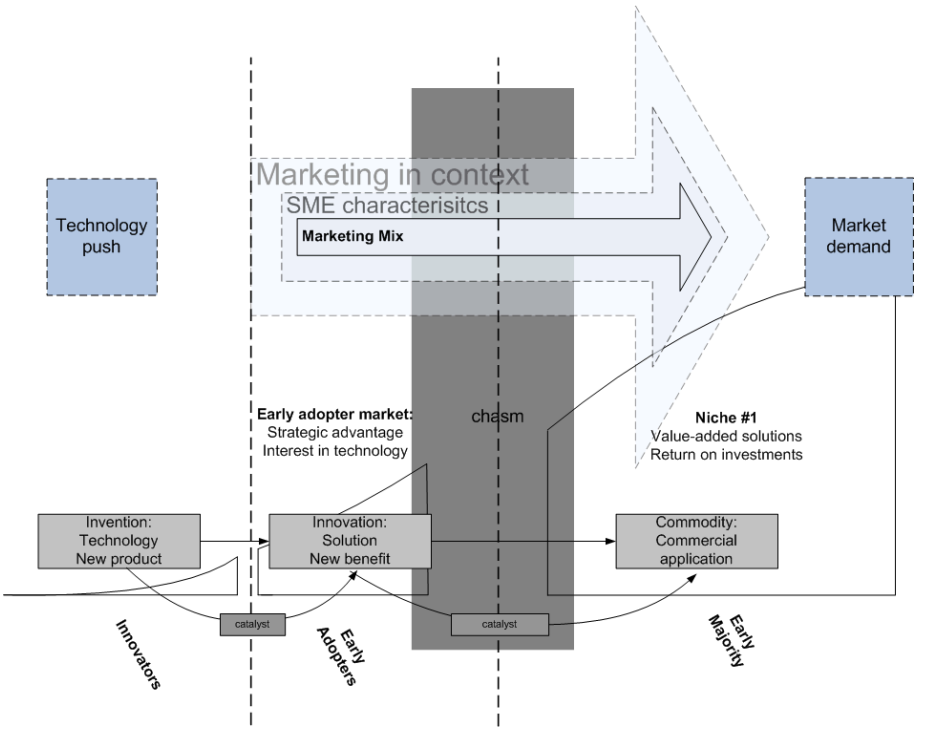
A different marketing strategy needs to be applied in moving from early adopter to early majority to accommodate different buying patterns. It appears that market entry can be achieved reasonably easily whereas survival cannot (Argarwal & Audretsch, 2001). The release of an innovative product to the mass market carries high levels of risk as well as manifold opportunities (Botting, 1997). The selection of a target market is a prerequisite to pursuing a niche marketing strategy within the early majority segment. As this has been identified as a main challenge in commercialising an innovative product, the capabilities of a firm should be aligned with the required strategies and tasks that are necessary to accomplish this goal (Slater & Mohr, 2006). A dilemma for small innovative software organizations is having an appropriate mix of marketing expertise in entering a mainstream commercial software environment (Dunn, Hulak, & White, 1999). Discovering the whole product solution including added-value and alignment with market needs (Cooper,2000; Davis & Moe,1997; Moore,2002) is necessary to establish and to isolate catalysts. Close customer relationships help to identify the needs of the target market. In SMEs this is most likely to be conducted through business networks. Dunne (1999) suggests that a direct sales approach is best suited to early adopters. Small firms often have limited resources for sales and marketing for commercialising products themselves. Marketing alliances through strategic networking therefore become important. Strategic alliances also encourage product promotion through word-of-mouth among industry consultants (Kohli,1999; Goldenberg, Barak, & Muller, 2002). To stimulate word-of-mouth communication, interpersonal communication and networking are important abilities that are required to actively promote the firm and the product to key contact points of the target group's network. Rowley (2004) describes three ways in which virtual marketing communication could be effective: creating presence, relationships and mutual value.

RESEARCH METHOD

An exploratory single case applying a deductive framework approach (Figure 1) has been adopted for this study. The case explored for this study was a small innovative software organisation whose core business is the design and implementation of a secure, spam-free interoperable grid infrastructure. This organisation is based in Auckland New Zealand. This organisation is the only one of its kind in New Zealand. The research questions were concerned with establishing an understanding of the factors that impact on the researched phenomenon and the interrelation between those factors. A holistic view of the research problem and the method applied was required in order to gain desired results. The phenomenon under consideration has been studied in its real-life context. In general, "how" and "why" questions help to investigate holistic characters of real-life events with its processes, life-cycles and relationships. Yin (2003) states that these are the forms of research questions that are posed in case studies. A "what" question can be also a "justifiable rationale for conducting an exploratory study" (Yin, 2003, p. 6). For instance, "What are the main factors that impact on …" clearly has an explorative character rather than an enumerative one.

A gap has been identified between scientific academic marketing theories, practitioner application and execution of marketing. Consequently, a more suitable approach is required that captures the dynamic and often chaotic growth, development and interaction of SMEs. An integrated approach that combines a post-positivist philosophy with a more interpretive approach is more suitable in the context of internationally operating SMEs according to Carson and Coviello (1996). Sinkovics Penz & Ghauri (2005) suggest a qualitative research approach that is flexible and open but that still follows conventional procedures of data

Figure 1. Marketing model for innovative software model (MISP)



gathering, analysis and interpretation. This research follows these recommendations for acceptance by academics as well as marketing practitioners.

EXPECTED FINDINGS

It is expected that the SME being studied will have a defined position on the MISP model and that marketing catalysts will not only be identified but also ranked in importance. Catalysts to move from innovator to early adopter are likely to be product information from external sources, acceptance by the innovator community, and evidence of functionality regardless of cost. Catalysts from early adopters to early majority pose a problem as there seems to be no effective cross-market communication between early adopters and the mass market of early majority adopters. Early majority adopters need to: solve an existing business problem with new benefits; minimise risk; and have sufficient trust and credibility in the new product. Results to date suggest that marketing innovative software products are dependent on the sector into which they are marketed. Because the existing interoperable infrastructure has such a dominant market position it would seem that the sales of this particular product are more likely to be made into companies operating closed grid systems – such as defence systems, systems requiring a high level of security or systems in which there currently is no such network in place. IT is not the network itself that will be the catalyst but rather products opera ting within the network.

FUTURE DIRECTIONS

Identification and rated importance of marketing catalysts should aid in developing a marketing plan for this particular SME. It is also expected that MISP will be applicable for further organisations. It is also envisaged that further evaluations of the model in other organizations will provide information to further fine-tune the model to make it more robust.

CONCLUSION

In this paper an evolutionary model (extended from Moore's (2002) crossing the chasm metaphor) for marketing innovative software products (MISP) has been proposed. It is expected that the completed research will identify the marketing catalysts required to move from innovator to early adopter and from early adopter to early majority. These catalysts will then facilitate the formation of a marketing place for this particular SME. These findings can not be generalised, however development of MISP adds to the body of knowledge for marketing innovative software products.

REFERENCES

Agarwal, R.,& Audretsch, D. B. (2001).Does entry size matter? The impact of the life cycle and technology on firm survival. *The Journal of Industrial Economics, XLIX*(1),21-41.

Botting, R. J. (1997). On the economics of mass-marketed software. In *Proceedings of the 19th international conference on Software engineering* (pp.465-470). Boston, Massachusetts, United States: ACM Press.

Carson, D., & Gilmore, A. (2000).Marketing at the interface: Not 'what' but 'how'. *Journal of Marketing Theory and Practice, 8*(2),1-7.

Cooper, L. G. (2000). Strategic marketing planning for radically new products. *Journal of Marketing 64*,1-16.

Dalgic, T., & Leeuw, M. (2006). Niche marketing revised: Concept, application, and some European cases. In T. Dalgic (Ed.), *Handbook of niche marketing: Principles and practice*(pp.3-25). New York: Haworth.

Davis, S. M., & Moe, K. (1997). Bringing innovation to life. *Journal of Consumer Marketing, 14*(5), 338-361.

Dunn, D., Hulak, J., & White, S. D.(1999). Segmentation high-tech markets: a value-added taxonomy. *Marketing Intelligence & Planning, 17*(4),186-191.

Goldenberg, J., Barak, L., & Muller, E. (2002). Riding the saddle: How cross-marketing communications create a major slump in sales. *Journal of Marketing, 66*, 1-16.

Kohli, C. (1999). Signalling new product introductions: A framework explaining the timing of preannouncements. *Journal of Business Research, 46*, 45-56.

Moore, G. A. (2002). *Crossing the chasm: marketing and selling high-tech products to mainstream customers*. New York: HarperCollins.

Rowley, J. (2004). Just another channel? Marketing communications in e-business. *Marketing Intelligence & Planning, 22*(1), 24-41.

Sinkovics, R. R., Penz, E., & Ghauri, P. N. (2005). Analysing textual data in international marketing research. *Qualitative market research: An International Journal 8*(1), 9-38.

Slater, S. F., & Mohr, J. J. (2006).Successful development and commercialization of technological innovation: Insights based on strategy type. *The Journal of Product Innovation Management, 23*, 26-33.

Yin, R. K. (2003). *Case study research : Design and methods* (3rd ed.). Thousand Oaks, California: Sage.

Social Learning and Self-Inclusion Through Women's Web Magazines

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What do users/readers of women's web magazines learn and how do they learn this? In this paper, women's web magazines will both be seen as a source for repeating and reinforcing heteronormative gender differences and as a tool for empowerment of their users. Most of this paper will focus on the processes through which the female users of women's web magazines acquire digital skills, get self-confidence and learn that the Internet is a place where they can feel 'at home'. They learn this through processes of 'assisted inclusion': through the design of websites, self-inclusion and social learning can be encouraged. Learning is considered to be a process of co-shaping of user and magazine, which takes place at both a material and a symbolical level: what gendered subjects are being produced by women's web magazines and what computers/Internet are users of web magazines producing?

Traditional women's magazines target middle class, middle aged, white heterosexual women, using and reinforcing traditional stereotypes of the attractive heterosexual partner, the productive modern housewife, the caring mother and supportive friend. Whereas women's web magazines repeat and reinforce these same stereotypes, e.g. by offering information about beauty, fashion and relationships, they at the same time stretch the traditional stereotypes of women to include the modern, computer competent and independent woman. Hence, they may help in breaking down some of the traditional stereotypes of femininity. Similarly, they can challenge the gender binary of women/serious/functional use versus men/fun/pleasure use. Or by allowing women to discuss their everyday life interests on a public forum, traditional binaries of women/private place versus men/public space may be loosened up. Finally, these stereotypes could have been loosened up by for instance presenting such a traditional, female connotated medium as a women's magazine on a, certainly at the time of conception of these web magazines, male connotated computer and Internet environment, giving them the incentive to use the Internet and facilitate self-inclusion in that respect.

To study what users of women's web magazines learn, creators and designers were interviewed and sites and discussion-threads were studied of the Norwegian web magazines 'Femme', the Irish 'eVenos', the Dutch 'Libelle' and Italian 'Donna Moderna'. In addition, two self-help mailing lists were studied, the Dutch Women On the Web ('WOW') aimed at women who start their own business or who want to develop their ICT competences and the Italian 'Sensa Maschera', aimed at people with 'Lupus', a serious illness that is more common amongst women than amongst men. In addition, surveys were held amongst users of Sensa Maschera, Donna Moderna, WOW and eVenos and (online) interviews were held with users of the latter two. All magazines had an early web-presence as they came online between 1996 and 2000. We can assume that the early web presence of these websites targeting women has contributed to the image of the Internet as it is now, a place where a diversity of users can find information they like. Arguably, this image has contributed to more equal statistics regarding the number of men and women that use the Internet. In and of themselves, these web magazines certainly attracted variable but high numbers of women. Whereas, for instance, the Irish web magazine eVenos is accessed by 790 visitors per month (MacKeogh, 2003), the Italian web magazine Donna Moderna attracted for instance an estimated one and a half million readers (Fortunati, 2004: 235) and Dutch web magazine Libelle had 13 million page views in a year (Slooten, 2003). In all these cases, a majority of users was female.

SELF-INCLUSION: COMMERCIALITY WITH A TWIST

What were the motives and intentions of the creators of the women's magazines we studied to 'go on line'? All four web magazines operated commercially. They hoped to directly earn money through advertisements on the Internet and indirectly by going on line as that would give their paper magazine a more modern image, again leading to (new) advertisers aiming at a younger audience and possibly to more buyers of their paper magazine. The magazines were founded in the period before the dotcom crash, in the same period that in the US and Canada 'active courting of the 'elusive female audience' began in earnest' as a result of some studies that showed that women 'accounted for 55% of web shopping' (Shade, 2000: 220). Hence, the creators had high expectations of huge growth rates and possibly even 'rolling out over Europe', as the creators of the Norwegian web magazine 'Femme' called it (Hestflatt, 2003).

All web magazines except Femme were magazines that already existed on paper, so their target users were somewhat younger but basically similar to that of their paper magazine, whereas the Norwegian magazine aimed to look similar to Cosmopolitan. In short, they all aimed at middle to upper-class women, which is not surprising 'given that advertisers want the most bang from their bucks' (Shade, 2000: 221). They tried to attract these women by addressing similar issues as they addressed in their paper magazines. According to sociologist McRobbie (1991), rather than dividing their target group according to interest, as is done when the target audience is male, girl-magazines 'assume that all girls are interested in romance, make-up, physical fitness, cooking, and fashion' (McRobbie, 1991). Indeed, the designers based many decisions on stereotypes rather than on user-research: as a Norwegian designer said 'certain things just belong to being a woman and to being female' (Hestflatt, 2003). Some designers also followed the so-called 'reflective I-methodology', as they assumed that their own interests would reflect those of the target users (Rommes, 2006), but perhaps most of all, they made their choices based on what they thought their potential advertisers would want to be on their site, which in the case of the Italian web magazine 'Donna Moderna' explained the attention paid to beauty topics.[1]

One of the common perceptions expressed by the producers of web magazines was that many women needed assistance to become web users. Generally, this was not based on a perception of female users as poor with technology, but in most cases it was felt that either women had no time for technology (Donna Moderna, eVenos) or had the ability but lacked the confidence (Women on the Web). For whatever reason, all the producers approached the user with 'kid gloves'. In particular, producers felt that the technology had to be 'easy to use' or 'user-friendly'. For example, the editor of Libelle felt very passionately about the importance of ease of use, and suggested that navigation should be : 'super, super simple; always visible, always knowing where you are, always recognizable … I would give my life if necessary to make sure that those requirements were met' (Slooten, 2003: 179). Hence, for the web magazine sites clear, traditional, fixed frames were used, explanations about how to use the site were given and the sites were made accessible at multiple platforms, e.g. also by Macintosh users and by not using flash.[2] So even though they did not think about their female users as incompetent, their websites could easily give that impression, especially if it is compared with similar web magazines for men.

All in all, these magazines used and reinforced traditional heteronormative stereotypes of women being interested in private and household issues and who are incompetent and need help in their use of the Internet. Whereas the users of magazines that targeted men and that were founded in the same period of time learned about a wide variety of ICT gadgets (Hestflatt, 2003), female users of these web magazines learned about how to make themselves more beautiful, how to improve their relationships and how to make a good meal. This reproduction and reinforcement of traditional stereotypes by commercial websites, web magazines, soap operas and games for girls has been extensively criticized by feminist researchers (Brunsdon, 1995; Cassell & Jenkins, 1998). Although many women

were clearly interested in the topics presented in these magazines, the success of the non-commercial websites Sensa Maschera and Women On the Web shows that other topics, like health, computer use or starting an enterprise were at least as popular. For a long time, Women On the Web was even the largest Internet community in the Netherlands (Drost & Jorna, 2000). Moreover, it seems that one of the most successful parts of the web magazines was not the content produced by the creators, but rather the communication and information exchange between the users of these sites on the many discussion boards that these sites hosted.

Although there is a lot to say against the repetition and reinforcement of stereotypes by these women's web magazines, they can also offer support and recognition in dealing with everyday life events, including how to deal with a gendered unequal society, and validation for undervalued female-connotated characteristics (Lovell, 1980). From a feminist standpoint position and from a diversity perspective, there is every reason to encourage an increase in female connotated values and topics on the Internet, and the main problem with these web magazines is that these topics are so clearly directed at 'women', rather than 'for everybody interested in these topics'. In a sense, these web magazines helped in constructing the Internet as an object of desire for users with a wider variety of interests, something that was clearly needed, looking at the historical roots and development of the Internet as 'a toy for the boys'.

Moreover, women's web magazines give the message that you can be a computer competent and confident woman and at the same time adhere to heteronormative requirements for women in present day society. These websites may attract female readers by offering the motivation and the opportunity to become familiar with the use of the Internet, e.g. they encouraged learning by doing, and several web magazine sites offered help for instance by offering an alphabet of 'technical terms'. 'Self-inclusion' thus flows from the relevance of the content of the magazine, the motivation this creates to be online and by reducing the amount of 'inclusion-work' by the users by connecting closely to the situation in which the user is, in terms of their everyday life experiences and their access to technological facilities, knowledge and skills. But even the large majority of women that is disinterested in women's magazine topics may experience that the creation of such 'places for women' or the addition of explicitly 'feminine' topics on the Internet gives the (implicit) message that the Internet is a place for women as well as for men.

SOCIAL LEARNING: WARM EXPERTS WITH A TWIST

As we have seen above, web magazines may be important instruments for assisted inclusion by providing for some relevant content, by facilitating more diverse learning methods than just learning by doing, and in symbolically transforming the meaning of the Internet to something that women feels fits with them. In addition, websites may assist inclusion by providing interactive mail lists, chat rooms and discussion boards where technical matters can be discussed and where users may develop social bonds and communities. This latter way of assisting with inclusion we will call 'social learning'. As with self-inclusion, however, the skills and knowledge that is being passed on between people is only a minor part of what needs to be learned. The symbolical and identity-work is at least as important, through which not just the perception of women as computer competent is changed, but also the perception of computers and the Internet as being relevant, fun and interesting is transformed.

In general, social learning is one of the main ways in which people learn to use new technologies and especially interactive ICTs (Rogers, 1995). People learn not just skills but also the relevance or entertainment-value of new ICTs from so-called 'warm experts': family members, friends or acquaintances who already have experience with the technology (Bakardjieva, 2001). A warm expert can 'translate' the usefulness of the technology and the language and skills needed for it in a way that fits with the everyday life experiences of the new user and can gear information towards specific questions and level of skills of users on a 'need to know' basis. This is hardly possible in manuals or during more formal learning settings. As many of the users of the women's web magazines remarked, however, such a 'warm expert' can also create an unwanted dependency relationship. One of the users of WOW said: 'I want to manage and maintain my own computer without being dependent on others'. Having a warm expert help may in fact increase the feeling of incompetence by the person being helped and even reinforce gender hierarchies (Rommes, 2002). Moreover, warm experts may not have time when needed or they may give wrong or unhelpful information.

The help women gave each other on-line had all the advantages of warm expert knowledge without the disadvantages. Answers were being checked by many other users, who would often provide additional information and the information was seen as more 'trustworthy', as they did not perceive any hidden agendas of the helpers. (Gendered) power-relations were absent as they were not in a personal relationship with the other users of the boards and almost all users were women. Most importantly, reading about personal experiences with technology but also with other recognizable stories of dealing with illness, discrimination or a (male) partner gave many of them more self-confidence in life and in dealing with technologies: they felt 'at home' on the Internet. As a user of WOW remarked: 'It gives me the feeling that I belong to it and because of this, I have started taking myself more seriously in the area of computers. Nowadays, I follow a master education media design'. In short, women would empower each other by being role model to each other. As two users of the mailing lists remarked of WOW and eVenos remarked: 'I have become so stubborn, I think: if others can do it, then why should I not be able to do it?' and another user said: 'by reading how others deal with computer problems (…) I get the sense that I could also learn it!' As we have shown in earlier research, being a role model for each other is one of the main advantages of women-only education in general (Rommes, Faulkner, & Slooten, 2005).

All in all, as a result of the self inclusion and social learning that was facilitated by the women's web magazines, both the female users of these websites as well as (perceptions of) parts of the Internet changed. Women perceived themselves as being computer competent and 'belonging' to the Internet. Simultaneously, the perception and content of the Internet changed. The Internet was no longer seen as a 'toy for the boys', but also discussion boards and topics were added and interfaces were changed as a result of requests by female users. Moreover, the female users of the discussion boards and mailing lists changed the discussion culture of the Internet, the 'Netiquette', at least for the boards and lists they were using. Rather than pasting short answers inside another woman's mail or replying 'RTFM' ("read the fucking manual') to questions, which had been the dominating discussion style on many mailing lists before, the discussion style on all discussion boards and mailing lists we studied was one of supportiveness, 'there are no stupid questions' and one in which women took time and space to answer questions elaborately and often illustrate them with personal stories and experiences (Herring, 1994). This chapter has shown the importance of changing both gender and technologies as a way of including gender in the information society, and it has shown ways in which this can be done.

REFERENCES

Bakardjieva, M. (2001, June 12-14 2001). *Becoming a Domestic Internet User.* Paper presented at the 3rd International Conference on Uses and Services in Telecommunications, Paris

Brunsdon, C. (1995). The role of soap opera in the development of feminist television scholarship. In R. Allen (Ed.), *To be continued... soap operas around the world* (pp. 49-65). London and New York: Routledge.

Cassell, J., & Jenkins, H. (1998). Chess for Girls? Feminism and Computer Games. In J. Cassell & H. Jenkins (Eds.), *From Barbie to Mortal Kombat; Gender and Computer Games* (pp. p.2-45). Cambridge/London: MIT Press.

Drost, K., & Jorna, M. (2000). *Empowering Women Through the Internet: Dutch Women Unite.* Paper presented at the INET, Japan.

Fortunati, L. (2004). Women and the Media System in Society. A Case Study: the Donna Moderna Site Forums. In N. Oudshoorn, E. Rommes & I. v. Slooten (Eds.), *Strategies of Inclusion: Gender in the Information Society. Vol.III: Surveys of Women's User Experience.* (Vol. 66, pp. 233-254). Trondheim: NTNU.

Herring, S. C. (1994, June 27). *Gender differences in computer-mediated communication: bringing familiar baggage to the new frontier.* Paper presented at the American Library Association annual convention, Miami.

Hestflatt, K. (2003). Strategies of inclusion in three Web-based Magazine: For 'women', for 'the advanced' and for 'the home user'. In C. MacKeogh & P. Preston (Eds.), *Strategies of Inclusion: Gender in the Information Society. Volume II: Experiences from private and voluntary sector initiatives.* (Vol. 65, pp. 91-114). Trondheim: NTNU.

Lovell, T. (1980). *Pictures of reality : aesthetics, politics, pleasure*. London British Film Institute

MacKeogh, C. (2003). eVenos.com: Creating a Space for Women on the Web. In C. MacKeogh & P. Preston (Eds.), *Strategies of Inclusion: Gender in the Information Society. Vol.II: Experiences from private and voluntary sector initiatives* (Vol. 65, pp. 385-404). Trondheim: NTNU.

McRobbie, A. (1991). *Feminism and Youth Culture; from 'Jackie' to 'Just seventeen'*. London: MacMillan.

Rogers, E. M. (1995). *Diffusion of innovations, the fourth edition*. New York: The Free Press.

Rommes, E. (2002). *Gender Scripts and the Internet; The Design and Use of Amsterdam's Digital City*. Enschede: Twente University.

Rommes, E. (2006). Gender sensitive design practices. In E. M. Trauth (Ed.), *Encyclopedia of Gender and Information Technology* (pp. 675-681). Heshey, London, Melbourne, Singapore: Idea Group Reference.

Rommes, E., Faulkner, W., & Slooten, I. v. (2005). Changing Lives: the case for women-only vocational technology training revisited. *Journal of Vocational Education & Training, 57*(3), 293-317.

Rommes, E., Stienstra, M., & Oudshoorn, N. (2003). KidCom designer case. In C. Mackeogh & P. Preston (Eds.), *Strategies of Inclusion: Gender in the Information Society; Vol. II: Experiences from private and voluntary sector initiatives* (pp. 189-218). Trondheim: NTNU 65.

Shade, L. R. (2000). Courting Women @ E-Com. In E. Balka & R. Smith (Eds.), *Women, Work and Computerization, Charting a Course to the Future* (pp. 217-224). Vancouver: Kluwer Academic Publishers.

Slooten, I. v. (2003). The Libelle website; A case study on the website of the Dutch women's magazine Libelle. In C. MacKeogh & P. Preston (Eds.), *Strategies of Inclusion: Gender in the Information Society. Vol.II: Experiences from private and voluntary sector initiatives* (pp. 163-188). Trondheim: NTNU.

Star, S. L. (1999). The Ethnography of Infrastructure. *American Behavioral Scientist, 43*(3), 377-391.

ENDNOTES

[1] Similarly, in the development of a new electronic toy for girls, the designers based their final decision about the color of the toy on what they expected the parents of the girls would like, rather than on what they knew the girls they had studied would like (Rommes, Stienstra, & Oudshoorn, 2003).

[2] This is an often underestimated aspect of software, as e.g. Star noted: 'It seemed the difficulty was not in the interface (…) but rather in infrastructure - incompatible platforms' (Star, 1999: 380)

Information and Communications Technology (ICT) as a Vehicle for Economic Development: Challenges Facing the Caribbean Common Market (CARICOM) States

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INTRODUCTION

This paper proposes to examine the potential of information and communications technology (ICT) as a vehicle for promoting the economic objectives of the Caribbean region and specifically those of the Caribbean Common Market (CARICOM) member states. Among the expressed objectives of CARICOM is "the strengthening, coordination and regulation of economic and trade relations in order to promote accelerated, harmonious and balanced development.(Palmer 2002)" Understanding and appraising the nature of the challenges to be faced in leveraging the potential of ICT for the economic development of the region is a critical contribution to this cause. The current standing members are: Antigua and Barbuda, The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname and Trinidad and Tobago.

Just over 200 years ago, the Caribbean Archipelago was the economic cockpit of the world, supply European industries with the vital raw materials from cash crops such as cotton, sugar, tobacco, cocoa, coffee and spices. The island of San Domingue (Hispaniola), now comprised of the Republic of Haiti and the Dominican Republic, held center-stage then, as the most prosperous European colony of the New World(Williams 1970). The Hispaniola of old is no more, now a landscape of economic stagnation that stands testimony to the economic despair that has griped the region since the heydays of the eighteenth century.

The island is now comprised of the Spanish-speaking Dominican Republic, occupying the eastern two-thirds and Haiti to the west, which still retains a very strong French influence. Haiti became the first black republic, following a slave revolt in 1802 that won its independence from France. Today Haiti holds the unenviable status as the poorest country in the Western Hemisphere and among the poorest in the world (Verner and Egset 2006). The juxtaposition of these two divergent cultures that comprise the land mass of Hispaniola characterizes the challenge to be surmounted in attempting to foster economic cooperation.

Once jealously guarded by their colonial rulers, these former pockets of economic opportunity for European investors have since been plagued by persistent economic stagnation. Recent international trends such as globalization and the outsourcing of light industry to the Far-East have greatly exacerbated the spiral. Each island is a truly unique and complex micro-state bearing the distinct imprint of its European colonial heritage. This proposal outlines a path of future study to use ICT as a vehicle for development in the region.

ICT AS A VEHICLE FOR DEVELOPMENT

Information and telecommunication technology (ICT) holds many promises as a vehicle for addressing the economic and other challenges faced by CARICOM member states. Clearly fostering internal economic cooperation in this Galapagos-like setting would pose a phenomenally rich setting for research. On the surface it may seem that the cultural and ethnic divergence of the region is not unlike the challenges faced by other similar efforts at economic cooperation, such as the European Union. But there are profound differences. Steeped in a legacy of economic dependency, geographically and otherwise fragmented, the island nations of the Caribbean possess their own litany of challenges. In this paper we propose to address these issues, drawing parallels from other successful efforts at regional cooperation, but mindful of those issues that can only be fully comprehended when framed in the historical and social legacy of the region. We propose to examine the potential for ICT applications in the following functional areas as they relate to the fifteen member states of the Caribbean Community (CARICOM), as briefly outlined below:

1. ***Economic Development and Cooperation:*** Limited size and resources makes economic cooperation an imperative for the future economic viability of the region, especially in the face of globalization (Byron 2004). The problem is compounded by the fact that the economies of the region are by definition open and export-oriented, each island possessing closer economic ties with the European mother-country and very limited intra-regional trade. The concept of *supply chains*, which is firmly grounded in the application of modern information technology to foster economic collaboration across industries, is a fitting example of how ICT can promote economic cooperation in the region. Other possible applications will be explored, taking cues where possible from successful regional projects elsewhere.
2. ***Education:*** The proverbial "brain drain" is yet another persistent problem of the region. For many of its inhabitants who are afforded advanced education the urge to migrate, beckoned by the prospect of higher wages and living standards abroad, is overpowering. For those left behind there are the dim prospects of a lifetime of underemployment and lack of access to the few skilled jobs available. There exists an unending spiral: migration of skilled workers depletes labor reserves, which in turn reduces the ability to attract investments. Could ICT provide the means for mitigating this problem?
3. ***Tourism:*** ICT could assist in the development of the tourism industry, facilitating better planning and resource utilization at a regional level. For example, e-markets and e-changes could potentially assist in the marketing of fresh produce, fruits and vegetable to support the hotel industry, yet another problem that characterizes the region.
4. ***Other dimensions of cooperation:*** E-health, e-government, regional security; these are all aspects of Caribbean life that can be potentially addressed through the applications of ICT-based solutions.

SUMMARY

The task of charting a path for economic development can be aided by learning from efforts pursuing similar economic objectives elsewhere. The case of the European Union immediately comes to mind. There may be several parallels, but the unique historical and political legacy of the Caribbean demands that the application of ICT, while holding significant potential as a vehicle for development,

should be tempered by other relevant concerns that may not be readily apparent to the researcher. This paper proposed an insight into the nature of Caribbean societies addressing those issues that could have a significantly impact on ICT related projects.

REFERENCES

Furnished upon request.

E-Learning and an Implementation in Yildiz Technical University

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In a globalizing world, the rapid advancements in technology affect education as well as the other sectors. To keep up with the innovations in information and technology, it is imperative to implement communication technologies within instructional settings. The use of internet and web in education is important especially for keeping the graduate curriculum that aims to equip students with modern trends in order to prepare them for the work force updated and for reaching more people without any time or location limit.

Today, most institutions draw on lecture-oriented methods. Traditional education has its limitations in terms of its engagement with students due to the inadequate use of audio-visual technology, causing a setback by not letting the learner to study in his/her own speed. (Inoue, 2004). Furthermore, there are other educational methods such as case study analysis, role-playing, conducting research, which provide students to have real life experiences. However, the insufficient funds together with the growing population of students require new alternatives to be employed by institutions as a means to complement the current instruction methods.

In this sense, technological advancements serve the educational institutions by both providing them with access to internet and to other communication technologies to help them create new learning and teaching opportunities.

E-learning is an example of the communication technology usage in higher education level. Some Turkish Universities follow "distance learning" and "e-learning" implementations by both practicing and blending it with other learning activities to attain to the modern education standards, to meet the increasing educational demand independent of any locational limits, with 7 days 24 hours access, and with less costs and more participants. In a supporting manner, the draft report of 2006-2008 Higher Education Strategy for Turkey, stipulates a %10-%30 percent increase in higher education programs via e-learning with the purpose of increasing the capacity of Turkish Universities. Also, the inter-university project; titled as "e-campus" supports the transformation of knowledge community in the higher educational level. (Yalabık, 2004)

Yildiz Technical University (YTU) , to which we belong, is also among the Turkish Universities which utilizes e-learning. 2006-2008 Strategic Plan of YTÜ attempts to make sure that each YTÜ student takes at least one e-course before graduation. In the strategic plan, the role and the short, intermediate and long term goals of YTÜ E-Learning Commission, decisions about the usage of blended learning model and the introduction of e-learning technologies to instructors and students have been emphasized.

Table 1. The electronic courses in YTÜ

Course Title	**Micro Economics**	**Macro Economics**	**English-Listening**	**Instructional Technology and Material Development**	**Design Languages and Figuration Grammars**	**Data Structure and Algorithms**
Department	Economics	Economics	Foreign Lang.	Computer and Inst.Techn.	Comp.Eng.	Architecture
Class	2	2	Prep	3	2	Graduate
Instructor's Title	Prof.Dr.	Prof.Dr.	Lecturer	Asst.Prof.Dr	Prof.Dr.	Prof.Dr.
Credit	3	3	3	3		
Requisite	Requisite	Requisite	-	Requisite	-	Requisite
Prerequisite	Prerequisite	Prerequisite	-	Prerequisite	-	-
Updating	updated	not updated	not updated	updated	not updated	not updated
First Semester*	2003-2004 autumn	2003-2004 autumn	2003-2004 autumn	2003-2004 autumn	2003-2004 autumn	2003-2004 autumn
Last Semester**	2006-2007 autumn	2005-2006 spring	-	2006-2007 autumn	-	-
New Course Suggestion***	International Economics	International Economics	no	no	no	no
Research****	yes (Eren& Dondu-ran, 2005)	yes	no	yes	no	no
Membership*****	yes	yes	no	yes	no	no

**The first semester of the electronic course*
***The last semester of the electronic course*
****Will the department suggest new e-course?*
*****The research about the success or satisfaction after the e-course implementation.*
******Membership of E-Learning Commission.*

The mission of the project titled as "e@yildiz"; is primarily to raise the quality of education, and secondarily to maximize the efficiency in facility management and human resources by applying distance learning technologies along with traditional models. For the effective usage of distance learning technologies, a preparation committee was constituted in May 2002. In 2003-2004 fiscal year, 5 courses from various disciplines have been offered on the web: Instructional Technology and Material Development, Micro Economics, Data Structure and Algorithms, Design Languages and Figuration Grammars, English-Listening courses. In the 2006-2007 fiscal year, three of these courses are still presented via web. A chart about YTÜ's e-courses is given below.

In addition to the courses presented in Table 1, the departments of Business Administration, Economics, Civil Engineering, Western Languages and Literature have suggested four more courses to be transferred to the web. This four courses including Human Resource Management course which is suggested by our division of Management and Organization in the Department of Business Administration have been endorsed by the commission as a part of the e-learning project.

This study involves the scenario work of the above-mentioned HRM course which has been prepared within the framework of Blended Learning Model.

E-learning can be described as an instruction in the electronic environment and has been defined by the American Society for Training and Development's e-learning glossary as "a wide set of applications and processes, such as Web-based learning, computer-based learning, virtual classrooms and digital collaboration" (Derouin, Fritzsche and Salas, 2004). E-learning provides synchronized and asynchronized education via computers, internet/ intranet, network, CD-ROM technologies.

Besides, blended learning is defined as an integrated model that unites the strengths of the face to face teaching activities in the classroom and online learning environments such as information and communication technology instruments (Hummel, 2006, 3). The notion here is that e-learning elements or modules are combined with traditional methods to make a hybrid learning experience (Kovaleski, 2004, 35; Coné, 2002, 19).

Each method and instrument has its own strengths and weaknesses in its own context. Today it is accepted that communication instruments should be mixed in best fit to be able to provide a more effective education.

Bersin identifies these instruments as classroom instruction, books, conference meetings, CD-ROMs, PPT presentations, handbooks/guides, education softwares, web pages, online simulations, web based discussion groups, mentoring programs and videos. He also mentioned that there is no need to use all of these materials to succeed in blended learning, but rather just two or three of them will be sufficient if they're consistent with the course content.

To be able to carry on HRM course in a more updated and affective manner, the courses presented in Table I have been investigated. HRM e-course had been adapted from the Instructional Design Model of Kemp, Morrison and Ross (Morrison, Ross and Kemp, 2001).

In this study, undergraduate students' readiness for self-directed learning and technical readiness (Chapman, 2004, 351), learning behavior of their age, size of the group, their interest and needs had been taken into consideration while setting the instructional objectives and constituting the content and the scenario. Differently from target audience analyze, course contents' predisposition to visuality and the appropriateness of showing most of the HRM applications on web were also affected the selection. Students take this basis and single course of HRM along their management education so the HRM functions and main concepts are intended to make known.

While configuring the HRM course content in the "instructional objectives setting" stage, the objectives indicated within the context of YTÜ EKSİP (Continual Quality Improvement Project in Education) were treated as the guidance.

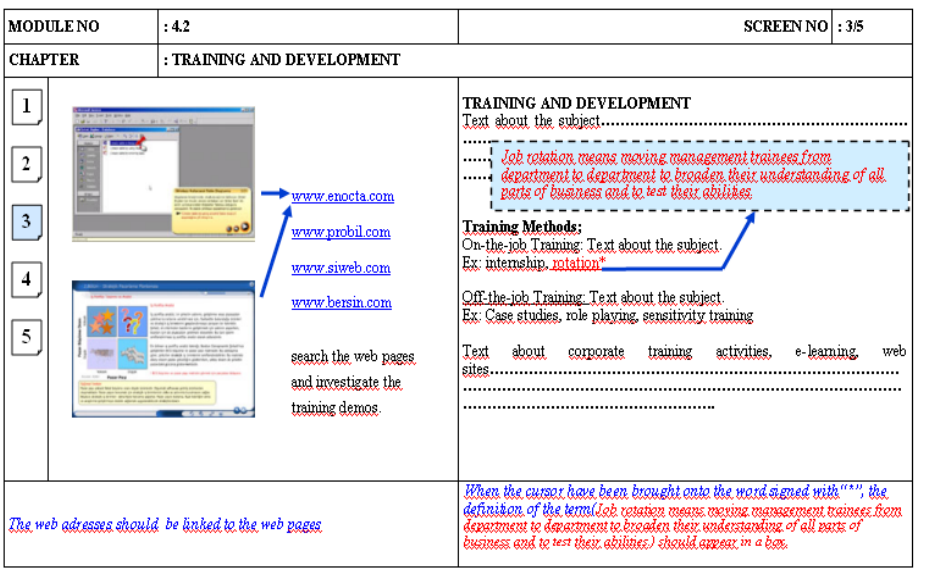
The knowledge had been separated in the modules that have integrity inside. The objectives for each module had been determined, some had been planned to be given in blended learning and the others in face to face instruction.

In the "instructional objectives organizing" stage, the learning behavior that will be introduced to students were prepared in accordance with Bloom's Taxonomy of Educational Objectives. Taxonomy consists of three domains of learning: cognitive, affective, and psychomotor. In addition; six levels of cognitive domain; knowledge, comprehension, application, analysis, synthesis and evaluation have been taken into consideration. The objectives in knowledge and comprehension level had been thought to fit to e-learning, the ones in application and advanced levels to classroom education.

For the purpose of informing students about the content of the course and to motivate them, the objectives of the new module will be presented in the first page of the module. By using the most appropriate language for the student, the new issues which will be introduced him by that module at the end of the session will be emphasized. By means of these, it is aimed for the student to be prepared and open for learning.

In the "module design" stage, some limitations have been assigned for both written texts part and visual expressions part. Allocating the subject into chapters, giving a heading to each chapter, allocating the chapter headings into subheadings, designating progressivity incisively, approaching a new subject under a new heading, scheduling the time table for module accesses and location selections(classroom or lab) for the courses, preparing an interactive visual material, writing the scripts

Figure 1. Interface sample



of animations, using maximum seven visual materials for a plain interface, not using horizontal scroll bar, using vertical scroll bar for the large charts, creating the texts and visuals for the 800x600 pixel resolution, disposing the written texts in the right side of the interface, never using an horizontal scroll bar in this written area and using the vertical one for maximum three times scrolling are basic standards.

YTÜ uses IBM Learning Space 5.0 in its project. The interface of the program has three main parts. Visual expressions such as figures, tables, charts, animations are found in the midst of the screen, thumbnails in the left part of the screen and the written texts of the course are found in the right side of the screen. (see www.e-learning.yildiz.edu.tr)

The visual expressions in the centre part can be changed easily to click on the links in the text or thumbnails in the left part. The thumbnails which are lined up one under the other represent the number of visual expressions in the module, the colored icon represents the actual visual material on the screen just in that moment.

In the scenario study of e-HRM course, visual expressions and written texts showed course content and screen flows is being arranged following the instructional texts are prepared in summarized formats. Scenario study is simply a plan that explains things that student will see, hear and do on screen during the e-course process.

In this study, an interface template of Learning Space 5.0 has been constituted to guide the web design team. In the lower-middle part of the template the verbal exposition about the visual material in the midst of the screen is found. If there's an annotation about the written text, this can be found lower-right cell of the template.

Furthermore a notation is created for facilitating the communication process between web design team and instructor and getting them understand the requests about the interface easily. Notation can be defined as a system of numbers and signs. Some notation examples are given in the Table 2.

In the "content constitution" stage, the objectives and contents of HRM courses in foreign universities are investigated and benchmarked to see the HRM relevant literature which is predominantly consisting of foreign sources as well as to be able to read the global implementations. The extent and classification of Dessler (2005) and De Chenzo(2001) in HRM were helpful while preparing of our own.

The HRM course contents of Melbourne Business School, AUSTRALIA; McGill University, CANADA; Nottinghom University Business School, UK ; Seattle University & Washington State University & Yale School of Management; New Haven USA; and the contents of Turkish Universities HRM courses; Marmara University, Yıldız Technical University have been benchmarked.

Some important differences have been detected in the course contents in terms of "speed of change" and/or "cultural diversities". To state as an example, although employer-employee relations, collective bargaining, racial and religious discrimination are frequent subjects in foreign and most notably in USA origin HR literature, the same subjects are emphasized less frequently in Turkey; and accordingly, they didn't take a place in our e-course.

We tried to show and give examples to the daily practices and business life experiences in the content preparation process. A self produced video about competency-based recruitment&selection and a 360-degree performance feedback test for the students' term project in which the evaluation of instructor, project team members, classmates and the student himself have been taken into consideration for his performance were specially created to be used in the modules. These are some examples for the most outstanding tools used in the program. On the other hand, the compensation management function of HRM had been left out of the content because it's difficult to build up the subject with audio visual stimulus in electronic media and also it's best fit to face-to-face learning. As a support for this elimination, a research of YTÜ Department of Economics puts forward some important evidences. The research showed that the students achievement has fallen after the web-assisted education; although previously an improvement had been expected. As one of the reasons behind these results, it was stated that the students were used to traditional style education, especially to the blackboard illustrations of technical issues (Eren&Donduran, 2005, 197), such as graphics or the compensation charts of HRM.

Student access scheduling and arrangement of the modules are modified in terms of opening each module just after the former module is worked up and being able to access the corequisite modules concurrently.

At the end of the process of "deciding on the instruction strategies", YTU decided to use Blended Learning Model during all the term, right along with the modules which have been followed through the web, and with the process of face to face instruction readings, discussions, case studies and workshops. Mid term and end-term evaluations will be done in class as it is in traditional education. The activities will be sent to the teacher or tutor by e-mail, the evaluations will be done at class, by that way the mutual interaction between the teacher and the student will be able to be provided.

The learning of lesson over web will be done by presentation. First of all the whole will be shown and explained by the method of deduction, then examples will be given. Every week after the students checked the modules, teachers and students will meet at the class, they plan to overview the details if needed, debate and summarize the subjects. The activities in the class should not be as a repeat of the subjects on the web; rather they should be in a complementary and supportive manner. The issues like student-student and instructor-student interaction and active engagement to the class have not been maintained in a satisfactory manner with virtual class and synchronized practices in e-learning and they are tried to be maintained with face-to-face education.

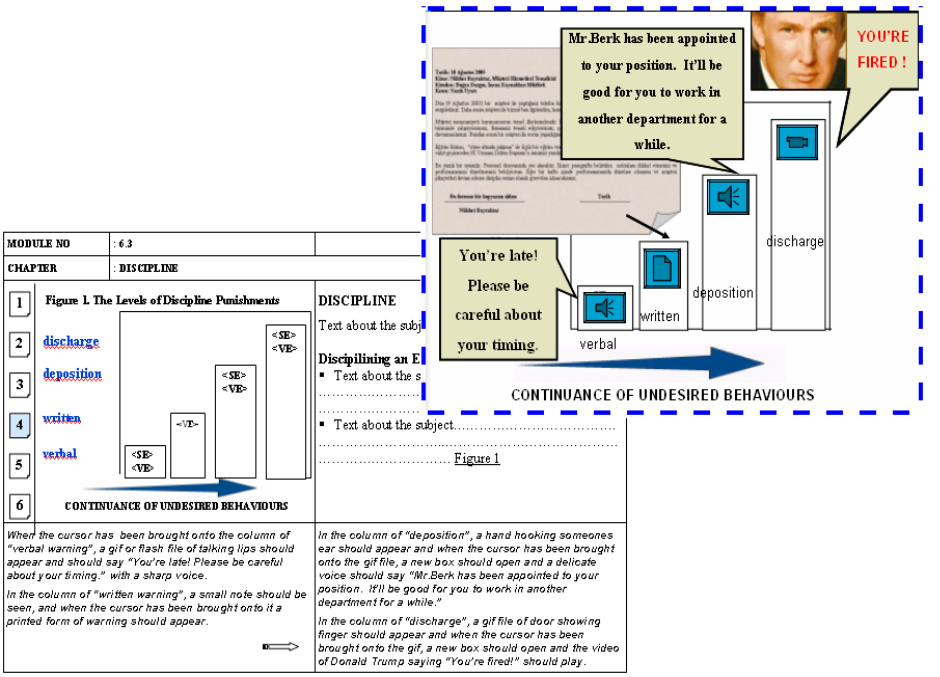
In "the design of modules" stage, IBM Lotus Learning Space 5.0. Program will be used. Learning Space 5.0 is a software with user-friendly interface that provides to constitute on-line courses, to manage them, to communicate the contents to students and to check out the courses. Finally, after preparing the summarized formats within the framework of the mentioned standards and limitations above, the scenario plan showing course content and screen flows with written texts and visual expressions has been arranged following the instructional texts. LMS (learning management system) will also provide glossary, notebook, reading room, print, download and help options. Glossaries and online dictionaries are the most preferred web-assisted functions in terms of perceived usefulness in the communities whose mother tongue isn't English. Notes, powerpoints and multimedia projects are following the glossaries. (McNaught&Lam, 2005, 610). In our project HR terms, reading room, print and download options are planned to be used in an efficient way.

The new information and communication technologies such as web journal/blog, podcasting, wiki, e/pop are supposed to be used in the near future of Turkey. The infrastructure and limited bandwidths are needed to be developed and the instructors need to be more enthusiastic with the instructional technology use both in and out of the classroom. Poscasting is a new concept and an alternative delivery for any content including the educational ones which can be thought as university lectures. It is a combination of *iPod* (Apple's popular audio player)

Table 2. Notation sample [1]

Italic	=	*guideline for designers*
Normal	=	just the text
Underlined	=	link to any document or web page
Italic bold underlined	=	***link to attachment***
<SE>	=	sound effect
<VE>	=	visual effect
<1>	=	1 second blank

Figure 2. Scenario screen sample



and broadcasting (Elliott, 2006; Crofts, Dilley, Fox, Retsema & Williams, 2005; Jardin, 2005). Podcasts, audio podcasts, video casts can be played on any computer, and downloaded to almost any portable music player (Toole, 2006). E/pop is a new video conference method that lets instructors and students not only see each other but also lets them send documents and mails, see the others' desktops on their own screens and use it interactively. This technology is especially ideal for small group courses.

The HRM course is planned to be opened as an e-course in 2007-2008 fiscal year after the web design team transfers the scenario to web. The preparation process requires the interaction and exchange of ideas between instructor, subject field specialists and web design team so we're looking forward to hear the participants' contributions and criticisms.

REFERENCES

Asirvatham, S. (2000). Beyond the distance barrier. *Journal of Property Management*. September/October, 65, 42-46.

Bersin, J. (2003). What works in blended learning. *Learning Circuits, July.* Retrieved October 15, 2006 from: http://www.learningcircuits.org/2003/jul2003/bersin.htm

Campbell, G. (2005). There's something in the air: Podcasting in education. *Educause.* Review. November/December. Retrieved December 30, 2006 from: http://www.educause.edu/ir/library/pdf/erm0561.pdf

Chapman, D.D. (2004). Review: Preparing learners for e-learning, Edited by George M. Piskurich. San Francisco: Pfeiffer, 2003. *Human Resource Development Quarterly*, 15, 3, fall, 351-357.

Coné, J. (2002). E-learning: how to spot the good and discard the bad. *Strategic HR Review*. July/August, 1, 5, 19.

Crofts, S., Dilley, J., Fox, M., Retsema, A., & Williams, B. (2005). Podcasting: A new technology in search of viable business models. First Monday, 10, 9 . Retrieved December 30, 2006 from: http://www.firstmonday.org/issues/issue10_9/crofts

De Cenzo, D. A.& Robbins, S. (2001). *Human Resource Management*. (7th edition) USA: John Wiley&Sons.

Derouin, R. E. , Fritzsche, B.A. & Salas, E. (2004). Optimizing e-learning: research-based guidelines for learner-controlled training. *Human Resource Management*. Summer/Fall , 43, 2 & 3, 147-162

Dessler, G. (2005) *Human Resource Management*, (10th edition), New Jersey: Prenctice Hall.

DMI educates with e/pop (March 2006). E-learning age.

Elliott, W. (2006). The audiocast diaries: reflections on radio and podcasting for delivery of educational soap operas. *International Review of Research in Open and Distance Learning*, December 7, 3, 1-11.

Eren, E. and Donduran, M. (2005).Bilgisayar destekli mikro iktisat eğitimi: bir uygulama. *İktisat Eğitimi:Ulusal İktisat Sempozyumu,* Ankara::İmaj Yayınevi, 189-205.

Hummel, H.G.K. (2006), Feedback model to support designers of blended learning courses. *International Review of Research in Open and Distance Learning. December, 7,3, 1-16.*

Inoue, V. C. (2004). E-learning: all that we need for keeping us updated*, Technology anf Learning and Development,* October .

Jardin, X. (2005). Podcasting killed the radio star. Wire News. Retrieved December 30, 2006 from: http://www.wired.com/news/digiwood/0,1412,67344,00.html

Kovaleski, D. (2004). Blended learning in focus, *Corporate Meetings&Incentives*.

McNaught, C. & Lam, P. (2005). Building an evaluation culture and evidence bas efor e-learning in three Hong Kong universities. *British Journal of Educational Technolog.* 36, 4, 599-614.

Morrison, G. R., Ross, S. M. and Kemp, J. E. (2001). *Designing Effective Instruction.* (3rd Edition). New York: John Wiley and Sons.

Shulman, L. S. (2002). Making differences: a table of learning. *Change.* November/December, 34, 6, 36-44, retrieved December 04, 2006, from http://www.carnegiefoundation.org/publications/sub.asp?key=452&subkey=612

TAP goes blended . (2006)., *E-Learning Age*, March.

O'Toole,G. (2006) Multimedia-casting syndication for educational purposes considerations of a podcast for use in higher education. *British Journal of Educational Technology*

Troha, F.J. (2002) The Right Mix: A Bulletproof Model For Designing Blended Learning**",** *USDLA Journal*, May, 15, 5.

Yalabık, N. (2004) Turkish inter-university project; e-campus, Distance Education Workshop, April 30, Mersin, Turkey.

YTU e-yildiz project (2003). *Lecturer handbook,* Retrieved December 25, 2006, from www.e-learning.yildiz.edu.tr

http://e3learning.edc.polyu.edu.hk
http://www.wiredred.com/epop_products_epop.html

ENDNOTE

[1] The notation for the scenario work is constituted by the researcher.

E-Government and Its Impact on the Informal Sector in Turkey

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INTRODUCTION

In recent years Turkey faced with large budget deficits. After the financial crisis in 2001, budget deficits had reached a critical level. In order to deal with the problem, Turkish goverment have taken some actions to increase its revenues and to reduce its expenditures. The government has been working with the IMF to bring about structural changes and governmental reforms. As a result, a stabilization program has been put in place under IMF directions. Also, Turkey is currently in the negotiation process for EU full membership. The implementation of e-goverment is seen as a large step in governmental reform and another step towards EU standards.

E-government was introduced as one of the ways to increase tax revenue collections, which has been a major problem causing the deficits. The study is focused on e-taxation which was introduced as a way to effectively collect taxes which are the most important revenue resources of the government. Another focus is on the informal sector of the economy (or underground economy). In Turkey, efficient tax collection system is needed because of non-collection from its large informal sector. Gerxhani (2004) reported the average size of this sector in developing countries to be as high as 44% of GNP in Africa and 35% in Asia. This sector has also been significant in the Turkish economy as well. Therefore, the target for higher rate of tax collections comes from this sector of the economy.

Informal sector is a very important area to investigate because it inhibits productivity, discourages business investment and has the potential to reduce economic growth (Capp et al., 2005). According to a study by OECD (2006) of Turkish economy, a major factor which caused a relatively low GDP per capita is its low level of productivity, especially in the informal enterprises. Informality therefore reduces the overall growth potential of the Turkish economy. We expect that the implementation of e-taxation has significantly increased tax revenue collections coming from the informal economy. The following section presents a brief review of informal economy.

REVIEW OF INFORMAL ECONOMY

The informal economy is a vague, multidimensional and interdisciplinary concept therefore, it is necessary to define the boarders of the areas under investigation. In this study, we take similar interpretations from the OECD report (2005) on informal economy as the unobserved economic activities that are driven by tax evasion or by attempts to avoid legal standards and procedures. Therefore, it excludes criminal activities and non taxed activities such as domestic labor. According to this definition, registered businesses in informal sector may keep substantial parts of their earnings unrecorded and evade substantial tax payments. This group includes, for example, self-employed businesses, restaurants and traders whose tax amounts depend on their declarations. Tax evation behavior exists in some businesses and in all sectors of the economy, however, the magnitude of informality depends on the special structure of that sector (Sarili, 2004). For example, in those sectors where auditing is difficult to implement such as small companies serving individuals and labor-intensive sectors, business owners are more likely to hide their real earnings.

There is a positive correlation between tax rates and the level of informal economy. The higher tax rates in developing countries, with respect to developed countries, lead to larger informal economies (anonymous, 2001). Another significant incentive for informal economy in Turkey is the presence of high value added tax rates. This often leads to undocumented trade by increasing the propensity of purchasers towards bargaining for not taking the receipts. Thus, it should be expected that such bargains will reduce when the VAT rates are lowered. The European Union, is planning to harmonize the VAT practice. In the process of joining the EU, the VAT rates in Turkey will have to be aligned with these regulations.

Some of the primary economic reasons to participate in the informal economy related to unemployment and inflexible formal labor market; high tax rates and low audit probabilities; a declining real price of capital; the governmental over-regulation of the formal or market sector; and the high cost of formal production (Gerxhani, 2004). In Turkey, a large number of employment opportunities has been in the informal sector because the formal sector has been unable to absorb the growing labor force, especially in the urban area. Also, the Turkish labor market is over-regulated with very high taxes on labor, both of which serve as a large disincentive to formal sector employment (OECD, 2006).

Additionally, weak legal and law-enforcement systems contribute to the high percentage of informal economy. Tax amnesty programs has been put in place several times over the years in Turkey. They seem to encourage tax evasion and informal economic activities. Under the expectations of the next amnesty, taxpayers postpone their tax payments. This has been possible because of lack of effective tax auditing. According to the Ministry of Treasury statistics, the number of tax auditors in the last 17 years declined by 68%. From 1985 until 2001, the population in Turkey grew from 50.3 million to 68.6 million, that is 36.4%. Thus, while the population grew, the number of auditors reduced, which implies that both the frequency of tax auditing and the number of audited taxpayers has been reduced. It can be concluded that the government has been unable to collect a large portion of tax revenues. Over the recent years, the Turkish government has concentrated on borrowing, thus, it indirectly encourages those taxpayers to continue their informal activities. As a result, the internal and external debt of the country has been large.

ANALYSIS OF E-TAXATION AND INFORMAL ECONOMY

Kertesz (2003) proposes that governments need to evaluate their e-government projects for the economic value using cost-benefit analysis (the net present value method) since hundreads of millions of dollars are spent on such projects. Picci (2006) propose a structural modelling approach to analyze the economic impact of e-government. Others such as e-government readiness report (available at http://www.unpan.org/e-government5.asp) assesses UN member states to ascertain how willing and ready the governments are to use ICT to improve the access and quality of basic social services to the people for human development. Curtin (2006) offers a framework for e-government model and measurement. In this research, the authors attempts to explore e-taxation issues and its impact on informal sector by using various measurement methods, for example, econometric models, monetary approach and production of electricity approach. Specifically, it is expected that there has been an increase in tax revenues collected by the government after the implementation of e-taxation, and the revenues have come from previously undeclared informal economic activities. Comparison will be made from data gathered before and after e-taxation implementation. The authors will offer analysis, conclusions and recommendations based on results from various measurement methods.

REFERENCES

Anonymous (2001) “Kayıt Dışı Ekonomi Özel İhtisas Komisyonu Raporu”, Sekizinci Beş Yıllık Kalkınma Planı, Ankara.

Capp, J., Jones, B., Elstrodt, H. And Jones, W. B. (2005) "Reining in Brazil's Informal Economy", McKinsey Quarterly, Issue 1.

Curtin, G. G. (2006) "Issues and Challenges Global E-Government/E-Participation Models, Measurement and Methodology: A Framework for Moving Forward", http://www.unpan.org accessed 5 January, 2007.

Gerxhani, K. (2004) "The informal sector in developed and less developed countries: a literature survey", *Public Choice*, 120.

Kertesz, S. (2003) "Cost-Benefit Analysis of e-Government Investments", Harvard University, J.F. Kennedy School of Government, http://www.edemocratie.ro/publicatii/Cost-Benefit.pdf accessed 8 December, 2006.

OECD (2005) "The Informal Economy in Albania: Analysis and Policy Recommendations", http://www.oecd.org, accessed 7 November 2006.

OECD (2006) "Economic Survey of Turkey, 2006", http://www.oecd.org, accessed 7 November 2006.

Picci, L. (2006) "The quantitative Evaluation of the Economic Impact of e-Government: A Structural Modelling Approach", Information Economics and Policy, 18.

Sarili, M. A. (2002) "Türkiye'de Kayıt Dışı Ekonominin Boyutları, Nedenleri, Etkileri ve Alınması Gereken Tedbirler", Bankacılık Dergisi, Sayı:41

Pre-Mortem Factors for ERP Projects: Preliminary Findings

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ABSTRACT

While ERP systems have the potential to provide significant benefits, they are often mismanaged, with unrealistic expectations, or fail outright. This research focuses on applying organizational reliability to ERP systems. Findings from preliminary analysis of exploratory interview data from a group of ERP implementation managers/consultants are examined within the context of Sullivan and Beach's (2004) model for how High Reliability Organizations (HROs) manage complex systems. The model is comprised of five broad categories: risk factors, expectations, resources, organizational competence, and consequences. ERP implementations and HRO systems share considerable commonality, and thus, it is anticipated that ERP implementations could adopt HRO techniques to improve outcomes. By understanding organizational readiness issues for ERP projects, areas of weakness can be identified, and project performance metrics can be forecasted. This would enable ERP project managers to understand project vulnerability better and strengthen areas of weakness before the project begins.

INTRODUCTION

This research addresses recurrent problems with ERP systems. Four ERP managers/consultants have been interviewed (so far) to obtain perspective of factors that are critical for success with their absence contributing to failure. Sullivan and Beach's (2004) model for High Reliability Organizations (HROs) provides a basis for understanding success in managing complex systems. HROs have one difference; failure is the exception rather than the rule. By understanding the successes of HROs and overlaying that against ERP failure factors, it may provide a basis for a pre-mortem framework for improving ERP system management. If successful, this research will provide practitioners the ability to:

1. assess organizational readiness for undertaking an ERP project,
2. identify areas of weakness, and
3. predict with a degree of confidence the outcome of the project in terms of common project metrics such as budget, schedule, and system capability.

EXPLORATORY RESEARCH: PRELIMINARY FINDINGS

ERP implementation managers/consultants rarely have authoritative roles however their close proximity to the authoritative core of these projects provides a insightful perspective into ERP project management. It is recognized that four interviews with this set of participants is not a representative sample of the entire ERP universe. However, these participants were chosen because of their experience in a variety of industries and organizations. A list of factors is provided (Table 1) along with the number of participants who identified those factors. These were considered necessary for success, yet were frequently absent and contributed to failure.

Missing, or misplaced, *accountability* is where project managers are not held accountable for managing projects effectively. Failure does not lead to consequences. Misplaced accountability occurred when the only people held accountable were, "outside the client's organization" (i.e., the consultant or vendor), "anyone but the in-house people." Overwhelmingly, the participants believed that if internal project managers were held accountable for the success or failure of a project, they would succeed far more often.

The consultants reported a lack of *organizational learning*, where organizations failed to learn from past mistakes or the mistakes of others. While there are critics of the effectiveness of organizational learning strategies (Anheier, 1999; Husted and Michailova, 2002; Mellahi, 2005), there are cases where it is commonly used effectively (Garvin, 1993; Laise, 2004), particularly in cases of organizational benchmarking or Total Quality Management (TQM) (Camp, 1993; Yasin and Zimmerer, 1995; Daniels, 1996). While transferring learning strategies may not be universally effective, there is evidence that some organizations can learn from others.

Table 1. Factors emphasized by ERP managers/consultants

ERP Factors	Participants
Accountability	4
Organizational Learning	4
Reward Optimization	3
Leadership	3
Risk Management	4
Personnel Alignment	4
Change Management	4
Performance Monitoring	3
Business Processes	3

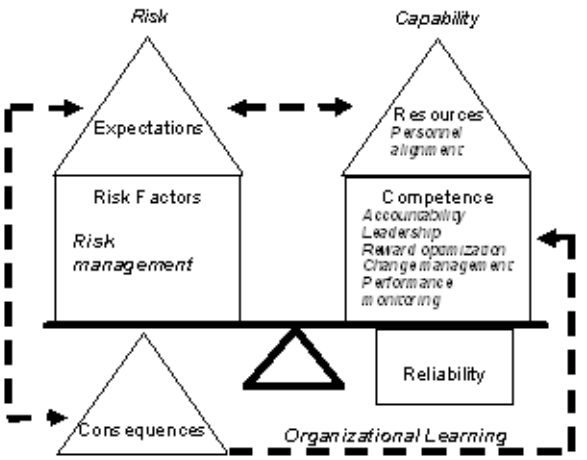
Reward optimization was another theme that emerged from the interviews. Three of the participants believed that organizations often reward behavior that improves the performance of a small component of the organization, at the expense of the greater organizational goals. "…this type of sub-optimization of an organization's overall goals occurs quite frequently. …subverts the overall goals for the maximization of their own personal goals." Thus, rewarding the highest *good* for an organization requires an understanding by its members of what that *good* is.

There is also a need for strong *leadership*. Managers "don't take ownership of the project" and that lack of leadership will allow problems to develop unmitigated. Ineffective or indifferent leadership sends a message to subordinates that the project is not viewed as important by senior management. Managers often delegate too much responsibility to consultants and vendors, and that lack of involvement results in a lack of understanding by internal personnel of the day-to-day management of the system.

Risk management was also reported as a problem for ERP projects. One participant said that many are aware of risk, but its affects are underestimate. Types of risk unaccounted for include, "amount of user acceptances, number and quality of resources assigned, data quality, willingness to change, and user skills, or lack thereof." Difficulties in large scale IT projects should be expected and contingencies should be available in such cases.

Organizational alignment means having the properly skilled personnel assigned to the proper job to avoid "people related problems." Further, "many of the reliability challenges you face with ERP do not deal with the system, but the business process and people instead." Having people assigned to jobs for which they are

Figure 1. Conceptual model for how HROs manage complex systems



not fully qualified develops weaknesses in the implementation process that persist over the duration (often years) of the project.

Another critical area of need is that of effective *change management*. ERP systems often require fundamental changes in the way an organization operates. One trap that some organizations fall into is excessive customization, "to make the ERP system look like our old system." As a result, they failed to recognize that ERP systems often require fundamental changes in the way the business operates.

Many of the participants mentioned that structured *business processes* were necessary. This process-orientation of ERP systems is a completely different perspective from the traditional functional orientation. Properly implemented business processes enhance the way departments interact. However, there appears to be considerable difficulty in getting managers to commit to the change in thinking from departmentalization to process orientation.

Finally, the organization must continuously monitor its performance. *Performance monitoring* provides feedback on the progress of the project. Participants recommended that a set of specific and measurable goals must be established, documented, and communicated among members of the organization. Key Performance Indicators (KPIs) that remove subjectivity are used as a standard set of metrics for measuring the performance of an ERP project. The Y2K problem is an example. When January 1, 2000 was reached, Y2K compliance was either achieved or not achieved, with the non-achievers being the more obvious cases.

DISCUSSION

While far from conclusive, there is considerable agreement in these areas. By aligning these areas with HROs, similar in terms of system complexity, budget size, project duration, and strategic importance of systems, much can be learned. Notably, accountability, leadership, and organizational learning are among the weakest. Understanding how HROs address these areas may provide insight into managing ERP systems.

Managing HRO Systems

HROs have been very successful in managing complex systems such as those controlling nuclear power stations, military operations, and chemical processes (Bierly and Spender, 1995; LaPorte, 1996; Britkov and Sergeev, 1998; Roberts and Bea, 2001; Weick, 2004). Yardsticks for HROs include, "How often could this organization have failed with dramatic consequences?" If failure could have occurred thousands of times, but did not, the organization is highly reliable (Roberts, 1990).

The ability to balance capability and risk in the presence of high consequence separates HROs from traditionally less critical organizations (Sullivan and Beach, 2004). The Sullivan-Beach Model (Figure 1) provides an illustration of the dynamics of managing complex systems in HROs using a scale to represent the weight of risk and the required weight of capability to counteract that risk. Failure occurs when risk, comprised of expectations and risk factors, outweighs an organization's capability, comprised of resources and organizational competence. In such cases the scale tips out of balance, and consequences follow. Bilateral relationships in this model exist between expectations and consequences, as well as expectations and resources. Additionally, a one-way relationship between consequences and organizational competence exists.

Expectations and consequences are related in that the consequences for failure are consistent with the degree of missed expectations. For example, a delay in launching the space shuttle by one day violates an expectation that the shuttle program stay on schedule. However, the consequences of failing to meet this expectation are minimal. Higher order expectations include returning the shuttle and its crew safely to earth. Failing to meet those expectations involves severe consequences (ibid). The relationship between expectations and resources is demonstrated when stakeholders provide resources to a project. Certain expectations, or a return on investment, accompany those resource commitments. Conversely, if resources are withdrawn, project managers will insist that stakeholders lower their expectations, or failure will result. Similarly, if expectations increase, managers will demand additional resources (ibid).

Finally, the one-way relationship between consequences and organizational competence is best described as organizational learning. When HROs fail, an investigation follows, and what is learned contributes to changes in policies and procedures that increase organizational competence so that the potential for failure is significantly reduced (ibid). ERP projects exhibit many of the same characteristics as HRO projects. The key to success for ERP systems might be found in the differences.

Comparing and Contrasting HRO and ERP Systems Management

Based on the Sullivan-Beach Model, HROs share considerable commonality with ERP implementations:

- complex, highly integrated, systems,
- significant resource investment,
- high expectations for success,
- risk factors that threaten success,
- significant consequences for failure (punitive, financial, etc.),

Managing ERP and HRO systems involve similar factors that influence their success. System complexity, resource commitments, high expectations, and risk all interrelate in their respective environments. However, there are differences. Preliminary findings from this research suggest one significant difference: the accountability and organizational learning connection between failure and enhanced competence. For example, losses of the space shuttles Challenger and Columbia involved significant consequences where NASA was held accountable. Consequently, they learned from their mistakes and became more competent. Even though the findings are not yet conclusive, it appears that accountability is frequently misplaced or absent in ERP implementations. Thus, an avoidance of certain types of consequences negates the benefits of organizational learning, and failures repeat.

CONCLUSION

Preliminary findings from ERP managers/consultants provided some insight into causes for failure. Using the Sullivan-Beach Model for how HROs manage complex systems, it provides understanding into how some organizations manage complex systems effectively and apply those techniques to those that do not. Additional data in the next phases of this research will build upon these preliminary findings.

Ultimately, this research seeks to develop a framework for practitioners to assess organizational readiness for undertaking an ERP project, identify areas of weakness, and provide the opportunity to correct weaknesses before the project begins. This pre-mortem organizational assessment model can be derived from prioritizing factors that contribute to success to provide insight into organizational shortcomings while there is time to correct them. Considering the immense resource commitments of ERP projects, opportunities to correct weaknesses in advance could be worth millions of dollars in wasted resources.

REFERENCES

Anheier, H. K. (1999). *When Things Go Wrong. Organizational Failures and breakdowns*, Sage Publications.

Bierly, Paul E. III and Spender, J.C. (1995). "Culture and High Reliability Organizations: The Case of the Nuclear Submarine," *Journal of Management*, Volume 21, Issue 4.

Britkov, V. and Sergeev, G. (1998). "Risk Management: Role of Social Factors in Major Industrial Accidents, *Safety Science*, Volume 30: pp.173-181.

Camp, Robert C. (1993). "A Bible for Benchmarking, by Xerox," *Financial Executive*, Volume 9, Issue 4: pp. 23-27.

Daniels, Shirley (1996). "Benchmarking," *Work Study*, Volume 45, Issue 3: pp. 18-20.

Garvin, D. (1993). "Building a Learning Organization," *Harvard Business Review*, July/August: pp. 78-91.

Husted, K. and Michailova, S. (2002). "Diagnosing and Fighting Knowledge Sharing Hostility," *Organizational Dynam*ics, Volume 31, Issues 2: pp. 60-73.

Laise, Domenico (2004). "Benchmarking and Learning Organizations: Ranking Methods to Identify 'Best in Class,'" *Benchmarking: An Internatioal Journal*, Volume 11, Issue 6: pp. 621-630.

LaPorte, Todd R., (1996). "High Reliability Organizations: Unlikely Demanding and at Risk". *Journal of Contingencies and Crisis Management*, Volume 4, Issue 2: pp. 60-71.

Mellahi, Kamel (2005). "The Dynamics of Boards of Directors in Failing Organizations," *Long Range Planning*, Volume 38: pp. 261-279.

Roberts, Karlene H. (1990). "Managing High Reliability Organizations," *Organization*, Summer, 1990 issue.

Roberts, Karlene H. and Bea, Robert (2001). "Must Accidents Happen? Lessons from High Reliability Organizations," Academy of Management Executive, Volume 15, Issue 3.

Sullivan, John J. and Beach, Roger, (2004). "A Conceptual Model for System Development and Operation in High Reliability Organizations," In Hunter, M. Gordon and Kathy Dhanda (eds.). *Information Systems: Exploring Applications in Business and Government*, The Information Institute, Las Vegas, Nevada. USA.

Weick, Karl E. (2004). "Normal Accident Theory as Frame, Link, and Provocation," Organization & Environment, Volume 17, Issue 1: pp. 27-31.

Yasin, Mahmoud M. and Zimmerer, Thomas W. (1995). "The Role of Benchmarking in Achieving Continuous Service Quality," *International Journal of Contemporary Hospitality Management*, Volume 7, Issue 4: pp. 27-32.

Organizational, Environmental and Technological Determinants of E-Commerce Adoption in Botswana

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ABSTRACT

A number of studies have applied the technology innovation models to the adoption of ecommerce. However, it is observed that no singular model fits the contextual situations of developing countries due to country specific factors such as culture, technology competency, government policy, and educational level. This study proposes an interactionist model termed technology readiness model (TRM) in the study of factors negatively affecting the ability of businesses in Botswana to adopt e-commerce. The findings show that organizational, internet marketing and customer/logistic factors have significant influences on e-commerce adoption. Security factor was however not identified to impact significantly on the decision to adopt e-commerce. The second phase of the study determines the impact of each organizational variable on e-commerce adoption.

Keywords: E-commerce, e-readiness, developing countries, technology adoption, technology readiness model

1.0 INTRODUCTION

Majority of studies on e-commerce adoption were in developed nations (Hawk 2004), while predictions point to a significant growth in e-commerce in developing countries in the first decade of the twenty first century (McConnel 2000). Recent studies have attempted to identify factors that affect organizations in the decision to adopt e-commerce in developing countries (Aghaunor and Fotoh 2006, Uzoka *et al.* 2006). However, most of these studies have emphasized the influence of contextual impediments related to economic, technological, legal, and financial infrastructure as major determinants of e-commerce adoption

Botswana is one of the countries in the Southern African Development Community (SADC) with a good degree of e-readiness (World Development Report 2003), and one of Africa's best performing economies (World Economic Forum, 2003). A report by Ifinedo (2005) shows Botswana as having an e-readiness value of 2.47 (on a five point scale), only after South Africa with an e-readiness value 2.78, and an African mean of 2.2. A previous study (Uzoka and Seleka, 2006) identifies Botswana as having a low level of e-commerce adoption. This study seeks to identify the factors militating against the adoption of e-commerce in Botswana, and determine the effects (if any) of organizational factors on e-commerce adoption in Botswana.

2.0 THEORETICAL FRAMEWORK AND METHODOLOGY

Most innovation adoptions promote several dominant perspectives: managerial imperative, organizational imperative, technological imperative, and environmental imperative (Molla and Licker 2005). Technological imperative models include the diffusion of innovation [DOI] (Rogers 1995), technology acceptance model [TAM] (Davis 1989), and the theory of planned behavior [TPB] (Ajzen, 1991). This study leans towards the interactionism as the theoretical framework for the adoption model.

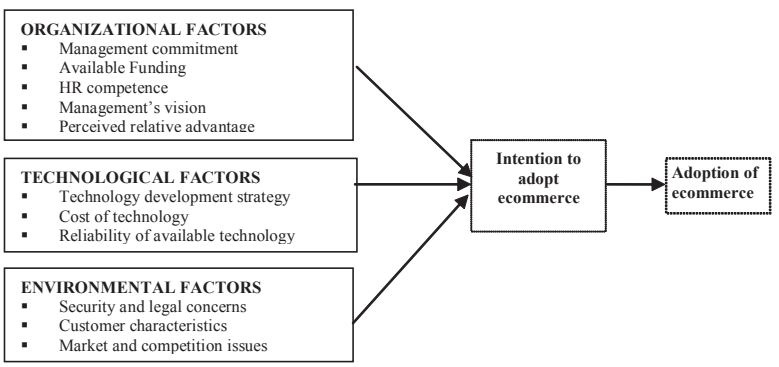
Some literature have adopted the interactionist models, which attempt to fuse the features of the managerial, organizational, technological, and environmental imperatives to technology adoption (Nelson and Shaw 2001, Molla and Licker 2005, Aghaunor and Fotoh 2006). This study leans towards the interactionism as the theoretical framework of adoption model. We posit that organizational, technological, and environmental factors can provide meaningful predictors of e-commerce adoption in Botswana. We refer to the model as *technology readiness model* (TRM) depicted in Figure 1.

Based on the TRM model, the following initial hypotheses were formulated:

H^1: There is a positive relationship between organizational characteristics and ability to adopt e-commerce.

H^2: Customer characteristics and logistics exert a significant influence on the organization's ability to adopt e-commerce.

Figure 1. Technology readiness model (TRM)



H^3: Internet marketing variables exert an influence on the adoption of e-commerce.

H^4: Security concerns significantly affect an organization's decision to adopt e-commerce.

Table 1. Results of exploratory factor analysis

	Factor			
	ORGANIZ	**CUSTLOG**	**INTERMKT**	**SECURIT**
lfd	.650			
smc	.658			
ids	.504			
hrs	.493			
wds	.551			
mvs	.629			
csa				.962
cll				.621
cbe	.473			
cli		.557		
cai		.692		
ccl		.714		
gcc		.635		
acc		.613		
mim			.677	
ora			.722	
ccp			.561	
tri			.444	
wdp			.577	
mrp			.475	
Eigen values	3.053	2.794	2.670	1.706
% Variance explained	26.937	14.042	6.137	3.999
Cronbach's Alpha if Item Deleted	.706	.706	.706	.706

Extraction Method: Maximum Likelihood.
Rotation Method: Varimax with Kaiser Normalization.

Two hundred questionnaires were administered to product/service organizations in both public and private sectors of Botswana. Twenty four variables relating to ecommerce adoption were identified through literature search and utilized for the purpose of analysis (Appendix A). The first part of the analysis involves the use exploratory factor analysis to reduce the variables into few factors that could affect the adoption of e-commerce in Botswana. Following the factor analysis was the use of K-means cluster analysis in grouping the respondents into two clusters relating to the effects of the identified variables on the adoption of e-commerce. The reliability of the resulting data was measured using the Chronbach's alpha. Multiple regression analysis was further carried out in order to test the hypotheses relating to the effects of the factors obtained in the exploratory factor analysis.

3.0 INTERMEDIATE RESULTS

The exploratory factor analysis (Table 1) produced four extracted factors which were considered interpretable.

The following factors were extracted:

a. *Organizational factor (ORGANIZ)*, which relates to organizational influence on the adoption of e-commerce.
b. *Customer/Logistic factor (CUSTLOG),* which represents the influence of customer characteristics and logistics on the adoption of e-commerce
c. *Internet marketing factor (INTERMKT)*, which represents issues relating to internet marketing as they affect developing countries (such as Botswana). Such issues include credit card penetration, internet access, and technical reliability.
d. *Security factor (SECURIT)* relates to security concerns.

The cluster analysis shows that 69.84% of the respondents agree that the variables under consideration exert an aggregate influence on their ability to adopt e-commerce, while 30.16% do not. The regression analysis shows an adjusted R^2 of 3.02, which indicates the predictive capability of the model. The model has a low predictive capability because other behavioral variables were excluded from the model [having been previously tested in (Uzoka *et al.* 2006)].The regression analysis (Table 2) shows that ORGANIZ, CUSTLOG and INTERMKT exert a significant influence on the firm's decision to adopt e-commerce, while the security factor (SECURIT) is not significant in a firm's decision to adopt e-commerce.

4.0 DISCUSSION AND FURTHER WORK

The findings show that organizational, internet marketing and customer/logistic factors have significant influences on e-commerce adoption, thus H^1, H^2, H^3 are supported. Security factor was however not identified to impact significantly on the decision to adopt e-commerce, thus H^4 is not supported.

Organizational factor is a major determinant in a firm's decision to adopt e-commerce. Variables such as level of funding available for retail development on the Internet, senior management's level of commitment to e-commerce, company's Internet development strategy, level of human resources available, web design skills of company personnel, management vision of the usefulness of the Internet and conviction about the benefits of e-commerce are key organizational issues

Table 2. Regression statistics

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.824	.080		35.293	.000		
	ORGANIZ	.513	.092	.449	5.588	.000	1.000	1.000
2	(Constant)	2.824	.076		37.009	.000		
	ORGANIZ	.478	.088	.418	5.429	.000	.988	1.012
	INTERMKT	.325	.089	.281	3.654	.000	.988	1.012
3	(Constant)	2.824	.075		37.902	.000		
	ORGANIZ	.464	.086	.405	5.375	.000	.984	1.016
	INTERMKT	.295	.087	.256	3.377	.001	.972	1.028
	CUSTLOG	.229	.087	.200	2.647	.009	.978	1.023

identified to affect e-commerce adoption. This agrees with the postulations of the DOI model (Rogers 1995) and the results obtained by (Aghaunor and Fotoh 2006). A key issue here is the negative attitude of management towards e-commerce (Orlikowski 1993). This attitude could be attributed to a number of factors, including the level of information systems (IS) literacy of top management. Until recently, IS courses have not been prominent in the syllabi of tertiary institutions, and when they were, at best, they were theoretical, leaving the students with no good level of appreciation of IS. Organizational culture is another factor, which could be influenced by xenophobia (Campbell 2003) that hinders innovations.

Internet marketing factor exerts some good level of influence on the ability to adopt e-commerce. This in line with the findings by (Aghaunor and Fotoh 2006) and is supported by the 'facilitating conditions' component of the theory of planned behavior (Ajzen 1991). In most developing countries, the internet market is not well developed with low credit card penetration (Hawk 2004). Often times, the costs associated with telecommunications and courier services to Africa and some parts of Asia are enormous. Some credit card companies even refuse credit card payments from Africa. This tends to alienate African countries from the digital market, thereby expanding the digital divide between the developed and developing countries. Customer characteristics also impact significantly on the firm's decision to adopt e-commerce. Key issues here are: customers' levels of access to the Internet, levels of computer literacy and internet awareness, gender of company's target customers, and age of company's target customers. Customer's characteristics are particularly instructive in developing countries where the access to internet is low and the level of IS awareness is equally low (Swami and Seleka 2005). Interestingly, the study reveals that security concerns does not significantly affect the firms decision to adopt e-commerce. This is in consonance with the results obtained in (Lawson *et al*. 2003), and could be explained by the reasoning that security only becomes an issue when the infrastructure and the enabling environment are in place.

Botswana is identified as one of the countries in Africa with a good e-readiness score. However, there is a low level of e-commerce adoption due to organizational and socio-economic structures. This study identified organizational, internet marketing and customer characteristics factors as impacting on the ability of organizations to adopt e-commerce. We have distributed questionnaires on the effects of the organizational variable on e-commerce adoption. We are currently analyzing the data using the method adopted in the preceding study, which is reported in the 'research in progress' paper.

REFERENCES

Aghaunor L, and Fotoh X (2006), Factors Affecting Ecommerce Adoption in Nigerian Banks. Downloaded from www.diva.org/diva/getDocument?urn_nbn_se_hj_diva-477-1_fulltext.pdf on Sepetember 24, 2006.

Ajzen I (1991); The Theory of Planned Behaviour. *Organizational behavior and Human decision Process*, 1(50): 179-211

Campbell E.K (2003), Attitudes of Botswana Citizens towards Immigrants: Signs of Xenophobia. *International Migration*, 41(4): 71-11

Davis F.D (1989); Perceived Usefulness, Perceived Ease of Use, and User Accdeptance of Information Technology. *MIS Quarterly*, 13:319-340

Ifinedo P (2005); Measuring Africa's e-readiness in the global networked economy: A nine-country data. *International Journal of Education and Development using ICT*, 1(1): 53-71

Hawk S. (2004); A comparison of B2C e-commerce in developing countries. *Electronic Commerce Research*, 4 (3): 181-199.

Lawson, R., Alcock, C., Cooper, J., & Burgess, L. (2003). Factors affecting adoption of electronic commerce technologies by SMEs: an Australian study. *The Electronic Journal on Information Systems in Developing Countries,* 14(1), 1-9.

McConnell International LLC, Cyber Crime (2000) . . . and Punishment? Archaic Laws Threaten Global Information . Downloaded from www.mcconnellinternational.com on July 30, 2005.

Molla, A., & Licker, P.S. (2005); Ecommerce adoption in Developing Countries: a model and instrument. *Information & Management,* 42(6), 877-899.

Nelson M.L and Shaw M.J (2001); Adoption of Technology Standards in Supply Chains: A Case of Adopting Rosettanet Standards. Downloaded from www.citebm.business.uiuc.edu/IT_cases/Rosettanet.pdf on September 24, 2006

Orlikowski W.J (1993). Case tools as Organizational Change: Investigating Incremental and radical Changes in Systems Development. *MIS Quarterly*, 17(3):309-340

Rogers E.M (1995). *Diffusion of Innovations*. 4th Ed. New York: Free Press

Swami, B. and Seleka, G.G. (2005); Problems, Prospects, and Development of e-Commerce – Case Study of Southern African Development Community (SADC). *IADIS International Conference e-Commerce*, (Porto, Portugal, December 15-17, 2005). 379 - 384

Uzoka F.M.E, Seleka G.G (2006); B2C E-Commerce Development in Africa: Case Study of Botswana. *ACM Ecommerce Conference*, Ann Arbor, USA, June 11-15, 2006: 290-295

Uzoka F.M.E, Seleka G.G and Shemi A.P (2006); Infrastructural and Behavioural Influences on the Adoption of E-commerce in Developing Countries. *IST Africa Conference Proceedings,* South Africa, May 3-5, 2006

World Economic Forum, *The Networked Readiness Index Rankings 2003,* downloaded from http://weforum.org on September 15, 2005

World Development Report 2003; *World Bank*, Downloaded from http://econ.worldbank.org on August 31, 2005

APPENDIX A: E-COMMERCE ADOPTION VARIABLES

a. Level of funding available for retail development on the Internet (LFD)
b. Senior management's level of commitment to e-commerce (SMC)
c. The company's Internet development strategy (IDS)
d. Level of human resources available (HRS)
e. Web design skills of company personnel. (WDS)
f. The management vision of the usefulness of the Internet (MVS)
g. Suitability of product range for Internet retailing (SPR)
h. Concerns about security aspects (CSA)
i. Concerns about legal and liability aspects (CLL)
j. Costs of development and computer networking technologies (CDN)
k. Limited knowledge of e-commerce models and methodologies (LKE)
l. Conviction about the benefits of e-commerce (CBE)
m. Company's logistical infrastructure (CLI)
n. Company's target customers' levels of access to the Internet (CAI)
o. Company's target customers' levels of computer literacy and internet awareness (CCL)
p. Gender of company's target customers (GCC)
q. Age of company's target customers (ACC)
r. The current size of on-line market place (CSM)
s. The maturity of Internet market (MIM)
t. Other retailers' on-line retail activities (ORA)
u. Credit card penetration (CCP)
v. Technical reliability of the Internet (TRI)
w. Web developer's promotional offers (WDP)
x. Media reporting about the positive and negative aspects of the Internet (MRP)

Towards a Knowledge-Based Society: The Need for a Continuous Life-long Learning Programme – The PRILHE Project

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The development of a knowledge-based society requires the contribution of a technological infrastructure as well as a workforce with the necessary skills, knowledge and competences, supported by a well-structured initial education and a continuous learning program. The individuals in this workforce must be autonomous, independent and reflective learners, because this is the only way to take advantage of a life-long learning programme and, in so doing, remain in employment at a time of global change. How can we help our students to become more autonomous, reflective and independent? What kind of strategies should be used in the classroom? What are the best practices? This paper sets out to answer these urgent, contemporary questions.

Project PRLIHE – Promoting Reflective Learning in Higher Education [113869-UK-2005-G1] - developed under the framework of the European Commission Socrates Programme - aims to identify the learning processes which enable adult students in Higher Education to become independent and reflective learners, to identify how this process could be better supported, to examine the interface between learning from experience and academic learning and to identify models of good practice in higher education institutions across Europe.

To achieve these objectives, a consortium was formed, with partners from Germany, Sweden, Finland, Portugal, Spain, Poland and UK. The consortium developed a questionnaire and distributed it to students and lecturers; this was then backed up by face-to-face interviews. The answers and opinions obtained have been compiled into a Handbook for Students and a Toolkit for Lecturers.

Some of the results reveal that students learn better when they are able to build bridges between life / work experience and the topics to be learned, when they share different points of view, when they discuss with others, when the learning process occurs in a supportive environment, when there is teamwork / interaction, when they see the practical use of what is being taught. For some of them, the guidance or instructions are an important issue; for others, it is important to be on their own. They prefer to explore the topic alone. One can also say that some of the students prefer to work alone while some others prefer to be in groups and discuss the contents with their colleagues. Anyway, there are different routes to become an independent, reflective and autonomous learner. One step in the right direction involves the discovery by the student of his / her best way to learn (and be conscious of that) as well as the help of the lecturer in a supportive environment. Of course, we realize that this process is not easy. Lecturers are, generally speaking, aware of this problem. They try to bring the experience of the students into the curriculum and use it to make the learning process more successful. However, there are difficulties that prevent success. Some of these are:

- as students work, they do not have a lot of time (time to study, time to attend classes, to be with the family, …), they are not able to arrive on time to classes or they miss classes. They have some difficulties reconciling family, profession and studies.
- Difficulties related to their academic background – they have a lack of knowledge to understand the subjects, they have bad learning habits (acquired in the past) which prevent their progression, they are more sceptical in relation to what the teachers say and so they have more difficulty in changing their opinion.
- they have more enthusiasm than the traditional students but they give up more easily, it is difficult to help them to change their study habits, some have lack of motivation, lack of objectives. They work at different rhythms and have different objectives; the standardization of subjects and contents do not meet all the interests of each individual. It is difficult to initiate them into critical reflection.

Although we realize that some of these difficulties are real, we also observed that there are lecturers who do not try to change the way they lecture – maybe because they have a lot of work (lack of time to prepare new lessons) or just because they are lazy (they have been in this profession for so long that they just repeat the contents without updating it). Anyway, we feel that there are still a long way to go in preparing the workforce for the knowledge based society; this involves students, lecturers and the institutions.

In this paper, we present project aims, objectives and methodology. We also report the lessons learnt and best practices identified. We believe that the preparation of the knowledge based society starts at school, helping students to become autonomous and reflective learners.

Approaches to Valuing Information: Exploratory Research

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ABSTRACT

This paper introduces a piece of exploratory research carried out into issues around organizations 'valuing' their information resources. Academic and practitioner research over the past 15 years have identified issues around the use and appreciation of information as an asset by organizations. Drawing on this published information, an interview schedule was developed and used with ten individuals who used and/or were responsible for information. Initial analysis of the findings suggests that organizations still have difficulty with their approaches to information as an asset. The data also suggests that there are some serious cost and efficiency implications resulting from this difficulty. It is also apparent that being able to value information in some way may help to raise awareness of information as an asset and therefore improve the management of information. However an economic approach is not seen as necessarily the best way. Analysis of the interviews is continuing to explore non-economic methods of valuation.

APPROACHES TO VALUING INFORMATION: EXPLORATORY RESEARCH

This paper is an introduction to a piece of exploratory research being carried out as part of a doctoral research project on the attitudes and behaviors of project teams towards their information resources. It explores the background and context to the research and how we developed a semi-structured interview schedule. It then discusses some of the initial findings from this exploratory research and our next steps in the research project.

BACKGROUND AND CONTEXT TO THE EXPLORATORY RESEARCH

Academic and practioner research over the last 15 years has highlighted some key issues with the way organizations 'value' their information as an asset in the twin sense of seeking to estimate the worth of their information assets and expressing that worth, and ensuring that information assets are treated as worthwhile. In the same timeframe, the regulation, direct and indirect, of information and information management has changed significantly.

One of the first signs of change in the way the business world values information was the Hawley Committee report which published the results of an investigation by a group of companies into information management in large UK businesses. The report made several recommendations concerning the management of an organization's information assets, including its Board of Directors taking a "systematic approach to ensure appropriate policies and practices are in place and to check the adequacy of their arrangements for information assets." (Hawley, 1995, p.7).

Research into the use of the UK's FRS 10 accounting approach to valuing goodwill and intangible assets provided interesting insights into more recent thinking and practice on information as a valuable company asset. The researchers found that "very few companies held a register of their information assets or had taken steps to identify or assess them on an organizational level." (Wilson, Stenson & Oppenheim, 2000, p.13) This suggests that little had changed since the publication of the Hawley Committee report. Concerns about how much organizations and their top management teams value and protect their information assets have not abated since.

Over the last decade a variety of internationally recognized standards and codes of practice have emerged focusing on improving information management practices. In parallel, government legislation in most OCDE countries has modified the regulatory frameworks in which many businesses operate. The emphasis of these frameworks and legislation has been on the secure and good management of information whilst the information is of use to the organization and beyond the information's original value to the organization.

Recent research into information security and information assurance has highlighted shortcomings with the attention organizations pay to their information resources (Ezingeard, McFadzean & Birchall, 2005). The same research has suggested that aligning information assurance with organizational strategy can deliver a wide range of benefits including improved customer service, better governance, and better information usage.

THE VALUING OF INFORMATION

Tensions exist in an organization valuing its information assets. For example, information required for decision-making in a project is of use to the organization, and therefore of value, at the time the project is being undertaken. An information stakeholder, such as a regulator, may want access to the information at some future date, when the information is of value to the regulator but not the organization. Hence, despite this apparent lack of value, the organization still has to maintain the information securely and in good condition. However, the research discussed above, and anecdotal evidence would suggest that organizations do not value their information as well as they should. But how is information valued and how should its value be expressed?

Repo provided an extensive review of economic and management science research into the value of information (Repo, 1989). He concluded that the research was mainly theoretical and that two approaches could be taken to valuing information. Firstly that the "exchange value of information products (….) should be studied using 'classical' economic methods." Secondly, "value-in-use", should be studied using the "cognitive approach which takes the user, the use, and the effects of the use of the information into consideration." (Repo, 1989, p.81). An approach that could be described as cognitive is explored by the IS success model (DeLone and McLean, 2003), and the information orientation model (Marchand, Kettinger & Rollins, 2001). Both models reinforce that it is important for an organization, through the people that work for it, to exhibit the correct attitudes and behaviors towards their information assets.

THE EXPLORATORY RESEARCH

As previously mentioned, the Hawley Committee, Wilson et al, and Ezingeard et al suggest that there is a problem with organizations valuing their information assets and that there are implications for not treating information as an asset. These findings underpin the first question we tried to answer:

1. Are there shortcomings in the way organizations manage their information resources, and more specifically value that information (in both sense of the word 'value')? If so, what is the impact on these organizations?

Repo's analysis of economic methods and the complex picture he portrayed of this approach to valuation suggested a second line of questioning:

2. What would be the benefits of organizations ascribing an economic value to their information resources?

Lastly, Repo's cognitive approach to information valuation and the attitudinal and behavioural aspects of DeLone and McLean, and Marchand et al suggested a further line of investigation focused on the following group of three questions:

3. What kind of non-economic valuation mechanisms might be useful and what benefits might there be?
4. What policies and procedures might an organization employ to show that it valued its information and how might these help the organization look after its information?
5. What attitudes and behaviors might be appropriate to show that an organization valued its information resources?

These five questions formed a framework for a semi-structured long interview schedule. Ten interviews have been undertaken for this exploratory research. The interviews involved individuals who are responsible for information management in their organization and/or are significant users/processors of information. The interviewees were drawn from both public and private sector organizations. Eight individuals were interviewed face-to-face, one over the telephone and a tenth made a written submission using the interview schedule as a guide. Each interview lasted for approximately an hour. Eight of the interviews were recorded, with the permission of the interviewee. All recordings were transcribed. An initial analysis of the ten sets of data collected has been carried out using a manual thematic coding approach with seed codes developed from the literature and interview schedule. Subsequent analysis will be carried out using HyperResearch 2.7 (a qualitative software package) along with the seed codes and other codes generated from the interview data itself.

INITIAL FINDINGS

In this section we concentrate on two of the question themes identified above namely questions 1 and 2.

Is There A Problem, To What Extent, and What Is Its Impact?

The interview responses suggest that there is still a problem with organizations treating their information as an asset. Indeed evidence from the interviews suggests that little progress has been made since the publication of the Hawley Committee report. The evidence is threefold.

Firstly, the majority of respondents considered information to be "vital", "very important", "absolutely crucial – a differentiator" and "fundamental to the business". One interviewee argued that the importance of information to the business depends on the business context. It is clear though that information is a key component of most, if not all, organizations.

Secondly, most interviewees felt that organizations valued their information badly. Here value is used in the context of how well they look after their information, how well it is managed. In the words of one individual "people tend to worry about it a lot but [do] not do a lot about it". There were some arguments to suggest that data is managed better because it is more structured, and that the concepts and ideas behind the databases that usually manage this data are more embedded in the organizational psyche. One respondent felt that the lack of information value amongst senior management was down to the increasing invisibility of information caused by the move from information as physical paper to the more ethereal bits and bytes of databases and electronic document management systems.

The third strand of evidence focuses on how well organizations manage their information. Again the majority of interviewees felt that organizations managed their information poorly though there was an acknowledgement that there are examples of good practice. One respondent suggested that this poor capability was perhaps down to "an overemphasis on technology [and] underemphasis on business processes and values and behaviours.". Examples of the impact of poor information management ranged from unnecessary information re-creation to unnecessarily long periods of time taken to find information appropriate to the task in hand. All respondents argued that having some kind of mechanism for valuing information was of use. One interviewee did apply a caveat - the application of a valuation mechanism should depend on the category of information involved. Some information should be valued and some could be regarded as a commodity of little value (typically operational information or 'data'). This point raises issues around terminology – data versus information – and what drivers an organization might use to influence the valuation of its information.

The Economic Valuation Of Information

Most of the interviewees considered an economic valuation to be of use, especially as it would be a simple and easily understandable approach to convince organizations, particularly Western organizations, to invest in information and information management. It was also suggested that economic valuation is easier for some types of information and some types of organization. For example, an organization whose principal output is information, such as a consultancy, might benefit more from the exercise in so far as it would help it communicate with its staff, in particular around performance standards and desired outcomes. The exercise could also help in communications with investors.

However there is a recognition that due to the complex properties of information, an economic valuation would be subject to so many variables that the cost of developing a mechanism probably outweighs the benefits. For example, there is the notion of subjectivity: a piece of information that is valuable to a journalist is not necessarily of equal value to his/her readers. This is further complicated by the temporal nature of information – what is valuable today is not necessarily valuable next week.

Economic approaches suggested by interviewees tended to concentrate on the cost of production of information, the finding of information, and the subsequent maintenance of the information during its lifetime. A number of respondents described the real value of information in terms of its use or exploitation. In the words of one respondent "the value of information is really in the use you put it to and so having the information is not of value in itself". This, what can be called Latent value, was considered difficult to quantify in economic terms because of the variables, described earlier, which come into play.

NEXT STEPS

It is acknowledged that the work described here is exploratory research with no intention for the data presented to be generalizable. However it does give tantalizing glimpses into the state of information management in some organizations today. Based on the interview analysis carried out so far it is apparent that problems still exist with organizations' 'valuing' their information resources in terms of taking care of it, and in ascribing some kind of economic or other type of value to it. Through examples given by interviewees it also seems to be an issue worth pursuing to develop some practical answers and solutions.

Work is continuing to complete the detailed analysis of the collected exploratory data with the intention of answering questions 3 to 5 above. The next stage is to then use the insights gained from the exploratory data to create a more focused research strategy with the intention of gathering data from a wider range of sources. The outcomes from this wider data will then be used to help develop some practical solutions to aid organizational and individual management of information.

REFERENCES

DeLone, W. H. & McLean, E., R (2003). The DeLone and McLean Model of Information Systems Success: A Ten-Year Update. *Journal of Management Information Systems,* 19 (4)**,** 9-30.

Ezingeard, J-N., McFadzean, E. & Birchall, D. (2005). A Model Of Information Assurance Benefits. *Information Systems Management,* 22 (2)**,** 20-29.

Hawley Committee. (1995). Information as an asset : the board agenda; a consultative report. London, Hawley Committee.

Marchand, D. A., Kettinger, W. J. & Rollins, J. D. (2001). *Information Orientation,* Oxford, Oxford University Press.

Repo, A. (1989). The Value Of Information: Approaches In Economics, Accounting And Management Science. *Journal of the American Society for Information Science,* 40 (2)**,** 68-85.

Wilson, R. M. S., Stenson, J. & Oppenheim, C. (2000). *The Valuing of Information Assets in UK Companies*. *Research Series Paper 2000: 3.* Loughborough, The Business School, Loughborough University.

Knowledge Management Approaches and Knowledge Gaps in Organizations

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ABSTRACT

Nowadays, knowledge has been recognized as an indispensable strategic resource in organizations. Therefore organization` s capability in acquiring, developing, sharing and applying knowledge is expected to lead to their sustainable competitive advantage. It seems that the first step to be taken in order to enter the world of knowledge management is to analyze different approaches that exist in the field. Then it would be essential to identify knowledge management gaps. Organization` s inability to identify and fill these gaps before implementing knowledge management programs will obviously have unwanted effects on implementation stage. This paper is aimed firstly at a review of knowledge management history from 1700 A.D till now. Then its approaches (Mechanistic, systematic, core competencies and behavioral-cultural) are reviewed and two models of knowledge management gaps are studied. The inefficiencies due to the implementation of knowledge management systems and also an investigation into the context of knowledge growth in Iran are correspondingly represented. It also encompasses a contrast between some developed and developing countries including United States of America, Japan, United Kingdom, Germany, France, India, Turkey and Pakistan denoting the criteria of their economic status and knowledge growth. In conclusion, the priority to adopt systematic, behavioral/cultural and core competencies approaches in contrast to traditional mechanistic approach will be emphasized. The first model of knowledge gaps which will be presented in this paper is based on individuals` socio-economic status and situation- specific factors. In the second model of knowledge management gaps, six gaps have been recognized due to perception, strategic, planning and implementation aspects. It will also be mentioned that the first model is appropriate to be applied at macro level whereas it will be appropriate to apply the second model at micro level.

Keywords: Knowledge management, knowledge gaps, Systematic approach, Behavioral/cultural approach, Core competencies approach

1. INTRODUCTION

Today, knowledge has been recognized as an indispensable strategic resource in organizations. Therefore organizations` capability in acquiring, developing, sharing and applying knowledge is expected to lead to their sustainable competitive advantage. The organizations which are equipped with knowledge resources are able to deliver superior value to customers by combining traditional resources in the new ways.

In fact, it is the organizations` knowledge that enables them to develop their resources and processes, to reinforce their core capabilities and to create sustainable competitive advantages.(sharkie, 2005)

Knowledge management systems, both from their strategic core capability point of view and also as vital resources, have gained increasing importance in organizations. (Ahn and Chang, 2004)

In order to exploit knowledge workers as organizations` intellectual assets and disseminate knowledge to promote organizational learning, decisions` effectiveness and improve their competitive position, many organizations have implemented knowledge systems and processes. (Rao, Muati and Bryson, 2006)

Of course, in this époque, the most important opportunity for organizations is the availability of new and web-based information technology and mobile communication services that enable organizations to overcome geographical and organizational barriers to communicate and transfer knowledge in discrete networks. (Corso, Martini & Pellegrini, 2006)

In the present article, short descriptions of knowledge management history and knowledge management approaches have been discussed and finally a review on existing models of knowledge management gaps in organizations have been developed.

With emergence of service society after the 2nd world war, the importance of the role of the employees` knowledge and innovation has increased. (Malhotra, 2000, p.5)

At present, in the era of globalization, collective learning, knowledge sharing and creating institutionalized networks beyond country borders, has become as an important subject for politicians, managers and citizens. (Zhu, 2004, pp.76)

These days, economy has become global and knowledge- intensive. In this economy, what a company knows is more important than traditional resources of economic power such as land, factory, equipment and workforce. Though, availability of natural resources does not lead to competitive advantages. In fact, prosperous companies are the ones who are able to perceive and organize their knowledge. Today, corporates` success is due to their ability to acquire, encode and transfer knowledge more efficiently than their competitors. It has been widely acknowledged by experts that during the last fifty years, developing companies have evolved so that knowledge. (Davenport, De Long, 1997)

Based on the results of the survey conducted by Darroch (Darroch,2003),the organizations which have developed behaviors and procedures of knowledge management, in contrast to other countries present more innovation and higher levels of performance. (Darroch, 2003, pp.52)

In fact, this organizational phenomenon complete and reinforce other organizational procedures such as TQM, process reengineering and collective learning by focusing on sustaining organizational competitive advantage. (Sharma, 2004)

2. KNOWLEDGE MANAGEMENT AND THE NECESSITY OF ITS IMPLEMENTATION

Some definitions of knowledge management developed by some scholars are as follows:

"Knowledge management is the process of knowledge creation and dissemination to effectively implement it in organizations." (Hoffman, Hoelschler and Sherif, 2005)

"Knowledge management is the conscious design of processes, tools, structures and etc… to increase, renew, disseminate and improve the utilization of structural, human and social knowledge."

Results of different researches and surveys demonstrate that nations which have superseded others in creating knowledge even have higher ranks according to competitive growth and economic power. Also, companies that suffer from inappropriate economic situation do lack appropriate knowledge infrastructures.

The following table demonstrates the significance of this debate.

Table1. Situation of knowledge in some countries

	U.S.A	Japan	U.K	Germany	France	India	Turkey	Pakistan
Rank (GCI)*	2	9	11	13	27	55	66	91**
Number of Scientific Products (2004)	450287	84395	90443	84266	57774	23748	14107	1048
Number of Knowledge Products (per one billion GNP)	41.14	19.22	53.84	40.43	39.05	41.67	71.32	13.51***
GDP per capita	39820	36205	36042	32862	30713	640	6700	2100****

**Growth Competitiveness Index*
*** These figures are related to GCI ranking (2004)*
****www.iranknowledge.irandoc.ac.ir*
*****World Bank Group(2004)*

In the table above, Growth Competitiveness Index (GCI) is measured by criteria such as quality of economic macro environment, conditions of public administrations and level of country's preparation to acquire technology. All the figures refer to the year 2004.

Scientific products refer to registered records in Information Science Institute, USA in any document or language.

In order to compare statistics, figures from five developed countries (U.S.A., Japan, France and Germany) and three developing countries (Pakistan, Turkey and India) have been acquired.

Also, according to relevant literature review, the quantity of scientific products and the quantity of knowledge production per 1 billion $ GNP, are amongst the index to measure knowledge development in different nations. (www. iranknowledge. irandoc.ac.ir)

In organizational context, the importance of knowledge management augments (Increases) when according to global competition; organizations are in excessive need to acquire knowledge about their potential business competitors in present and future, their clients and scientific and technological progresses which could be replaced by their goods and services.

It could be claimed that one of the reasons of existing problems and weaknesses in all levels of Iranian organizations, is the lack of systematic processes of knowledge management that leads to creating, sustaining and transferring knowledge. In case an organization lacks such processes, there will occur an extensive gap between its existing and required knowledge. Therefore, consequences such as occurrence of frequent errors, repetitive processes, increased costs, decline in the quality of goods and products, dissatisfaction of internal and external customers and lack of competitive power in national and international levels. Also, lack of systematic processes of knowledge management and emergence of knowledge gaps will lead to disappearance and devaluation of the great part of the organizational knowledge and automatically, a great deal of this valuable stock which has been acquired by allocating valuable resources of time and money, will be ignored and no solutions will be thought of.

3. HISTORICAL BACKGROUND OF KNOWLEDGE MANAGEMENT

As Ferdowsi (Ferdowsi, 940) – the Persian well-known poet- has introduced knowledge and wisdom in his well-known poem As the foundation of power, also Francis Bacon in his well-known statement , " Knowledge is power" has gained global fame. In his first publication, "In praise of knowledge"(1592), even defined the individual by his/her knowledge.

Nguen, quoting Peter Drucker in his well-known publication "The post-capitalist Industry" has described the historical trends of knowledge management. He believes that the social intentions of knowledge have evolved in three phases:

- Firstly, it has taken place before 1700 A.D. and the attitude of knowledge for knowledge, wisdom and enlightment has been pursued.
- Secondly, it has occurred during 1700 and 1800 A.D. In this era, by stressing on technology creation, knowledge has shifted to organized, systematic and goal-oriented entity.
- Thirdly, it has commenced from 1800 A.D. and has reached the peak by Fredrick Taylor's principles of scientific management. Scientific management was to make some attempts to formulate the skills and experiences of its employees to the scientific and goal-oriented knowledge which reflects the era of applying knowledge for knowledge.(Nguen,2002)

Although, Islamic Republic of Iran has no place among 117 countries of the world according to GCI, based on other statistics , Iran ranks 11 among sixteen countries including U.S.A. , U.K., Japan, Germany, China, France, Canada, South Korea, India, Turkey, Iran, Egypt, U.A.E, Kuwait and Iraq and its knowledge production percentage is 0.19 % (Ensafi,2006).

Therefore, all these figures demonstrate that in contrast to other developing and developed countries, Iran has a long way to effectively manage the knowledge and in order to be able to compete with its competitors; it has to acquire systematic techniques to manage knowledge and bridge the existing gaps between present knowledge and required knowledge.

In the relevant literature, poverty does not only signify the lack of economic resources, but also it includes lack of hygienic facilities, knowledge capabilities and appropriate management skills.

Before shifting to the knowledge-based economy in the post-modernist perspective, the major sources of economic value creation has been tangible assets namely factory, land, tools, machinery and raw material (which are identified as structural, physical and hard capital), whereas in knowledge-based economy, intangible resources are the strategic resources of value creation. Intangible assets include the informal knowledge embedded in organizational structures, processes, systems, work teams such as communities of practice, innovative networks and competencies. (Corson, Ranzjin & Mardsen, 2004)

It could be acknowledged that the historical origins of knowledge management are as follows:

1. Religion and philosophy to comprehend the nature and role of knowledge
2. Psychology to comprehend the role of knowledge in organizational behavior
3. Economics and social sciences to outline the role of knowledge in society
4. The business theory to conceive the role of knowledge in work and its organization(Wiig,1999)

4. KNOWLEDGE MANAGEMENT APPROACHES

In this article, four approaches of knowledge management, the mechanistic approach, the systematic approach, the core capability approach and the cultural /behavioral approach have been discussed. (Sharma, 2004)

4.1 The Mechanistic Approach

The mechanistic and hard approach to knowledge management involves applying technology and resources to do more of the same better. The main assumptions of this approach include:

Better accessibility to information is a key, including enhanced methods of access and reuse of documents.

4.2 The Systematic Approach

The systematic approach involves the systematic practices in order to disseminate knowledge and information among appropriate people in appropriate time, to create value.

A Knowledge management system involves the representation, acquisition, creation, usage and evolution of knowledge in its many forms and the modeling, analysis and design of technical systems for supporting all facets of knowledge management.

Some key assumptions of this approach are as follows:

The most important thing is to achieve sustainable outcomes but not the processes, technologies or definitions people present. Managing a resource without being modeled is not possible. However, many aspects of organizational knowledge could be modeled as an explicit and observable resource. Also, solutions could be found in a wide range of disciplines and technologies. It is also possible to re-investigate the nature of knowledge work and to solve knowledge problems by applying the traditional methods of analysis. Therefore cultural issues are important but their analysis should be done systematically. This probability exists that some changes occur among employees but definitely, policies and procedures require changes. It is also possible to successfully apply technology to resolve knowledge problems.

4.3 Core Competency Approach

One way to manage knowledge-based organizations is developing knowledge competencies. Core performance capability and core knowledge capability are two distinct concepts, though complementary but each of them is a component of organizational identity.

Core competencies approach is a mechanism to convert core knowledge capabilities to goods and services. Core performance capabilities are processes that enable organizations to deliver goods and services with high quality, speed and efficiency to customers. These capabilities include high-speed delivery of new products to markets, product customization for customers, optimal management of logistics, employing qualified employees, learning and vision dissemination and are regarded as a key for organization success.

4.4 Cultural/ Behavioral Approach

This approach which has its origins in change management and business process re-engineering, regards knowledge as a managerial issue. Based on this approach, although technology is necessary for the management of explicit knowledge resources, it is not the only solution for knowledge management. Based on this approach, focus is more on innovation, creativity and learning organization rather than focusing on manipulating explicit resources or knowledge creation.

The dissemination and sharing of knowledge is embedded in interactions and networks among people and their institutionalized groupings e.g. teams, organizations and etc… that enable us to access the diverse resources of intelligence.

The key assumptions of this approach are as follows:

In information-intensive environments where organizations are losing their efficiency and effectiveness according to the business objectives, implementing changes in organization's culture and behavior seems to be vital.

Organizational culture and behavior involves changes while traditional technologies and solutions have reached their boundaries of effectiveness.

At present, cultural factors which have an important role in organizational change, have been devaluated, therefore implementation of cultural/ behavioral factors will probably lead to profitability for organizations. (Sharma, 2004)

5. INCONVENIENCIES OF KNOWLEDGE MANAGEMENT SYSTEMS

After investing large amounts of money on implementation of knowledge management systems in organizations, they face inconsistencies between these systems and managerial and cultural philosophies and business processes. Therefore they feel being conceived. Some of these problems include:

- In most cases, the Idealist designers and implementers of knowledge management systems are isolated from the rest of the organization and instead of designing the systems, taking account of the priorities and organizational characteristics and processes; they design them according to their own perceptions and personal beliefs.
- Most of the knowledge management systems have unrealistic capabilities that in fact cause users to become annoyed and upset.
- Instead of focusing on business needs and opportunities, they regard knowledge management as a general capability and do neglect the value creation for organizations.
- Many attempts in the field of knowledge management lead to failure because of the allocation of inappropriate employees and other resources.

In the era of knowledge-based economy, organizations have realized that a key factor in their success is the application of appropriate knowledge management approaches.

Based on a survey conducted by Chong et al (chong, 2002) in twenty-five international corporations, it was revealed that the majority of the senior managers of the so-called organizations believed that they had lost many opportunities in business according to the adoption of weak and inefficient practices of knowledge management (Guang, 2006).

6. KNOWLEDGE MANAGEMENT GAPS

Knowledge gap is defined as the difference between the corporate`s present capability and the required capability in the field of knowledge management. (Hall & Andriani, 2002)

Various studies have been conducted to define knowledge gaps as " the difference between the corporate`s present capability and the required capability in the field of knowledge management." Lovrich and Pierce have identified two gaps namely: socio-economic factors and socio-specific situation that will be discussed later.

Tiwani (Tiwani, 2001) has also introduced some infrastructural gaps which hinder the creation of knowledge management systems.

Hall and Andriani (Hall and Andriani, 2002) have also identified the existing gaps between the current knowledge possessed by organization and the required knowledge while introducing new products and services.

Wild (Wild, 2002) has introduced knowledge gap as the qualitative and quantative difference between the existing and the required knowledge.

Also, a model has been introduced by Lin, Yeh and Tseng (Lin, Yeh and Tseng, 2005) to represent six gaps in strategic, planning, implementation and perception levels.

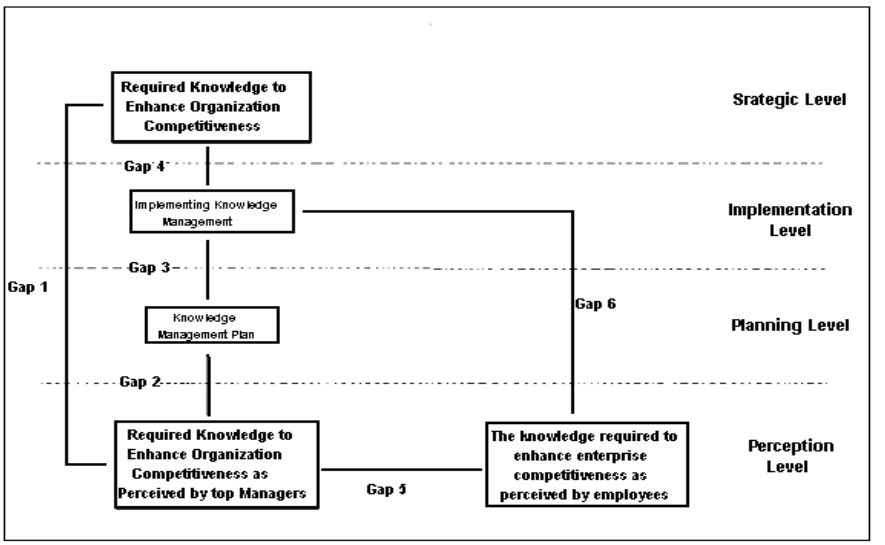
It is necessary to mention that any failure in identification and bridging knowledge gaps before implementing them will have unwanted effects on implementation stage, therefore actions such as knowledge requirements analysis, knowledge management systems assessment and the identification of obstacles seems to be essential. (Lin, Yeh, Tseng, 2005)

7. KNOWLEDGE MANAGEMENT MODELS

7.1 The First Model

Literature on the distribution of public affairs knowledge among citizens identifies a "knowledge gap" separating persons of higher and lowers socioeconomic status (SES). More precisely, lower SES persons typically exhibit lower levels of policy-relevant information. They also usually respond more slowly to mass media-infused attempts to increase the public's knowledge.

Figure 1. The model of the KM gap (Source: Lin,Yeh,Tseng,2005)



Ettema and Kline (1977) identify two types of explanations for the knowledge gap. One is rooted in "trans situational "conditions associated with living at lower SES levels. One of these conditions is a hypothesized lack of communication skills on the part of lower SES persons. In contrast to transsituational explanations, some scholars advance a situation-specific theory. This view suggests that gaps widen in those circumstances in which lower SES persons are less motivated to acquire the information or in which the information is less functional for them.

These two rival theories focus attention on the respective roles of SES and individual motivation in explaining individual holding of information. (Lovrich,Pierce,1984)

7.2 The Second Model

This model has been developed based on knowledge value chain (Holsapple and Singh, 2001) and knowledge spiral (Nonaka, 1991) to demonstrate the managerial gaps occurring during the implementation of knowledge management systems. As depicted in figure no….. , there are six gaps in this model that could be identified from four perspectives:

7.2.1 Strategic Perspective

In order to increase organizations` competitiveness, organizations must continuously scan their internal and external environment. Failure in doing so, will probably lead to the gap between the knowledge required to increase organization`s competitiveness (as perceived by top managers) and the real knowledge required to increase organization`s competitiveness. (Gap 1)

Failure to evaluate knowledge management processes leads to the creation of gaps between the outcomes of the implementation of knowledge management systems and the perceived outcomes of top managers.

7.2.2 Perception Perspective

It is probable that top managers do not have sufficient capability to identify the knowledge, organization requires to enhance its competitiveness therefore a gap appears between the top manager`s perception of the appropriate knowledge management plans and the existing knowledge management plans in the organization (Gap 2).

Also, in an organization, due to the differences between the role, position and the knowledge of top managers and employees, some differences may exist between their perceptions (Gap 5).

It is also possible that a gap exists between the organization`s required knowledge for enhancing competitiveness and employee's perceptions of the required knowledge while implementing knowledge management systems (Gap 6).

7.2.3 Planning Perspective

The appropriate internal and external environmental perception of top managers causes to plan appropriate programs for knowledge management. If top managers can not apply this acquired knowledge from environment during knowledge management systems implementation, gap 2 appears. If employees fail to comprehend knowledge management plans while facing them, gap 3 appears.

7.2.4 Implementation Perspective

If implementations of knowledge management systems are not congruent with its plans, gap 3 occurs. Also, it is essential that employees gain appropriate perception of the required knowledge to enhance organization`s competitiveness otherwise gap 4 appears.

7.3 Knowledge Gap Definitions

Generally speaking knowledge gap is defined as the difference between organization`s current capability and its required capability to manage knowledge. (Hall and Andriani, 2002)

The definitions of knowledge gaps according to the second model are as follows:

Gap 1: The gap between top manager`s perception of the required knowledge to enhance competitiveness and the real knowledge required.
Gap 2: The gap between top manager`s perception of the required knowledge to enhance competitiveness and knowledge management plans.
Gap 3: The gap between top manager`s proposed plans and the progress of knowledge management plans.
Gap 4: The gap between the acquired knowledge after implementing knowledge management systems and the required knowledge to enhance organization`s competitiveness.
Gap 5: The gap between top manager`s perception of the required knowledge to enhance organization`s competitiveness and employee's perception of this subject.

Gap 6: The gap between top manager`s perception of the required knowledge to enhance organization`s competitiveness and the acquired knowledge after implementing knowledge management systems.

8. CONCLUSION

In this paper, after a short review on the historical background of knowledge management, four knowledge management approaches including mechanistic approach, systematic approach, core competencies approach and cultural/behavioral approach have been discussed. It seems that in knowledge era, mechanistic approach that only focuses on physical tools and information technology infrastructures is not sufficient. In other word, it is better to adopt an integrated approach based on the systematic, core competencies and cultural / behavioral approaches in order to be able to take into account the people, physical and core knowledge competencies aspects of knowledge at the same time.

According to knowledge gap models, the 1st model is applicable in macro and country level regarding the socio-technical factors and people` s motivation to acquire knowledge and the 2nd model is applicable in organizational level regarding 6 knowledge gaps in strategic, planning, perception and implementation levels.

REFERENCES

1- Carson E. , Ranzijn A,Mardsen H.(2004). Intellectual Capital : Mapping Employee and Work Group Attributes. Journal of Intellectual Capital. Vol.5 , No. 3 .p.445

2- Corso, Mariano , Martini Antonella , Pellegrini Luisa (2006) . Managing Dispersed Knowledge Workers : The New Challenge In Knowledge Management . Technovation . Vol. 26 . p.554

3- Davenport Thomas H , De Long David W. , Beers Michael C. (1997). Building Successful Knowledge Management Systems . Managing The Knowledge Of The Organization . Ernest and Young LLP. p.2

4-Ensafi, Sakineh(2005),Iran knowledge in international level. Access date:2006,retrieved from: www.irandoc.ac.ir

5-Hall Richard , Andriani Pierpaolo (2002). Managing Knowledge For Innovation . Long Range Planning . Vol. 35 ,p. 33

6- Hoffman James , Hoelscher Mark L. ,Sherif Karma (2005). Social Capital , Knowledge Management and Sustained Superior Performance . Journal Of Knowledge Management .Vol.9 , No.3, p. 178

7- Huang Hua-wei, Shih Hong-Yu ,Lin Che-Hung .(2006). Can Knowledge Management Create Firm Value?: Empirical Evidence From United States And Taiwan .Vol.5 ,. P.

8- Lin Chinho, Yeh Jong-Mau, Tseng Shu-Mei (2005). Case Study On Knowledge Management Gaps . Journal Of Knowledge management . Vol. 9 No. 3 .pp.37,38

9- Lin Chinho , Tseng Shu-Mei (2005). Bridging The Implementation Gaps In the Knowledge Management Systems For Enhancing Corporate Performance . Expert Systems With Applications . Vol. 29 , p.163

10- Lovrich Nicholas P , Pierce John c. (1984). " Knowledge Gap " Phenomena effect Of Situation-specific And Transsituational Factors . Communication Research . Vol.11, No. 3, pp. 415-418

11 - Muller-Merbach Heiner (2005) . Francis Bacons Praise : Knowledge ,the source of power . Knowledge management Research and Practice . Vol. 3 .p. 45

12- Nguen, Tin Van(2002). " Knowledge management literature review and findings about perceptions of knowledge transfer in collaborative and process-oriented teams " . The faculty of graduate school of education and psychology . Pepperdine University. Proquest Information and Learning Company .pp.1-118.

13-Rao Lila , Muata Kweku , Bryson Osei (2006) . Towards Defining Dimensions Of Knowledge systems Quality . Expert Systems With Applications . p. 1

14- Sharkie Rob (2005). Precariousness under the new psychological Contract : The Effect Of Trust And Willingness to Converse And Share Knowledge . Knowledge Management Research And Practice . Vol.3 . p.37 .

15- Sharma Pankaj(2004). Knowledge Management . (1st Ed.). India: APH Publishing Corp.

16- The world bank Group . (2004) . " Data Query " .(Access Date : 2006) . {online } retrieved from: www.worldbank.org

17- Wiig Karl (1999) . Knowledge Management : An Emerging Discipline rooted in Long History .Knowledge Research Institute Inc. p.5

18- Wiig Karl. (2002).New Generation Knowledge Management : What May we Expect ? . Knowledge Research Institute Inc.p.2

A Weighted Average Scale for Multi Stakeholder Evaluations of Enterprise System Success

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1. ABSTRACT

An Enterprise System (ES), unlike a traditional Information System (IS), entails many stakeholders ranging from top executives to data entry operators. These stakeholders typically have multiple and often conflicting objectives and priorities and rarely agree on a set of common aims. The importance of gathering perceptions of IS-success at multiple levels in organizations has been discussed among academics for several decades. However, there is no universal agreement on what stakeholders should be canvassed and how to interpret results. This research attempts to design a weighted average scale to better interpret findings when gathering data from multiple stakeholders.

2. INTRODUCTION

Enterprise Systems entail multiple stakeholders. The importance of gathering perceptions of System success at multiple stakeholders within an organization has been discussed among academics for several decades (e.g. Cameron and Whetten 1983; Leidner and Elam 1994; Tallon, Kraemer et al. 2000; Sedera 2004). Contemporary IS-success (ES is an archetype of contemporary IS) studies have used various stakeholders making it difficult to generalize the findings and impossible to make comparisons. Moreover, there is no universal agreement on (i) what stakeholders should be canvassed, (ii) whether all stakeholders are adequately informed about every dimension of the system and (iii) whether differential weightage is required to interpret the results of success assessments.

Previous studies have treated multiple stakeholders and the data collected from them, without any distinction. Every stakeholder group would have a different perception of ES success but by grouping their responses together we are ignoring the difference in their perception.

In an attempt to minimize perplexity and to increase our understanding of interpreting multiple stakeholder responses when assessing ES-Success, this research attempts to develop a differential weighting scale. Such a weighted average scale is valuable for contemporary IS research to understand: (1) the views of multiple stakeholders, (2) the influences of the lifecycle phases when interpreting responses, and (3) whether certain stakeholders are better informed on certain success dimensions. The following section outlines the aforementioned objectives.

1. **Multi-Stakeholders:** An ES, unlike a traditional Information System, entails many 'users' ranging from top executives to data entry operators. These stakeholders typically have multiple and often conflicting objectives and priorities and rarely agree on a set of common aims (e.g. Cameron and Whetten 1983; Quinn and Rohrbaugh 1983; Yoon 1995). There is no Universal agreement on what stakeholders should be canvassed in an ES-Success study. Many IS success studies seek only a top-management perspective (Shang and Seddon 2000; Shang and Seddon 2002), yet research suggests that ES often succeed or fail at the operational level. In order to gain a 360-degree view of the ES, it is important to analyze ES-Success at all levels of the organization; from multiple perspectives. The proposed differential weighting method and instrument is designed explicitly for this purpose. Sedera et al (2006) demonstrated the evolution of employment cohorts in IS-success studies over the past decade by demonstrating a decline on data collection of *Operational* staff and a strong incline in *Strategic* and *Management* Staffs. Their study empirically identified four internal stakeholders of ES (i) Strategic, (ii) Management, (iii) Operational and (iv) Technical.
2. **ES-Lifecycle phases:** Ross and Vitale's (REFERENCE) ES lifecycle model identified a dip in organizational performance [ES-Success] post- 'Go Live', thereafter followed by steady improvement. Such a normative model and related ES-Success scores can aid organizations to better manage expectations of new ES, and to better plan mid- and longer-term for evolution of the ES. In example, it may be appropriate to place relatively greater emphasis on the Quality dimensions (Information & System) early in the lifecycle (during and soon after the 'dip' it is too soon for 'Impacts' to have been realized), and relatively greater emphasis on the 'Impact' dimensions (Individual & Organizational) later in the lifecycle. The different stakeholders place emphasis on different dimensions during the ES lifecycle phases. For example, during the implementation phase the managers may place emphasis on data accuracy and this could shift to a greater emphasis on system quality or process re engineering in the post implementation phase. Therefore there is need for these dimensions to be measured differently.
3. **The foci on multiple stakeholders:** Using the multiple stakeholders – Strategic, Management, Operational and Technical – researchers (Sedera et al., 2004; Sedera et al., 2006) have demonstrated that certain stakeholders tend to be better informed about, and more influenced by a particular ES-Success dimension(s). Not surprisingly, these employment cohorts place relatively greater emphasis on those dimensions that they are better informed about. For example, Strategic employment cohorts may place a greater emphasis on Organizational-Impact compared to Technical respondents' emphasis on System-Quality.

3. STUDY APPROACH

The stakeholder classification is developed based on the three kinds of knowledge that is required for an ES implementation (Davenport, 1998), the knowledge matrix (Sedera et al., 2003) and the four stakeholders (Sedera et al., 2006). Respondents' knowledge is assessed on the knowledge of the (i) system, (ii) business processes and (iii) the organization. The intended weighted average model would include the three aspects, in combination with traditional "job title" to determine the *degree of proficiency*, which extends over a continuum, from novice → intermediate → expert (Ericsson and Charness, 1994). The a-priori model will be tested using survey data.

This differential weighting scale would generate scores that provides in-depth information on the stakeholders (For example, Final Score = {Raw Score *[Factor of experience]*[Factor of Lifecycle Phase]}). Employing a differential weighting approach, organizations might place relatively greater emphasis on a particular stakeholder based on their proximity to a particular success dimension. Sensitivity analysis can yield the best overall measure of ES-Success. Analysis of survey data using the ES-Success approach, would seek to gauge how sensitive results are to variation in weightings across the dimensions, and thereby calibrate the model weights for a given organization-system context.

Table 1. Raw scores

Stakeholders (Designation)	Organisation Impact				Raw Score	System Quality				Raw Score
	OI_1	OI_2	OI_3	OI_4		SQ_1	SQ_2	SQ_3	SQ_4	
Director	4	5	4	5	4.5	4	3	2	4	3.25
Technical	6	4	6	4	5	5	3	2	4	3.5

Table 2. Proficiency scores

Stakeholders (Designation)	System	Business Process	Organisation
Director	4	5	6
Technical	6	4	5

4. RESEARCH METHODOLOGY

The study employs the ES-Success Measurement Model (Sedera et al., 2004; Gable et al., 2003) to measure the perceptions of employment cohorts[1]. The ES-Success Measurement Model employs 27 measures of success arranged under 4 dimensions (System-Quality, Information-Quality, Organizational-Impact and Individual-Impact). These 27 measures can be better interpreted using the intended scale. A survey instument will be provided to all the stakeholders in an organisation in order to collect this data. A separate instrument will be developed to understand the degree of profeciency of each stakeholder in the three areas: (i) system, (ii) business processes and (iii) the organization.

The following hypothetical example using the Organization Impacts and System Quality, together with extreme stakeholder group values (e.g. Director and Technical) demonstrate the value of such a weighted averaged scale. See details in table 1.

A separate survery instrument will be developed to understand the level of profeciency for each stakeholder group. The following example (table 2) demonstrates hypothetical profeciency scores measured in a 7 point Lickert scale. This example illustrates only the degree of profeciency and does not include the effect of weighted average score due to the lifecycle phase or foci of stakeholders on the raw scores.

Then for the final score:

Final Score = Raw Score * profeciency score / 7
Director OI = 4.5 * 6/7 = 3.9
Technical OI = 5 * 5/7 = 3.5

In the example, the Director's raw score for OI was 4.5 which was less than the Technical person's score of 5. By looking at only the raw score, one would then interpret that the technical person's evaluation of Organisation Impacts of ES is higher than the perceptions of the Director.

However, the raw score ignores the fact that one stakeholder group (i.e. director) is closer to the dimension that is under evaluation (i.e. OI) than the other stakeholder group (i.e. technical), thus the aggregation of stakeholders may provide misleading management information.

The weighted scores, using the level of proficiency, takes into account the knowledge that one would posses in the dimension that they evaluate. Having moderated the scores using the weighted averages by the profeciency level/score, the scores provide a more meaningful management information. In deriving the final score, for example, the Director would have a higher level of profeciency in the management or functioning of the organisation than the technical person.

5. REFERENCES

1. Cameron, K. S. and D. A. Whetten (1983). Some Conclusions About Organizational Effectiveness. Organizational Effectiveness: A Comparison Of Multiple Models. New York, Academic Press**:** 261-277.
2. Leidner, D. E. and J. J. Elam (1994). "Executive Information Systems: Their Impact On Executive Decision-Making." Journal of Management Information Systems **10**(3): 139-156.
3. Tallon, P. P., K. L. Kraemer, et al. (2000). "Executives' Perceptions Of The Business Value Of Information Technology: A Process-Oriented Approach." Journal of Management Information Systems **16**(4): 145-173.
4. Sedera, D., and Gable, G. (2004). A Factor and Structural Equation Analysis of the Enterprise Systems Success Measurement Model. International Conference of Information Systems, Washington, D.C.
5. Quinn, R. E. and J. Rohrbaugh (1983). "A Spatial Model Of Effectiveness Criteria: Towards A Competing Values Approach To Organizational Analysis." Management Science **29**(3): 363-377.
6. Yoon, Y., and Guimaraes (1995). "Assessing Expert Systems Impact on Users' Jobs." Journal of Management Information Systems **12**(1): 225-249.
7. Shang, S. and P. B. Seddon (2000). A Comprehensive Framework For Classifying Benefits Of ERP Systems. Proceedings of the 6th Americas Conference on Information Systems, Long Beach, California, Association for Information Systems.
8. Shang, S. and P. B. Seddon (2002). "Assessing And Managing The Benefits Of Enterprise Systems: The Business Manager's Perspective." Information Systems Journal **12**(4): 271-299.
9. Gable, G., D. Sedera, et al. (2003). Enterprise Systems Success: A Measurement Model. Proceedings of the 24th International Conference on Information Systems, Seattle, Washington, Association for Information Systems.
10. Sedera, D., Gable, G., and Chan, T. "Knowledge Management For ERP Success," Proceedings of the 7th Pacific Asia Conference on Information Systems, Association for Information Systems, Adelaide, Australia, 2003, pp. 1405-1420.
11. Sedera, D., Tan, F., and Dey, S. "Identifying and Evaluating the importance of multiple stakeholder perspective in measuring ES-Success," European Conference of Information Systems (ECIS '06), AIS, Goteborg, Sweden, 2006b.
12. Davenport, T.H. "Living with ERP," in: *CIO Magazine*, 1998a.
13. Ross, J. W. Vitale, M. R. (2000) " The ERP Revolution: Surviving Vs. Thriving", Information Systems Frontiers, 2(2): 233-241
14. **Ericsson**, K. A., & **Charness**, N. (**1994**). Expert performance: Its structure and acquisition. American Psychologist, 49(8), 725-747.

ENDNOTE

[1] The authors claim that ES-Success Measurement Model is the most comprehensive and complete model available to-date in the academic literature.

Everyone Is Different! Exploring the Issues and Problems with ERP Enabled Shared Service Initiatives

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1. ABSTRACT

In today's increasingly competitive environment, there is constant pressure for corporate leaders to add value to their organizations. These contemporary organizations are increasingly moving into business models that attempt to reduce duplicate supporting processes and staff by streamlining processes that are not central to the organization's operations and concentrating on strategies on strategic or core, business processes. This concept, known as Shared Services, attempts to bundle some of the supporting processes and non-strategic activities into a separate organization, which in turn treats those processes and activities as the core of its own business. Shared services consolidate and support redundant functions, such as accounts payable and procurement, for disparate business units. By leveraging economies of scale from a common IT infrastructure, such a group is able to market specific services to business units. Many organizations are employing Enterprise Resource Planning (ERP) systems, for example SAP, to facilitate shared service initiatives by aggregating backroom functionality across departments.

2. INTRODUCTION

Shared Services is defined as a concentration of company resources performing like activities, typically spread across the organization, in order to service multiple internal partners at lower cost and with higher service levels, with the common goal of delighting external customers and enhancing corporate value (Schulman et al. 1999). In a Shared Services, the disparate activities and operations (such as finance, human resources, payroll, and marketing) that have been seen by business executives as back office and secondary to the core business processes are treated as if they themselves were the core processes. A Shared Services Initiative typically expects tangible benefits such as expense reduction, increased productivity and economies of scale and skill. Intangible benefits range from enhanced customer service to standardized business process and consolidation of Information Technology.

Increasingly, organizations utilize ERP systems to facilitate Shared Services Initiatives by leveraging on such features like (i) process standardization, (ii) common information systems platform, (iii) common databases, (iv) process automation and (v) ERP workflow (Markus et al. 2003). Many such organizations are creating '*shared service centres*' that perform administrative transactions for numerous divisions or subsidiaries of the same company, rather than having those transactions conducted in every division or subsidiary. The shared services centres enable organizations to use ERP systems to retain control of core functions while maximizing cost efficiencies. The concept is simple bring-together functions that are frequently duplicated across divisions, subsidiaries or operating units and offer these services more efficiently and at a lower cost.

This study is motivated by the disparate reports on the success of shared services initiatives and the lack of discussion in academic literature. With the limited trade press reports it is clear that despite the positive objectives, evidence of shared services initiatives has been mixed with some organizations showing positive impacts to the organization, while others have shown nil or detrimental impacts. This paper specifically investigates the issues and problems of shared services initiatives from the point-of-view of ERP systems. The preliminary study results are derived secondary data from fourteen (14) private sector and five (5) public sector case studies published in trade press. The paper begins with a synopsis of objectives of shared services initiatives and the details the role of ERP systems in a shared services initiative. Next, the paper introduces key activities of an ERP enabled shared services initiative. The final section seeks to demonstrate the issues and problems with an ERP enabled shared services initiative.

3. OBJECTIVES OF SHARED SERVICES INITIATIVE

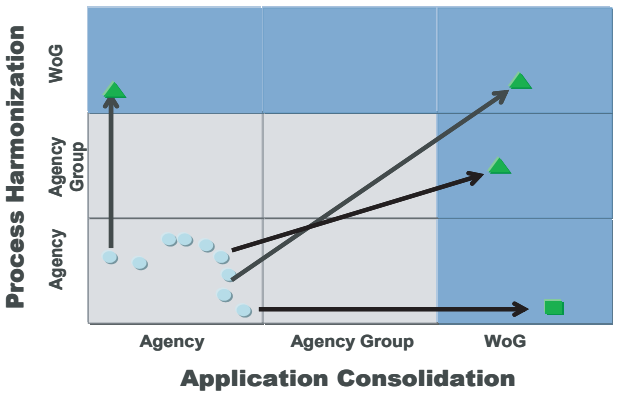
The overarching objective of a Shared Services initiative is to re-direct savings (and potential savings) to direct service delivery and also to better focus on the main business processes with an organization. Moreover, in a group of organizations – especially in public sector, where there are many organizations providing services to the community – shared services facilitate greater consistency of services. Similarly, shared services increase the transparency in costs of services between the organizations. It is believed that greater transparency increase healthy competitiveness within fellow organizations. Furthermore, a number of organizations embarking on a similar business processes for shared services facilitate better environment for skill development, training and career enhancement. From an information system viewpoint, shared services enable organizations to consolidate information technology assets. Especially, in relation to the ERP systems, shared services organizations could engage in shared maintenance of the system and other cost consolidation activities.

4. THE ROLE OF ERP SYSTEM IN A SHARED SERVICE INITIATIVE

Provision of adequate Information Technology infrastructure across the shared services organizations is one of the important aspects of a contemporary shared services initiative. An ERP system not just provides the necessary technical backbone, but also provides an environment with standardized business processes across many organizations. To get maximum benefit out of shared services, all the Information Technology operations in an organization need to have a common system platform so that the supporting business activities and processes are consolidated and standardized. ERP systems present an opportunity to do this from the technical perspective. Since an ERP system provides an integrated suite of applications which provide transaction processing and management information systems for the common core of business processes, consolidation becomes easier. Moreover, ERP systems provide comprehensive administrative systems and help to automate and streamline business processes. It is argued that ERP systems facilitate organizations to combine information from multiple, but disparate business entities to achieve a unified system and business processes.

According to a recent survey conducted by Accenture, '*having an ERP system*' has been regarded as the key enabler for successful shared services implementation. This is evident in recent examples of shared services initiatives in large number of *Fortune 500* companies, including Microsoft, Chevron Texaco, and HP. According to a survey conducted by the National University of Ireland, 30% of the companies surveyed identified '*lack of a common system*' as the biggest obstacle to facilitate functionality of a shared service center. Usage of an ERP system allows management of massive amounts of transactional information rapidly with minimum human interference and standardization of transaction data processing. This allows organizations to develop better contractual agreements with suppliers and consistent service to customers. Not having an ERP system to facilitate

Figure 1. The key activities of an ERP system enabled shared services initiative



a shared service initiative may require organizations to integrate a number of disparate systems and to consolidate data into a standard format.

5. KEY ACTIVITIES OF A SHARED SERVICES INITIATIVE

Using the ERP system as an enabler, the case organizations attempt to 'Harmonize' the business processes from the organization level to a 'Whole-of-Enterprise (WoE)' level. Similarly, the case organizations attempt to 'Consolidate' the applications from the organization level to a 'whole-of-Enterprise' level (See Figure 1)

The intended outcomes of process harmonization include: (i) reduce process variability across organizations, (ii) greater consistency of information across all organizations, (iii) economies of scale and skill, (iv) greater transparency in costs and services, and (v) promoting efficiency in internal business processes. The application consolidation attempts to achieve (i) permits infrastructure and support consolidation, (ii) economies of scale and skill in application maintenance and upgrade, and (iii) cost effective implementation of new technology.

6. KEY FINDINGS

Though the move towards shared services centers using Process Harmonization and Application Consolidation tends yield aforementioned benefits, it tends to compromise the individual needs of each organization. It is expected that for both the Shared Service Centers and the individual organizations require a major change management exercise to cope with the transformations in business processes and information technology. The importance of achieving the common business requirements for a range of organizations that engage in a range of different (organization specific) business objective has been identified as one of the key issues. Furthermore, the move towards application consolidation compromises the in-house applications that many organizations had developed to cater for the 'out-of-scope' SAP functionality.

7. ISSUES AND PROBLEMS WITH SHARED SERVICES

The preliminary findings identified several issues and problems that may hinder the potential benefits of shared services initiative. One of the main challenges of a shared services initiative is the amount of changes made to the business processes and systems. Since many organizations attempt embarking on shared services when the ERP applications in each organization are at the mature stage of the ERP lifecycle, converting 'intra-organizational' standardized applications to 'inter-organizational' standardized applications is harder. Secondly, as a result of achieving a common business practice, many compromises are made against organizational specific business requirements. In organizations where many ERP modules from many versions of the same ERP application are being used, it is debatable which version to consolidate the applications to and which modules to consolidate. Similarly, different hardware and operating platforms provide similar issues for shared services organizations. In many instances, organizations decide to upgrade into a higher version of the ERP application through the shared services initiative. Another issue that shared services organizations face is the out of scope functionality in the ERP software. With the introduction of 'common functionality' to facilitate shared services, many organizations reported 'out of scope functionality' in the ERP software as an issue for many specific functionality. Timing considerations were also reported as a problem in a shared services initiative. Many organizations have reported lengthy time delays in introducing shared services. A commonly stated issue in shared services was the difficulty of managing change within the organizations. With many specific system features and business processes compromised, tasks and roles changed for employees, shared services initiatives undergo intense resistance.

8. REFERENCES

1. Schulman, D., Danleavy, J. R., Harmer, M. J., Lusk, J. S. (1999) "Shared services: adding value to the business units" Wiley New York
2. Markus, L. Axline, S. Petrie, D. Tanis, C. (2003) " Learning From Adopters Experiences With ERP: Problems Encountered And Success Achieved" in Second-Wave Enterprise Resource Planning Systems (Eds. Shanks, Graeme Seddon, Peter B. Willcocks, Leslie), Cambridge, UK, Cambridge University Press, PP 23-55.

Determinants of Marketer Satisfaction with the Choice of Electronic Marketplace Type

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ABSTRACT

An empirically testable model is suggested which improves understanding of supplier motivations for participating in various types of electronic marketplace structures and also how suppliers evaluate the performance of their electronic marketplace choice. Performance is considered as a multi dimensional construct. The theories of behavioural psychology, relational exchange, strategic networks, political economy, population ecology and transaction cost are synthesized to develop the proposed model.

Keywords: electronic marketplace, transaction cost theory, strategic network theory, relational exchange theory, performance as a multi-dimensional construct, asset specificity, market fragmentation.

INTRODUCTION

Electronic marketplaces are increasingly important to the organization of procurement and sales activities and analysts predict that, by the end of 2005, electronic marketplaces may account for more than 50% of all online B2B ecommerce, perhaps over 4 trillion USD volume worldwide (Zank and Vokurka 2003).

The growth of B2B marketplaces has also driven the evolution of a variety of newer market structures for conducting business through electronic markets. Le, Rao and Troung (2004) found that though 54% of 286 firms surveyed had utilized an electronic marketplace that only 31% of those users found them as having lived up well to their expectations. How do we then answer the crucial question of when and how to exploit electronic markets to maximally take advantage of their inherent value propositions?

The focus of this proposal is to suggest an empirically testable framework which significantly improves our ability to understand supplier motivations for participating in various types of electronic marketplace structures and also how suppliers evaluate the performance of their electronic marketplace choice. The extant literature indicates that ability to fit the electronic marketplace type with existing market structure, company size, prior experience, role (buyer or seller) all impact expectations for performance in electronic marketplaces.

Much of the research in this realm of study to date, however, has relied upon a transaction cost theory explanation (Malone et al. 1987, Bakos, 1991, Mahadevan 2003). In the spirit of the "blended" models of Barringer and Harrison (2000) and Christianaase and Markus (2003), the proposed model also allows consideration of the perspectives of behavioural psychology, relational exchange theory, strategic network theory and political economy perspectives as well as those of transaction cost theory. Mahadevan's (2003) proposed typology of market, competitive and product/service characteristics which favor various electronic marketplace types is used to provide a transaction cost perspective.

This model is also the first that in this area of research study that considers that marketers evaluate performance as a multi-dimensional construct, building on the work of Clark (2000). The sizeable body of literature on consumer and employee satisfaction is also employed to extend Clark's (2000) work to incorporate the relationship between the performance of and satisfaction with participation in electronic marketplaces.

In sum an empirically testable and comprehensive model is suggested which incorporates the rather diverse, embryonic and limited research in this area of study. The complete research model is shown in Figure 1.

SAMPLING AND DATA COLLECTION

The survey instrument to test the model has 80 questions including indicator questions . To achieve a desired return rate of at least 500 questionnaires required for structural equation modeling, an email list of 7654 Canadian B2B marketers has been compiled via Scott's directory and additional online verification.

I am currently collecting data by means of an electronic questionnaire. It offers some considerable advantages compared to mail surveys as it eliminates data re-entry errors while reducing the costs and the response cycle time (Dillman, 2000).

METHODOLOGY

Structural Equation Modeling will be used and Lisrel will be the software of choice given the criterion for analysis. Most variables will be measured by 4 to 6 questions or indicators based on both previously validated questions (Clark 2000, Arnemann, 1994) and newly constructed ones derived from an extensive review of constructs proposed by others (Mahadevan 2003, Rask and Krogh, 2004, Christianaase and Markus 2003). The proposed model, though complex is recursive and over identified. Though the model is complex, a piece wise approach (Garson, 2006) will be employed. Should overall model fit be poor, partial models which assess marketing performance evaluations as a multi-dimensional construct, the importance of market structure factors in satisfaction with electronic marketplace choice, and the effect of the specificity of expectations on the performance/satisfaction all can potentially make a contribution to electronic commerce and marketing literature.

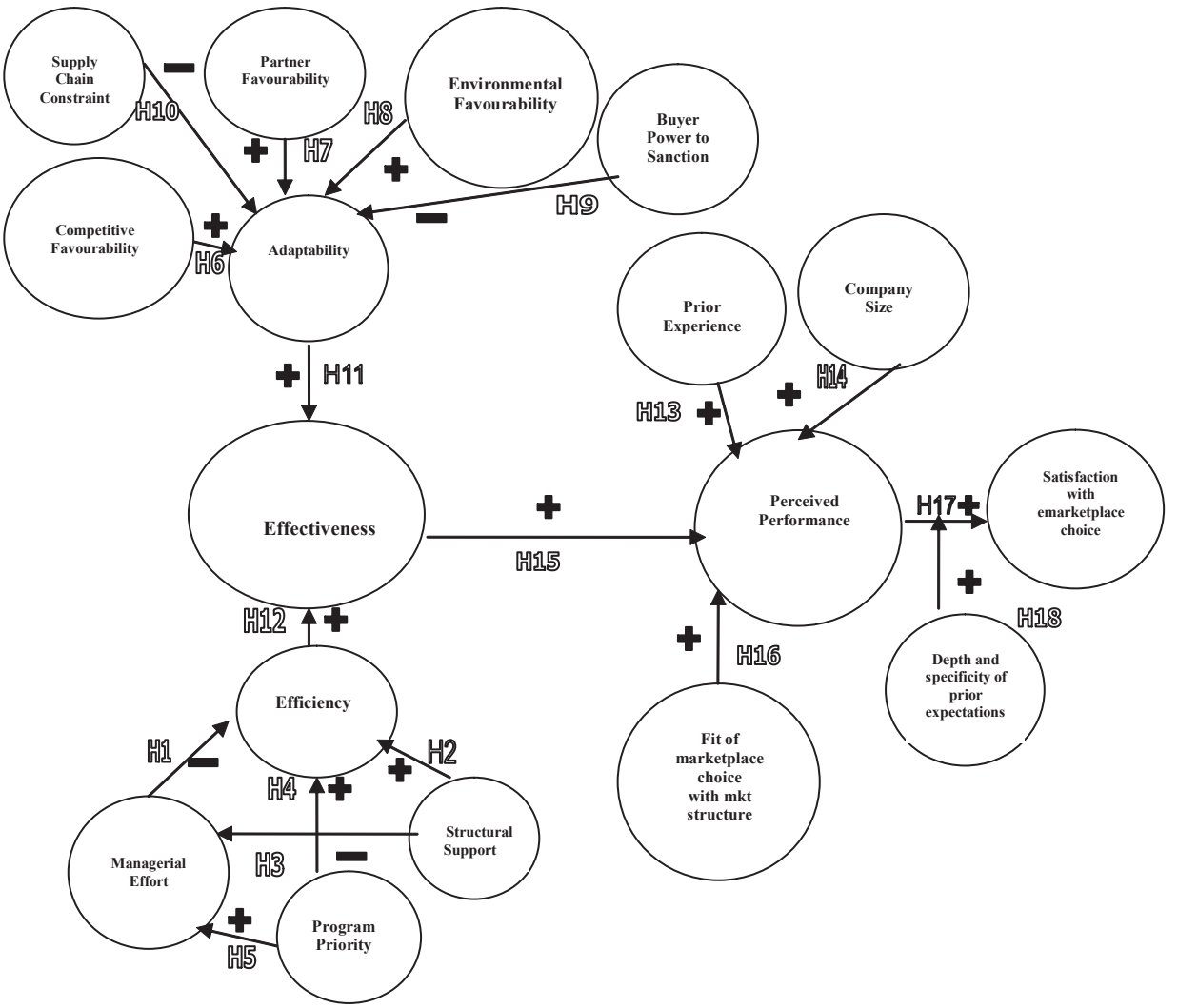
Hypothesis 18 requires the use of a moderating latent variable (depth and specificity of prior expectations) An interaction exists when the direction and/or strength of association between predictor (perceived performance) and outcome (satisfaction) variables are modified at different levels of interaction variables (moderators in this case high and low depth and specificity).

Data is currently being collected and data analysis and model verification should be complete by the date of the 2007 IRMA conference.

IMPORTANCE OF THE RESEARCH

Firstly this research makes a rather significant and unique contribution to the study of how marketers judge marketing performance. Clark (2000) found marketers use multiple performance measures. He found a mean number of 2.68 measures and with just 21% of respondents reporting one measure. I could find no paper since the publication of Clark's (2000) paper that incorporated more measures. It is surprising, to say the least, that a science such as marketing that is so strongly grounded in a plethora of underlying psychological and sociological constructs such as brand performance, consumer satisfaction and buyer expectations has not paid greater attention to similar determinants of its own practitioner's perceptions of these constructs. .

Figure 1. Determinants of marketer satisfaction with the choice of electronic marketplace type (Knight, 2005)



Academically Clark (2000) suggests that understanding how perceptions of performance are developed should be useful in two senses. First it is relevant to know what performance measures marketers attempt to maximize. Second, as marketing performance evaluation moves to multi-dimensional techniques such as balanced scorecards and executive support systems these systems should use measures that are reflective of how marketers judge performance in reality. Clark (2000) has provided a strong research framework by demonstrating that marketers judgments of performance are multidimensional but how do we begin to operationalize those dimensions to improve our understanding of specific marketing activities are judged?

The proposed research can perhaps provide a significant step in this regard. B2B transactions are often incredibly complex and to compound this effect electronic marketplaces are rapidly evolving in terms of structure and application (Mahadevan 2003). Participation in electronic marketplaces is fraught with uncertainty and risk and marketers would seem to make decisions about the type of participation based on a great deal of uncertainty in a highly dynamic environment. To operationalize Clark's (2000) typology of a generalized model of marketer's perceptions of success a setting is chosen which has few established norms. The often conflicting goals of market integration and brokerage, the risk of market power effects and the growth of complex interfirm networks (Christianaase and Markus, 2003) typify the environment of firms participating in electronic marketplaces. Though a variety of perspectives have just recently been posited as being explanatory of electronic marketplace formation and participation, the dominant explanatory theory has been that of transaction cost economics. This research topic and proposed model therefore provides fertile ground for greater understanding of how given bounded rationality (Simon, 1976), marketers set expectations, judge performance and achieve satisfaction in this dynamic environment. By providing a multidisciplinary and multidimensional operationalization of marketer's satisfaction in this environment, important research footprints could be laid down to further understand the construct of marketer satisfaction.

A second and less ambitious contribution, but one perhaps of more immediate interest to researchers of electronic marketplaces is also made by this research. This is the first research that I am aware that attempts to integrate transaction cost theory as well as other recently posited theories concerning the formation and adoption of electronic markets such as strategic networks theory, relational exchange theory, principal-agency theory, population ecology theory and behavioral psychology into an integrative and empirically testable model.

REFERENCES

Arnemann, Anna Marie (1994) "Expected performance as a predictor of satisfaction with performance" Ph.D thesis, Hofstra University

Bakos, J.Y. (1991) "A strategic analysis of electronic market places," MIS Quarterly, 15, no.3, (1991): 295 –310.

Barringer, B.R. and Harrison J.S.. (2000). "Walking a tightrope: Creating value through interorganizational relationships." Journal of Management, 26(3): 367-403.

Christianaase, Ellen and Markus, Lynn M (2003) "Participation in Collaboration Electronic Marketplaces" Abstracts Proceedings, January 6-9, 2003, Big Island, HI, USA. IEEE Computer Society, 2003, ISBN 0-7695-1874-5 - Track 7:

Clark, Bruce (2000) "Managerial perceptions of marketing performance: efficiency, adaptability, effectiveness and satisfaction" Journal of Strategic Marketing (8) 3–25

Dillman, D.A. (2000), Mail and Internet Surveys: The Tailored Design Method, John Wiley, New York.

Garson, D (2006) Electronic Course Notes ,PA 765, Structural Equation Modeling, North Carolina State University, http://www2.chass.ncsu.edu/garson/pa765/structur.htm.

Mahadevan, B. (2003). "Making Sense of Emerging Market Structures in B2B E-Commerce".California Management Review, (46), 1, 86-100.

Malone T.W, J. Yates and R.I. Benjamin, (1987) "Electronic markets and electronic hierarchies," *Communications of the ACM,* 30 : 484 – 97

Rask, Morten and Hanne Kragh (2004) "Motives for e-marketplace Participation: Differences and Similarities between Buyers and Suppliers", Electronic Markets,Volume 14, Number 4 / 270 - 283

Simon, Herbert A (1976), *Administrative Behaviour* (3rd ed.). New York, NY: The Free Press.

Thuong T., Le, S. Subba Rao and DoThang, Truong (2004) "Industry-Sponsored Marketplaces Electronic Marketplaces", Electronic Marketplaces, Volume 14 (4): 295–307

Zank G.M., Vokurka, R.J., (2003) "The Internet: Motivations Deterrents and Impact on Supply Chain Relationships" SAM Advanced Management Journal, 68(2), pp.33-40.

Understanding Gender Differences in the Use of Instant Messaging

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Increasingly, Instant Messaging (IM) has been accepted as a communication and collaboration tool in many organizations (Hu, Wilcox, and Hansen 2002). Ferris Research predicted that the number of IM users will reach 183 million by 2007. Unlike other communication tools such as email and groupware, however, IM was initially designed for home users as a social networking tool to connect families and friends via the Internet and only gained its popularity in business after individual users started using IM as a substitute for face-to-face communication with co-workers. Thus, the adoption and use of IM in organizations have some unique characteristics. First, many corporate users may have had prior experience with IM before they begin to use it for business purposes. Second, the inherent social features of IM may affect how business users interact with each other and possibly change the ways in which business tasks are accomplished. These characteristics could have significant implications for promoting and managing IM use in organizations.

Li, Chau, and Lou (2005) examined IM adoption and use in a social context. Based on the motivation and interpersonal theories, they identified perceived usefulness, perceived enjoyment, relationship commitment, attachment motivation, and perceived critical mass as antecedents to intention to use of IM. Perceived enjoyment was found to play a central role in predicting intention to use. Different from prior studies, perceived enjoyment was found to have as significant effects on intention to use as perceived usefulness. One explanation was that the activities supported by IM in that study were social interactions as opposed to work-related activities. The effects of relationship commitment and attachment motivation on intention to use were also mediated by perceived enjoyment. Furthermore, the study showed that perceived critical mass had direct effects as well as indirect effects through perceived usefulness and perceived enjoyment on intention to use.

Gender has been suggested as one of the moderating factors in using IM (Ilie, Van Slyke, Green, and Lou 2005). Studies in sociology have shown that men and women hold different attitudes towards social interactions and have different communicate goals and patterns. For example, women are more likely to enjoy social-oriented activities, value connection and cooperation, and share emotions. Men, on the other hand, tend to focus on task-oriented activities and communicate based on social hierarchy (Meyers, Brashers, Winston & Grob 1997, Wood and Rhodes 1992). Taking the diffusion of innovation approach, Ilie, and her colleagues (2005) examined how gender moderated the impact of innovation characteristics on intention to use. They found that men and woman are different in a number of ways. Ease of use and visibility were found to be more important to intention to use for women than for men. On the other hand, relative advantage, result demonstrability, and perceived critical mass were more important for men.

This research focuses on the role of gender in IM adoption from a social and interpersonal perspective. Specifically, we examine whether gender moderates the relationship between perceived usefulness, perceived enjoyment, relationship commitment, attachment motivation, and perceived critical mass and the intention to use of IM. Data was collected using a survey of IM users. Preliminary analysis shows that the impact of the above social factors on intention to use was very different for men and women. Final results will be presented at the conference.

Usability Attributes of the Celluloid Interface: Perceptions of Interactivity in the Age of "Blade Runner"

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A user interface can broadly be defined as being those attributes of a system that a user connects with. It is a conceptual structure made up of an input language for the client, an output language for the system and a modus operandi for choreographing interaction. The usability of an interface is defined as the efficiency and level of gratification with which users can accomplish tasks in a specific environment of a product. High usability means that a system is typically easy to learn and remember; efficient, visually and perhaps aurally satisfying and fun to use; as well as swift in its capacity to recover from errors (Nielsen, 1993).

Some media theorists view cinema as being a kind of cultural interface for society that acts akin to a collective consciousness (Manovich, 2001) but more generally the notion of the user interface is applied within the context of human-computer interaction. What is the mainstream public's view of the human-machine interface?

Cinema is a popular form of entertainment that implicitly shapes the belief of the masses on a wide variety of concerns. This art-form also has the capacity to mirror the predominant societal customs, issues and systems of the time. A film can contain a wealth of detail in its sub-text that when subject to interpretation can be transformed into new knowledge. Indeed, in this vein, academic studies have explored diverse topics ranging from the cinematic image of chief executive officers of non-profit organizations in the U.S. (Lee, 2004) to the pedagogic effects of motion picture depictions of analytical chemistry in action (Lucy, 2000). In the latter paper the author remarks that fictional representation can function as a mechanism to foster contemplation of an actual scientific technique's authentic potential for better or worse.

McMurdy (1973) argues for a closer relationship between imaginative literature and public administration scholarship, highlighting the significance of personal discernment in the evaluation of organizational phenomena and the beneficial role that fiction could have in testing existing theories and developing new insights. Academic interest in the fictional portrayal of some occupations such as the legal profession has grown appreciably in the past decade, a fact noted in a recent study of admiralty lawyers in popular culture by Jarvis (2006). Computer science and information systems, though, are lagging behind in this eclectic technique of mining popular culture for wisdom that could inform scholarly progress. The commentaries by Mathews & Reifers (1984) and Grupe (1996) are a rare exception as they examine nascent public attitudes towards the computer as reflected in cartoons published in print media since the 1940s. In a more applied outlook, the Institute for Creative Technologies (affiliated with the University of Southern California) is a research centre that is a partnership between the Hollywood entertainment industry, the U.S. military and academia (e.g., Gratch, Rickel, André, Cassell, Petajan & Badler, 2002). The goal of the centre is to create technical environments that evoke synthetic experiences for learning, training and other operational functions and it does so with input from film personnel such as cinematographers as well as traditional IT researchers.

Films of the science fiction and action genres often feature plots where computers are prominent devices (Vos Post & Kroeker, 2000). Clarke (1993) notes that the stories of science fiction author Isaac Asimov could shape the destiny of computer ethics. Aaron Marcus, a leading user interface designer, claims to have developed an early interest in his current field of expertise by being exposed to images of future technology at the movies and on TV (Marcus, 2006). Indeed, some scholars have advanced the notion that works of speculative fiction in general can act as an inspiration for future technological development in an actual sense (Boutillette, Coveney, Kun & Menides, 1999).

In terms of the technically literate audience, is the public perception of the usability of current and future computer systems being influenced by what is depicted in the cinema? In this study, examples of usability issues from films such as "Blade Runner", "2001: A Space Odyssey", the "Matrix" trilogy and "Minority Report", amongst others, will be investigated in terms of their technical validity, ethical rationale and potential cultural side-effects. An allied matter to be addressed is whether or not the creative inclinations of user interface designers are shaped by these genre-based forces. The usability attributes of the fictional interfaces depicted in films of the science-fiction variety will be classified in the long-term and arguments will be raised as to the effect these have on the expectations of users as they relate to actual human-computer interface technology.

"Blade Runner" is a science fiction film released in 1982 but it depicts a dystopian Los Angeles in 2019, a future where the technologies on display are a hybrid melange of the past, present and futue. There is a sequence in the story where the lead character Deckard (portrayed by Harrison Ford) is using a computer device known as an Esper. This apparatus is employed in this scene to manipulate photographic imagery in the search for a particular individual. Terse vocal commands of an alphanumeric nature control the mechanism in its operation, with the Esper providing feedback via high frequency sounds. A person viewing this scenario who is not an IT practitioner or academic may be oblivious to the technical minutiae unfolding at this juncture. Perhaps they may even be bored by the detail. Accumulated technological wisdom, however, may affect the experience of the viewing. With this background, the sequence could serve as a touchstone for debate about usability issues. To a computing academic experiencing this "Blade Runner" segment, what is the meaning of the Deckard-Esper interface as enacted on screen? This key question will initiate a novel phenomenological study to launch the overall research project.

Phenomenology is a research technique employed to obtain an intricate, richly textured understanding of human experience in a wide variety of contexts. In stark contrast to positivist enquiries, this practice concentrates on subjective experience as being the prime source of all knowledge defining objective phenomena. Akin to producing a complex piece of literature that juggles multifarious dominant themes interleaved with allusions, the output of this research approach succinctly describes observed commonalties in terms of ideas, issues and subject matter when individuals are confronted with a phenomenon that they experience. To achieve this goal requires the pursuit of four main stages of the phenomenological process: epoche, reduction, imaginative variation and synthesis of composite structural descriptions (Moustakas, 1994). Epoche is an idiosyncratic term coined by the originator of phenomenology Edmund Husserl and refers to the initial step of sweeping aside the personal bias of the researcher in order to accentuate a naïve interpretation of the human experience under consideration.

Once the state of epoche has been suitably negotiated, the reduction stage is undertaken by describing the phenomenon using richly textured language so as to obtain a deep level of comprehension. All statements rendered in the ensuing text are then inspected with the thought that they are of equal value, this being a procedure known as "horizonalizing". The aim is to extract a structural appreciation of the interweaving between person, conscious experience and the phenomenon that stimulates the latter. The third step, imaginative variation, revolves around speculative ruminations to explore possible experiential meanings through divergent thinking and systematic reflection. To conclude, synthesis assimilates the structural and textural vantages encountered in the previous stages into a coherent unified statement, which encapsulates the quintessential nature of the phenomenon.

West (1997) advocates the existence of a "hermeneutic computer science" to augment the formalist orthodoxy permeating the study of information technology. Such an approach can provide strategies to deal with the problems encountered with complexity. Hermeneutics is the study of interpretation, usually of texts but also of systems in general. Phenomenology is one strand of this paradigm and the concepts to be plumbed in the ensuing investigation will possibly include multiple-perspectives, cooperative and transient meaning, emergence, self-organization, variation, evolution as well as elucidation in general.

The "Blade Runner" film segment as described above will be employed as a phenomenological stimulus to be viewed by a number of academics from the domain of information systems. The interpretive research methodology as outlined above will then be adopted to gauge the subjective experience of this unique cohort. Conventional HCI research often involves the deployment of usability labs that consist of sophisticated video recording equipment and observation facilities such as one-way mirrors to permit fastidious scrutiny of users engaging with the interface of a product (Dillon, 1988). In an ironic sense, the motion picture sequence to be viewed in this research project will be akin to a cinematic usability lab, the one-way mirror here being the film artifact and the message that its viewers experience via the unilateral conduit of entertainment.

REFERENCES

Boutillette, M., Coveney, C., Kun, S. & Menides, L. J. (1999**). The influence of science fiction films on the development of biomedical instrumentation.** *Proceedings of the IEEE 25th Annual Northeast Bioengineering Conference*, 143-144.

Clarke, R. (1993). Asimov's laws of robotics: implications for information technology - Part I. *IEEE Computer*, *26*(12), 53-61.

Dillon, A. (1988). The role of usability labs in systems design. In: E. Megaw (ed.) *Contemporary Ergonomics 88*. London: Taylor and Francis, 69-73.

Gratch, J., Rickel, J., André, E., Cassell, J., Petajan, E. & Badler, N. (2002). Creating Interactive Virtual Humans: Some Assembly Required. *IEEE Intelligent Systems*, *17*(4), 54-63.

Grupe, F. H. (1996). Computoons: The evolving image of computers in cartoons. *IEEE Computer*, *29*(4), 55-62.

Jarvis, R. M. (2006). The admiralty lawyer in popular culture. *Journal of Maritime Law & Commerce*, 37, 23-48.

Lee, M. (2004). What does Hollywood think nonprofit CEOs do all day? Screen depictions of NGO management. *Public Organization Review: A Global Journal*, *4*, pp. 157-176.

Lucy, C. A. (2000). Analytical Chemistry: A Literary Approach. *Journal of Chemical Education*, *77*, 459-470.

Manovich, L. (2001). *The Language of New Media*. Cambridge, MA: MIT Press.

Marcus, A. (2006). CHI at the Movies and on TV. *interactions*, *13*(3), 54-55, 71.

Mathews, W. M. & Reifers, K. (1984). The computer in cartoons: A retrospective from *The Saturday Review*. *Communications of the ACM*, *27*, 1114-1119.

McCurdy, H. E. (1973). Fiction Phenomenology and Public Administration. *Public Administration Review, 33*, 52-59.

Moustakas, C. (1994). *Phenomenological Research Methods.* Thousand Oaks, CA: Sage.

Nielsen, J. (1993). *Usability Engineering*. Boston, MA: Academic Press.

Vos Post, J. & Kroeker, K.L. (2000). **Writing the future: Computers in science fiction.** *IEEE Computer***,** *33***(1), 29-37.**

West, D. (1997). Hermeneutic computer science, *Communications of the ACM***,** *40***(4), 115.**

Improving Corporate E-mail Communications with Employees at Remote Locations: A Quantitative Study in Progress

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INTRODUCTION

Today's company managers are under pressure to manage employees residing in different cities, states and countries, and are pressured to adapt to the changing definition of the workplace. Mayor (2001) describes the traditional 9:00-5:00, one office location, as archaic; advocates for having employees at remote locations; and advises managers to learn to effectively communicate without the luxury of in-person or face-to-face interaction. Companies are setting up remote offices so employees or telecommuters can work from or near home, are physically close to clients, and to cross boundaries of time, distance, culture, and geography. Melcrum (2000) wrote that the increase in the number of remote locations accommodates work/life balance of teleworkers by reducing travel and time away from home, and is supported and enabled by technological advancements such as computers, the world wide web, video conferencing, cellular phones, pocket-size computers, wi-fi, and electronic mail (email) - the predominant communication channel of teleworkers and the topic of this quantitative research project.

If Janove (2006) and Enemark (2006) are correct - knowledge, trust, and connectedness are critical to managing offsite employees, and a common success denominator of the three elements is effective communication, which has distinct performance challenges. Kuzma (2006) wrote that a prominent issue for companies managing teleworkers is the pervasive use of email and its associated communication problems. Enemark (2006), Kuzma, (2006), and Suler (1997) agree that the absence of verbal and non-verbal communication signals, present in face-to-face and telephone interactions, can lead to misconstrued email tones or meanings, miscommunications, disorientation, and lingering bad feelings. "While email may indeed smooth the load to some degree, it also carries a big potential for misunderstanding. The problem, however, is not email but communication skills. Employees who cannot communicate, whether orally or in writing, are less effective" (Gibbs, 1998, p.1). But managers of teleworkers in virtual communities often defer to this most popular corporate communication channel of email and therefore need tools to enhance the effectiveness of email communications.

STATEMENT OF THE PROBLEM

Email is a dominating corporate communication channel, replacing even the telephone (PcPheat, 2002). Email is an invasive, technological phenomenon that should be used proficiently. It can build or destroy relationships, and has the legal power of the printed word which cannot be taken back once the send button is pushed. Resources for writing effective emails are abundant but are limited in focus to netiquette, content, format, and proper/legal use. Interpersonal communication experts advise on the art of communication but the advice is written for face-to-face or phone interactions rather than for email interactions. Decker (1996), Hunsaker (2005) and others have written at length regarding the need for managers to build trust and relationships with employees by actively listening and sending encouraging verbal and nonverbal communication signals through the use of behavioral skills like appropriate eye contact, open posture, suitable facial expression, encouraging gestures, verbal prompts - all present in synchronous interactions but all nonexistent in an environment dependant on asynchronous interactions like email. "The inability to develop personal rapport over e-mail makes relationships fragile in the face of conflict" (Enemark, 2006, p.1). Seeley and Hargreaves (2003) wrote that email is the "DNA of communications," (p. 4) and that some managers receive an average of 68 emails a day. Managers need performance enhancing tools and techniques to act as surrogates for email's missing verbal and nonverbal signals to help build trust and relationships with telecommuters and offsite employees, and to enhance productivity and profitability.

Business communicators know that one way to improve communications is to first study and understand the various styles of communication (Wilson, 2004). Once the communication style of a client or employee is determined, then managers who have been trained to use the skill of adapting behaviors to mirror those of others can effectively learn to communicate in the native styles of a client or an employee (Alessandra & O'Connor, 1996). Managers who understand style differences and then learn to adapt to the styles of others benefit greatly and help reduce communication barriers and misunderstandings (Hunsaker, 2005), but these critical skills relate to face-to-face interactions. And an online poll of 1,013 Canadians conducted in the spring of 2006 revealed that face-to-face conversations account for 38% of daily interactions and are closely followed by email exchanges at 30% of interactions (mobile telephones account for 12%, and home telephones about 20%) which illustrates the need to develop tools and techniques for maximizing the effectiveness of email exchanges (Canadian Newswire, 2006).

Additionally, it is estimated that there are over eight million teleworkers in the United States and that the most popular channel of communication of these individuals is email. There are intrinsic problems with understanding the tone of email exchanges, recipients correctly interrupt emails only about 50% of the time, often leading to misunderstandings, ill will, flame wars, and a lack of trust and connectedness - all of which negatively impact production and profit. Enemark (2006) wrote of a study conducted by Kruger and Epley in 2005 that proved a link between email misunderstandings and egocentrism, meaning, that people tend to write and interpret emails solely from a single perspective and assume that email receivers understand exactly what the senders intended. Enemark (2006) further described the findings of this study to include the confirmation that the lack of verbal and nonverbal cues is a problem with emails; and that because emails are quickly transmitted and informal they imitate face-to-face interactions but are missing the critical paralinguistic signals of the spoken word. Jourdain (2002) reminds that only seven percent of a message interpretation is based on the actual written or spoken words and that the remainder of the message is subject to the receiver's filters. The Kruger and Epley research found in five separate studies that email senders believe they clearly communicate 78% of the time; that email recipients believe they properly interpret emails 89% of the time; and, in reality, the receiver only correctly interprets email 56% of the time, indicating room for miscommunication (Enemark, 2006). "To avoid miscommunication, e-mailers need to look at what they write from the recipient's perspective, Epley says" (Enemark, 2006, p.1).

RESEARCH PROJECT DESCRIPTION

Communication suffuses most everything in life therefore any and all improvements to communication process effectiveness is beneficial (Jackson, Dawson,

& Wilson, 2002). Identifying and adapting face-to-face communication styles is a process for improving communication effectiveness that is not new; it has been taught and successfully used in corporations for over 45 years (TRACOM Group, 2004), was created as a way to understand the perspective of message recipients and to demonstrate respect. What ***is*** new is the concept of applying the identification and adapting techniques to email interactions to determine email styles or e-styles. Before a technique or model for adapting e-styles can be developed, the hypotheses that e-styles exist, are predictable, and correlate to face-to-face styles must be researched. The researcher will work to prove or disprove the theory that communication styles manifest not just during face-to-face interactions but also in email communications.

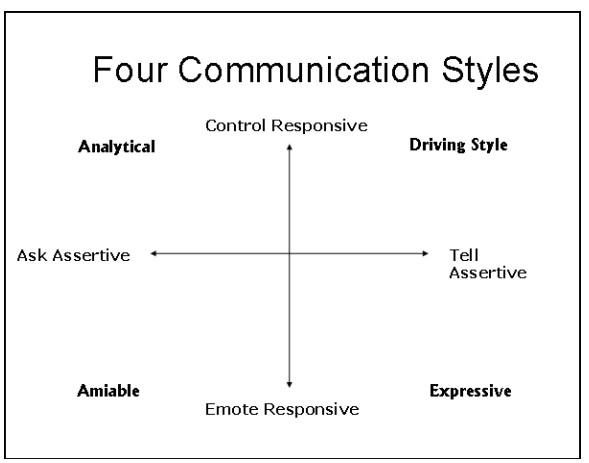
The TRACOM SOCIAL STYLES Model SM is based on the premises that there is no communication style better than another; there are four basic styles – analytical, amiable, driving, and expressive; styles are identified by analyzing physical and verbal behaviors that are measured on two axes or continua of assertiveness and emotiveness; and that the key to using this information to improve communications is in the ability of the person transmitting the message to style-adapt to the person receiving the message.

First is style identification and second is style adaptation. Benefits of adapting include learning to speak in a client's or employee's style language which will increase comfort, help make a difficult message palatable, and emphasize the content of the message rather than the delivery style of the message. Focus will remain on the message content and reduce misunderstandings or misconstrued negative feelings, attributable to style differences, which the manager may have unintentionally communicated to the employee.

The TRACOM Corporation's SOCIAL STYLE SM MODEL has well documented evidence of four basic communication styles and of the effectiveness of adapting. TRACOM has a tested and proven methodology for identifying styles by analyzing specific physical and verbal behavioral patterns such as eye contact, speech, and body movement (TRACOM Corporation, 2001). TRACOM places specific behaviors on two continua. One continuum is described by behaviors that determine a person's amount of Tell/Ask assertiveness or level of influence. About half the population is more tell- assertive, the other half is more ask-assertive (Bolton and Bolton, 1996). Driving style and expressive style are the two styles considered tell-assertive and analytical style and amiable style are ask-assertive (TRACOM Corporation, 2004). TRACOM's model determines assertiveness by analyzing specific behaviors.

The second continuum is described by behaviors that determine a person's amount of responsiveness or levels of evident emotion and are called Emote/Control responsive. About half the population is more emotionally controlled and the other half is less emotionally controlled and both are determined by examining levels of obvious displays of emotion and attention to people versus attention to numbers and statistics (Bolton & Bolton, 1996). Driving and analytical are the two styles considered more emotionally controlled, and expressive and amiable styles are less emotionally controlled. TRACOM determines emotiveness also by analyzing specific behaviors.

Figure 1. The four communication styles quadrant



The styles are then determined when the two continua are combined to form a quadrant with assertiveness on the horizontal axis and emotiveness on the vertical axis. People who are tell-assertive and more emotionally controlled are driving style. People who are tell-assertive and less emotionally controlled are the expressive style. People who are ask-assertive and less emotionally controlled are the analytical style, and people who are ask-assertive and more emotionally controlled are the amiable style. TRACOM's objective approach to analyzing behaviors for determining styles is captured in Figure 1 on a quadrant. The lines with the arrows are the continua and the combination of assertiveness and emotive behaviors when placed on the quadrant indicate style.

During this study a similar diagnostic tool using two continua and a quadrant will be created to capture and analyze the email writing behaviors that would define e-styles. The researcher will model the styles descriptors and the identification after TRACOM's SSP system but proposes the following titles for the four e-styles. The researcher's e-styles and TRACOM's in-person styles names are, respectively (a) logical/analytical, (b) supportive/amiable, (c) straightforward/driving style, and (d) communicative/expressive. Diagnosing styles is the first step to improving interpersonal communications and regardless of what the names of the styles are, once an employee's style is determined it is advisable for managers to take the second step and adapt behaviors in a way that emulates that of the employee's style. Adapting will result in fewer misunderstandings and encourage trust and open communication. The adapting technique is important to use for a variety of reasons including increasing the employee's receptivity to hearing a difficult or complicated message. But before adapting e-styles, comes analyzing and identifying e-styles, which is the focus of this study.

By proving the hypothesis that e-styles exist could result in the creation of a training solution for managers to: (a) identify e-styles; (b) craft effective emails by adapting to the e-style of others; (c) increase the recipient's understanding; and (d) decrease the potential for miscommunication. Second, the creation of e-styles predictor software has important applicability to corporations managing remotely. Additionally, if the research provides evidence that e-styles and in-person styles correlate, then the theories and practices regarding in-person styles identification can be applied to e-style identification. Managers who understand and value the premise of identifying in-person communication styles of employees may also see a value for identifying e-styles of employees however; research has not been conducted on predicting e-styles.

PURPOSE OF THE STUDY

The purpose of this study is to develop a tool to test the theory that e-styles exist, can be identified, and correlate to in-person styles. Once proven, training will be developed to instruct managers how to adapt to the e-styles of others. The research will require the development of a software model designed to analyze email characteristics and to identify data trends that can be categorized as e-styles. The characteristics are derived based on behavioral criteria similar to those used by the TRACOM SOCIAL STYLES Model SM. The researcher will analyze approximately 2,000 emails collected from 100 eligible participants and, to explore a second hypothesis, correlate the data with data collected on the participant's in-person styles. If the study proves the hypothesis that e-styles correlate to in-person styles then the literature and practices of in-person communication styles theories will apply to e-styles.

Two hypotheses have been formulated for this study. The first hypothesis is that e-styles can be predicted by analyzing email correspondence. The researcher will study email characteristics, or predictors, to identify trends in levels of emotiveness and assertiveness which when placed on continua indicate the writer's e-style. The second hypothesis is that e-styles correlate to in-person communication styles. If the second hypothesis is true then theories, research, practices, and literature on in-person styles can be applied to e-styles.

RESEARCH FRAMEWORK

The information gained during this quantitative research study will test the hypothesis that e-styles of employees can be determined by examining specific email characteristics that when placed on two continua describe how best to understand an employee's written e-style. Similarities and differences may surface during this study between email and in-person communication characteristics used to predict

the styles which will disprove or prove a correlation between the two. Information from this research study will provide new communication improvement resources for management to use in developing and improving relationships with employees at remote locations. Additionally it is expected that participation of 100 will be achieved because managers are interested in learning about communication styles and will be interested in receiving a free style profile assessment.

The study described is designed to test the hypotheses by (a) studying about 2,000 emails from about 100 participants to determine email communication style indicators; (b) by identifying participant's in-person communication styles, using the TRACOM SSP-E online profile method; and (c) by comparing e-Com styles with the in-person profile results to see if there is a correlation. The results of the study will be compiled into and communicated through a manager's training curriculum. The training will be designed to be used as a strategic internal communications plan component, will link improved email communication skills to corporate business operations initiatives, and may be a viable HPI training solution.

The researcher will use data mining and conduct a neural networks regression analysis driven by R-Software of which the predictors or independent variables are email characteristics and the response variables or the dependant variables are the 2,000 emails submitted by the participants. The characteristics will be reviewed and parameters extracted using a C++ language program developed by a data analyst for this project. The parameters will then be fed into R-Software which is the user interface for running the neural networks. Neural networks is a computational information processing model that will be trained, by using the TRACOM model as a basis, on what the appropriate relations between email attributes and e-styles are and will determine the probability that a set of emails comes from a person having a particular e-style. If a model that can relate email attributes to in-person styles can be built then e-styles exist. The e-styles will be categorized as communicative, logical, supportive or straightforward. The researcher's theory regarding e-style identification is that managers with communicative styles will issue more directives and make fewer requests and will refer more to feelings. Managers of the logical style make more requests, issue fewer directives and will refer more to facts. Managers who email in the supportive style will make more requests, issue fewer directives and refer more to feelings; and managers of the straightforward style will issue more directives rather than making requests, and will refer more to facts.

CONCLUSION

Improved email communications with employees at remote locations translates to improved relations, trust, productivity, and ultimately profitability. The development of an e-styles identification tool and training curriculum are timely, would offer companies a new HPI training solution for improving the performance of managers and others, and would be a viable component of a corporate internal communications strategy. The ability to identify e-styles will provide guidance to managers seeking a technique to write emails that are non-inflammatory, correctly interpreted, and that successfully and professionally disseminate information to peers, subordinates, supervisors, and clients of different styles. Given the importance of effective communication with clients, employees and others, and the fact that many companies have gone global and need tools and techniques to effectively communicate via email the timing and importance of this study are appropriate.

The Evolving Concept and Practice of Knowledge Management: Seeking a Common Understanding and Definition

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ABSTRACT

This research traces the roots of knowledge management (KM) to assess how its origins relate to current variation in terminology, concepts, theory, and practice. The objective is to provide a framework for clarifying the relationships among these divergent views and move toward a more common understanding and definition of KM.

INTRODUCTION

The past two decades have witnessed the rapid evolution of knowledge management (KM) as a concept and as an area of study and practice. Some researchers suggest that KM has matured to a level to be recognized as an academic discipline in its own right (Jennex and Croasdell, 2005). However, the literature offers little agreement on a common definition of KM or its foundations and methods. In fact, almost every KM source offers its own unique definition.

The KM umbrella has, in fact, become very broad. It has introduced new concepts such as the knowledge worker, chief knowledge officer, knowledge economy, intellectual capital, and knowledge as a tangible asset. It has also evolved to encompass all or many of the following concepts, depending on the source: work flow, document control and distribution, e-mail, performance support, best practices, organizational learning, organizational memory, collaborative computing, data warehousing, data mining, and knowledge portals. Other sources also include Intranets, Extranets, e-business, customer relationship management, and business intelligence. All of these, and more, are discussed in various ways by different sources under the knowledge management umbrella.

The idea of the importance of knowledge is not new, of course. Yet as a concept and an organizational process, KM takes on an entirely different meaning, which has gained widespread attention on a global scale. At the same time, however, the concept has lacked unity, and its rapid popularization has made it difficult to sort out the hype from the reality. As often happens when a new concept becomes popular, there has been a rush to rename existing technologies or products to make them more marketable. As a result, systems that have been around for a long time, such as artificial intelligence, expert systems, workflow management, databases, document management systems, and most recently corporate Web portals, now are touted as KM systems.

This study hypothesizes that the lack of consensus around a common definition of KM relates to its divergent roots. The literature reveals that the origins of KM have not been well researched (Bertels, 1996; Sveiby, 2001). The purpose of this research, therefore, is to identify the various disciplines or threads in which KM has roots and to assess how these varying roots relate to the current variation in terminology, perspectives, and recommended approaches to KM. The objective is to provide a framework for clarifying the relationships among these divergent views and move toward a more common understanding and definition. This insight will be critical to defining KM as a discipline and clarifying its foundations, theories, and methods as well as validating its business value.

LITERATURE REVIEW

The literature provides a plethora of definitions for KM (Alavi & Leidner, 2001; Awad & Ghaziri, 2004; Ayerton, 1998; Gates, 1999; Grundstein, 2006; Konda & Steenkamp, 2004; Malhotra, 1999; Sveiby, 2001, Regan, 2007; Regan & O'Connor, 2002). The lack of agreement on a definition is problematic for an emerging discipline that traces its roots back at least two decades. Even the most recent textbooks spend an entire chapter just explaining what KM is and what it is not, and provide an entire page of definitions (Awad & Ghaziri, 2004; Regan & O'Connor, 2002).

Systematic analysis of the literature on knowledge management reveals at least seven distinct roots or disciplines related to the evolution of KM. While these different roots share common concepts, they also reflect sharp differences. The current status of KM appears to represent a convergence of these distinct roots—rather than a progression from any single discipline. The analysis suggests that this convergence of several different disciplines accounts, in large part, for both the disparity of viewpoints and what seems like an explosion of interest.* A very brief summary of each of these roots follows:

- *Best practice transfer*. One dominant theme of KM is the systematic transfer of best practices. According to a study conducted by the American Productivity and Quality Center (APQC, 1996), best practice management was the one strategy pursued by 100 percent of the firms implementing KM approaches. The use of benchmarking and best practices gained widespread industry acceptance in the early 1990s (O'Dell & Grayson, 1998). This perspective is represented in the O'Dell and Grayson book (1998), *If Only We Knew What We Know*, based on APQC's work with Fortune 500 firms.
- *Information and records(or resource) management (IRM)*. KM also has roots in document management, both paper and image. Both the Association of Information Image Management (AIIM) and ARMA, International, the former Association of Records Managers and Administrators, have a huge presence in the KM market. This approach reflects a strategic view of managing and safe guarding information resources from a corporate perspective. It also suggests the origins of the life cycle concept frequently applied to KM. IRM is the approach reflected in the book by Jan Duffy, *Harvesting Experience, Reaping the Benefits of Knowledge*.
- *Organizational learning and organizational memory*. The concept of the learning organization is generally associated with Peter Senge, author of *The Fifth Discipline*. It embodies the notion that organizations as well as individuals can learn from experience, and it emphasizes the need for information sharing and collaboration. Concepts such as organizational intelligence and self-organizing knowledge would fall within this tradition as well (Allee, 1997). Many researchers also consider *The Knowledge-creating Company: How Japanese Companies Create the Dynamics of Innovation*, by Ikujiro Nonaka and H. Takeuchi (1995) to be a seminal work in the area of organizational learning.
- *Electronic performance support systems (EPSS)*. One of the early precursors of KM is electronic performance support, the concept of just-in-time delivery of online reference, training, and help. During the 1980's hundreds of firms focused on creating online performance support and computer based training using new computer authoring and reference systems. Another related concept was Information Mapping, a process for analysing, organizing, and presenting information for reference, which originated for paper documents and was then adapted for electronic presentation. The EPSS approach is described in books such as *Designing Electronic Performance Support Systems* by Gloria J. Gery and *Designing and Writing Online Documentation* by William K. Horton. Another widely recognized pioneer in this area is Dr. Ruth Clark, author

of *Building Expertise: Cognitive Methods for Training and Performance*, and other books and articles on learning objects, online learning, workplace performance, and instructional design.

- *Technological methodologies*. Another perspective is based on technological methodologies related to data warehousing, data mining, and business intelligence. This thread has its foundation in information systems and technologies. It tends to focus more on knowledge taxonomies and to view knowledge more from the perspective of objects rather than process. One of the weaknesses of early data warehouses was that they tended "to create massive data and text archives of dubious value" (Sveiby, 2001, online). This approach is represented in works such as Thomas H. Davenport and Laurence Prusak, *Working Knowledge: How Organizations Manage What They Know* (1997)
- *The knowledge economy and knowledge as a corporate asset.* Another perspective is based on economic concepts related to productivity and measuring economic value in the new economy. Economists and business leaders today are concerned with whether traditional accounting and statistical models are capable of calculating the true productivity gains created by knowledge in the new economy. Intellectual capital, which has long been regarded as an intangible quality of individuals and organizations, is now gaining ground as a tangible line item on the corporate balance sheet. Recent works in this area include Paul A. Strassman, columnist on knowledge metrics for *Knowledge Management Magazine* and Thomas A. Stewart, author of Intellectual Capital: The New Wealth of Organizations (1997). Another example is found in Housel and Bell (2002), *Measuring and Managing Knowledge*.
- *Internet and Web Portals*. The Internet has created a common, relatively low cost networking platform that has opened access to information and greatly expanded the options for enterprises to share information both internally and externally. The influence of this approach has expanded more recently to include customer relationship management, business intelligence, and portal technologies. It is a major focus of *Knowledge Management Magazine*, subtitled Business Intelligence for Strategic Decision Makers, aimed at executives interested in organizational and technological knowledge-management strategies (Roberts-Witt, 1999).

We might also add the discipline of library and information sciences to this list, which is being transformed by digital technology and online access to information resources. Indeed some excellent practitioners in KM come from the library sciences. Astra Pharmaceuticals is among the documented case studies where enterprises made a decision to include people from the world of library and information sciences in key KM positions (Regan & O'Connor, 2002).

Sveiby (2001) seeks to explain the wide disparity in understanding KM concept s by analyzing what people in the field are doing—researchers, consultants, vendors, KM users, companies, and other practitioners. He suggests two difference tracks. An Information Technology (IT) KM Track that focuses on the Management of Information and a People KM Track that focuses on the Management of People. He suggests that researchers and practitioners in the IT KM Track tend to come from computer and information science backgrounds. They are involved in applications such as information management systems, reengineering, artificial intelligence, data warehouses, groupware, etc. To them knowledge equates to objects. On the other hand, researchers and practitioners in the People KM Track tend to come from business/management, psychology, philosophy, or sociology. They are primarily engaged around workplace performance, professional development, and organizational learning. To them knowledge equates to processes. Grundstein (2006, p1259) makes a similar distinction between two main approaches underlying KM: "(1) A Technological Approach that answers a demand of solutions based on the technologies of information and communication; (2) A Managerial Approach that integrates knowledge as resources contributing to the implementation of the strategic vision of the company."

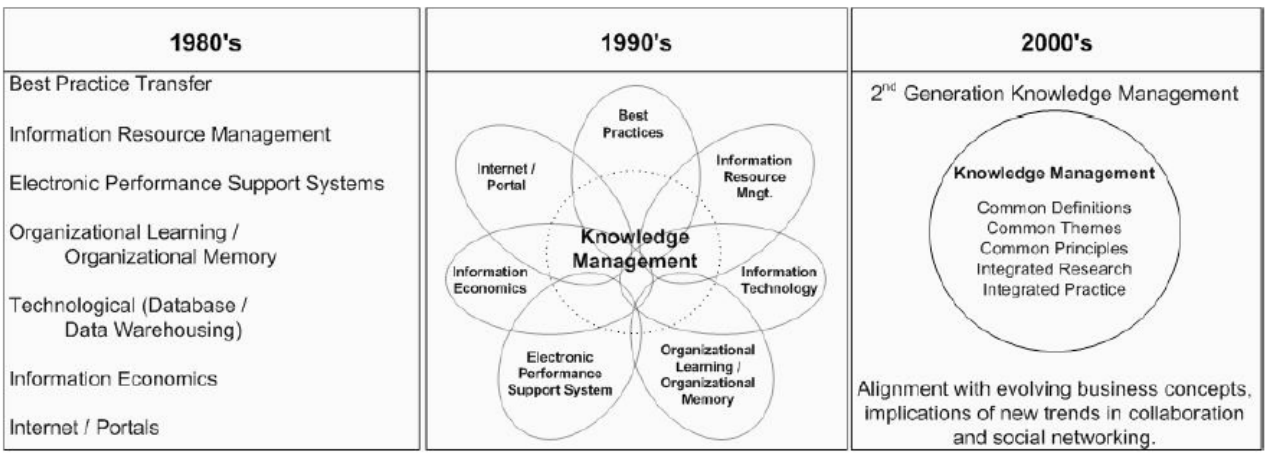
Consequently, according to Sveiby (2001, online), there are "paradigmatic differences in our understanding of what knowledge is." Researchers and practitioners who view knowledge as objects, tend to rely on concepts of information theory in their understanding of knowledge, whereas those who view knowledge as process tend to take their concepts from philosophy or sociology. "Because of their different origins, the two groups use different languages in their dialogues and thus tend to confuse each other when they meet" (Sveiby, online).

Konda and Steenkamp (2004) offer yet another approach to classifying the varying KM perspectives. These include the technological, organizational, process-based, product-centric (or asset-focused), and strategic perspectives. Researchers and practitioners have proposed several variations of knowledge life cycle models that emphasize one or more of these perspectives while neglecting others.

ANALYSIS

This legacy helps explain, at least in part, the contradictory views, inconsistencies, multiple perspectives, and plethora of definitions surrounding the concept and emerging discipline of knowledge management. Although the different threads share some common themes, they also reveal fundamental differences in our understanding of what KM is and is not. They represent different foundations and use different languages in their descriptions and approach to KM. They also differ in the types of applications and problems that they address and the approaches that they take to these problems. For example, technology approaches generally emphasize explicit knowledge and focus on how to create, store, retrieve, and use the explicit knowledge artefacts; whereas organizational learning approaches generally emphasize the importance of tacit knowledge and focus on personal, organizational, and inter-organizational learning and knowledge transfer. What is needed in practice is a more holistic or balanced approach that would ensure

Figure 1. Evolution of KM: A convergence NOT a progression from a single discipline (Source: Regan, 2007)



an optimal integration of tacit and explicit knowledge to serve the needs of the business (Konda & Steenkamp, 2004).

The research provides little evidence of a shared awareness among the communities of practice and research associated with each of these threads or traditions (Jennex & Croasdell, 2005). This silo effect is evident from the apparent lack of cross-referencing of research and practice in the literature of these different traditions. This silo effect suggests that the current state of KM represents a convergence of these different traditions with little integration of theories or methods. Although common themes have emerged around the concept of knowledge management, wide disparities continue to exist in theory, terminology, and practice. Thus, as suggested by Figure 1, the current status of KM as a concept, represents a convergence of multiple disciplines and approaches, which has not yet truly coalesced into a discipline in its own right. Kondra and Steenkamp (2004, p1383) also argue the need for an integrated KM framework that comprehends all the perspectives of knowledge to present a holistic approach. They propose an Integrated Knowledge Management Framework (IKMF) based on five perspectives: strategy, organizational entity, knowledge process, knowledge asset, and information technology. They suggest that, "No treatise on KM is complete unless it addresses all the issues arising out of a comprehensive view of entire KM domain" (Kondra & Steenkamp, 2004, p1384).

CONCLUSIONS AND FUTURE RESEARCH

This research focuses on the variety of traditions from which KM has its roots to assess how they relate to the current variation in terminology, perspectives, definitions, and recommended approaches to KM. Current evidence shows little shared awareness among these different traditions. This research suggests a need to work toward development of a holistic KM model that recognizes the entire spectrum of research and practice. Future research also is needed to validate common themes and practices among these separate traditions. If researchers continue to work in their own silos, KM will continue to be characterized by a general lack of agreement and congruence. More importantly, the opportunities for richness and insight of a more holistic, multi-disciplinary perspective will be missed. To be viable, it would seem that any movement toward establishing KM as a discipline must be inclusive and recognize the full range of research and practice.

REFERENCES

Alavi, M. and Leidner, D. (2001). Review: Knowledge Management and Knowledge Management Systems: conceptual foundations and research issues. *MIS Quarterly*, 25(1), p.107-136.

Allee, Verna (1997). *The Knowledge Evolution: Expanding Organizational Intelligence.* Woburn, MA: Butterworth-Heinemann.

Ayrton, H. American Productivity & Quality Center (1998). *Knowledge Management.* Online **http://www.apqc.org/km/**, accessed 12/22/2000.

Awad, EM. and Ghaziri, H.M. (2004). *Knowledge Management*, Upper Saddle River, NJ: Prentice Hall.

Bair, J. (May 14, 1998). *Knowledge Management Is About Cooperation and Context*, Gartner Group Advisory Services, CD-ROM. Cambridge, MA: Gartner Group Inc.

Barth, S. (2000). Number Theory: Miles to Go: Many firms still misunderstand the fundamental opportunities and challenges of knowledge management. *Knowledge Management Magazine*, 3(6), p.31.

Bertels, T. (1996). Cited in The Knowledge Management Forum: The Early Days. What is Knowledge Management? Online **http://www.km-forum.org/what_is.htm** accessed August 2006.

Clark, R. (1998). *Building Expertise: Cognitive Methods for Training and Performance*. International Society for Performance Improvement.

Davenport, D.H. and Prusak, L. (1998). *Working Knowledge: How Organizations Manage What They Know*. Boston: Harvard Business School Press.

Do We Know How to Do That? (February 1999). Understanding Knowledge Management. *Harvard Management Update* 4(2), 1.

Duffy, J. (1999). *Harvesting Experience: Reaping the Benefit of Knowledge*. Prairie Village, KS: ARMA International.

Dyer, G. (2000). IDC State of the Market Survey: KM Crosses the Chasm, published in *Knowledge Management Magazine*, 3 (March 2000), 52.

Editors, (1999). The knowledge management movement gained traction in technology, economics and organizational practice. KMM spots the 10 strongest trends. *Knowledge Management Magazine*, 2 (December 1999), 35.

Gates, B. with Hemingway, C. (1999). Business @ the Speed of Thought: Using a Digital Nervous System. New York: Warner Books, Chapter 14.

Gery, G. (1991). *Electronic Performance Support Systems: How and Why to Remake the Workplace through the Strategic Application of Technology.* Boston: Weingarten Publications.

Grundstein, M. and Rosenthal-Sabroux, (2005) C. Towards a model for global knowledge management within the enterprise. *Managing Modern Organizations with Information Technology*, Proceedings of the IRMA International Conference, Idea Group Inc., 1259-1262.

Housel, T. and Bell, A.H. (2001). *Measuring and Managing Knowledge*. New York: McGraw-Hill Higher Education.

Jennex, M.E., and Croasdell, D. (2005). Editorial preface: Is knowledge management a discipline? *International Journal of Knowledge Management*, 1(1), i-v.

Konda, D. and Steenkamp, A. L. (2004). Integrated knowledge management framework: A coherent set of multi-faceted, and multi-dimensional knowledge-centric life cycle models. *International Journal of Knowledge, Culture, and Change Management*, 4, 1383-1397. www.Management-Journal.com

Malhotra, Y. (1999). Knowledge management for the new world of business. www.brint.com/km/whatis.htm, accessed August 2006.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science*, 5(1), 14-37.

Nonaka, I. And Takeuchi, H. (1995). *The Knowledge-creating Company: How Japanese Companies Create the Dynamics of Innovation*. Oxford University Press.

O'Dell, C. and Grayson, C.J. with Essaides, N. (1998). *If Only We Knw What We Know: The Transfer of Internal Knowledge and Best Practice*. New York: The Free Press.

Regan, E.A. (2007). Knowledge Management: Evolving Concept and Practice. International Journal of Knowledge, Culture, & Change Management, V6.

Regan, E.A. and O'Connor, B.N. (2002). Chapter 5 Knowledge Management, End-User Information Systems: Implementing Individual and Work Group Technologies. Upper Saddle River, NJ: Prentice Hall, 159-203.

Roberts-Witt, S.L. (1999). Making Sense of Portal Pandemonium, *Knowledge Management Magazine*, July 1999, 45. citing Daniel Tkach, IBM worldwide marketing manager for Knowledge Management Solutions.

Senge, P. (1990). *The Fifth Discipline*. New York: Doubleday.

Stewart, T.A. (1997). *Intellectual Capital: The New Wealth of Organizations*. New York: Doubleday.

Sveiby, K.E. (2001). *Intellectual Capital and Knowledge Management*. Accessed July 2006, http://www.sveiby.com/Portals/0/articles/IntellectualCapital.html

The American Productivity and Quality Center (APQC), 1998, online). http://www.apqc.org. Accessed August 2006.

ENDNOTE

* see especially Regan (2007) for a sampling of KM definitions representative of the 7 different KM roots.

The Management and Engineering of IT-Intensive Systems: A Systemic Oriented View

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ABSTRACT

Studies in Software Engineering (SwE) and Systems Engineering (SE) disciplines have alerted on the increasing complexity of software-intensive systems in the last 15 years. As a response to this phenomenon, it has been recognized the need to strengthen the SE and SwE curricula mutually through a unified Software Systems Engineering discipline. In turn, a common definition of the Information Systems (IS) discipline indicates that IS concerns with the study of Information Technology-based systems (IT) for managerial purposes as well as with the dual nature – technical and social- of its management. This paper, -product of a research in progress- develops the case for a Management & Engineering of IT-intensive Systems view under the following rationality: (i) the technical and social complexity of the issues related with the emergent information systems -built on software-intensive systems- that is demanded by organizations escapes of the scope of knowledge of the traditional IS discipline, (ii) the IS discipline has arrived to such degree of fragmentation that it has became in a set of knowledge islands, and (iii) an interdisciplinary –systemic- approach provides the adequate philosophical paradigm and methodological research tool to cope with this phenomenon through the systemic interaction of traditional IS, SwE and SE disciplines. In pursuit of this purpose, this paper reviews the origins, foci, objects of study, main disciplines of reference, and main research methods used in these disciplines, and uses a Systems IS research framework for theoretically justifying their integration. Discussion of benefits and barriers for its development are also finally reported.

Keywords: IT-intensive systems, Information Systems, Systems Engineering, Software Engineering, Interdisciplinary Research, Systems Approach.

INTRODUCTION

Studies in Software Engineering (SwE) (Andriole & Freeman, 1993; Sommerville, 1998; Boehm, 2000, 2006) and Systems Engineering (SE) (Sage & Cuppan, 2001; Keating et al, 2003) disciplines have alerted on the increasing complexity of software-intensive systems in the last 15 years. For the former case, this identification has been through the concepts of software-intensive systems (Andriole & Freeman, 1993; Boehm, 2000); socio-technical software-intensive systems (Sommerville, 1998) and software-intensive systems of systems (Boehm, 2006) while that for the latter case, through the emergence of the concepts of system of systems (SoS) (Sage & Cuppan, 2001; Keating et al, 2003) and complex systems (Senhar & Bonen, 1997; Mage & de Weck, 2004; Cleary, 2005).

As a response to this phenomenon, it has been recognized the need to strengthen the SwE (Sommerville, 1998; Hecht, 1999; Bate, 1998; Johnson & Dindo, 1998; Denno & Feeney, 2002) and SE (Brown & William, 2000; Rhodes, 2002) curricula mutually. Furthermore, a unified Software Systems Engineering discipline it has also posed by other studies (Andriole & Freeman, 1993; Thayer, 1997, 2002; Boehm, 2000). In turn, the SE disciplines per se, has been also required to wide its scopes to managerial duties (currently it is taught as Engineering Management, Industrial Engineering or Project Management topics) in order to SE provides the systems-view for managing the complete organization and only the traditional technical processes for engineering a product or provision a service (Farr & Buede, 2003; Arnold & Lawson, 2004; Emes et al, 2001).

Hence, while the SE and SwE disciplines have started to interact in the last 15 years to address the design of complex software-intensive systems -but composed of hardware components also like automotive systems, airspace systems, mobile telephone systems, etc-, a highly related discipline –*e.g.* Information Systems- has largely ignored such issues. Then, given a common definition of the Information Systems (IS) discipline as concerning with the study of computer-based systems –now called Information Technologies - for managerial purposes as well as with the dual nature – technical and social- of its management process (MIS Quarterly, 2006) and where the IS development (Nunamaker et al, 1991) and the IS design process (Hevner et al, 2003; 2004) are considered part of the practitioners duties and research paradigms, this paper -product of a research in progress- develops an initial case for a Management & Engineering View of IT-intensive Systems as discipline.

This perspective is developed under the following rationality: (i) the technical and social complexity of the issues related with the new information systems demanded by organizations escapes of the scope of the traditional monolithic view of IS, (ii) the IS discipline has arrived to such degree of fragmentation that it has became in a set of knowledge islands, and (iii) an interdisciplinary –systemic- approach (Ackoff, 1960) provides the adequate philosophical paradigm and methodological research tool to cope with the phenomena of interest to be studied through an unified view of IS, SwE and SE disciplines.

In pursuit of this purpose, the paper is structured as follows: in next section an extended review (Mora et al, 2006a) of the origins, foci, objects of study, main disciplines of reference, and main research methods used in these disciplines is reported. We continue -by using a systemic IS research framework (Mora et al, 2006b, 2007)- with the theoretical justification of the integration posed through an initial case. Finally, we conclude with a brief discussion of the benefits and barriers for its further development.

A SYSTEMIC REVIEW OF THE SE, SWE AND IS DISCIPLINES.

The concept of modern SE, SwE and IS disciplines –*e.g* as systematic generation and deployment of scientific knowledge- emerged historically during late 1930's for SE and late 1950s and 1960 for IS and SwE respectively. Some reports (Buede, 2000; Gonzalez, 2005; INCOSE, 2004) point out that SE principles have been used by urban architects or early civil engineers through the construction of large-scale systems such as: Egyptian pyramids, Roman aqueducts, bridges and buildings, and early mechanic and naval engineers with heavy industrial machinery, trains and ships. However, modern and systematic SE discipline is born with the integration

of a multidisciplinary engineering team in the British air defense systems in 1937, the first SE course at MIT in 1950, the establishment of a systems development division by RAND corporation in 1955, and the publishing of the first textbook on SE from H. Goode & R. Machol in 1957. At present, after 40 years, the existence of undergraduate and graduate programs discipline (Brown & Scherer, 2000), professional societies as INCOSE, worldwide conferences and scientific journals proves that SE is a well-recognized discipline.

The term of IS –originally named Management Information Systems- was coined in 1958 by Leavitt & Whisler (cited by Adam & Fitzgerald, 2000). The first textbook appears in late 1960s (Dearden & McFarlan, 1966; cited also by Adam & Fitzgerald, 2000) as well as the first graduate program in the University of Minnesota. As the same as the SE discipline, 40 years after, the IS discipline is well-recognized by the existence of the similar aforementioned indicators (*e.g.* programs, conferences, journals, etc). In turn, SwE concept was formulated in a NATO's Conference in late 1960s (Bauer, 1969; cited by Pressman, 1997) despite of the development of computer programs, languages and operating systems was done previously from the 1950s. However, these technological developments are related with Computer Sciences or Electrical Engineering disciplines. The first SwE textbook appears on the early 1970s, but is until the 1980s and the 2000s when the first graduate and specialized undergraduate programs in SwE are available respectively. However, despite of the delays in its evolution, the current existence of focused graduate and undergraduate programs, professional societies, conferences and journals in SwE supports evidences to consider the SwE as a discipline separate from its origins –*e.g.* Computer Sciences or Electrical Engineering-. Hence, the historical order of apparition of these disciplines suggests that SE is a more mature discipline –supported by the large-scale projects where it has successfully used as well as by the stability and standardization of its theories, methods and tools developed (Honour, 2004) -. In second place is the IS discipline and finally the SwE discipline. However, recent studies in the three disciplines –fostered by the increasing of IT-based systems and inherently complexity- are alerting on a required convergence or interdisciplinary curricula, research and praxis. In next section we develop an initial case for it, but it is required firstly to analyze the current foci, disciplines of reference and body of knowledge as well as the main research methods for each discipline.

According to Mora et al (2006a) there is not a standardized definition of what is SE, SwE and IS. Nevertheless, from several sources (INCOSE, 2004; SEI, 2003; MIS Quarterly, 2006), it is feasible to report the common definitions. Their systemic analysis is done with the construct <PQR-system> (Checkland, 2000) and exhibited in Table 1. From Table 1, it could seem that the systems of study for each discipline are disparate: a physical system, a software system and an IT-based system. However, the definition for SE implies the integration of several engineering disciplines as the physical system demands a special expertise for its development. In particular it has been identified a trend on the increasing development of systems coordinated by SE that are intensive in software (Andriole and Freeman, 1993; Bohem, 2000, 2006). Rhodes (2002) –nevertheless – remarks that software is other critical component like hardware and people involved in the entire man-made organizational system developed by systems engineers.

In turn, in the SwE discipline has been suggested that software systems must be considered as socio-technical software-intensive systems –e.g. "*systems where some of the components are software-controlled computers and which are used by people to support some kind of business or operational process … therefore, always include computer hardware, software .., policies and procedures and people … [and] operate in a systems-rich environment where different systems are used to support a range of different processes*" (Sommerville, 1998, pp. 115).

For the IS discipline, the new definition of software systems corresponds to what is considered an *Information System* (Mora et al, 2003). Furthermore, as it was already indicated, SE discipline is facing the challenge of design and development of more very complex and large systems where not only the technical or operational issues are relevant but also the political and economic ones. A specific new direction on these new demands is through the concept of System of Systems Engineering (SoSE) (Keating et al, 2003). Hence, then there are initial evidences of a required interaction between the SE, SwE and IS disciplines due to the common sub-systems or components based on software or IT in the whole systems addressed by SE.

Table 2 exhibits the relation of the three disciplines of interest with their reference disciplines through a qualitative 5-points scale from 1 (very low support) to 5 points (very high support). These disciplines shares common reference disciplines. Table 2 was populated from a conceptual analysis of several sources (Sage, 2000; Emes et al; 2005 for SE, SWBOOK (IEEE, 2001) for SwE, and Culnan & Swason, 1986; Vessey et al, 2003; Glass et al, 2004; for IS). A different grey intensity level is also used in the cells to emphasize the support score assessed for each discipline. From Table 2, some useful inferences can be supported. Firstly, SE and IS disciplines have been shaped by at least two fundamental disciplines (IE/OR and MS&OR for SE; B&OS, S&BS and IS self-referenced for IS). However, for the case of SwE seems to be a weak disciplinary reference support where only CSc (e.g. with a 5 points level) was fundamental in its original development. Furthermore, SwE was largely considered as a research stream and body knowledge of Computer Sciences (Denning et al, 1989). Nevertheless, in the last decade, it has been recognized in SwE the relevance of disciplines such as: SE, MS&OR, and B&OS (Kellner et al, 1991; Fuggetta, 2000). Secondly, despite of the Systems Science should be a common discipline (at least by the utilization of the concept *system* in the name of two disciplines and the emergent software-intensive system engineering discipline posed for SwE), only SE has kept it as strong theoretical foundations for the discipline.

In the case of IS, Systems Science was an original discipline of reference as main two IS research frameworks report (Nolan & Wetherbe, 1980; Ives et al, 1980). However, despite some proposals have been reported in IS literature to re-incorporate it (Mora et al, 2003; Gelman et al, 2005; Alter, 2006), few evidences of a reincorporation of Systems Science exist at present. SwE also seems to be an

Table 1. A systemic comparison of the conceptual definition of the SE, SwE and IS disciplines

PQR-system Construct	**Discipline**		
	<S: Systems Engineering>	***<S: Software Engineering>***	***<S: Information Systems>***
<S> is a system to do <P> …	… is an interdisciplinary approach and means to <**P**: enable the realization of successful systems>	… is the technological and managerial discipline concerned with <**P**: systematic production and maintenance of software products>	… [is the discipline] <**P**: concerning [to IT-based systems] >
through <Q> …	… < **Q**: [the integration of] all the disciplines and specialty groups into a team effort forming a structured development process that proceeds from concept to production to operation [and] considers both the business and the technical needs of all customers >	… that are < **Q**: developed and modified>	… <**Q**: [the scientific study and] the development of IT-based services, the management of IT resources, and the economics and use of IT >
in order to contribute to achieving <R>	… with the <**R**: goal of providing a quality product that meets the user needs>	… on <**R**: time and within cost estimates>.	… <**R**: [positive] managerial and organizational implications>

Table 2. Reference disciplines for SE, SwE and IS disciplines

Disciplines of Reference	SE	SwE	IS
Industrial & Manufacturing Engineering	●●●●●	●	●
Management Sciences & Operations Research (MS&OR)	●●●●●	●●●	●●●
Business/Organizational Sciences (B&OS) (Economy, Accounting, Marketing, Finance)	●●●	●●●	●●●●●
Social/Behavioral Sciences (S&BS) (Psychology, Sociology, Political Sciences, Law)	●●●	●	●●●●●
Mathematics and Statistics	●●●	●	●●●
Other Engineering and Physical Sciences	●●●	●	●
Systems Sciences (Systems Thinking, Systems Dynamic, Soft Systems , Critical Systems)	●●●	●	●
Computer Sciences (CSc)	●	●●●	●●●
Software Engineering	●●●	●●●●●	●●●
Systems Engineering	●●●	●●●	●
Information Systems	●	●	●●●●●

isolated discipline with few interactions with Systems Science. New proposals to interact with SE could robust it. Thirdly, while SE and SwE disciplines have started to acknowledge the need to interact between them in order to study and develop better software-intensive systems, the IS discipline still ignores this fact. Few efforts have been reported and more related studies in IS research despite do not address the SE discipline directly, are focused on a Design/Engineering paradigm (Hevner & March, 2003; Hevner et al, 2004). However, from a systemic view it can be argued that the SE discipline is a clear reference also for IS and it has been largely ignored in IS research, teaching and praxis.

Table 3 exhibits the main knowledge areas and general research streams derived for these disciplines from several sources. From Table 3, a first inference is that SE and SwE disciplines –by its engineering heritage- are most likely to interact in next 25 years. The IS discipline, in contrast seems to be unaware of the dramatic changes and challenges that world organizations are demanding via the emergence of complex socio-technical systems. A second argument is that in the cells with very low interaction (value of 1 point) is required an increment in the interaction in order to the discipline reduces the lack of such body of knowledge and with it can have a entire and holistic view of the systems studied and intervened. This implies –according to the Systems Approach- that any system only can be understood if it is studied: (i) from two perspectives (like a unitary whole or a set of parts interdependent) and (iii) within its wider system and comprising internal subsystems (Ackoff, 1971; Gelman & Garcia, 1989). Details of the need of Systems Approach in IS discipline has been also reported (Mora et al, 2003; Alter, 2003; Gelman et al, 2005; Mora et al, 2006b). Finally, Table 3 shows that SE requires fewer missing interactions than other two disciplines. A strong implication of this situation is that systems engineers are more holistically trained to cope with the study and implementation of large-scale and complex systems than software engineers and information systems practitioners. It is also worth

Table 3. Main knowledge areas and research topics for SE, SwE and IS disciplines

Main Knowledge Topics of Study and Teaching in Graduate Programs	SE	SwE	IS
Systems Engineering Foundations	●●●●●	●●●	● (Required)
Systems of Systems Engineering	●●●●●	●●●	● (Required)
Frameworks and Standards/Models of Processes for SE	●●●●●	●●●	● (Required)
Systems Engineering Management	●●●●●	●●●	● (Required)
Human Systems Engineering	●●●●●	●●●	● (Required)
Model and Simulation of Systems	●●●●●	●●●	● (Required)
Systems Thinking and Systems Foundations	●●●	● (Required)	● (Required)
Business Process Engineering	●●●	●●●	●●●
Systems Software Engineering Foundations	●●●	●●●●●	●●●
Frameworks and Standards/Models of Processes for SwE	●●●	●●●●●	●●●
Software Engineering Tools and Methods	●●●	●●●●●	●●●
Software Engineering Management & Quality	●●●	●●●●●	●●●
Information Systems Foundations	● (Required)	● (Required)	●●●●●
Business Foundations	●●●	● (Required)	●●●●●
Information Systems Technology	● (Required)	●●●	●●●●●
Information Systems Management	● (Required)	● (Required)	●●●●●
Frameworks and Standards/Models of Processes for IS	● (Required)	● (Required)	● (Required)
Specific Domains and Careers of Applications	●●●●●	●●●●●	●●●●●

Table 4. Main research approaches for SE, SwE and IS disciplines

Research Paradigms	SE	SwE	IS
Theoretical Approach (Theorem Proving, Mathematical Analysis, Conceptual Analysis)	●●●	●●●●●	●●●
Modeling Approach (Conceptual Modeling, Mathematical Modeling, Simulation)	●●●●●	● (Required)	● (Required)
Engineering Approach (Design of Artifacts)	●●●	●●●	● (Required)
Behavioral Approach (Survey, Case Studies, Social Experiments)	●●●	● (Required)	●●●●●

noting that IS frameworks and standards/models of processes (like CobIT, ITIL and derived) are scarcely researched and taught at present.

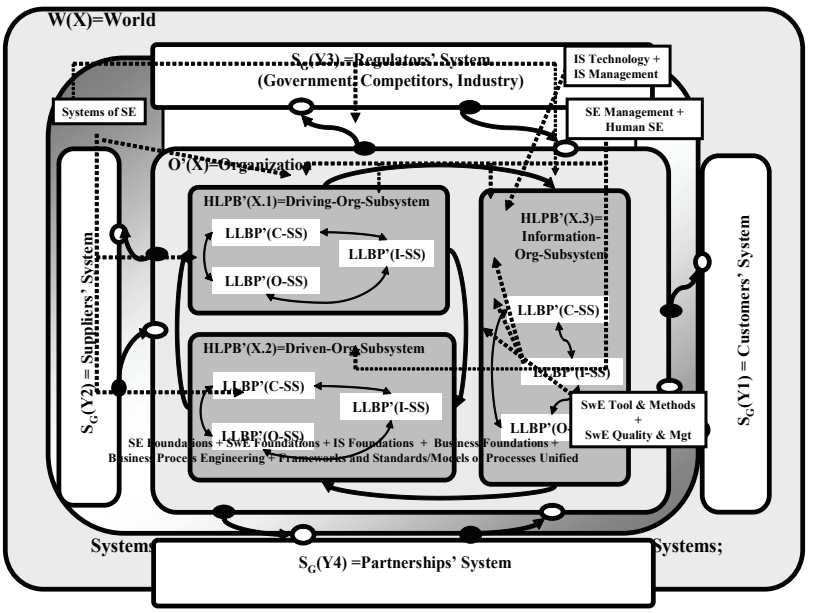
The Table 4 reports the levels estimated of types of research approaches mainly used in the three disciplines. Main categories of research approaches are adapted from Denning et al (1999), Hevner & March (2003) and Glass et al (2004). Theoretical and Modeling approaches can be considered pieces of conceptual research that study concepts, constructs, frameworks, methodologies, algorithms and systems without take data directly from real artifacts. Engineering and Behavioral approaches, in contrast, are pieces of empirical research that take data directly of artifacts, people or organizations.

The Table 4 shows that SE research is conducted mainly through a Modeling Approach–which is a core approach used in Systems Approach- but it also uses the other research approaches in a more balanced way than the other two disciplines. According to Glass et al (2004) theoretical/conceptual studies are more frequent than engineering studies in SwE. However, as a contrast with SE discipline, the modeling/simulation studies are few conducted. For the case of IS, due to its strong historical dependence of O&BS, most studies conducted are classified in the empirical approach (behavioral approach). The theoretical/conceptual studies are in second place and it is because of the B&OS influence. Recent studies have argued the necessity to use modeling/simulation (Mora et al, 2006b) and engineering approaches (Nunamaker et al, 1991; Hevner & March, 2003; Hevner et al, 2004) in IS discipline. In similar way, other studies have suggested that SwE must conduct empirical research (Kitchenham et al, 2002) and wide the few modeling/simulation approaches used.

THE MANAGEMENT & ENGINEERING OF IT-INTENSIVE SYSTEMS: AN INITIAL CASE

To complete this initial case, a description of how the integrated body of knowledge is required to cope with the management and engineering of complex IT-based information systems is reported by using a systemic IS research framework (Mora et al, 2006b; Mora et al, 2007a, 2007b). Figure 1, shows a mapping of knowledge streams reported in Table 3 into the main systems of interest for each discipline: the information organizational system for IS, the operational (information) subsystem for SwE and the driving, driven, information organizational systems or entire organization within the wider system called *world* and composed of the suppliers' system, customers' system, regulators' system and partnerships' system.

Figure 1. Mapping of SE, SwE and IS body of knowledge into the common systems of interest



Systems Thinking, Systems Foundations and Modeling/Simulation of Systems topics are suggested for being the most essential theoretical foundation for the common new integrated discipline. A systems thinking enables to practitioners and researchers to analyze any complex situation as a particular system of interest. In turn, the different conceptual systemic tools let them elaborate hierarchical models with the level of detail required for being studied or intervened. This holistic view of the situation can accommodate hard, soft and critical perspectives (Mora et al, 2007a), as well as quantitative or qualitative modeling. Fragmented and partial views of the systems of interest are reduced. Systems Thinking correctly applied also enables to formulate problems considering all stakeholders' rights.

In next level of common foundations, we suggest the integration of SE, SwE, IS and Business foundations as well as the topics of Business Process Engineering and Frameworks and Standards/Models of Processes. As it was identified, the most worldwide influential standard of processes (ISO 9000 series) has been founded in eight principles, two of them related with Systems Approach (Principle 5) and Process Approach (Principle 4). Furthermore, standards and models in SE and SwE have finally converged in unique view such as the CMMI-DEV, and ISO/IEC 15504 attest. A missing theoretical link between the concepts of *system*, *proces*s and *service* is missing but some initial efforts are being developed (Mora et al, 2007b).

The topic of SoSE (Systems of Systems Engineering) is also recommended as part of the body of knowledge of this integrated discipline because the emergence of large-scale and complex IT-intensive organizational and man-made systems. SoSE is an extension to classic SE methods to cope with systemic problems (negative emergent proprieties) generated for the composition of systems which subsystems works themselves as whole systems (Sage & Cuppan, 2001; Keating et al, 2003). In next level, the topic of SE Management and Human SE is suggested to address the organization as a system with your main three subsystems: the driving-organizational, the driven-organizational and the information-organizational subsystems. This view supports a modern cybernetic perspective based in control as a coordination act rather than a coercion act (Gelman & Garcia, 1989; Mora et al, 2003; Reyes, 2007). The IS Technology and IS Management topics are suggested to study and intervene on the information-organizational subsystem that is responsible to generate all IS/IT services in the organization (Mora et al, 2003; 2006a). Finally, to complete the mapping of the topics found in Table 3, the SwE Tools&Methods and SwE Quality & Management topics are required to study and intervene in the three sub-systems within the information-organizational subsystem. Each one of these subsystems, in turn, are composed of *systems* of tasks, personnel, tools&infrastructure, methods&procedures and socio-political issues (Mora et al, 2003; 2006a).

Hence, from the literature reviewed, the four tables of evidences generated and the mapping of concepts exhibited in Figure 1, we consider that an initial case for the interaction of SE, SwE and IS disciplines has been generated. Further research to refine and extend the knowledge and research topics will be conducted in next semesters by authors. Main benefits of this study are: (i) the novelty of the analysis on the body of knowledge of these disciplines that are required to interact in the short-term and be integrated in the long-term; (ii) the identification of the rationality for this interaction and integration suggested and (iii) the availability of a conceptual map of the systems of interest in the three disciplines for easing this interaction/integration. In turn, the main barriers for its acceptance are (i) the willingness for an interdisciplinary and systemic effort required and (iii) the lack of utilization, teaching and research based in Systems Approach in SwE and IS disciplines at present. In the meanwhile, however, we believe that IS and SwE community has been alerted of the emergence of these topics. A similar unified research effort is also conducted by the Service Science Management and Engineering initiative (Chesbrough & Spohrer, 2006). Its link with this research is required for further research.

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REFERENCES

Ackoff, R. (1960). Systems, organizations and interdisciplinary research. General System Yearbook, 5, 1-8.

Ackoff, R. (1971).Towards a system of systems concepts. Management Science, 17(11) 661-671.

Adam, F. & Fitzgerald, B. (2000). The status of the information systems field: historical perspective and practical orientation. Information Research, 5(4), 1-16.

Alter, S. (2003). 18 Reasons Why IT-Reliant Work Systems Should Replace "The IT Artifact" as the Core Subject Matter of the IS Field. Communications of AIS, 12, 366-395.

Andriole, S. & Freeman, P. (1993). Software Systems Engineering: the Case for a New Discipline. Software Engineering Journal, May, 165-179.

Arnold, S. & Lawson, H.W. (2004). Viewing Systems from a Business Management Perspective: The ISO/IEC 15288 Standard. Systems Engineering , 7(3), 229-242.

Bate, R. (1998). Do Systems Engineering? Who, Me? IEEE Software, Jul-Aug, 65-66.

Boehm, B. (2000). Unifying Software Engineering and Systems Engineering. Computer, March, 114-116.

Boehm, B. (2006). Some Future Trends and Implications for Systems and Software Engineering Processes. Systems Engineering, 9(1), 1-19.

Brown, D. & Scherer, W. (2000). A Comparison of Systems Engineering Programs in the United States. IEEE Transactions on Systems, Man and Cybernetics – Part C: Applications and Reviews, 30(2), 204-212.

Buede, E. (2000). The Engineering Design of Systems. Wiley Series in Systems Engineering, A. Sage (Ed). New York: Wiley.

Checkland, P. (2000); Soft Systems Methodology: a 30-year Retrospective; In: P. Checkland, Systems Thinking, Systems Practice; Wiley, Chichester, A1-A65.

Chesbrough, C. & Spohrer, J. (2006). A research manifesto for services science. Communications of the ACM, 49(7), 35-40.

Cleary, D. (2005). Perspectives on Complex-System Engineering. MITRE Systems Engineering Process Office Newsletter, 3(2), 1-4.

Culnan, M., & Swason, B. (1986); Research in Management Information Systems 1989-1984: Points of Work and Reference; MIS Quarterly, Sep, 289-302.

Emes, M., Smith, A., & Cowper, D. (2001); Confronting an Identity Crisis—How To "Brand" Systems Engineering; Systems Engineering, Vol. 8, No. 2, (pp. 164-186)

Denning, P. et al (1989). Computing as Discipline. Communications of the ACM, 32(1) pp. 9-23.

Deno, P., & Feeney, A.B. (2002). Systems Engineering Foundations of Software Systems Integration. In Proceedings of the OOIS Workshops, LNCS 2426, 245-259.

Farr, J., & Buede, D. (2003). Systems Engineering and Engineering Management: Keys to the Efficient Development of Products and Services. Engineering Management Journal, 15(3), 3-9.

Fuggetta, A. (2000). Software process: a roadmap. In: Proceedings of the International Conference on Software Engineering. Limerick, Ireland June 04 - 11, ACM digital library at www.acm.org.

Gelman, O., & Garcia, J. (1989). Formulation and axiomatization of the concept of general system. Outlet IMPOS (Mexican Institute of Planning and Systems Operation), 19(92), 1-81.

Gelman, O., Mora, M., Forgionne, G. & F. Cervantes (2005). Information Systems and Systems Theory, In: Encyclopedia of Information Science and Technology, Vol. 3, M. Khosrow-Pour (Ed.), Idea-Group Publishing, Hershey, PA: Idea Group, 1491-1496.

Glass, R., Vessey, I., & Ramesh, V. (2002). Research in Software Engineering: an Analysis of Literature. Information & Software Technology, 44(8) 491-506.

Gonzalez, R. (2005). Developing the Requirements Discipline: Software vs Systems. IEEE Software, March-April, 59-61.

Hecht, H. (1999). Systems Engineering for Software-Intensive Projects. In Proceedings of the ASSET Conference, March, Dallas, TX, pp. 1-4.

Hevner, A. & March, S. (2003). The Information Systems Research Cycle. Computer, November, 111-113.

Hevner, A., March, S., Park, J. & Ram, S. (2004). Design Science in Information Systems Research.MIS Quarterly, 21(8), 75-105.

Honour, E. (2004). Understanding the Value of Systems Engineering. Proceedings of the INCOSE Conference, 1-16.

IEEE (2001). SWEBOK: Guide to the Software Engineering Body of Knowledge. Los Alamitos, CA: IEEE Computer Society Press.

INCOSE (2004). Systems Engineering Handbook. INCOSE-TP-2003-016-02.

Ives B., Hamilton S., & Davis, G. (1980). A Framework for Research in Computer-Based Management Information Systems; Management Science, 26(9) 910-934.

Johnson, K., & Dindo, J. (1998). Expanding the Focus of Software Process Improvement to include Systems Engineering, Crosstalk: The Journal of Defense Software Engineering, 1-13

Keating, C. et al (2003). System of Systems Engineering. Engineering Management. 15(3), 36-39.

Kellner, M., Curtis, B., deMarco, T., Kishida, K., Schulemberg, M. and Tully, C. (1991). Non-technological issues in software engineering. In proceedings of the 13th International Conference on Software Engineering. ACM digital library at www.acm.org

Kitchenham, B., et al (2002). Preliminary Guidelines for Empirical Research in Software Engineering. IEEE Transactions on Software Engineering, 28(8), 721-734.

Magee, C. & Weck, de O. (2004). Complex System Classification. In: Fourteenth Annual International Symposium of the International Council On Systems Engineering (INCOSE), 20 June 20-24, 1-18.

MIS Quarterly (2006). Editorial Policy Statement. MIS Quarterly, 23(1), iii.

Mora, M., Gelman, O., et al. (2003). A systemic approach for the formalization of the information system concept: why information systems are systems ?; In Cano, J. (Ed). Critical reflections of information systems: a systemic approach. Hershey, PA: Idea Group, 1-29.

Mora, M., Gelman, O., Cano, J., Cervantes, F. and Forgionne, G. (2006a). Theory of Systems and Information Systems Research Frameworks. Proceedings of the 50th Annual Meeting of the International Society for the Systems Sciences, Somona State Universiy, CA, paper 2006-282, July 9-14, 1-7.

Mora, M., Cervantes, F., Gelman, O., Forgionne, G., & Cano, J. (2006b). The Interaction of Systems Engineering, Software Engineering and Information Systems disciplines: A System-Oriented View. In: Proceedings of the 18th. International Conference on Systems Research, Informatics and Cybernetics, Baden-Baden, Germany, August 7-12, 1-5.

Mora, M., Gelman, O., Forgionne, G., Petkov, D., & Cano, J. (2007a). Integrating the fragmented pieces of IS Research Paradigms and Frameworks: a Systems Approach. Information Resources Management Journal, 20(2), 1-22.

Mora, M., Gelman, O., & O'Connor, R. (2007b). Integrating the Fragmented Pieces on Models and Standards of Processes in SE, SwE and IT&S disciplines: Toward a Comparative Framework using the Systems Approach. Paper submitted to the ISOneWorld Conference, Las Vegas, NE, April, 2007.

Nolan, R. Wetherbe, J. (1980). Toward a Comprehensive Framework for MIS Research. MIS Quarterly, June, 1, 1-20.

Nunamaker, J., Chen, T. & Purdin, T. (1991). Systems Development in Information Systems Research. Journal of Management Information Systems, 7(3), 89-106.

Pressman, R. (1997). Software Engineering: a Practitioner's Approach. New York: McGraw-Hill.

Reyes, A. (2007). A Practical Method to Distribute a Management Control System in Organization. Information Resources Management Journal, 20(2), 122-137.

Rhodes, D. (2002). Systems Engineering: an Essential Discipline for the 21st Century. ACM SIGSOFT Software Engineering Notes, 27(5), 40-45.

Sage, A. (2000). Systems Engineering Education. IEEE TSMC-Part C, 30(2), 164-174.

Sage, A. & Cuppan, D. (2001). On the Systems Engineering and Management of Systems of Systems and Federations of Systems. Information, Knowledge, Systems Management, 2, 325-345.

SEI (2003). SEI Annual Report 2003; Software Engineering Institute, Pittsburgh, PA, USA.

Shenhar, A. & Bonen, Z. (1997). The New Taxonomy of Systems: Toward an Adaptive Systems Engineering Framework. IEEE Transactions on Systems, Man and Cybernetics – Part A: Systems and Humans, 27(2), 137-145.

Sommerville, I. (1998). Systems Engineering for Software Engineers. Annals of Software Engineering, 6, 111-129.

Thayer, R. (1997). Software Systems Engineering: An Engineering Process. In: R. Thayer & M. Dorfan (Eds), Software Requirements Engineering, 2nd. Ed. Los Alamitos: IEEE Computer Society Press, 84-109.

Thayer, R. (2002). Software Systems Engineering: a Tutorial. IEEE Computer, April, 68-73.

Vessey, I., Ramesh, V., Glass, R. (2003). Research in Information Systems: an Empirical Study of Diversity in the Discipline and its Journals. Journal of Management Information Systems, 19(2), 129-174.

Broadband Technology Services: A Survey of New Zealand ISPs

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ABSTRACT

Broadband technology services becoming increasing popular among home and offices users worldwide as the Internet access technology. This paper reports on a survey of New Zealand Internet Service Providers (ISPs) focusing on the current state of broadband services, the level of deployment, reasons for non-deployment, the scope of deployment, investment in deployment, problems encountered, and future plans. The study was conducted using a postal survey. A self-administered questionnaire was sent to some 40 New Zealand ISPs and a total of 15 replies were obtained from the respondents. Survey results show that New Zealand's pace in broadband technology services is still lagging behind the developed countries.

INTRODUCTION

Broadband technology services are becoming increasing popular for high-sped Internet access for both home users and businesses worldwide (Clarke & Kanada, 1993; Cloetens, 2001; Oh, Ahn, & Kim, 2003). More about Broadband services in New Zealand can be found in (Putt, 2006; *Wikipedia*, 2006; Williams, 2006).

In this paper, we report on a survey of New Zealand broadband technology services providers. The survey seeks to gauge the broadband technology awareness in New Zealand, including deployment of broadband services and users (type and the number of users adopting broadband services), ISPs' experiences with broadband technology and future plans (problems with deployment and maintenance). See Appendix for survey questionnaire.

To gain an insight into the broadband technology services in New Zealand, we compared our survey results with some developed countries. We found that New Zealand's pace in broadband technology is actually lagging behind a majority of the developed countries, including Australia and the USA.

COMPARISON

Digital subscriber line (DSL) is a popular broadband Internet access technology worldwide. Overall, 62% users are using DSL and its variants, 31% Cable modem, and the remaining 7% of users using other technologies, such as wireless and optical fibre.

Table 1 compares broadband subscribers per 100 inhabitants of 30 countries over 2001-2005 (http://www.oecd.org). It also shows OECD average and EU15. As seen in Fig. 1, New Zealand is lagging behind 21 developed countries in broadband subscribers and is below the OECD average. A summary of survey results are presented next.

SURVEY RESULTS

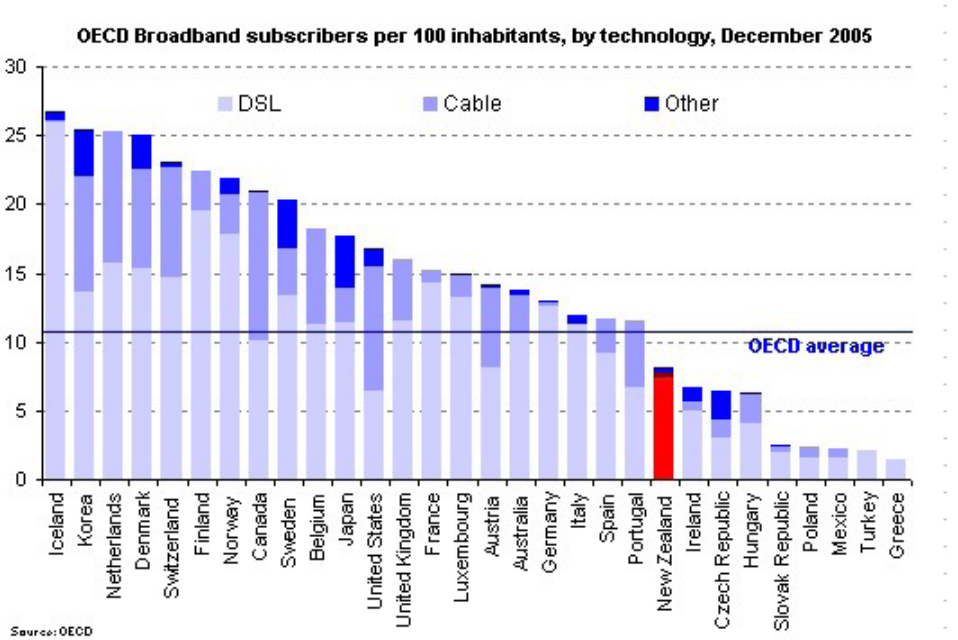
In this section we present the key results of the survey on broadband technology services provided by New Zealand (NZ) ISPs. All costs are in NZ$.

- **Deployment:** Twelve ISPs (out of 15) have indicated that they are currently providing broadband services. Three ISPs indicated that they are not currently providing broadband services, but are planning to offer them in the future. Those who are planning to provide broadband services either considered it too expensive or complicated, which is why they have not implemented broadband services yet.
- **Year of deployment:** The year that each ISP deployed broadband services ranged from 1996 – 2005. The larger ISPs have begun earlier, whereas some smaller ones may have only just began offering broadband services or planning to offer them in the future.
- **Technology:** Eleven ISPs have indicated that they are providing asynchronous digital subscriber line (ADSL) and wireless broadband services, two ISPs

Table 1. Comparison of broadband subscribers per 100 inhabitants

	2001	2002	2003	2004	2005		2001	2002	2003	2004	2005
Australia	0.9	1.8	3.5	7.7	13.8	Luxembourg	0.3	1.5	3.5	9.8	14.9
Austria	3.6	5.6	7.6	10.1	14.1	Mexico	0.1	0.3	0.4	0.9	2.2
Belgium	4.4	8.7	11.7	15.5	18.3	Netherlands	3.8	7.0	11.8	19.0	25.3
Canada	8.9	12.1	15.1	17.6	21.0	New Zealand	0.7	1.6	2.6	4.7	8.1
Czech Republic	0.1	0.2	0.5	2.5	6.4	Norway	1.9	4.2	8.0	14.8	21.9
Denmark	4.4	8.2	13.0	19.0	25.0	Poland	0.1	0.3	0.8	2.1	2.4
Finland	1.3	5.5	9.5	14.9	22.5	Portugal	1.0	2.5	4.8	8.2	11.5
France	1.0	2.8	5.9	10.5	15.2	Slovak Republic	0	0	0.3	1.0	2.5
Germany	2.3	4.1	5.6	8.4	13.0	Spain	1.2	3.0	5.4	8.1	11.7
Greece	0	0	0.1	0.4	1.4	Sweden	5.4	8.1	10.7	14.5	20.3
Hungary	0.3	0.6	2.0	3.6	6.3	Switzerland	2.0	5.6	10.1	17.5	23.1
Iceland	3.7	8.4	14.3	18.2	26.7	Turkey	0	0	0.3	0.7	2.1
Ireland	0	0.3	0.8	3.3	6.7	United Kingdom	0.6	2.3	5.4	10.5	15.9
Italy	0.7	1.7	4.1	8.1	11.9	United States	4.5	6.9	9.7	12.9	16.8
Japan	2.2	6.1	10.7	15.0	17.6	**OECD**	**2.9**	**4.9**	**7.3**	**10.2**	**13.6**
Korea	17.2	21.8	24.2	24.8	25.4	**EU15**	**1.6**	**3.4**	**5.9**	**9.7**	**14.2**

Figure 1. Comparison of broadband subscribers in OECD countries (Source: http://www.digitalstrategy.govt.nz)



indicated that they are offering cable modem, and the rest, two ISPs providing fibre optic and frame relay services. Although some ISPs offering several types of broadband services, ADSL services appear to be the most popular in New Zealand.

- **Cost of deployment:** Six ISPs have indicated that they have invested over $100,000 for the deployment of broadband services. Five ISPs indicated that they spent less than $10,000, one ISP spent from $10,001 to $20,000, and the remaining three ISPs did not provide deployment cost.
- **Setting up broadband services:** Six ISPs have indicated that they have implemented broadband using in-house services. Two ISPs indicated that they have implemented broadband services using third-party, and the remaining seven ISPs did not provide this information.
- **Deployment time:** The deployment time ranged from one week to six years and beyond. This was also dependent on whether the ISP was deploying in-house or whether they were reselling services to other ISPs.
- **Type of users:** Most of the ISPs (12 out of 15) are providing services to both residential customers and businesses, whereas the rest three ISPs offering services to government and schools. More users tend to connect to ADSL at 256 kbps, but gradually moving towards higher speeds.
- **Problems encountered:** Main problems associated with broadband deployment in New Zealand including, too many constraints, no system in place, making everything to be done was manual, poor support, problem with changeover from one ISP to another, limited visibility of network infrastructure, resource management, integration of broadband, and not adhering to their own procedures, bad congestion of network and outages due to overselling of services, restrictions to speed and price, constantly changing or deleting plans, everyone having to follow Telecom's rules, and time delays with ISPs that were not Telecom's. Other problems encountered include some technical difficulties, users have problems with understanding what to do, difficulty in contact regarding installation, reliability of ADSL in some areas were poor, slow and cumbersome installation, lack of government regulation, capital costs for building own network, and difficulty to make a profit.
- **Future plan**: The future plans for the ISPs, including wireless broadband services, continue to provide all available broadband services with better deals, build their own fibre optic network, and concentrate on business customers.

CONCLUSION

We have surveyed 50 large New Zealand ISPs to identify the current state of broadband services, the level of deployment, reasons for non-deployment, the scope of deployment, investment in deployment, problems encountered, and future plans.

While there is an increase in users opting to use broadband services worldwide, New Zealand is still lagging behind in broadband technology services and usage compared to other developed countries, including Australia and the USA. This lagging is due to the lack of users' knowledge about broadband services, high services cost, and the Telecom NZ monopoly on local loop (Nowak & Thomson, 2006).

REFERENCES

Clarke, D. E. A., & Kanada, T. (1993). Broadband: the last mile. *IEEE Communications Magazine, 31*(3), 94-100.

Cloetens, L. (2001). *Broadband access: the last mile.* Paper presented at the IEEE International Solid-State Circuits Conference (ISSCC'01) pp. 18-21.

Nowak, P., & Thomson, A. (2006, May 4). Telecom's Grip Severed. The New Zealand Herald.

Oh, S., Ahn, J., & Kim, B. (2003). Adoption of broadband Internet in Korea: the role of experience in building attitude. *Journal of Information Technology, 18*, 267-280.

Putt, S. (2006, August/September). Fair dinkum broadband. *Telecommunications users association of New Zealand (TUANZ) TOPICS, 16*(4), 15-20.

Wikipedia. (2006). Retrieved 15 May, from http://en.wikipedia.org/wiki/Broadband_Internet_access

Williams, R. (2006, December-January). Without Broadband, where will we be…? . *Tuanz Topics, 15*(6).

APPENDIX: SURVEY QUESTIONNAIRE

Section 1: Broadband Technology Awareness

All respondents complete this section.

1. What is the current state of the broadband services that you offer? (Tick one)
   We will not provide broadband services at all.
   We are planning to provide broadband services in the future.
   We are currently providing broadband services to customers.

2. If you are not offering broadband services, or has decided against it, why is this? (Tick all applicable)
   Unaware of it.
   Consider it too expensive.
   Consider it too complicated.
   Other (Please specify)

Section 2: Deployment of Broadband Technology

Only respondents that are providing broadband services complete this section.

3. Which year did you first offer broadband services?

4. What type of broadband services are you providing? (Tick all applicable)
   ADSL
   Cable
   Wireless
   Other (Please specify)_____

5. How much did you spend ($) for the deployment of broadband services? (Tick one)

< = $10,000	$40,001-$50,000	$80,001 - $90,000
$10,001 - $20,000	$50,001-$60,000	$90,001 - $100,000
$20,001 - $30,000	$60,001-$70,000	> $100,000
$30,001 - $40,000	$70,001-$80,000	

6. How did you set up or deploy broadband services? (Tick all applicable)
   In-house staff.
   Third-party specialist.
   Other (Please specify)_____

7. How long did it take to deploy broadband services? _____

8. Were there any problems that you encountered during the deployment of broadband services?

Section 3: Users of Broadband Technology

Only respondents that are providing broadband services complete this section.

9. What types of users are using broadband services provided by you? (Tick all applicable)
   Residential
   Business
   Other (Please specify)_____

10. Approximately how many users are you providing services to?

a. Residential

< = 100	301 – 400	601 – 700	901 - 1000
101 - 200	401 – 500	701 – 800	> 1000
201 - 300	501 – 600	801 – 900	

b. Business

< = 10	31 – 40	61 – 70	91 - 100
11 - 20	41 – 50	71 – 80	> 100
21 - 30	51 – 60	81 – 90	

c. Other (As specified in question 9)

< = 10	31 – 40	61 – 70	91 - 100
11 - 20	41 – 50	71 – 80	> 100
21 - 30	51 – 60	81 – 90	

11. Which type of broadband service do most users choose? (Tick one)

a. Residential
   ADSL
   Cable
   Wireless
   Other (Please specify)_____

b. Business
   ADSL
   Cable
   Wireless
   Other (Please specify)_____

c. Other (As specified in question 9)
   ADSL
   Cable
   Wireless
   Other (Please specify)_____

12. Which plan (speed) is the most popular choice for users? (Tick most applicable)

a. Residential

256K	2Mb	5Mb
512K	3Mb	6Mb
1Mb	4Mb	> 6Mb

b. Business

256K	2Mb	5Mb
512K	3Mb	6Mb
1Mb	4Mb	> 6Mb

c. Other (As specified in question 9)

256K	2Mb	5Mb
512K	3Mb	6Mb
1Mb	4Mb	> 6Mb

Section 4: Experiences with Broadband Technology

Only respondents that are providing broadband services complete this section.

13. What issues have you encountered with providing support to users for these broadband services, if any?

14. What issues have you encountered with the network performance and management of broadband services, if any?

15. Any other issues that you are facing now?

16. What are your plans for the future of broadband, if any?

E-Government in Caribbean States: From Rhetoric to Reality

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OVERVIEW

Caribbean States have undertaken E-Government initiatives to streamline administrative processes and to improve customer service. Meanwhile there has predictably been much hype surrounding such moves with lofty promises being made about the "leveling of the playing field". As with current E-Commerce efforts in this region there has not been the ready acceptance and support that might have been expected. This contribution focuses on the E-Government initiatives made by Jamaica, Trinidad and Tobago, and Barbados, perhaps the most developed of the English speaking Caribbean States and represents the initial phase of a larger project aimed at determining the Caribbean reality with respect to E-Government.

BACKGROUND

The three countries chosen for this study have been the leaders among English speaking Caribbean states in terms of their political, economic and developmental status. Jamaica (population of 2.6m) and Barbados (population of 0.25m) have followed very similar paths towards socio-economic development having had an agricultural and, more recently, small manufacturing background. Trinidad and Tobago (population of 1.3m) although having some involvement in those areas has an economy built on oil and gas resources contributing approximately 25% of its GDP. These countries share a common historical, political and cultural tradition and are all members of a regional grouping of English speaking countries called the CARICOM Community.

The removal of trade preferences enjoyed by these States in their trade dealing, mainly with Europe, has seen them gravitating towards a services economy. This international business and financial sector is characterized by fierce global competitiveness with corporations in the developed countries being very demanding in their dealings with their outsourcing partners. Information and Information and Communications Technologies (ICTs) have become critical components for both public and private sector agencies in transacting business.

ICT investments in over three decades have led to some gains in efficiency and effectiveness but much more is required. Indeed these countries have since the Nineties undertaken Public Sector Reform (PSR) to improve administrative capacity and reduce bureaucracy. Such reform has identified the need for better information availability and greater application of information systems in the public sector. Thus while the link between ICT and PSR has definitely been recognized, there has also been the realization that, in at least one of these countries, the public sector information systems might have been haphazard, if not archaic. Stagnation after earlier gains from such systems and failure to undertake evaluation of ICT implementation have been suggested to be major hindrances in the realisation of full benefits from use of these new technologies.

The temptation then might be to leapfrog and fast track the establishment of portals to bring these developing countries into the Information Society. About such thinking and the adoption of E-Government itself, Heeks cautions:

"Simply pulling Northern and/or private sector solutions off the shelf and trying to impose them on public sectors in developing countries will be like driving square pegs into round holes. E-Government solutions must be adapted, not simply adopted, to ensue that the design matches Southern realities."

He further identified two other challenges facing developing countries, namely e-readiness and large design-reality gaps, i.e. differences between design ideas and organizational realities in small States. While E-Government presents outstanding opportunities to effect more efficient and effective service delivery, planning of the transformation to E-Government is perhaps the single most important issue facing most governments today.(Sharma and Gupta 2003)

The introduction of E-Government in small states has also been likened to the creation and sustained development of an organization associated with which there are:

- external fundamentals related to its existence within its environment and community.
- internal and external stimuli contributing to its success and sustainability.

While there are challenges and threats to its eventual development, the opportunities and benefits can be most attractive. Among the critical success factors suggested for successful E-Government transformation are:

- entrepreneurship with risk taking and astute business management in this strategic undertaking. The nurturing role of project champion is very crucial.
- alliances with the private sector, other governments and international agencies.(Bishop and Savoury 2004)

CARIBBEAN E-GOVERNMENT INITIATIVES

Globally the move towards E-Government has been as a result of pressure from citizens groups, the private sector, other governments or even international agencies. Over jealous politicians may even see it as a way to boost their stakes in the eyes of the electorate. Governments have adopted different approaches towards the adoption of E-Government globally in both developed and developing countries.

The participation of Caribbean states in the World Summit of the Information Society and the assistance of the Economic Commission for Latin America (ECLAC) have been of tremendous help in the planning and transformation of their E-Government initiatives.

Sharma and Gupta (2003) have conceptualized a framework for E-Government implementation which will be used to evaluate the initiatives undertaken by the three States. This has been chosen since its building blocks correspond closely to the actual approach taken by the countries. The following phases in the transformation to E-Government are outlined:

i. the creation of a network and technical infrastructure in the form of public data communication network infrastructure and servers, e.g. internet, intranets.
ii. the digitization and data integration process with document management systems, e-mail, data management systems and data warehouses.
iii. the availability of internet and web-enabled E-government service with departmental web sites providing static information as well as two-way communication. The ultimate stage is the provision of a portal facilitating self service applications.
iv. the facilitation of user access to web-enabled services through multiple communication channels and access points, e.g. cell phones and personal digital assistants.

This framework should have a supporting infrastructure which would, inter alia:

v. create E-Government awareness.
vi. build a legal and regulatory infrastructure.
vii. create a critical mass of manpower and skills.

ECLAC conducted a series of surveys of various Caribbean states, including Jamaica, Barbados and Trinidad and Tobago, in 2006 in which progress towards the creation of an Information Society was investigated. The results of those surveys can be evaluated based on the above framework.

Phase 1 – creation of technical infrastructure. All states have completed the liberalization of their telecommunications sectors and there is vibrant competition between service providers. Internet access varies from 40 and 55 % of population in Jamaica and Barbados respectively to 12% in Trinidad and Tobago. Between 60 and 100% of the populations have mobile phones with broadband access estimated at about 10% . Regulatory institutions e.g. Fair Trading Commissions and Telecommunications Units have been set up. Some governments have also removed the import duty on computer equipment.

Phase2 – data integration process. After over 3 decades of computerization the public sector abounds with on-line computer applications e.g. collection of taxes. Customs modernization programmes have been undertaken and initial steps are being made to implement specialized applications such as geographical information systems. Public sector accounting and human resources functions are integrated with the SMARTSTREAM system.

Phase 3 –E-Government and ICT-related portals. Most ministries and several public sector units in the states have established a web presence. These are maintained by computer units within individual units and ministries. There are however central information technology centres in each state which have ultimate responsibility for that state's official Portal. These Portals are expected to be fully functional within 2 years. Currently static information is provided on most web-sites.

Phase 4 – User access. The states are not currently at the stage to tackle this aspect.

Phase 5 –Creation of E-Government awareness. The states have all established E-Government Units as well as E-Commerce Units to coordinate their initiatives. Additionally progress has been made towards the development of National Strategic ICT Plans with coordination by National Committees. To provide a more focused thrust specific responsibility for ICTs has been assigned to a particular ministry. There is in each state a high-powered committee, e.g. *the Fast Forward* Steering Committee in Trinidad and Tobago, comprising Government Ministers and Senior Officials which provides oversight, strategic guidance and sign-off on the matter of a National ICT Strategy.

Phase 6 – Legal and regulatory infrastructure. Both Barbados and Trinidad and Tobago have passed or have under consideration some legislation dealing with electronic and digital crime. Barbados has actual legislation on Electronic Transactions, IT Misuse and Consumer Protection with Data Protection and Freedom of Information Bills under active consideration. In Trinidad and Tobago Computer Misuse, Freedom of Information and Electronic Transfer of Funds Crime Acts have been passed but Data Protection and Digital Signatures Bills have been circulated for comment. Jamaica, on the other hand, has only Freedom of Information legislation.

Phase 7 – Creation of critical mass. E-Learning initiatives have been undertaken in all states at the primary, secondary and tertiary levels with teacher training accorded a high priority. International agencies e.g Inter-American Development Bank have funded several initiatives in the educational sector. Computer literacy programmes are available. In Barbados, for example, there is a government-sponsored Community Technology Programme providing training at the community level in Internet and e-mail usage, word processing and other basic IT skills.

Overall the three states appear to be approaching the transformation to E-Government in a satisfactory manner according to the framework cited. With the accustomed regional consultations between them, they have been able to benefit from each others experiences. Furthermore the involvement of ECLAC has been of considerable assistance in the formulation and development of these E-Government initiatives.

FURTHER WORK

This contribution reports on the initial aspect of the project, namely the preparatory steps taken by the three states towards E-Government. Other aspects would be:

i. Determination of their relative levels of e-readiness. Included herein could be the e-Government acceptance by citizens and stakeholders as well as their active involvement.
ii. Implementation issues being faced by the states.
iii. Possible comparisons with similar developing countries in terms of internet and economic capabilities in Asia to determine differences in approaches.
iv. Possible strategies for other developing countries not yet undertaking E-Government transformation.

Semantic Web Services Approaches: A Comparative Analysis

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ABSTRACT

"Hyperlinks are legacy and Web Semantics is the future". This statement truly represents the spirit of future web. Web is the ever growing phenomenon and web services are one of the most important ingredients of the Web recipe. Our work-in-progress primarily focuses on the comparative analysis of various approaches for the Semantic Web Services. We are going to summarize the analysis on the basis of various functional and non functional parameters related to the Web Services. We will be delivering our findings in a ready-to-use comparative matrix which may be used by the semantic web development practitioners and the semantic web researchers alike.

INTRODUCTION

Enterprise application unification and Business process management are the heart and soul to run businesses in the current internet era and Web Services are one of the vital technical components, playing an integral role into it. Existing Web Services standards including UDDI, WSDL are playing a pivotal role in the current web services scenario by providing the syntax for development and implementation of the web service but they lack in providing the semantics. Semantics in the web is the key for the future web. Lots of efforts are being made in this direction and various Web Services approaches like WSMO, OWL-S, and WSDL-S are unfolded in the due process. These approaches have their own pros and cons with respect to fulfilling the expected functional and non functional requirements of any working web service. Few of the semantic web services approaches like WSDL-S are evolutionary and are based on the existing WSDL standards. On the other hand semantic web services approaches like WSMO and OWL-S are absolutely revolutionary.

We have selected four predominant semantic web services approaches for the detailed study with respect to the functional and non functional parameters, as expected from any working web service. We are in the process of comparing the WSMO, WSDL-S, OWL-S and SWSF semantic web services approaches on various functional and non functional parameters. Few of the functional parameters under considerations are web service publication, discovery, selection, composition, mediation, compensation, replacement, invocation, orchestration, choreography etc. Few of the non functional parameters on which we are focusing the comparison are robustness, availability, scalability, security, network-related QoS, transactional, performance, trust, reliability etc.

RESEARCH GOALS

Semantic web industry confronted with various Semantic Web Services approaches in its day to day development and implementation processes. We believe that this area is bit diverged. Our research is targeted to understand all the predominant semantic web services approaches and to compare all of them with respect to functional and non functional parameters. In the process we will come out with a detailed comparison matrix. We believe that our research findings will surely help the semantic web industry to take a big leap into the next generation of the web services.

Criteria to Assess the Adaptability of Software Engineering Approaches

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ABSTRACT

Because of the characteristics of contemporary system development and system evolution, it appears necessary to come up with an approach that allows the permanent and evolutionary engineering of software for new and already-existing information and application systems. The requirement is to plan and construct with room for changes, adoptions and enhancements since this will happen in the lifetime of every large software product. This contribution provides first research results to plan for adaptability in software engineering based on the research project IOSEW[1]. For that criteria are explored which promise assessing software engineering approaches for adaptability. The contribution is submitted as research in progress paper.

FOUNDATION

Adaptability applies biologically-inspired methods to enhance the capabilities of the system in focus. Adaptability comprises several qualities. Within this contribution the term adaptability is to be understood as the ability of a system to adapt itself efficiently and fast to changed demands. An adaptive system is an open system that is able to adapt its behaviour according to changes in its environment or in parts of the system itself. Additionally, it recognises the demand for change itself. The structure is determined autonomously on the basis of the systems purpose and information exchange with the environment.

VIEW ON SOFTWARE ENGINEERING APPROACHES

What would adaptability mean for software engineering approaches? The goal is that the software system can be adapted over time by humans to changing conditions (termed as design-adaptability by Oreizy and Gorlick, 1999). Transferring the cybernetic view on systems on engineering approaches, the system elements would comprise the procedure model (e.g. waterfall, v model) and phases, the (human) actors also tools and surrounding conditions as organizational units, pre-set decisions et cetera.

CRITERIA TO ASSESS SOFTWARE ENGINEERING PROCESS MODELS

This section identifies criteria to reveal the adaptive capacity of software engineering procedures. The first set originates from factory planning but has also been successfully applied to assess and design for adaptability in information systems [Andr06]

Scalability

Scalability refers to the permanent state to operate effectively and efficiently at many different scales. A system is supposed to be scalable if it will remain effective when there is a significant increase/decrease in the number of recourses.

For the software development process scalability stands for the seamless addition or reduction of system elements as actors, resources, tools, functions. The process model is scalable if control structures as loops and iterations can be inserted or deleted leading to the above mentioned steps. The evaluation might be based on diagnosis features.

Modularity

Modularity generally means the structuring of a system into small, partly autonomous subsystems [WiPi+97]. A module consists of a module trunk and a module interface. The interface contains a specification on the characteristics to connect and communicate, which are of importance for its surrounding field.

The phases of a procedure model correspond to the idea of modules. Each phase defines a function, e.g. requirements analysis or testing. Within each phase activities and results may be defined. For example, the result of the requirements phase as a set of documentation.

Interoperability

This indicator refers to the ability of resources to place a high measure of compatibility and connectivity. It is commonly realised by deploying interface standards in the domain of information system architectures [HaSt03].

Interoperability in the context of procedure models stands for the transfer of input or output from one phase to another. The results of the requirements phase should be applicable in the next phase.

Independence

Independence raises the question of spatial and temporal unlimited access to subsystems (components). In information systems the criteria independence is interpreted as unlimited access to applications, functions and data by different technologies as web-browser, terminal-server for instance. Within software engineering the criteria adds an organizational aspect. If the phases of the procedure model are independent they can be performed at any location, in any country at any time for instance.

Redundancy

It is a principle in nature that important functions can be taken over by a near-by system if another breaks [Vest02]. Redundancy requires a fall-back strategy, if failure or unforeseen events happen. An engineering approach considering redundancy checks for results by control strategies as feedback loops and provides alternatives to solve process steps. Does the procedure model provide support for the change of organizational units along the development process?

Self-Organization

Self-organization (autopoiesis) marks the ability of a system to determine the systems structure by adjusting and steering mechanisms related to processes within the system in order to ensure the long-term existence of the system [MaVa87]. Thereby the resources and subsystems produce their own order by taking up information about their environment and their reciprocal effect with the environment.

Self-organization in software engineering is a goal oriented process whereby the phases define the main goals. However, the engineering process model does have to ensure the correct result along with the adequate means to (efficiently) deliver the outcome. It requires learning qualities as double-loop learning. Self-organization is one of highest form of behaviour of complex systems.

Knowledge

Knowledge about the engineering model denotes both – the person-bound and the explicit knowledge [GrKo+05]. The latter is presented for example in the form of writing fixed processes, rules, guidelines, responsibilities, communication channels, programming language and more.

Knowledge and information access support the rapid implementation of functional and organisational changes in general or the handling of the software specifically.

NEXT STEPS

A logical next step is the application of the criteria to discuss established process models as the V model, RUP (Rational Unified Process or eXtreme programming).

REFERENCES

[Andr06] Andresen, K.: Design and Use Patterns of Adaptability in Enterprise Systems, Gito, 2006.

[HaSt03] Hanisch, F., Strasser, W.: Adaptability and interoperability in the field of highly interactive web-based courseware. In: Computers & Graphics, Volume 27, Issue 4, August 2003; 647-655.

[GrKo+05] Gronau, N.; Korf, R.; Müller, C.: KMDL - Capturing, Analysing and Improving Knowledge-Intensive Business Processes. Journal of Computer Science, 4, 2005; 452-472.

[OrGo99] ‚Oreizy, P., M. M. Gorlick, et al. (1999). "An Architecture-Based Approach to Self-Adaptive Software."IEEE Intelligent Systems 14(3): 54-62.

[Vest02] Vester, F.: Vester, F.: Die Kunst vernetzt zu denken: Ideen und Werkzeuge für einen neuen Umgang mit Komplexität -der neue Bericht an den Club of Rome. Deutscher Taschenbuch Verlag, 2002.

[WiPi+97] [WiPi+97] Wiegand, R. T., Picot, A., Reichwald, R.: Information, Organization, Management, Wiley, 1997

[MaVa87] Maturana, H., Varela, F.: The Tree of Knowledge. Shambhala Publications, Boston, 1987;

[High00] Highsmith, J. A.: Adaptive Software Development: A Collaborative Approach to Managing Complex Systems. New York, Dorset House Publishing.

ENDNOTE

[1] IOSEW: Project on Intra-Organizational Software Engineering and Adaptability funded by German Research Ministriy (http://www.iosew-projekt.de)

Research Problem in Distributed Data Warehouse Environment

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We can't ignore the advantages realized during the past in the area of distribution and support for data localization in a geographically dispersed corporate structure. Therefore, many researches to date investigate building distributed data warehouses with particular emphasis placed on distribution design for data warehouse environment. This article presents the state of the art concerning many process of data fragmentation in data warehouse environment and proposes a number of technical issues that we believe are suitable topics for exploratory research.

1. INTRODUCTION

The users of Data Warehouses do not cease increasing. They are divided more and more geographically on several sites. In addition, data warehouse are characterized by their large size and by the complexity of decisional query requiring several operations of joins and aggregation. Consequently, centralized Data Warehouses are not adapted more to this kind of companies and generate an elevated cost of query execution. To answer to this new need, several techniques of fragmentation have been proposed for the decentralization of a data warehouse, and the optimization of the cost of query execution. The following section, presents some works treating the distributed architecture for a data warehouse. In section 3, some data warehouse fragmentation techniques which exist in the state of the art are evoked and in the section 4, a number of technical issues that we believe are suitable topics for exploratory research will be presented.

2. ARCHITECTURE OF DISTRIBUTED DATA WAREHOUSE

In [Noaman, Barker, 1997] and in [Noaman, Barker, 1999], authors proposed an architecture for distributed data warehouse. It is based on the ANSI/SPARC architecture that has three levels of schemas: internal, conceptual, and external. This work is based on TOP/DOWN approach and presents two fundamental issues: fragmentation and allocation of the fragment to various sites. Authors proposed a horizontal fragmentation algorithm for a fact table of a data warehouse. In [TEKAYA, ABDELLATIF, 2004], we have proposed a methodology for relational distributed data warehouse design. For this purpose, we develop a set of matrix: 'Matrix of data partitioning', 'matrix of data allocation' and a 'matrix of data source' and in [TEKAYA, ABDELLATIF, 2005] we adapt the same methodology to the multidimensional environment. In [Noaman, Barker, 1997], [Noaman, Barker, 1999], [TEKAYA, ABDELLATIF, 2004] and in [TEKAYA, ABDELLATIF, 2005], a basic architecture of a distributed data warehouse has been proposed; we suggest the implementation of these works in a distributed data warehouse environment.

3. TECHNIQUES OF FRAGMENTATION IN DATA WAREHOUSES

Several works shows the importance of fragmentation in a context data warehouse, it represents today a more challenging stake that in a relational or objects database context. In addition, several commercial products showed the utility of fragmentation in the process of queries optimization: In [TEKAYA, ABDELLATIF, MCSEAI'04], we proposed a matrix of fragmentation, 'Horizontal Matrix of fragmentation ', making abstraction to the approach of modelling, this matrix permits from a logical table to generate a set of fragments and it has as input: queries and their frequencies of use. Thereafter, we proposed a matrix of allocation permitting to allocate every fragment to the most adequate site. One data can be a table or a fragment of table, this as while taking account of frequencies of data utilization and the priority of sites. In [TEKAYA, ABDELLATIF, ISDM'05] the same solution was adapted in a dimensional environment; we have experiment the solution through an example. In [TEKAYA, ABDELLATIF, AICCSA'05] the problematic of data warehouse fragmentation was presented and some arguments are showed to prove the importance of fragmentation in distributed data warehouses environment. Otherwise, several works of research and the commercial products showed the utility of fragmentation techniques in the process of queries optimization [Sanjay and al., 2004]. Horizontal fragmentation in data warehouses is more challenging compared to that in relational and object databases. This challenge is due to the several choices of partitioning schemas that can be found: [Bellatrech and Boukhalfa, 2005]

1. *Partition only the dimension tables using simple predicates defined on this table, t*his choice is not suitable for OLAP queries for the following reasons: Any partitioning that does not take into account the fact table is discarded. [Bellatrech and Boukhalfa, 2005].
2. *Partition only the fact table using simple predicates defined on this table, t*his choice has been adopted in [Noaman and Barker, 1999]. The proposed work is essentially based on:
   a. the proposition of a distributed architecture of a data warehouse,
   b. the formal definition of the relational modelling of a data warehouse by the application of normalization rules,
   c. the replication of dimensions on the different sites of the enterprise,
   d. regrouping of selection predicates on facts tables. (Criteria of fragmentation),
   e. the application of the horizontal fragmentation algorithm presented in [Özsu and Valduriez, 1991] and [S. Ceri and G. Pelagatti, 1984].

   The algorithm generates a set of horizontal fragment based on the definite applications on the dimension tables in link with the table of facts. Note that a fact relation stores foreign keys and raw data which are usually never contain descriptive (textual) attributes because it is designed to perform arithmetic operations. On the other hand, in a relational data warehouse, most of OLAP queries access dimension tables first and then the fact table. This choice is also discarded.
3. *Partition some/all dimension tables using their predicates, and then partition the fact table based on the fragmentation schemas of dimension tables, t*his choice has been adopted in [Bellatreche, Karlapalem and Mohenia,2000] and in [Bellatreche, Karlapalem and Mohania, 2002]. This work aims essentially to:
   a. Propose an algorithm for partitioning dimension tables and the fact table of a star schema, (b) Fragmenting the fact table based on all predicates given in OLAP queries might be prohibitive.

Therefore, authors showed that dimension tables play a very important role in fragmenting the fact table. They develop a greedy algorithm for selecting the best dimension tables for partitioning the fact table. (c) Develop a cost model for executing the most frequent OLAP queries on partitioned and unpartitioned star schemas, finally to evaluate the partitioning algorithm with some experiments study and show the tradeoffs partioned and unpartitioned data warehouse. This approach is best in applying partitioning in data warehouses. Because it takes into consideration star join queries requirements (these queries impose restrictions on the dimension values that are used for selecting specific facts; these facts are further grouped and aggregated according to the user demands. The major bottleneck in evaluating such queries has been the join of a large fact table with the surrounding dimension tables).

An evolution of the same work has been proposed in [Bellatrech and Boukhalfa, 2005]. The proposed work is essentially based on:

1. The Formalization the problem of the horizontal fragmentation in data warehouse environment using star join diagram,
2. The Developpement of a methodology of fragmentation for the fact table, which is based on the genetic algorithms,
3. The Description a coding process of fragmentation diagrams. In order to measure the quality of the chosen solution and a model of cost (selective function) have been developed,
4. The implementation of the proposed solution, by the development of a genetic motor in Visual C and to validate the achieved survey, they used a Benchmark APB-1 IIS releases [Council, 1998].

Authors proposed the development or the planning of the genetic algorithm to take account of the query evolution (structures and frequencies). They also aimed an auto-evolutionary data warehouse.

4. PROBLEMS AND RESEARCH ISSUES

Few works quantified contributions of fragmentation in a data warehouse context. Several axes of researches are opened and several ideas remain to explore. The main objective is to bring kindness of techniques used in distributed databases to the domain of data warehouses and benefit the implication of distribution especially on the process of queries optimization. Applications only work on subsets of relations. It is therefore preferable to distribute these subsets.

We can distribute the complete relations but it would generate a lot of traffic, either a replication of data with all problems that it causes (problems of updating and problems of storage). The small fragment utilization permits to make turn more process simultaneously, what drags a better utilization of the computer network.

Therefore, a problem puts itself: how a good degree of fragmentation to define? In fact, the objective aimed by researches essentially consists in formalizing the problem of the horizontal fragmentation in a data warehouse environment and to propose an algorithm permitting to solve it. This solution has been developed through the application of a genetic algorithm in [Bellatrech and Boukhalfa, 2005]. The solution admits as input a list of dimension tables, fact tables and a list of queries including a set of aggregations functions; as result the algorithm generate an optimized fragmentation diagram. Some authors appraise that the set of queries can changes (in the level of structure or frequency) and therefore it is interesting to develop an algorithm witch take in account the evolution of queries. It becomes especially very important for the evolutionary information systems like a data warehouses. Queries evolves according to the informational needs of the enterprise, this evolution has two types: frequency and structure. One request can become less frequent or same unused during the time, another one becomes more important but change of structure, (change of attribute or condition of restriction). Aggregations functions are very frequent and changes according to needs. Of this fact, we must answer to new requests (utilization of news tables dimension or of facts) witch can be very important for the information system and answers must be imminent for the decision making. Therefore, the static fragmentation diagram cannot answer to all these new constraints. Consequently, works may be oriented to develop techniques that permit to take in consideration the evolution of queries of a data warehouse and generate dynamic fragmentation diagrams.

5. CONCLUSION

Distributed data bases system is sufficiently complete to unload users of all competition problems, reliability, and optimization of requests or transaction on data managed by different DBMS on several sites. Of this fact, we studied the contribution of distribution in domains of data warehouses characterized by their big volume of data and by a number of users distributed geographically more and more. We noted that fragmentation plays today a more important role in a context of data warehouse that in a relational or object context, we put some problematic and oriented readers toward several axes of researches. We synthesized techniques of fragmentation that have been achieved in data warehouse context; we noted that can works be more developed. The domain remains opened for possible researches.

6. REFERENCES

[TEKAYA and ABDELLATIF, 2004] Karima Tekaya, Abdellaziz Abdellatif, 'Modélisation de la répartition des données d'un data warehouse'. Eighth Maghrebian Conference on Software Engineering and Artifical Intelligence, (MCSEAI'04). 2004.

[TEKAYA and ABDELLATIF, ISDM'5] Karima Tekaya, Abdellaziz Abdellaziz, 'Modélisation dimensionnelle de la répartition des données d'un data warehouse'. Journal International des Sciences de l'Information et de la Communication (ISDM05)

[TEKAYA, and ABDELLATIF, AICCSA'05], Karima Tekaya, Abdellaziz Abdellaziz, 'Fragmentation and Replication process in data warehouse environment' The 3rd ACS/IEEE International Conference on Computer Systems and Application (AICCSA'05).

[Noaman and Barker, 1999] A.Y. Noaman, and K. Barker, 'A Horizontal Fragmentation Algorithm for the fact relation in a Distributed Data Warehouse'. Proceeding of the Eigth International Conference on Information and Knowledge Management (CIKM'99). November 1999, Pages154-161.

[Noaman and Barker, 1997] A.Y. Noaman and K. Barker. 'Distributed data warehouse architectures'. Journal of Data Warehousing, 2(2):37-50, April 1997.

[Bellatreche, Karlapalem and Mohenia,2000], Ladjel Bellatreche, Kamalakar Karlapalem, Mukesh Mohenia, 'What can partitioning do for your data warehouses and data marts', 2000.

[Bellatreche, Karlapalem and Mohania, 2002] Ladjel Bellatreche, Kamalakar Karlapalem, Mukesh Mohania. 'Some issues in design of data warehousing systems'. Data warehousing and web engineering". IRM Press Hershey, PA, United States. Pages 22 – 76. 2002.

[Bellatrech, Boukhalfa, 2005] Ladjel Bellatreche and Kamel Boukhalfa, 'La fragmentation dans les entrepôts de données: une approche basée sur les algorithmes génétiques', Revue des Nouvelles Technologies de l'Information (EDA'2005), Juin, 2005, pp. 141-160.

[Bellattreche, Lorinquer and Mohenia, 2004] L. Bellattreche, M. Schneider, H. Lorinquer, et M. Mohenia. 'Bringing together partitioning materialized views and indexes to optimize performance of relational data warehouse'. Proceeding of the international conference on Data Warehousing and Knowledge Discovery (DAWAK'2004), pages 15-25, September 2004.

[Bellatreche, Kamalakar and Mukesh, 2002] Ladjel Bellatreche, Kamalakar Karlapalem, Mukesh Mohania. 'Some issues in design of data warehousing systems'. Data warehousing and web engineering. IRM Press Hershey, PA, United States. Pages 22 – 76. 2002.

[Theodoratos, Sellis, 1999] Dimitri Theodoratos, Timos Sellis , ' Dynamic Data Warehouse Design'. Data Warehousing and Knowledge Discovery . 1999.

Introducing Computerized Accounting Information Systems in a Developing Nation: Egyptian International Motors Company (EIM) Case Study

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The use of computerized accounting information systems has become an integral part of accounting systems world wide. Most of the research and cases that examine issues related to choice and implementation of computerized accounting information systems have focused on developed nations. However, decisions relating to the choice and implementation of computerized accounting systems are very sensitive to cultural and environmental factors. Therefore, such decisions should be studied within the context of their own environments (Ismail and King, 2006). Environmental factors differ dramatically between developed and developing nations. In addition, within the context of developing nations, the cultural, political, and economic realities of each country are often very different. Therefore, it is better not to develop a standard prescription and make recommendations without first analyzing the specificities of each nation. Therefore, it is vital to improve our understanding of the process of choice and implementation of computerized accounting information systems in specific developing nations, such as Egypt.

The developments in both accounting and Information and Communication Technology (ICT) have made it easier for companies to migrate to computerized accounting systems. Accounting, in Egypt, has dramatically changed in the past ten years by the adoption of the international accounting standards (IAS) in 1992 followed by the dependence on the Egyptian accounting standards (EAS) in 1996 (World Bank, 2002). It is important to note that EAS were mainly a translated copy of the international accounting standards, with some differences[1]. This adoption increased the need for timely and accurate financial records, information, and statements. Integrating information communication technology (ICT) was described as one of the main tools to reach this end.

Egypt, as a developing nation faces many challenges in building an information society in order to bridge the digital divides. Egypt must overcome the barriers that constrain the use and spread of the new communications technologies and their applications. In Egypt efforts for ICT development are led by the government, in close partnership with the business community and the civil society (MCIT, 2006). The Egyptian government has focused on the development of ICT as a national priority to contribute to high and sustainable economic growth for the Egyptian economy. The government views the development of information and communications technology as a national priority. (American Chamber of Commerce in Egypt, 2002).

Egypt is trying to modernize itself technologically. There is a low PC penetration rate standing at 1.6 million stations although increasing at 50% growth rate annually (www.mcit.gov.eg). However, the investment and build-up of Egypt's information and communication technology infrastructure has taken massive steps since the early 1990s in different building blocks including human, systems, procedures, and hardware and information infrastructure (IDSC Annual Report, 2000).

The importance of the use of technology in accounting has been recognized by the Egyptian government. As part of a comprehensive e-government initiative, Egypt's Ministry of Communications and Information Technology (MCIT) has licensed a comprehensive range of Oracle technology to ultimately power and link up to 5000 financial units throughout the country. (MCIT, 2005).

This study aims to assess the implementation of accounting information system on a company in a developing nation. To answer this question this manuscript attempts to do the following: (1) identify the reasons for the shift to an automated system and the main goals that the company aim to achieve form this shift, (2) determine the company's strategic decisions like choices between outsourcing versus in-house development, and ready made packages versus tailor made software, (3) describe the steps of implementation, (4) understand the reaction of the employees to the new automated system, (5) study the required changes on the organizational chart and human resources qualifications that are required, (6) recognize the problems that the company met during the process, (6) point the advantages of the shift to the automated system.

The methodology of this case study will be through intensive interviews with the key players of the Egyptian International Motors Company (EIM), which started business in 1978 under the Egyptian corporate law (law 26/1954). EIM has five main sectors of operations: (1) General Equipment Division, (2) Logistic equipment Division, (3) Irrigation and Pumps Division, and (4) Renault Division, and (5) Yamaha Division.

The following table summarizes the financial position of the company on December 2004:

Balance sheet (EIM)
On December 31, 2004

Assets:		**Liabilities:**	
Current assets	288,000,000	Current liabilities	242,000,000
Long term assets	15,000,000	Long term liabilities	52,000,000
		Owner's equity	9,000,000
Total assets	303,000,000	Total liabilities and owner's equity	303,000,000

EIM has represented diverse multinational names over the years. EIM has created a very special position for itself in the market, serving a large number of clients of various sizes, ranging from major local and international contractors to individuals. In order to achieve the company's vision and the mission, in 2001 the company decided to update its manual accounting system and to introduce an electronic accounting system.

The choice of this company as a subject for this research was because it is a large local firm that implements a computerized accounting information system. The fact that the firm is a local firm and does not have an affiliation with an international firm is important to control the effect of any foreign company that might influence the choice and implementation process. If the firm had an affiliation with a foreign company that had implemented a computerized accounting system, it would dramatically affect the choice and implementation process of the computerized accounting system of the company.

I think that the implementation of the computerized accounting system will show that the company has benefited from this implementation but at the same time it will show that there will be some resistance by the employees. At the same time there might be some problems with the choice of company to use a ready made software that may not be flexible enough to meet the demands of the company.

REFERENCES

American Chamber of Commerce in Egypt. (2002). Telecommunications in Egypt. http://www.amcham.org.eg/BSAC/StudiesSeries/Report37.asp

Information and Decision Support Center (2000) Annual Report on Egypt.

Nobes, C. 2001. Introducing GAAP 2001: A Survey of National Accounting Rules Benchmarked Against International Accounting Standards. http://kpmg.de/library/pdf/011120_GAAP_2001_en.pdf

Ismail, N. & King, M.. (2006). The Alignment of Accounting and Information Systems in SMEs in Malaysia. Journal of Global Information Technology Management; 2006; 9, 3;

Ministry of Communications and Information Technology. (2006). Building Digital Bridges: Egypt's Vision of the Information Society. http://www.mcit.gov.eg/brochures/BuildingBridges(all).pdf

Ministry of Communications and Information Technology (2005) www.mcit.gov.eg (website), last accessed 20 February.

Ministry of Communications and Information Technology (MCIT). (2005). Oracle technology platform drives Egypt's comprehensive e-government initiative. http://www.ameinfo.com/61511.html

World Bank. (2002). Report on the Observance of Standards and Codes: Egypt – Accounting and Auditing.

ENDNOTE

[1] For a detailed reference to the differences between the International Accounting Standards and the Egyptian Accounting Standards refer to Nobes 2001

Understanding Context of Electronic Messages Between Diabetes Patients and Physicians

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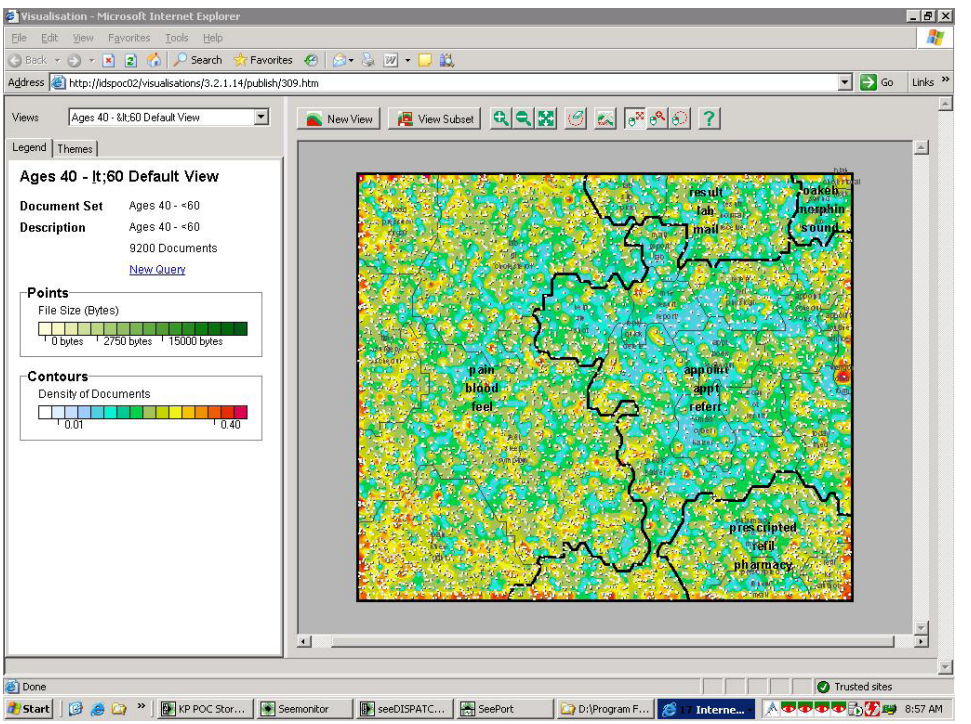
One of the first articles to discuss online delivery was Jerome Kassirer's editorial to New England Journal of Medicine in 1995, where he foresaw the internet as next transformation in the delivery of health care. The application of information and communication technology in healthcare has since grown exponentially over the last 15 years and its potential to improve effectiveness and efficiency has been recognized worldwide. Internet use has grown exponentially over the last decade and consumers' searching healthcare information has become a large part of the phenomenon (Baker, Wagner et al.2003; Ferguson 2000). Bundorf et al. (2006) suggested that the emergence of the Internet as a new media for health information provides a new impetus to study the determinants of demand for health information. A study from anadian shows that 10% to 15% of all patient encounters with primary care physicians involve patients who have already consulted sources on the Internet (PriceWaterHouseCoopers 1999). Remote patient management technology will change the way patients are treated, operated on, monitored and counseled. If patients could communicate with physicians or be monitored through the Internet, more than 20% of in-office visits could eliminated, according to respondents the PriceWaterHouseCooper survey (1999). The survey also concluded that more than 30% physicians' time will be spent using web-based tools by 2010.

Patient-physician messaging, email over secure connection is increasingly used to improve communication between patients and physicians. The Institute of Medicine identified email as valuable tool for flexible consulting and speculated that "instead of a $65 office visit and a half-day of work, a 2 minute email communication could meet many patients' needs more respectively and at a lower cost". Chronic patient care requires frequent communication that is often routine in nature. The asynchronous nature of online consultation also renders it more acceptable and efficient from the provider perspective than other remote but synchronous means of communication such as the telephone. Brown (2004) found that patients tend to be much more enthusiastic about messaging than their physicians, particularly for simpler issues. One particular study showed that patients also preferred messaging for more complex issues; perhaps owing to a particularly long waiting list for appointments. This research presents some core findings from an extensive statistical and contextual evaluation of patient-physician messaging on chronic patient care.

This paper is a part of an extensive research, where our overall objective is to understand the implications of messaging service to provider efficiency and use of resources. We wish to map the intervention's effects to patient care processes and use of different communication medias. From earlier results of studying the

Figure 1. Self organizing map (SOM) of the patient messages



same cohort we know that online messaging replaces communication in via other channels such as telephone and visits to the office. The objective of this paper is to analyze the nature of messages sent via the online channel. This study looks at two specific research questions: 1) What types of requests are submitted by the patients 2) how can the requests be categorized.

A study of 350 diabetes patients is conducted at Kaiser Permanente in Oakland, California. The cohort consisted of self-selected patients using the CyberKaiser system. We combined Electronic Health Record Data, messaging free text data and demographic data for our analysis. Diabetics were selected based on ICD-9 codes. We are using Foundation™ software to analyze the unstructured data of the patient messages and are categorizing the messages manually to 12 different categories (e.g. appointment request, medical advice, lab result interpretation etc.) based on the requests made in them. The software used draws Self Organizing Maps (SOM) from the unstructured data and helps us to find major categories and to identify most used terms in the messages.

Figure 1 presents and example graphic of a Self Organizing Map (SOM) used for the context analysis. However, in-depth analysis of the complexity of the messages required categorizing them by hand. We chose first message of each tread send by the patient within the study period of one year for review. Requests and length are categorized and statistical analysis will be performed on the results.

We are hoping to present significant findings on the nature of messages send via the online messaging services. Context analysis findings and categorization of the requests are expected to advance the future development of these services and answer to some concerns on the messaging as an appropriate media for healthcare communication.

REFERENCES

Baker, L., Wagner, T., Singer, S., Bundorf, K. (2003) Use of the internet and email for health care information: results from a national survey. Journal of American Medical Association. 289(18):2400-6.

Bundorf, M. Wagner T, Singer S. Baker, L. Who searches the internet for health information? Health Services Research. 2006. Jun:41. 819-36.

Brown E. (2004)The generation of wired physicians. Forrester research.; August 24

Ferguson, John. (2000) Healthcare meets the Jetsons: e-commerce has the power to dramatically modernize the future of healthcare management and delivery, Canadian Healthcare Manager, Toronto: Aug. Vol 7. iss. 5; pg. 41

Institute of Medicine (2001) Crossing the Quality Chasm. Washington DC. National Academy Press.

Pricewaterhousecoopers Report. Healthcast 2010:Smaller World, bigger expectations. November 1999.

Workshop Abstract
The Human Side of IT: A Strategic Approach to Developing Connected Technology Leaders (SM)

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WORKSHOP ABSTRACT:
The workshop "The Human Side of IT: A Strategic Approach to Developing Connected Technology Leaders (SM)" will be delivered in an interactive format. This workshop acknowledges that the field of IT and professionals employed in IT are among the most important variables in the future of organizations. However, a growing body of research indicates that the future of IT leadership is increasingly "less about the technology" and "more about empowering people to provide relevant business solutions." The challenge for IT professionals is to develop competencies for navigating social networks, influencing key decision-makers, and building consensus across organizations.

One of the workshop foundations is a research paper presented at the IRMA conference by Dr. Barbara Trautlein, titled: "The Whole World at Work: Managers Around the Globe Describe Their IT Experiences – Suggesting a New Framework for Global IT Leadership." Trautlein, the presenter/facilitator for this workshop, will illustrate why successful 21st century technology leaders will be more connected, communicative, collaborative and consensus-building. The key segments will highlight a holistic leadership development framework called "Connected Technology Leaders(SM)."

SEGMENT ONE: "Changing Expectations" – Dr. Trautlein will share highlights of the global research "The Whole World at Work," involving interviews with managers on five continents that revealed manager frustrations with, aspirations for, and heightened expectations of IT.

SEGMENT TWO: "Shifting Leadership Beliefs and Behaviors" – Successful IT executives and managers develop a high degree of self-awareness, relationship-building acumen, and the ability to think on behalf of the organization as a "whole system." Participants will be exposed to an assessment profile of a winning global IT leadership style for the future.

SEGMENT THREE: "Takeaways? – Defining Next Steps and Getting Connected" –A guided reflection and interactive dialogue will help participants consider the best ways to integrate these findings and approaches into organizations.

A Comprehensive Ontology-Driven Software Development Architecture: An Approach to Developing Romantic Software Products

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ABSTRACT

Information systems have been criticized for their lack of flexibility and content richness. The problem has been traced back to the developmental stages of these systems. Current ISD approaches are mechanistic, that is, they lack a way of capturing the humanistic element that is inherent in a socio-technical environment such as information systems. To address this anomaly, ontologies can be introduced at the developmental stages to capture the romanticism inherent in these systems, to mediate during the design and development of the software products for these systems and to facilitate easy sharing of information among different information systems. This paper discusses an architecture that positions ontologies at the center of a software development case tool. The ontology drives and coordinates, the requirements analysis, design, and coding of software products that are domain specific. Case based reasoning tools, Bayesian Networks, WordNet, domain specific ontology, conceptual graphs and formal logic are the tools that are incorporated into this software development architecture.

Keywords: Ontology, software development, Architecture, Romantic software products.

1. INTRODUCTION

"There is a reason why computers have not yet become fervent natural language speakers. (It's not a matter of processing power and never will be): we simply are not programming them correctly." ***(El Baze, 2005)***

Current Information systems exhibit a mechanistic character that has curtailed their usability. These systems are very efficient at structuring data to enable and facilitate its interpretation. Mechanistic systems are based on the concept of explicit programming (Agentis International, n.d). Explicit programming produces software products that do not capture semantic and context rich data, a characteristic that is needed in all modern day systems.

The American National Standards Institute (ANSI) proposed a conceptual schema for knowledge encoding in the 1970s (Sowa, 2000). While the schema can coordinate efficiently between the applications, user interface and database of a system, it relied on syntactic coding, and is not evolvable. Other software development paradigms such as the structured approach (Pressman, 2005), object oriented approach (Pressman, 2005, Dennis et al, 2002); software product lines approach (Carnegie Mellon Software Institute, n.d.) software kernels approach (Information Technology University, Denmark, n.d) have been introduced to try and improve the adaptability, evolvability, reusability of software products as well as increase the semantic richness of the resultant information systems. As their eighth basic principle of system development methodologies, Whitten et al (2004), tell systems developers to design their system for growth and change. Pressman(2004), in discussing the nine software myth, raises issues such as evolvability, quality measurement, throughput levels, reusability of software products, management of scope creep during development, and software products documentation as some of the most misunderstood aspects that need to handled carefully during a software development process.

This paper discusses how the ontological approach can incorporate the aspects into information system development. The rest of the paper is as follows. **Section two** discusses the software development problem, **section three** looks at the transition from mechanistic to romantic software products, **section four** briefly discusses the role of ontology in information systems and finally **section five** discusses an ontology driven software development architecture. The conclusion closes the discussion but also summarizes the way forward in the ontology research process in ISD.

2. THE SOFTWARE DEVELOPMENT PROBLEM

The problem in the resultant software products and whose characteristics subsequently emerge in the final information system have been tracked down to the developmental stages of the software product. The software development process is a part of a system development process that includes a set of activities, methods, best practices, deliverables and automated tools that developers use to develop and maintain information systems. Basden (2001), in his article "Christianity Philosophy and Information Systems" decried the continual lack of return of investment from information systems investments. He noted that there is something deeply wrong in the way the "artifact" is developed. This artifact is the software product. He further searches for the problem and the solution. "What is wrong? "and "what do we do about it?" His solution set coupled with other researchers suggestions are herein included as a way to improving the usability of the software product.

2.1 Software Development Issues

Issues considered during the software development process play a vital role in shaping and determining the qualities of the software product. Basden (2001) noted four areas of concern that can be addressed to improve the quality of the product. The areas look at fashioning of technical artefacts for use, development of technology from which we fashion an artefact, the use of the artefact and users' and developers' overall perspective on the use of technology (herein we add the social context of information systems and their situated ness). In addition, other issues require:

- Developers to focus on designing reusable components
- Developers to focus more on the innovative elements of a software product design
- That the innovative elements of a software product represent the domain related additions that make the difference between domain packages.

Managing these issues leads to a gradual change from mechanistic to romantic systems.

3. DEVELOPING ROMANTIC SOFTWARE PRODUCTS

To bridge between the mechanistic development methods and the required romantic methods, we are going to use the ontology artifact. Romantic systems possess a certain degree of humanistic behavior. They are open, non-deterministic and

do not subscribe to mechanistic ideas of representation, formalization, program, order, reason, stability and control like machines. These systems borrow their definition from romanticism (Basden, 2001; John, n.d.; Gregor, n.d; Loflin, n.d) which imitates belief systems that depend on "irrationalism and feelings".

Ontology has enjoyed many definitions in the literature. The section below gives a brief of the common accepted meanings to ontology. This is the definition widely used in information systems development.

3.1 Ontology of a System

Ontology can be viewed as an engineering artifact. In this part, ontology consists of a specific vocabulary used to describe a certain reality (Guarino, 1998). The vocabulary used is accompanied by a set of explicit assumptions, which give people the intended meaning of such a vocabulary.

Studer et al (1998) add that ontology is an explicit formal specification of a shared conceptualization. Formalization looks at machine readability (syntactics) of the ontology. Explicit specification incorporates the clear identification of concepts, properties, relations, functions, constraints and axioms (semantics) within a universe of discourse. If a thing is clear to a subject, that thing should make sense to the said subject(Mavatera, 2004b). The addition of the phrase 'shared conceptualization' denotes ontologies as abstract models of phenomena in the world with implicit knowledge in them. Furthermore, there is some sense of mutual understanding of the concept among people in the same contextual environment (pragmatics).

Neches *et al* (1991) defined ontology as 'the basic terms and relations comprising the vocabulary of a topic area, as well as the rules for combining terms and relations to define extensions to the vocabulary'. Swartout *et al* (1997) describe ontologies as a hierarchically structured set of terms for describing a domain. Gruber (1993) defines ontology as 'a specification of a representational vocabulary for a shared domain of discourse…' He goes on to say that ontology is an 'explicit specification of a conceptualization'. In a more literal way, Ontology consists of a set of concepts and their relationships, forming a conceptual structure that underlies the interpretation of any system model. In short, ontology of a system can be taken as a set of representational terms in the universe of discourse. The ontology is used for 'sharing and reuse of formally represented knowledge'.

4. ONTOLOGY IN INFORMATION SYSTEMS

The purpose of using ontology is to develop software products that capture semantics and social context of information systems through the development of databases of domain ontologies and application packages that capture semantics, context and the situated ness of organizational information systems. It is:

'*…about awareness, connection and meaning, impact versus activity and knowledge versus data'. in-PharmaTechnologist.com (2005)*

The ontology replaces the conceptual schema at the center of an integrated information system as previously stipulated by ANSI (see section 1 above). In this research, we take advantage of ontology characteristics such as easy to use, different formal expressiveness with reasoning support, integrated form generation to acquire instances, ability to build test cases and use the cases to check consistency, ability to be manipulated and reason at run time, ability to drive control logic of a program, ability to be tuned so as to automate the software testing process as well as ability to allow user involvement at any stage of the development to position it at the center of the development of romantic software products.

In short putting ontology at the center of the software development tool allows the resultant software products to be adaptable, evolvable and be context aware.

5. ONTOLOGY DRIVEN SOFTWARE DEVELOPMENT ARCHITECTURE

Figure 1 below shows the architecture of the software development tool that we refer as the OntoSoft case tool. The OntoSoft tool has three major components, the knowledge base repository, the designer engine and the reasoner.

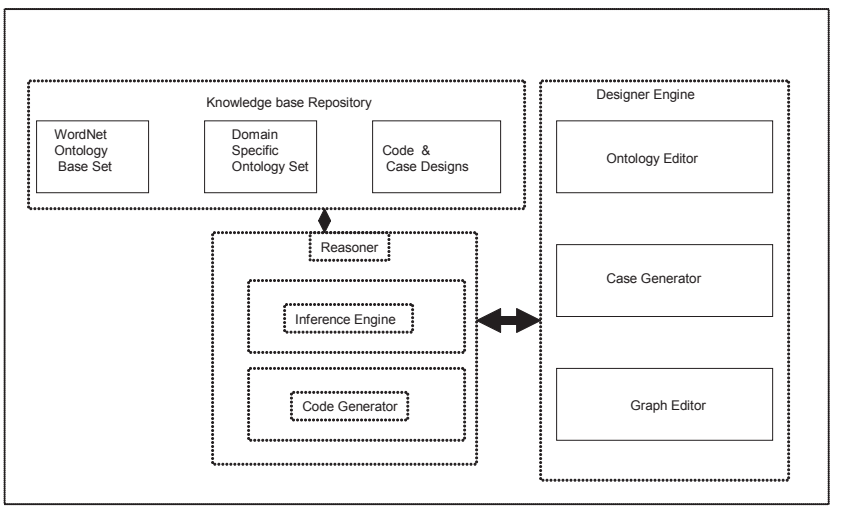
5.1 The Knowledge Base Repository

Unlike the Rebuilder case tool discussed in Gomez,(2004), the OntoSoft knowledge base repository consist of three parts, the WordNet ontology base, the domain specific ontology base(not found in Rebuilder or any other case tool developed so far) and a code and case base set.

The WordNet ontology base is taken and maintained "as is" . WordNet is a type of terminological ontology(Sowa, n.d). It is a lexicon and consists of information about " syntax, spelling, pronunciation and usage of words" In short, it is a natural language knowledge base. It is not updated so as to maintain linguistic consistency in terms of international grammar and general meanings to terms.

The domain specific ontology set is specific to an application software domain and is allowed to change according to the different conceptualizations and ontological commitments(Guarino, 1998) to a certain domain. This is the knowledge base that users' and developers can fine tune to suit their application domains. Finally, the case and code designs base store new and old designs that are relevant to a specific application domain.

Figure 1. Ontology software development case tool architecture



5.2 The Designer Engine

It consists of an ontology editor, case generator and graph editor. The three are used to develop domain specific ontology on the run, cases that capture the differing designs in the application domain and graphs that are used to map related concepts in a domain through their respective conceptual relations.

The designer engine uses the same principles as Rebuilder in terms of case indexing with the only difference being the graph editor. Rebuilder uses UML as case editor. UML as a case editor does not link the cases to the meaning of the cases which are stored in the domain ontology. It is purely syntactic. OntoSoft uses conceptual graphs that are a graphic notation for logic based on existential graphs. The conceptual graphs are augmented with features from linguistics and the semantic networks of artificial intelligence. Conceptual graphs can be used to map to and from natural languages. As a presentation language, they are used for displaying logic in a more human readable form. The conceptual graphs will be linked to the domain specific ontology to beef the knowledge content of the cases and designs.

5.3 The Reasoner

The reasoner consists of the inference engine and a code generator. The inference engine is like the communication engine between the designer engine and the knowledge base repository. It accepts user queries, retrieves old cases, and links new cases to WordNet and domain specific ontologies, links code to the cases and conceptual graphs. In fact, it is the brains behind the OntoSoft case tool.

The code generator automatically develops code specific to a retrieved or adapted case. The reasoner uses Bayesian Networks (BN) techniques to index cases and case based reasoning (CBR) principles which are well covered in Gomez(2004). CBR is based on the reuse of experience. It captures every reasoning instance as an episode that is registered and stored in a case. As each case captures a specific situation and is context related, then the syntactic, semantic and pragmatic aspect of the situation is also captured(Mavetera, 200b). The reader is directed to this article for further explanation on case based reasoning.

6. CONCLUSIONS

This paper discussed problems that currently bedevil our information systems to a proposed development architecture that can solve most of these problems. Of importance is the focus of the paper on the "artifact" during software products development. Unless the artifact is made adaptive, evolvable during the design stage, software developers must not expect the resultant information system to be adaptive and evolvable. The paper positions ontology at the center of romantic software products development process. These products will be reusable, process able, and in addition, they can be adapted and evolved to come up with entirely new software products. The software myths (Pressman, 2005), Software Product Lines(Carnegie Mellon Software Institute, n.d), software kernels (Dittrich & Sestoft, 2005) are all issues that can be solved by positioning ontology at the center of the software development process.

The next stage of the research is to engage industry partners, initially to investigate the software development practices that are in existence, the approaches, the methods, techniques, and the tools they use to come up with a product that give information systems their social situated ness. These findings are a very good tool which can be used to validate and motivate the industry use of the OntoSoft case tool framework. The OntoSoft case tool will also be tested using a prototype.

7. REFERENCES

AGENTIS. n.d. *Simplifying the complexity of Application Development. Developing and deploying J2EE solutions with Agentis Adaptive Enterprise TM Solution Suite,* Agentis International, Inc.

BASDEN, A. 2001. Christian Philosophy and Information Systems. Presented to institute for Christian studies, Toronto. [Online]. Available: http://www.isi.salford.ac.uk/dooy/papers/cpis.html. [Cited on 31 August 2006].

CARNEGIE MELON SOFTWARE ENGINEERING INSTITUTE, nd. Software Product Lines. [Online]. Available: http://www.sei.cmu.edu/productlines/ , [Cited 14 August 2006].

DITTRICH, Y & SESTOFT, P. 2005. Designing Evolvable Software products: Coordinating the evolution of different layers in kernel Based Software Products. [Online]. Available: http://www.itu.dk/research/sdg/doku.php . Cited October 2006].

EL BAZE, N. 2005. Cracking Software Development Complexity: In order to reap the benefits of progress in processor technology, we must fundamentally rethink how to write software, *Line 56-The Business Executive daily*. [Online], Available: http://www.line56.com/articles/, [Cited 30 March 2005].

GOMEZ, P., 2004. Software Design Retrival using Bayesian networks and WordNet

GREGOR, S. n.d. The Struggle torwards an understanding of theory in information systems.School of Business and Information Management, The Australian National University. [Online]. Available:http://epress.anu.edu.au/info_systems/ part-ch01.pdf. [Cited 31 August 2006].

GRUBER, T. A.1993. Transition Approachto portable ontology specifications. *Knowledge Acquisition*. Vol.5.1993. p.199-220.

GUARINO, N., 1998. Formal Ontology and Information Systems. *In Proceedings of FOIS'98,* Trento, Italy, 6-8 June, 1998. Amsterdam, IOS Press, p.3-15.

IN-PHARMA TECHNOLOGIST.COM, 2005, Improved data dealing drives drug discovery. [Online], Available: http://www.in-pharmatechnologist.com/news/, [Cited, 30 March, 2005].

JOHN, R.R. 2003. When Information Come of Age: Technologies of Knowledge in the Age of Reason and Revolution, 1700-1850. In William and Mary Quarterly, Vol. LX, No. 2, Reviews of Books.

LOFLIN, L. n.d. Romanticism Notes, [Online]. Available:http://www.sullivan-county.com/nf0/nov_2000/romanticism.htm. [Cited on 4 September 2006].

MAVETERA, N. 2004a. The Use of Ontologies in Designing Agents for E-Markets: From a Mechanist to a Romantic Approach: *In Proceedings of the International Business Information Management Conference (IBIM '04),* July, 2004, Amman, ISBN: 0-9753393-1-1

MAVETERA, N. 2004b. The Philosophy of Ontologies: A new Information Systems Development Paradigm. *In proceedings of the International Science and Technology Conference (ISTC'04),* Vanderbailpark, SA

NECHES, R.; FIKES, R; FININ, T; GRUBER, T; PATIL, R; SENATOR, T; SWARTOUT, W.R.1991. Enabling Technology for Knowledge sharing. *AI Magazine*. Winter 1991. p.36-56.

PRESSMAN,R.S 2005, Software Engineering : A Practictitioner's Approach, 6th Ed, MacGraw–Hill, International Edition.

SOWA, F. J. 2000. Ontology, Metadata and Semiotics. Conceptual structures: Logical, Linguistic and computational issues., Springer-Verlag, Berlin, 2000, p 55-81, Ganter & Mineau, Eds. (*Lecture notes in AI #1867)*

STUDER, R., BENJAMINS, R. & FENSEL, D. 1998. Knowledge Engineering: Principles and Methods. *Data and Knowledge Engineering*. Vol.25. p.161-197

SWARTOUT, B., PATIL, R., KNIGHT, K. & RUSS, T. 1997. Toward Distributed Use of Large Scale Ontologies. *Ontological Engineering.* AAAI-97, Spring Symposium Series. 1997. p138-148.

TURBAN, E., MCLEAN, E. & WETHERBE, J. 2004. *Information Technology for Management: Transforming organisation in the Digital Economy, 4th ed*. John Wiley & Sons, Inc.

WHITTEN, J.L & BENTLEY, L.D. 2004. Systems Analysis and Design methods. Irwin/McGraw- Hill

The Effects of User Interface on Decision Making in Mobile and Traditional Environments: A Comparative Model

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ABSTRACT

Mobile communication technologies have penetrated consumer markets throughout the world. Traditionally, mobile services mainly facilitate voice communication. Recently, new forms of mobile services have made possible text messaging, web surfing, digital imaging, payments, banking, financial instrument trading, and shopping. These new functions of the mobile services require powerful interface features. These interface features must be easily customizable to fit the taste of an individual user's decision making. Besides, it was predicted that mobile tools, mobile e-services, and wireless Internet protocols will mark the next major sets of development in DSS, thereby expanding the accessibility of the tools to decision-makers wherever they may be. Thus the research studies and compares the user interface features in both the mobile and traditional decision making in order to find the advantages and challenges in user interface deisgn in the two environments. It also dighlights the distinct interface features of mobile device and applications that encourage users' decision to adopt mobile commerce. The study on mobile user interfaces features and their effects on decision making will have singnificant influence on the mobile commerce activities, consumer behaviors, mobile communication markets and also the decision science research.

INTRODUCTION

Mobile communication technologies have penetrated consumer markets throughout the world. According to Universal Mobile Telecommunications System (UMTS) Forum, the global mobile market has grown rapidly to about 1.2 billion subscribers in 2003, with an approximate increase of 20% since 2001. It is also anticipated that there will be more than 2 billion mobile users between 2007 and 2010.

Mobile services have primarily facilitated voice communication. However, recently new forms of mobile services have made text messaging, web surfing, digital imaging, payments, banking, financial instrument trading, and shopping possible. (Mao et. al., 2004) The mobile technology should be low cost with minimal difficulty for implementation. (Zucker et al, 2005). All these requirements of user interface features will have the influence on the individual user's decision making for mobile commerce. According to Daft (1991), a decision is "a choice made from among available alternatives" (p. 180). Choosing from among alternative courses of action lies at the heart of decision making (Payne, 1982). Decision quality is a measure of the goodness of this choice. A user interface supports both the mechanics of the interaction and facilitates the broader notion of a dialogue between human and computer. As used here, a user interface is an "observable two-way exchange of symbols and actions between human and computer".

LITERATURE REVIEW

The rapid growth of mobile telephony has fueled the expansion of the mobile Internet as a foundation for mobile commerce (Lee and Benbasat, 2004). Mobile Commerce or M-commerce is defined as buying and selling of goods and services through wireless handheld devices such as mobile telephones and personal digital assistants (PDA) (Bhuyan, 2005). Mobile Commerce represents the convergence of two technologies – the web and wireless technology. While the former hasradically changed the way business is conducted, the later has added a mobile dimension to e-commerce and mobile computing through mobile devices such as cell phone, PDA, or pager (Coyle 2001). The adoption of electronic commerce has made the significant impact on the organizational formation, decision making, business strategy and other business related issues.

Despite the sanguine expectations of many observers and the enhanced capabilities of mobile systems, few researchers on information systems (IS) have empirically studied interface designs for m-commerce. Human-computer interaction (HCI) researchers have explored interface designs for mobile devices through which users experience a very different environment than with personal computers (Lee and Benbasat, 2004). For many decades, there are large numbers of studies in decision making and decision support systems. Gorry and Morton(1971) developed a framework to help the decision makers to understand the evolution of MIS activities within the organization.

Sauter (1999) defined four types of decision making style: left-brain, right-brain, accommodating and integrated. Todd and Benbasat (1992) presented the importance of cognitive effort in Strategy selection and decision making and pointed out that the cognitive cost perspective is helpful in understanding the influence of DSS on decision making. Decision makers utilize the tools provided in such a way as to limit their overall expenditures of effort. In regard to the cognitive support for decision making, Lerch and Harter (2001) examined how decision makers manage their attentional resources when making a series of interdependent decisions in a real-time environment and indicated that decision strategies for real-time dynamic tasks consist of two main overlapping cognitive activities: monitoring and control.

The proposed model is an extension of Lee and Benbasat (2004) 7C model for mobile commerce interface design and traditional interface design. It compares the user interface features in both the mobile and traditional decision making in order to find the advantages and challenges in user interface deisgn in traditional and mobile environment.

Synthesizing the past literature leads to the following general research model emerges. Description of the individual boxes is given in the following sections. It is clear from the past literature that a pattern of evolution in the user interface can be observed. In 1960s, Scott Morton and others started demonstrating befits of using computer based decision support systems. Decision support concepts and technologies were developed in 1970s. With the introduction of personal computers in 1980s, we can observe a rise in the group decision support systems.

PROPOSED RESEARCH MODEL

On the basis of Lee and Benbasat 7C model for mobile commerce interface design, decision making theory as well as the cognition and intuition characteristics of problem understanding, we propsed following research model. The model shows that the both the mobile decision making and traditional decision making process will lead a better problem understanding which has the influence on the individual user's decision making efficiency and quality.

According to lee and Benbasat (2004), the mobile commerce interface framework is composed of: context, content, community, customization, communication,

Figure 1. Areas of study for comparing user interface features on decision making in traditional and mobile environment

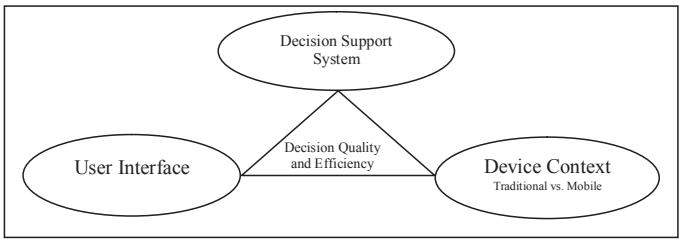

Figure 2. Framework for Information Systems (Gorry and Morton,1971)

	Operational Control	Management Control	Strategic Planning
Structured	Accounts Receivable	Budget Analysis — Engineered Costs	Tanker Fleet Mix
	Order Entry	Short-Term Forecasting	Warehouse and Factory Location
	Inventory Control		
Semi-Structured	Production Scheduling	Variance Analysis — Overall Budget	Mergers and Acquisitions
	Cash Management	Budget Preparation	New Product Planning
Unstructured	PERT/COST Systems	Sales and Production	R&D Planning

connection, and commerce. Context captures how Web sites are developed, consisting of functionality and aesthetics; Content focuses on what a site presents, comprising the offering, appeal, multimedia mix, and content type; Community concerns interaction between users, including interactive and non-interactive communication; Customization refers to a site's ability to tailor itself (tailoring) or to be tailored by users (personalization); Communication is defined as dialogue between sites and users: broadcast, interactive, and hybrid; Connection refers to the extent of formal linkages between sites, consisting of outsourced content, percentage of home site content, and pathways of connections. Commerce is concerned with interfaces related to sales of goods and product services, such as a shopping cart and order tracking.

Several researches have been conducted to study the powerful interface features to meet the users sepcific needs. Albers and Kim (2000) asserted that the small screen would interfere with navigation because information is too fragmented on separate pages to develop an integrated mental model given the user's limited short-term memory. Jones et al.(1999) compared users' navigation activities on small and big screens (640 × 480, 1,074 × 768), and found that navigation activity—the number of scroll up/down and left/right actions.

According to Gallivan and Shen (2005), the introduction of mobile technologies in organizations requires mobile users to have certain new skills, or to increase the level of certain skills they already have. First, mobile workers need to manage distributed objects. Second, mobile users need to maintain a high level self-discipline. Third, mobile users have to deal with high cognitive load. Fourth, employees using mobile technologies face the challenge of balancing work and personal life. Those challenges in user technology interaction in mobile commerce ask for powerful interface design in order to fit the taste of an individual user to faclitate their decision making.

Traditional decision making encompasses three main elements (1) user interface, (2) human computer interaction and (3) decision support systems. This decision making also relies on the development of problem understanding which in turn is developed by intuition and cognition. Decision making is traditionally measured in terms of quality and the efficiency of the decision.

CONCLUSION

Our study has compared the user interface features in both the mobile and traditional decision making in order to find the advantages and challenges in user interface deisgn in traditional and mobile environment and to indicated the distinct interface features of mobile device and applications, hence encouraging users' decision to adopt mobile commerce. Besides, the study on mobile user interfaces features and their effects on decision making will have the singnificant influence on the mobile commerce activities, consumer behaviors, mobile communication markets and also the decision science research.

This research has implications for research on not only mobile device interface design and decision support system but information systems interfaces as well as it addressed the issues of user interfaces in mobile and ubiquitous devices. For practitioners who develop mobile decision support interfaces and applications, this study will serve as a means of understanding user needs effectively.

All research studies have limitations and this one is no exception. The study does not study impact of other features of mobile experience such as connection speed, technologies (2G, 3G), rich diversity of power and specific functionality of devices

REFERENCES

1. Albers, M. & Kim, L. (2000). User Web browsing characteristics using palm handheld for information retrieval. In Proceedings of IEEE Professional Communication Society International Communication Conference and ACM Special Interest Group on Documentation Conference. Cambridge: IEEE Educational Activities Department, 125–135.
2. Bhuyan, A.(2005). The Why and Hows of M-Commerce, Financial Times Information.
3. Coyle, F. P.(2001). Wireless Web: A Manager's Guide, Addison Wesley, NJ.
4. Daft, R. L. (1991). Management (2nd ed.). New York: The Dryden Press.
5. Gallivan, M. & Shen Y. (2005). Examining User-Technology Interaction: Toward a Sociotechnical Theory for Understanding User Adjustment to Mobile Technologies. In Proceedings of the Eleventh Americas Conference on Information Systems, Omaha, NE, USA.
6. Gorry, G. A. , Morton, M.S.S. (1971). A Framework for Management Information Systems, Sloan Management Review, 30(3), 49-62.
7. Jones, M., Marsden, G., Mohd-Nasir, N., Boone, K., & Buchanan, G. (1999). Improving Web interaction on small displays, In Proceedings of the Eighth International Conference on World Wide Web, Amsterdam: Elsevier North-Holland, 1129–1137.
8. Lee Y. E. & Benbasat, I. (2004). A Framework for the Study of Customer Interface Design for Mobile Commerce, International Journal of Electronic Commerce, 8(3), 79–102.
9. Lerch, F. J. & Harter, D. E. (2001). Cognitive Support for Real-time Dynamic Decision Making, Information Systems Research, 12(1).
10. Mao, E., Site, M., Thatcher, J. B., & Yaprak, O. (2004). A Research Model for Mobile Phone Service Behaviors: Empirical Validation in the US and Turkey. Journal of Global Information Technology Management, 8(4).
11. Payne, J. W. (1982). Contingent decision behavior. Psychological Bulletin, 92(2), 382-402.
12. Sauter, V.L. (1999). Intuitive Decision Making Association for Computing Machinery. Communications of the ACM, 42(6), 109.
13. Todd, P. & Benbasat, I. (1992). The use of information in decision making: An experimental investigatio n of the impact of computer-based decision aids, MIS Quarterly, 16(3), 373-393.
14. Zucker, D., Uematsu, M., & Kamada, T. (2005). Marup-based SmartPhone User Interface using the Web Browser Engine, XTech Conference , ACCESS Co., Ltd.

An Algorithm for Market Intelligence Data Collection from Heterogeneous Sources with Similarity-Based Selection Clustering Technique Using Knowledge Maps

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ABSTRACT

Business Intelligence (BI) has emerged as one of software solutions that have maximum allocated investments by many organizations for the year 2005. Among various forms and application-based business intelligence, market intelligence (MI) is viewed as a crucial factor for a company to succeed both operationally and strategically in today's' competitive environment. Capturing market intelligence data has apparently become easy, especially with the proliferation of the Web. But, this has made data collection more difficult in reality from the system's point of view, as data sources on the web are voluminous, heterogeneous in terms of structures and semantics, and some part of it may be irrelevant to a specific organizations' marketing decision-making context, which is the primary premises of market intelligence systems. To address these three specific problems, an algorithm based on similarity measures and multi-dimensional scaling (MDS), which produces hierarchical clusters of knowledge maps from a training data-source set for collecting inputs from heterogeneous sources for capturing market intelligence, is proposed in this paper. The paper illustrates that this algorithm can reduce irrelevant or highly similar data sources for inclusion in the selected data-source repository – represented in the form of clusters of knowledge maps. Therefore, it acts as a similarity-based selection and filtering tool also, with the specific purpose of data collection for MI.

Keywords: Market Intelligence, Business Intelligence, Multi-dimensional Scaling

1. INTRODUCTION

1.1 Business Intelligence and Market Intelligence

According to the report of Nucleus, a market research firm on IT, in their research about Top 10 IT predictions for 2005, (Nucleus Report 2005) BI has emerged as the first among the maximum sought-after solutions. Amongst various Business Intelligence elements, Market Intelligence is one of the most significantly and practically applied concept or tool. (Future-Group 1997 and subsequent reports). However, the volume and heterogeneity of information available in the internal and more prevalently external domains (e.g. the Internet), create a huge information overload. (Bowman et.al 1994). In this paper, an algorithm is proposed for collecting market intelligence associated with its three primary problems like relevance, volume and heterogeneity.

The algorithm in specific, and the process, in general, use:

- Knowledge maps for identifying a relevant source of data → addressing the problem of relevance
- Knowledge maps as a selection clustering tool : not for classification or grouping, but for selecting and filtering the data → addressing the problem of volumes
- and then again knowledge maps for transforming all the relevant and filtered data from various heterogeneous systems to a homogenous platform so that various analytical tools can be applied to the resultant data-set → addressing the problem of heterogeneity

1.2 Existing Technologies for Collecting Market Intelligence

In recent years, business intelligence tools have become important for analysis of information on the Web (Fuld et al 2003). Despite recent Improvements in analysis capability there is still a long way to go to assist qualitative analysis effectively. Due to limited analysis capability, existing tools are weak at summarizing a large number of documents collected from the Web, thus handling the problems of relevance, heterogeneity and volume.

1.3 Information Overload- handling techniques

Few algorithms proposed in text/web mining and document clustering find relevant applications here. Lin (1997) identified various display formats for handling multi-dimensional data e.g. scatter displays (Spence 2001) and map displays- to provide a view of the entire collection of items at a distance (Lin 1997). Shneiderman proposed a task by data type taxonomy (TTT) to study the types of data and tasks involved in visual displays of textual information (Shneidermiin 1996), (Wise et al 1995). Most processes of document visualization involve three stages i.e. document analysis, algorithms, and visualization (Spence 2001). He et al. (2001) proposed an unsupervised clustering method that was shown to identify relevant topics effectively. Bharat and Henzinger (1998) augmented a connectivity analysis-based algorithm with content analysis.

1.4 Algorithms

Partitioned clustering, in context of unstructured documents, assigns objects into groups such that objects in a cluster are more similar to each other than to objects in different clusters. Typically, a clustering criterion is adopted to guide the search for optimal grouping. Using this criterion in image segmentation (Shi and Malik 2000) and Web page clustering (He et al 2001) has been shown to achieve high performance. But, heuristics are needed to find good values to the criterion selected.

1.5 Multidimensional Scaling

Multidimensional scaling (MDS) algorithms consist of a family of techniques that portray a data structure in a spatial fashion, where the coordinates of data points x_{ia} are calculated by a dimensionality reduction procedure (Torgerson 1952). The distances (d_{ij}) among data sources can be calculated as follows

$$d_{ij} = [\sum \{x_{ia} - x_{ja}\}^p]^{1/p} \quad (p >= 1),\ x_{ia} <> x_{ja}$$

p is referred to as the Minkowski exponent and may take any value not less than 1. r is the coordinate of point on dimension a, and J is an r-element row vector from the i^{th} row of a/i-by-r matrix containing all *n* points on all r dimensions. The MDS procedure constructs a geometric representation of the data (such as a similarity matrix), usually in a Euclidean space of low dimensionality (i.e.. *p = 2)*.

2. KNOWLEDGE MAPS FOR COLLECTING MARKET INTELLIGENCE

In this section, we present these requirements of an effective market intelligence collection system as shown in Figure 1, which depicts the problems addressed in this paper, namely relevance, volume and heterogeneity of information.

2.1 Collection of Data Sources

From Figure 1, it can be seen that there are two major data sources: internal and external. Both these major sources have mixed type of data elements in them i.e. structured (e.g. from RDBMS, data warehouses, ERP backend databases, MIS, spreadsheets etc,) or unstructured (e.g. text, hypertext, multimedia, binary files and so on). Primary problem therefore is to deal with external data sources that exist in various forms unknown to the organization and in various degrees of unstructured-ness. Techniques like meta-searching and automatic parsing and indexing are commonly used for such data collection problems.

For example, the word-type information can be used in the co-occurrence analysis. Each key word or noun phrase for example can be treated as subject descriptor type. Based on a revised automatic indexing technique (Bowman et.al 1994), the term's level of importance can be measured by term frequency and inverse data-source frequency.

2.2 Co-occurrence Analysis

Co-occurrence analysis can convert data indices and weights obtained from inputs of parameters and various data sources into a matrix that shows the similarity between every pair of such sources. The similarity between every pair of data sources contains its content and structural (connectivity) information. He et al. (2001) designed an algorithm for computing the similarity between every pair of Web documents by a combination of hyperlink structure, textual information, and co-citation. This algorithm has been used in this paper to compute the similarity between data sources, as follows:

Similarity between data source I and data source j is

$$W_{ij} = \alpha \{A_{ij} / |A|_2\} + \beta S_{ij} / |S|_2 + (1 - \alpha - \beta) C_{ij} / |C|_2$$
$$0 < \alpha, \beta < 1,\ 0 <= \alpha + \beta <= 1,$$

where A, S, and C are matrices for A_{ij}, S_{ij}, and C_{ij} respectively. Values for A_{ij} will be 1 if data source I has a direct link to data source j, else 0. S is the asymmetric similarity score between data sources I and j, and is calculated as follows:

$$S_{ij} = sim(D_i, D_j) = [[\sum_{k=1}^{p} d_{ki} d_{kj}] / [\sum_{k=1}^{n} d^2_{di}]] \text{ X } S_{ji} = sim(D_j, D_i)$$

where:

1. n is total number of terms in D_i, m is total number of terms in D_j, p is total number of terms that appear in both D_i, and D_j.
2. d_{ij} = (Number of occurrence of term j in data source i) X $\log((N/d_{fj}))$ X w_j) X (Term type factor)
3. d_{fj} is number of data sources containing term j
4. w_j is number of words in term j
5. Term type factor = 1 + ((10-2 X $type_j$ / 10), where $type_j$ = minm 1 if term j appears in title, 2 if it appears in heading, 3 if it appears in context text etc.)
6. C_{ij} is number of data sources pointing to both source I and source j (cocitation matrix).

3. CREATING THE KNOWLEDGE MAPS

The data sources for Market Intelligence, be it structured or unstructured i.e. text/ binary objects/ documents, can be represented in the form of a graph consisting of nodes as the data sources and edges as the similarities between data sources. Using hierarchical and partitioned clusters simultaneously, a hierarchy of similarity clusters of data sources based on their parameters or properties can be created in

Figure 1. Market intelligence data collection system using knowledge maps

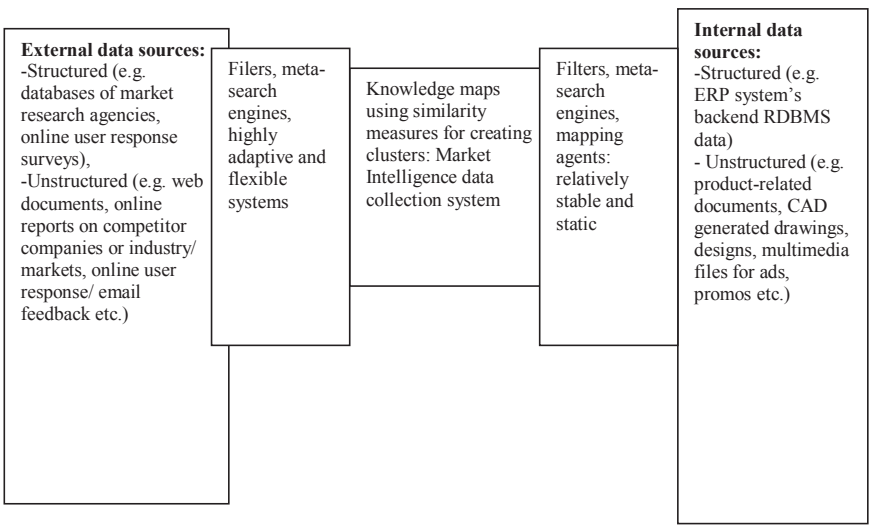
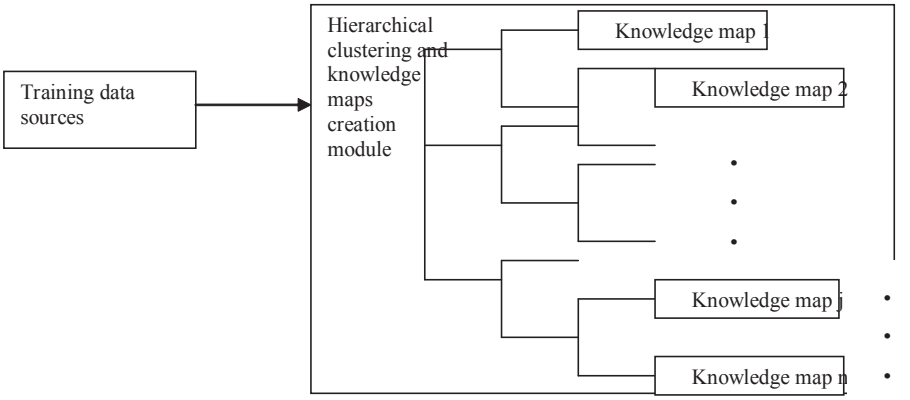


Figure 2. Example of a hierarchical graph of knowledge maps



the training phase. Then these clusters can be transformed into two-dimensional knowledge maps using MDS.

Example Run of the Proposed Algorithm:
Let us consider an example where we have n data sources as training data set for training the selection clusters. These training data sets will be used to create a hierarchical graph of clusters transformed into knowledge maps, as shown in Figure 2 below. Partitioning of a graph, say G, can be done in various ways, for example, by using similarity measures as below:

Normalized Cut on graph G = {cut between (A, B)/ assoc(A, V)} + {cut between (A, B)/ assoc (B,V)}

where, Cut between (A,B) = $\sum_{i\in A, j\in B} W_{ij}$, W_{ij} is similarity between nodes i and j of the graph. A cut on a graph G = (V, E) is defined as removal of a set of edges such that the graph is split into disconnected sub-graphs, thereby can be converted into a hierarchy of knowledge map.

Torgerson's classical MDS procedure, (Torgerson 1952), can be used here for it's simplicity and ease of implementation. The MDS procedure can be implemented using the following steps.

First, Similarity matrix is to be converted into a dissimilarity matrix D by subtracting each element by the maximum value in the original matrix. Then matrix B which is a scalar product is to be calculated, by using the cosine law. Each element in B is given by:

$$b_{ij} = -1/2 \left[d_{ij}^2 - 1/n \sum_{k=1}^{n} d_{ik}^2 - 1/n \sum_{k=1}^{n} d_{kj}^2 + 1/n^2 \sum_{g=1}^{n} \sum_{h=1}^{n} d_{gh}^2 \right]$$

where d_{ij} is an element in D, n= number of nodes in the data-source graph

After calculating B, singular value decomposition is performed using the formula as below:

$B = UxVxU'$, $X = U\,X\,V^{1/2}$

(where U has eigenvectors in its columns and V has eigenvectors on its diagonal.)

Therefore, B = X x X'.

The first two column vectors of X thus calculated now can be used to obtain the two-dimensional coordinates of points, which can be used to place the data sources onto knowledge maps.

4. USING KNOWLEDGE MAPS FOR CREATING CLUSTERS OF COLLECTED DATA

Creation of knowledge maps from a graphical representation of various data sources, based on their similarities or, more specifically and logically their degree

Figure 3. Data sources as inputs to the clustering and knowledge maps creation module

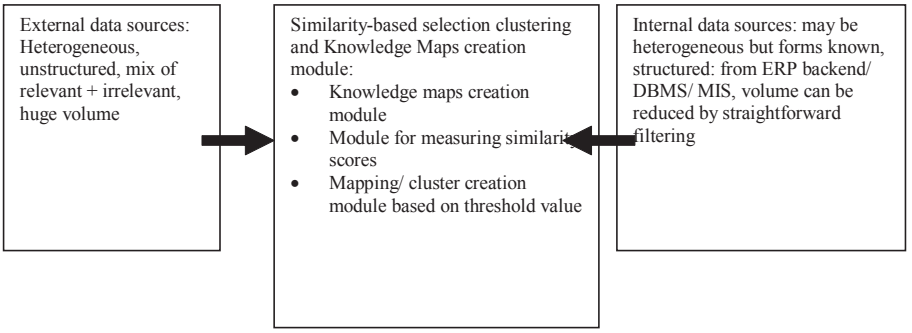
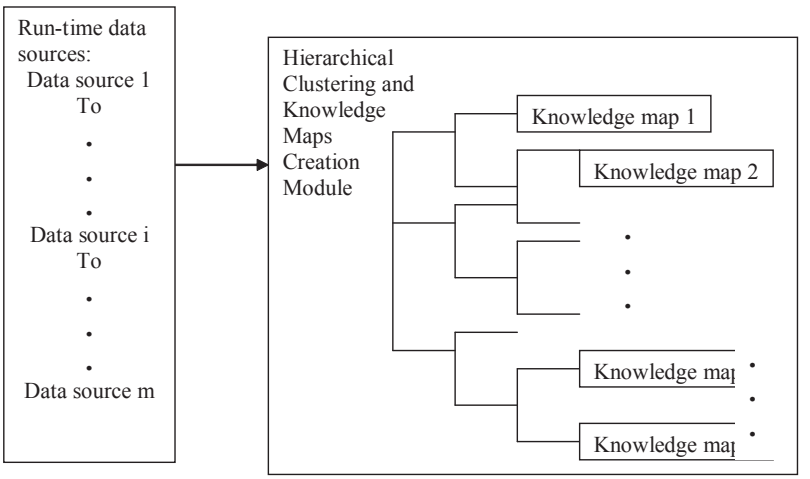


Figure 4. Run-time collection of data sources



of dissimilarities, is shown earlier. Basically, by segregating the graph representing the data sources, we get a hierarchical cluster of various knowledge maps where these knowledge maps can be seen as representing similar data sources. This is what is to be done in the training phase of the clustering and knowledge maps creation module, as explained in Figure 2 in terms of training the modules with the data sources and Figure 3 in terms of the various data sources themselves in the context of Market Intelligence requirements of an organization.

After the use of training data sources a set of hierarchical clusters with knowledge maps have been created and thereafter the run-time data collection has to start. During the run-time, two events can take place. Say, a data source i is being input to the module as shown in Figure 4 below. Now the similarity score of this data source will be calculated by the appropriate sub-module in respect to the existing Knowledge Maps that are already trained into the module. The thershold value of this score will have to be given by the user. It can be given one-time, or it can be exectuion envrionment/ run-time specific depending on the degree of filerting/ reduction requirements. If the similarity score of data source i is found to be closer(i.e. lesser that the thershold value given) to any of the existing knowldeg maps in the hierarchical cluster, then it is included in that knowledge map. Here a possibility is that the closely-matching knowledge map can be futher fine-tuned with the data-source i input's parameters and properties. In that case, it will be like a fine-tuning training phase going in tandem with the run-time phase. But here the data source colelciton will be more enriched , more representative and inclusive.

The other possibility is that the data source i does not have a close proximity to any of the existing knowledge maps in terms of it's similarity value and the threshold(i. e. the similarity score in terms of all existing knolwdge maps is more than the threshold value). In such situation, a new knowledge map has to be created and put in the approrpasite place in the hierachy of knopwldge map clusters.

As explained above, the steps in Figure 4 can be explained as given below:

Steps:

1. One data source i arrives for feed into the module which has sub-modules like Knowledge Map creation module and similarity scoring module
2. Similarity scoring module measures the similarity score of the data source (for i = 1, $S_{ij} = 0$, during the training phase) and a KM for data source i, say KM_i is created.
3. The similarity score is calculated and compared against all existing KMs, i.e. KM_1 ti KM_n
4. If the similarity score is < threshold value given for data reduction for any existing KM say KM_j, then the KM_i gets mapped or included into KM_j and KM_j learns for similarity patterns from KM_i and refines itself.
5. If similarity score is > threshold value, KM_i creates another cluster of it's own.
6. Go to step 1.

Using this algorithm, the primary three problems that were introduced in the previous sections, gets addressed.

1. First, by using training data sources, the trained Knowledge Map clusters have the patterns identified only for relevant data which has been included in the training data. So the problem of relevance i.e. eliminating/ reducing irrelevant data collection is achieved to a limited scope depending on the choice and exhaustibility of the training data source-sets.
2. Second, the problem of volume is addressed by using Knowledge maps and similarity-based clustering where similar data sources are not repeatedly included in the collected repository of KM-represented data.
3. Third, the problem of heterogeneity is addressed as all the heterogeneous structured or unstructured data sources are finally being represented in the form of Knowledge Maps, which can then be used as a homogenous input to the analytical modules of the MI systems.

CONCLUSION

This proposed algorithm has been shown to handle the three primary problems of data collection for market intelligence in an organization. Further extensions may include exploring various other knowledge map creation mechanisms including the Genetic Algorithm approaches and extrapolating the Knowledge maps into the analytical systems required for analyzing and visualizing the Market intelligence data.

REFERENCES

Bharat, K., Henzinger. M.R.(1998), "Improved algorithms for topic distillation in hyperlinked environments", Proceedings of the Twenty-First International ACM SIGIR Conference on Research and Development in Information Retrieval. New York: ACM Press: 104-111.

Bowman, C.M., Danzig. P.B., Manber. U.; Schwartz, F.(1994) "Scalable Internet resource discovery: Research problems and approaches", *Communication of the ACM. Vol* 8 : 98-107.

Fuld, L.M.: Singh. A.: Rothwell. K.; and Kim, J. (2003) *Intelligence Software Report™ 2003: Leveraging the Web.* Cambridge. MA: Fuld & Company.

Futures-Group Ostriches & Eagles.(1997) The Futures Group Articles, Washington, DC, (available at www.futuresgroup.com).

He. X.; Ding. C; Zha. H.; and Simon, H.(2001)" Automatic topic identification using Webpage clustering", In X. Wu. N. Cercone, TY. Lin, J- Gehrke. C.

Clifton. R. Kotagiri. N. Zhong. and X. Hu (eds,). *Proceedings of the 2001 IEEE International Conference on Data Mining.* Los Alamitos. CA: IEEE Computer Society Press. 2(X)I. : 195-202.

Lin, X. (1997) "Map displays for information retrieval",*Journal of the American Society for Information Science. 4H.* 1: 40-54.

Nucleus Report (2005) *Top 10 IT Spending for 2005: Survey of CIOs in MNCs: Survey Report March 2005 by Nucleus Research*, http://www.nucleus.com/surveys/2005

Shi. J., and Malik. J.(2000) "Normalized cuts and image segmentation", *IEEE Transactions on Pattern Analysis and Machine Intelligence. 22.* S (2(X)0):, 8S8-905.

Shneidermiin, B.(1996) "The eyes have it: A task by data type taxonomy for information visualizations", *Proceedings of IEEE Symposium on Visual languages.* Los Alamitos, CA: IEEE Computer Society Press : 336-343.

Spence, R.(2001), *Information Visualization.* New York: ACM Press, 2001.

Torgerson, W.S. (1952)"Multidimensional Scaling: Theory and method", *P.sychometrika. 17.4*, 401.19..

Wise, J.A.; Thoma, J.J.: Pennock. K.; Lantrip, *D.:* Pottier, M.; Schur, A.; and Crow, V. (1995)"Visualizing the non-visual: Spatial analysis and interaction with information from text documents",*Proceedings of IEEE Symposium on Infonnation Visualization.* Los Alamitos, CA: IEEE Computer Society Press: 51-58.

Young, F.W. (1987),*Multidimensional Scaling: History, Theory, and Applications,* ed. R.M. Hamer. Hillsdale, NJ: Lawrence Erlbaum.

Evolving Stochastic Context-Free Grammars Using Genetic Algorithm

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ABSTRACT

The learning of stochastic context-free grammars from corpus using genetic algorithm is explored in this work. Minimum description length principle is used for deriving the fitness function of the genetic algorithm. Stochastic context-free grammars are evolved by optimizing the parameters of the covering grammars. I provide details of my fitness function for grammars and present the results of a number of experiments in learning grammars for a variety of languages.

INTRODUCTION

Stochastic context-free grammars (SCFGs) are perhaps best known as a tool for expressing the syntactic structure of natural languages. Practical techniques for grammar induction have many important applications or a wide range of natural language (NL). In recent years SCFGs have been widely applied to problems in computational biology, such as modeling the secondary structure of RNA families. Other applications include visual recognition of activities and language modeling for speech recognition, robotics. A problem of central importance in each of these applications is inducing SCFGs from data.

Inferring a stochastic grammar from data, as revealed by most previous practice, involves in general two essential sub-tasks, one to infer a set of phrase structure rules (or productions), another to estimate a correspondent set of probabilistic parameters (i.e., production probabilities) The inference can be viewed as a search process for the best grammar allowable in a predefined grammar (or hypothesis) space. There are many sophisticated algorithms exist to facilitate the searching, e.g., genetic algorithm and stimulated annealing algorithm. However, no matter how sophisticated is the search method in use, the goodness criterion to guide the searching remains a critical issue. It is this criterion that tells a search algorithm which grammar is better. In this project we developed a suitable criterion for the estimation of the parameters of the stochastic context-free grammars. It is based on the classic and algorithmic information theory and on the Minimum Description Length (MDL) principle and genetic algorithm.

STOCHASTIC CONTEXT-FREE GRAMMAR (SCFG)

A stochastic context-free grammar (SCFG) is a variant of ordinary context-free grammar in which each grammar rule is associated with a probability, a real number in the range [0,1]. The set of production probabilities will be referred to as the parameters of the SCFG. For a SCFG to be proper, the probabilities associated with all rules that expand the same non-terminal symbol must be one.

The language L(G) generated by a SCFG G comprises the set of all strings of terminal symbols derivable from the start symbol of the grammar. In addition, the parameters define a probability distribution over strings in L(G). For a string $\alpha \in$ L(G), the probability of a parse tree for α is given by the product of the probabilities of all the grammar rules involved in its construction. The probability $P_G(\alpha)$ of the string α is the sum of the probabilities of all of its parses.

S → AB (1.0)
A → a (0.6)
A → CS (0.4)
B → b (1.0)
C → a (1.0)

The above SCFG, with the probability associated with each production is given in parentheses, generates the language $\{ a^n b^n | n \geq 1\}$, where $P_G(ab)=0.6$, $P_G(aabb)=0.24$ and so on.

BIASED WEIGHT GRAMMARS

Biased Weight Grammars are similar to SCFGs in that they associate numerical parameters with the rules of the grammars, a bias and a weight. Any BWG G can be converted to an equivalent SCFG G'. Let Grj denote the set of rules in G that expand the same nonterminal symbol as rule rj. Then each rule rj in G with bias bj and weight wj has a corresponding rule rj' in G' with associated probability pj given by

$$P_j = \frac{b_j w_j}{\sum_{r_k \in Gr_j} b_k w_k} \quad (1)$$

The language generated by a BWG G to be the same as L(G'), the language generated by its equivalent SCFG G', with the same associated probability distribution over its sentences.

CORPUS-BASED GRAMMATICAL INFERENCE

A corpus C for a language L is a finite set of strings drawn from L, where each string $\alpha \in C$ is associated with an integer f_α representing its frequency of occurrence. The size N_c of the corpus is defined as the sum of the frequencies of the individual strings in C. That is

$$N_c = \sum_{\alpha \in C} f_\alpha \quad (2)$$

The relative frequency p_α of a string $\alpha \in C$ is defined as $p_\alpha = f_\alpha / N_c$ Given a corpus C as training data, the inference problem is to identify a SCFG that (a) models the corpus as accurately as possible and (b) generalizes appropriately to the wider language from which the corpus was drawn. This problem is tackled by trying to identify a BWG with these properties taking its associated SCFG as the one learnt by our system.

For any probabilistic language model, natural measure of accuracy is the probability of the corpus data given the model. In this case, the most accurate model in this sense is that grammar G" given by

$$G" = \text{argmax}_G P(C|G) \quad (3)$$

Where P(C|G) (the conditional probability of the language data C given by the grammar G) is defined as

$$P(C|G) = \frac{N_C!}{\prod_{\alpha \in C} f_\alpha!} \prod_{\alpha \in C} P_G(\alpha)^{f_\alpha} \quad (4)$$

On the other hand, simply maximizing the probability of the corpus data will not generally meet the further requirement of generalization. A perfectly accurate model is one which generates exactly the finite corpus and assigns to each string the correct relative frequency. In otherwords, the most accurate grammar will over-fit the training data. What actually require is the grammar that is most probable given the training data. That is, a grammar G" such that

$$G" = \text{argmax } G\ P(G|C) \quad (5)$$

Unfortunately, it is not clear how to calculate P(G|C) directly. From Bayes rule

$$P(G|C) = \frac{P(G)P(C|G)}{P(C)} \quad (6)$$

Ignoring P(C), which is a constant, maximizing P(G|C) just corresponds to maximizing the product of P(C|G) (which can be calculated directly) and P(G), the prior probability of the grammar G. This poses the problem of fixing an appropriate prior probability distribution over grammars. In principle there are many different priors that could be chosen, but it seems reasonable to assume that we should prefer smaller and simpler grammars to larger, more complex ones. Our choice of prior is therefore related to the minimum description length principle of Risannan as well as earlier work on inductive due to Solomanoff.

THE MINIMUM DESCRIPTION LENGTH PRINCIPLE

Given some data D, we should pick that theory T which minimizes:

$$L(T)+L(D/T)$$

Where L(T) is the number of bits needed to minimally encode the theory T, and L(D/T) is the number of bits needed to minimally encode the data D given the theory T.

From Shannon's information theory, we know that if we have a discrete set X of items with a probability distribution P(x) defined over it, then in order to send a message identifying x ε X we need approximately $L(x)= -\log_2 (P(x))$bits. In other words,

$$P(x)= 2^{-L(x)} \quad (7)$$

This enables us to interpret the M D L principle in Bayesian terms. From the equation it can easily be seen that minimizing L(T)+L(D/T) corresponds to maximizing P(T)P(D/T) and hence P(T/D).

It should be noted that for us the most useful feature of the M D L Principle is that it can be used "inverse". Information theory (Shannon 1948) tells us how work out minimum code lengths given prior knowledge of the probability distributes over items in some set of interest. The M D L Principle enables us to assign prior probabilities to items in some set in a meaningful way, even if we do not really have enough prior knowledge. We can do this by attempting to find minimal length encoding for the items and then use equation (4) to work out the probabilities.

THE GENETIC ALGORITHM FOR SCFGS

Given a corpus C as training data, our approach to grammatical inference involves the following steps

1. Construct a covering grammar that generates the corpus as a (proper) subset.
2. Set up a population of individuals encoding parameter settings for the rules of the covering grammar.
3. Repeatedly apply genetic operations (crossover, mutation) to the selected individuals in the population until an optimal set of parameters in found.

The covering grammar is in the Chomsky Normal Form (CNF) and contains every rule of the form A → BC and every rule of the form A→ a.

A member of the population encodes a set of weights for the rules of the covering grammar. Each weight is encoded as a binary integer, using w a fixed length bit string. The bias associated with each rule is determined in advance according to a prior probability distribution p" over grammar rules. Thus, for a rule r in the covering grammar the associated bias is given by p"(r). The prior distribution is chosen to reflect a preference for shorter, simpler rules. This makes it easier for the genetic algorithm to learn grammars of the sort we prefer(simpler and shorter) because changes to the weights of more heavily biased rules have a greater effect on the resulting probabilities of the sentences in the corpus. Consequently the algorithm is far more sensitive to simpler, shorter rules.

The members of the initial population are generated randomly after which the genetic algorithm repeatedly executes the following select-breed-replace cycle.

Select a random member of the population for breeding using roulette selection method.
Breed by applying crossover and mutation to produce two children.
Replace the weakest parent by the fittest child.

In crossover operation, variable size cromosomes are used. In making a chromosome for a set rules, only those rules are included for which the weight is not zero.

THE FITNESS FUNCTION

In practice, it is not convenient to compute the conditional probability P(G|C) directly as a means of evaluating the fitness of grammars. Instead, the genetic algorithm uses an objective function F given by

$$F(G) = \frac{K_C}{L(C|G) + L(G)} \quad (8)$$

Maximizing F(G) corresponds to minimizing the denominator of equation. This in turn just amounts to maximizing P(G|C). The numerator Kc is a problem(corpus) dependent normalization factor that yields fitness values in the range [0,1].

Since $L(C|G)= -\log_2 P(C|G)$ it is given by

$$L(C|G) = -\log_2 \left(\frac{N_C!}{\prod_{\alpha \varepsilon C} f_\alpha!} \right) - \sum_{\alpha \varepsilon C} f_\alpha \log_2 (P_G(\alpha)) \quad (9)$$

The first term is a constant (depending only on the corpus) and therefore can be ignored in minimizing the denominator of equation 5. The second term is Nc times the cross entropy of the corpus C given the model provided by the grammar G. It can be interpreted as the number of bits needed to communicate the corpus (with the frequencies given) using a code guaranteed to minimize message length if the sentences had occurred in the corpus with probabilities as given by the grammar.

In order to compute L(G), the grammar is represented as a code. Different choices of coding scheme give rise to different probability distribution over the set of grammars. In genetic algorithm, a coding scheme is used in which a grammar can be represented in any convenient fashion as a genome, compute its length according to our chosen coding scheme and hence assign it a prior probability.

For BWGs with a fixed determined set of biases, a grammar is completely specified by some set of pairs of the form (r,w), where r is a rule and w its weight. Pairs are omitted if their weight is zero. The length for the whole grammar is given by the

sum of the lengths of the codes for each of its rules, where the length of the code of a rule is given by the length of a code for r plus length of a code for w.

To encode a weight w, one of a family of prefix codes for integers which all form good approximations to the minimal encoding can be used. These codes represent an integer by a code for the integer itself, preceded by a code for its length. The code for the integer w requires

approximately $\log_2(w)$ bits while the code for its length needs roughly $\log_2(\log_2(w))$ bits(using normal binary encoding). However this does not give any way of deciding where the code for the length ends and the code for the integer w itself begins. Therefore a code is used which duplicates every binary digit of the integer representing the length followed by a single 0. This means that an integer w will need approximately $\log_2(w)+2\log_2(\log_2(w))+1$ bits.

To compute the code lengths for r, a probability distribution P"(r) over the rules is defined. A natural way of computing the probabilities of each r_j is to look at the probabilities of the symbols in each position of the set of rules in the covering grammar. In particular, we look at the set of symbols allowed at a given position in the rules given the preceding symbols. If all legal symbols at that position can occur with equal probability, then P"(r) can be computed as follows

Let N be the set of non-terminal symbols in the covering grammar G and let n be the length of right hand side of the longest rule. Now write each rule r_j in the form $S_{j_0} \rightarrow S_{j_1} S_{j_2} \ldots S_{j_n}$ where S_{j_m} is defined to be a special "blank" symbol for all m greater than the length of the right hand side of rule r_j. Define S_{j_k} $(0 \le k \le n)$ to be that set of symbols given by

$$S_{j_k} = \begin{cases} N & \text{if } k=0 \text{ and} \\ \{ Sjk \mid \ni r_i \varepsilon G \text{ such that } S_{i_l} = S_{j_l} \ (0 \le l \le k) \} & \text{otherwise} \end{cases} \quad (10)$$

The probability P"(r_j) of rule r_j is than given by

$$P"(r_j) = \prod_{0 \le k \le n} P_{j_k} \quad (11)$$

Where $Pjk(0 \le k \le n)$ is defined as $1/|S_{j_k}|$

Given the probability distribution P over rules, the number of bits needed to represent a particular weighted grammar is given by

$$\sum_{(r,w)\varepsilon G} (-\log_2(P"(r) + \log_2(w)+2\log_2(\log_2(w))+1 \quad (12)$$

This quantity is of course $L(G) = -\log_2(P(G))$

ALGORITHM FOR EVOLVING STOCHASTIC CONTEXT-FREE GRAMMAR

To identify a Stochastic Context Free Grammar for a given corpus as training data that (a) models the corpus as accurately as possible and (b) generalizes appropriately to the wider language from which the corpus was drawn, the steps involved are as follows

Step 1: Identify a covering grammar for a given corpus as training data using Sequitur algorithm. The grammar must be as small as possible and simple.

Step 2: Generate all parses for all strings in the corpus derivable from the covering grammar using All Parse algorithm.

Step 3: Convert a stochastic context free grammar in to a biased weight grammar. Associate numerical parameters with the rules of the grammar, a bias and a weight

Step 4: Code grammar using prefix coding scheme for integers. This scheme is used to represent a grammar a convenient fashion as a genome. Compute its length according to our chosen coding scheme. The length of the whole grammar is given by the sum of the lengths of the codes for each of each of its rules, where the length of the code of a rule is given by the length of a code for r plus length of a code for w.

Step 5: Determine an objective function for the genetic algorithm to evaluate the fitness of grammars.

Step 6: Apply genetic algorithm for setting the parameters of the stochastic context-free grammar.Genetic algorithm is repeated until a threshold value is achieved for parameters of SCFG or a maximum iteration value is reached. Threshold value is dependent of the type of the language generated by the grammar G.

EXPERIMENTAL RESULTS

We have conducted a number of experiments in learning grammars for a range of formal languages. These languages are representative of those considered in other studies.

1. (a+b)*bb: the language is the set of strings ending with a sequence of at least two **b**s.
2. **EQ**: the language of all strings consisting of equal number of **a**s and **b**s, (ab+ba)(ab+ba)*.
3. The language $a^n b^n$ $(n \ge 1)$.
4. **BRACKET**: The language of balanced brackets.
5. **PAL**: palindromes over {a,b}.

For each experiment, a corpus was first produced automatically using a hand-crafted SCFG for the target language. This involved randomly generating on the order of 1000 strings up to a pre-specified 'maximum sentence length' (typically 6 or 8). For each problem, the population size was fixed to 25.

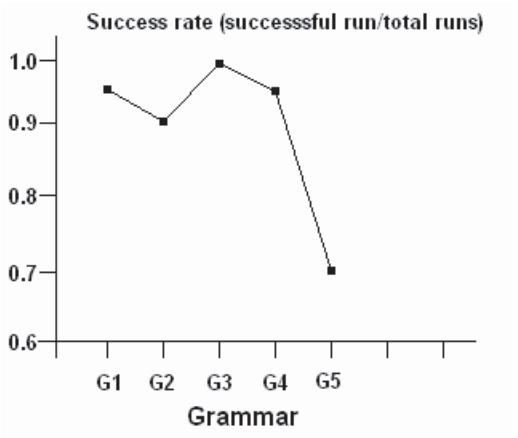
In order to assess the performance of the genetic algorithm, 20 runs were completed on each language learning task. A run of the genetic algorithm was terminated as 'successful' if a SCFG was found with fitness above a threshold value of 0.93. While this figure is somewhat arbitrary, experience has shown that grammars attaining this fitness are usually correct in the sense that they generate the target language exactly, and assign appropriate probabilities to the strings. Runs of the genetic algorithm that failed to attain the threshold value were terminated after a maximum number of select-breed-replace cycles. The number of cycles was set individually for each problem and was high enough to ensure convergence in the population.

The results of the experiments are summarized in the table given above. For each learning task, the table gives the number of non-terminals used in the covering grammar, the number of parameters to be optimized, the success rate (number of runs that attained the threshold fitness value) as well as the maximum fitness value found on the best and the worst runs of the genetic algorithm. As can be seen,

Table 1. Experimental result for different type of grammars

Language	Non-terminals	Parameters	Success rate	Best fitness value	Worst fitness value
G1: (a+b)*bb	3	6	19/20	0.972	0.946
G2: EQ	3	5	18/20	0.970	0.681
G3: BRACKET	3	5	20/20	0.955	0.949
G4: $a^n b^n$	4	5	19/20	0.978	0.866
G5: PAL	5	10	14/20	0.951	0.869

Figure 1. Graph between success rate and grammar given in table 1



the first four tasks ((a+b)*bb, EQ, $a^n b^n$, BRACKET) presented little difficulty. Inspection of the grammars produced on successful runs for these experiments showed that they were indeed correct. For the occasional unsuccessful runs the relatively poor fitness values attained suggest the presence of local maxima around which the population has converged. The palindrome example PAL provided the algorithm with a rather harder test. Here, the success rate fell to around 65% to 70%. On runs where the algorithm failed to find the correct grammar, inspection of the best grammars showed that the population had converged on solutions, which had the correct rules for palindromes starting with any of the available symbols, except for one. Because these grammars covered the palindromes while assigning generally low probability to a range of other sentences they still managed to attain a relatively high fitness.

Figure 1 shows that success rate is generally greater than 90% for the grammars. It depends on the complexity of the grammar.

CONCLUSIONS

The approach to grammatical inference described in this project differs from previous works using genetic algorithms in addressing the problem of corpus-based inference of stochastic context-free grammar. In our approach number of rules in covering grammar is reduced by using sequitur algorithm and convergence rate of genetic algorithm is speedup by using variable crossover over variable length chromosome algorithm. This makes direct comparison our results with those of other algorithms difficult. However, the experiments that we have conducted are typical of those in other studies and the results reported in this project appear promising. The approach also appears to compare well with other (non-genetic) techniques for stochastic grammatical inference.The main limitation of our approach is the cost involved in evaluating the fitness of each candidate solution, which requires parsing every string in the corpus in all possible ways. Success rate of our algorithm depends on the complexity of the grammar. Although inference can be performed very quickly for small covering grammars, the number of parses that must be considered increases exponentially with the number of rules in the grammars. This problem can be solved by including the possibility of a massively parallel implementation of this algorithm.

REFERENCES

[1] K.L.P. Mishra, Theory of Computer Science (Automata, Languages and Computation), PHI, 2000.
[2] Dan W. Patterson, Introduction to Artificial Intelligence and Expert Systems, PHI, 2001.
[3] Elaine Rich and Kevin Knight, Artificial Intelligence, Tata McGraw-Hill, 2000.
[4] Alfred V. Aho, Ravi Sethi and Jeffrey D. Ullman, Compilers Principles, Techniques and Tools, Low Price Edition, 2000.
[5] Herbert Schildt, The Complete Reference C++, Tata McGraw-Hill, 1999.
[6] Sahni, Data Structures, Algorithms, and Applications in C++, McGraw-Hill, 2000.
[7] Marjan Mernik, Matej Crepin¡sek, Goran Gerli¡c, Viljem Zumer, " Learning Context-Free Grammars using an Evolutionary Approach", University of Maribor, 2000.
[8] Lukasz Debowski, "On the Best Theories for Learningful Texts", Institute of Computer Science-Polish Academy of Sciences, 2002.
[9] F. Amaya, J.M. Benedi and J.A. Sanchez, "Learning Of Stochastic Context-Free Grammars From Bracketed Corpora By Means Of Reestimation Algorithms*", Department of system information and computation.
[10] Moses Charikar, Eric Lehmany, Ding Liu, Rina Panigrahy, Manoj Prabhakaran, April Rasala, Amit Sahai, abhi shelat, "Approximating the Smallest Grammar: Kolmogorov Complexity in Natural Models", 2002.
[11] Steve Lawrence, C. Lee Giles_, Sandiway Fong, "Natural Language Grammatical Inference with Recurrent Neural Networks", NEC Research Institute.
[12] "Stochastic context-free grammar", http://www.cse.ucsc.edu/research/compbio/scfg.html
[13] "Automata and Formal grammars", http://www.csee.umbc.edu/~sdoshi1/Inferring%20Graph%20Grammars.pdf
[14] "Minimum Description Length Principle", http://citeseer.nj.nec.com/cache/papers cs/24767/http:zSzzSzwww3.oup.co.ukzSzcomputer_journalzSzhdbzSzVolume_42zSzIssue_04zSzpdfzSz420260.pdf/rissanen98hypothesis.pdf
[15] http://citeseer.nj.nec.com/cache/papers/cs/1016/ftp:zSzzSzftp.cogs.sussex.ac.ukzSzpubzSzuserszSzbillkzSzicml97.pdf/evolving-stochastic-context-free.pdf
[16] "Language definitions", http://www.csee.umbc.edu/help/theory/lang_def.shtml
[18] "Introduction to genetic algorithms", http://lancet.mit.edu/~mbwall/presentations/IntroToGAs/

Intelligent Collaboration: The Paradox of "Ethical Agency" and "Corporate Governance"

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ABSTRACT

The unprecedented technological developments witnessed in the 21st centuary have been accompanied with a growing importance of "information ethics" due to their far-reaching effects especially for global transactions. Such importance has also moved a wide range of "issues" to the front line agenda of enterprises. The measures used to approach the resulting or potential "ethical dilemma" continued to be oriented towards the minimization of threats and improving privacy through technological and legal measures. Howevere, the use of advanced intelligent technologies such as software agents technology brings the issue of "ethical agency" to the surface and calls for a "redefinition" and paradigm shifts with regards to the way 'information ethics" is conceptualized.

1. INTRODUCTION

The recent technological advancements have significantly redefined the context and domain of data acquisition, processing, and sharing. While new patterns, platforms and architectures are being developed for the maximization of benefits from data, the growing emphasis on "collaborative work", "responsiveness" and "building of alliances" is reshaping the way global enterprises do business. Coupled with their process-oriented "enabling" features, the use of global networks and web based systems has turned enterprises into an archipelago of "integrated" islands of performance. The resulting new digital global economy is becoming increasingly based on global networks of "capital", "information" and "power" and is driven by institutional concepts of "deregulation", "liberalization", and "re-engineering" (Tagelsir, 2006). Within this context, the effort of enterprises is being directed towards process-centered activities that affect corporate functionalities such as:

a. Maintaining operationally-feasible process-technology matrix in a way that sets both the "rationale" and "foundation" for business process reengineering and continuous improvement.
b. Developing data repositories and adopting alternative forms of database creation, tuning and sharing using alternative architectures, platform and software engineering methodologies.
c. Mobilizing resources (including global networks and other related componenets) in pursuit of improving their potential to facilitate the provision and integration of e-services.
d. Managing information-intensive applications by incorporating "security" and "ethical" dimensions into their core processes.

The main focus of this paper will be on understanding the dimensions of "corporate governance" and "ethical promotion" for global enterprises with emphasis on copyright mechanisms and "ethical agency".

2. INFORMATION ETHICS

Information ethics is the field that investigates the ethical and moral issues associated with the development and application of information technologies in different domains. While it has been regarded as the theoretical foundation for "computer ethics", the focus of information ethics tend to be oriented towards addressing information privacy and confidentiality, data and application misuse, content management and web based interactions, online information authorization and verification, confidence building, resource sharing and the life cycle of information especially ownership, copyright and digital divide.

However, the continous organizational, institutional and operational transformations associated with the use of global networks are challenging enterprises to strike a balance between "information-sharing" and "information protection" and to effectively manage the ethical dimensions that govern the dynamics of "confidence" and "control" in pursuit of improving the capcity to develop and use alternative methods of "information distribution" and "information encryption". Building confidence as an ethical virtue, also demands enterprises to create "balanced and flexible" institutional measures and procedures that appropriately make this virtue "the responsibility of all".

The issue of content management and regulation are also becoming intensively ethics-related considerations. This is because the dynamics of "global access" demands enterprises to maintain "long reach" interfaces on the one hand and promote "corporate governance" and conviviality on the other hand. The ethical dimension of universal access originates from the interplay of different "technological" and "situational" change agents that may result into "disorder" and "unethical" practices if not applied properly. The growing amount and multiplicity of data types, diversity of data structures, hetrogenity of information representation architectures, and the growing capacity of web based systems and portals to manipulate, in a way or another, the way information is being accessed and used are generating fundamental information ethics and moral considerations. Some content-management issues like multilingualism, semantic and ontological considerations are introducing additional ethical dimensions and are acting at the same time as determinants for striking a balance between "access" and "sustainability".

The concern for information ethics especially for global enterprises originates from a set of reasons:

1. Competition in the global market is becoming increasingly resource-based, responsive and knowledge-intensive. The critical success factor for global enterprises, in this regard, is to effectively provide clients an integrated interface. Because global competition is dictating new axioms for the diffucion of technology, the question of information ethics emerges because the mechanisms of information use and protection significantly affects the capacity of enterprises to build international alliances.
2. Globalization processes increase the importance of information ethics because they lead to fundamental structural changes offered by the opportunities and threats available in the operating environment of enterprises and the growing importance of increased application and integration of advanced information and communications technologies into core business processes.
3. The emerging multiple formats and uses of information for web based processing and interaction requires continual reconsideration of ethical principles and how these codes are being adopted and applied. This is because information ethics influence personal decisions, professional practice, and public policy (Elrod & Smith, 2005).

3. MANAGING INFORMATION ETHICS

Because the nature and magnitude of "information ethics" is usually viewed within the context of a "networked" intersection of organizational, institutional, technlogical, cultural and political variables (Rafael 2000), alternative approaches and measures are being adopted over time to manage the issues associated with "information ethics".

The development of information and communications infrastructure has been widely used to "safeguard" information ethics by using robust, global, broadband and high-capacity processing platforms including the internet, Integrated Broadband Networks (IBN) and Integrated Services Digital Network (ISDS) (Manuel, 1996). However, the majority of these technology-centered interventions continued to be oriented towards maintaining, improving and promoting ethics by emphasizing on reducing security and ethical threats and to some extent, improving privacy.

A wide range of multiple legal measures are also being used as means for maintaining information ethics in enterprises such as Article 12 of the Universal Declaration of Human Rights, The UN Guidelines for the Regulation of Computerized Personal Data Files (1990) and the guidelines of Fair Information Practices. Howevere, the "sole" use of legal measures is challenged by the difficulty of maintaining acceptable levels of applicability between national laws and international legal frameworks. Such difficutlies have made global enterprises to continuously face difficulties with regards to developing effective customer relations' management systems, building effective international business alliances and meeting the operational requirements of global processing.

As a part of formal protection, intellectual property rights, copyrights, patents and trade marks proved to be effective mechanisms for securing information ethics within the context of collaborative global connectivity. A system of intellectual property rights (IPRs) is necessary to ensure that individuals or companies will carry out innovative activities otherwise imitation will erode the inventor's profit rate, and hence lower the incentive for inventive activities. An IPR, such as a patent, grants the inventor a legal monopoly to the commercial exploitation of the invention (Bekkers, et al 2002).

Through patents, for example, an IPR system enables the monopolization of inventions (for different time periods in different counties) in accordance with their satisfaction to certain country-specific and sometimes international requirements that qualify them for protection. The invention has to be new, involve an inventive step and be capable of industrial application. This means that nobody can carry out the invention claimed in the patent without express permission from the patent owner (Kennedy 2002). Despite the universal applicability of intellectual property rights, emphasis continued to be made on the decisions whether or not to patent using intellectual property rights based on a variety of decision attributes in pursuit of ensuring flexibility through flexible copyright modification and customization (Bulut & Moschini, 2006; Anton & Yao, 2004; Denicolo & Franzoni, 2004).

Despite the considerable benefits of such mechanisms, their efficiency in meeting the challenges posed by globalization tend to be questionable at least if they are not used collectively. While some efforts are done to examine the relationship between the use of copyrights and the process of building global alliances, little have been done to investigate their impact on the capacity of enterprises to benefit from technological developments and use of alternative intelligent (and other) frameworks to implement web based global trasactions especially when software agents' technology is being used and their resulting "moral and ethical" agency dimensions.

4. THE DOMAIN OF MORAL/ETHICAL AGENCY

Information ethics are strongly affecting the management of decentralized operations, building of alliances, enhancing coordination and sharing functionalities among web based applications. In addition, they have also been affecting the way enterprises are developing and using platforms for the "management of complexity" and enhancing "corporate governance".

Howevere, while enterprises are implementing decentralized activities through delegation and empowerment, the growing deployment of e-services and processing has motivated the use of "software agents" as means for supporting or acting on behalf of their "owners" or "users". The use of agent-based systems technology is growing in different domains because of their ability to offer modularity and abstraction necessary for facilitating the management of real, complex, large, and unpredictable problem domains (Tagelsir, 2006). Their deployment in different areas proved their relevance to handle complex, distributed problems involving a multiplicity of interconnected processes whose solutions demand the allocation of fusion of information and expertise from demographically distributed sources (Power 2000; Iglesias, et al, 1998). Especially in distributed environments where decision making data tend to be decentralized and the need for global control of the entire system increases, software agents must be able to interoperate cooperate and coordinate with each other in peer-to-peer fashion to increase their problem-solving scope through the use of multiagent mechanisms. Multiagent systems approach problems through the development of functionally specific, and possibly heterogeneous specialized modular components (agents) to solve particular problems by using their own most appropriate problem solving paradigms and interact in order to reach an overall goal and support different people (using different information sources and communication links), at different times, with different software tools and techniques. They generate approximate solutions by dividing the necessary knowledge into subunits, associating an intelligent independent agent to each subunit, and coordinating the overall agents' activity.

The context of "moral agency" tends to be oriented towards the conceptualization of information ethics of "mobile" multiagent systems by approaching the matter within the domain of "ethical decision making". The ethical principles that govern agent interactions and functionalities greately reflect the patterns and approaches used by their "owners" and "users" to conceptualize and justify their actions as either ethical or not.

However, by generally defining "ethics" as being doing with making a principle-based choice between competing alternatives, the use of multiagent systems provides different characteristics for the resulting "ethical dilemma" and "ethical decision making". The difficult task in this context is to approach the problem "logically" and make decisions based on well-reasoned, defensible "ethical principles", value judgments, and (formal & informal) guidelines. The emphasis on "deontology", articulation of rights, the definition of professional relationships and efficacy as means for maintaining confidentiality and impartiality and the adoption of different types of consequentialism (egoism, utilitarianism, and altruism) may all be necessary for approaching information ethics within the context of intelligent agent interactions.

The context of moral agency tend to be oriented towards examining the "morality" of artificial agents, cross-agent interaction in the infosphere and the problems arising from the life-cycle i.e., creation, collection, recording, distribution, and processing of information especially ownership and copyright, digital divide (Wikipedia website).

The issues of ethical or moral agency takes place clearly in multiagent mobile systems rather than single or limited-agents systems whose functionality is governed by limited boundaries of processing and information sharing and use. Within this context, the potential of ethical dilemma exists in two situations:

a. Because mobile agents interact with other agents outside the entire multiagent organization either to access databases or carry out transactions on other servers, an ethical dilemma may exist when:
    1. The mobile agent, either deleibrately or not, reacts (in a way or another) to the ethic-oriented dimensions of technology that characterize its use in different sirtautions such as amplification, routinization and sublimation. The ethical dimensions associated with such technological attributes stems from their ability to improve the sensory and interception ability of the entire mobile agent through the use of use of zoom lens, listening devices, and heat-detection toolsas well as their ability to "sustain" unethical actions and complicate their detection. All of these concerns increase the potential of an entire mobile agent to find "escape gates for bad unethical behaviour".
    2. The agents "visited", "interacted" or "consulted" by the entire mobile agent bring it into the "trap of unethical domain". These actions range from denying access, wrong-directing, and arresting, among others.
b. Despite the fact that the functionality of the entire mobile agent is governed by the processing and communication models incorporated into its knowledge and inference engines, it became confused about "what to do" when it finds itself faced by critical situations that are not predefined. And this brings to attention the basic question regarding the level of "autonomy" to be provided to the mobile agent and its ability to use its sensing abilities to "adjust its behaviour" in response to the changes taking place in its environment. It also has to do with the type of "ethical decision making" principle adopted by its "owner" or "user" and whether alternative paths of action or decision making models are allowed, whether the agent can "consult" with other agents in its entire multiagent organization, whether it returns back to the owner or user or commit unethical actions and justify them using the egoism principle.

But will the use of intellectual property right systems (including copyrights, trade marks and patents) "relaxes" or "complicates" the resolution of the resulting ethical dilemma? Will the actions committed by the entire mobile agent (irrespective of

their type and magnitude), be regarded as "ethical" or not? While the analysis of such dilemma remains "situational" and "domain-specific", at least providing an "yes" answer to the above mentioned questions remains questionable keeping in mind that the functionality of "mobile" multiagent systems remains governed by a complex cause-effect and reasoning context. However, the "reluctance" to have a "yes" originates from the fact that while the use of "databases and resources" copyrighting, encryption and other forms of information protection may "organize and regulate" the capability of the entire mobile agent to migrate across different servers, but it also encourages the "hosting" agents residing on these servers to bring the "visiting agent" into the ethical dilemma. Because the management of websites these days is becoming increasingly sensitive to breach of information privacy and confidentiality (and even political ones associated with war against terror), the continous change of website addresses or encryption keys may provide a room for unethical actions.

5. INTELLIGENT INTERACTIONS AND ETHICAL AGENCY: DIRECTIONS FOR RESEARCH

Because the use of web based inteligent frameworks are witnessing a growing deployment and infusion in core processes of global enterprises, the emphasis on the context of "information ethics" and the use of alternative mechanisms to regulate information access and use, special attention need to be directed towards some key research issues such as:

1. To avoid the downside risks associated with the use of copyrights and other intellectual property mechanisms and their impact on potential "unethical" agency, a "structrual" paradigm shift is looming very big. The refinement and orchestration of such mechanisms used to expand their focus beyond "lawful thinking" to move a step forward and incorporate "implementation" requierements and benefiting from the outstanding capabilities of the emerging technologies. Without such a shift the "conceptualization" of the domain of "information ethics", ethical agency and accordingly "operationalizing concepts" through acceptable implementation will not go hand-in-hand.
2. While the use of intelligent agents will continue to act as a major "enabling" platform for global interactions, the context of "ethical agency" need to be "mirrored" against threats associated with global collaboration, preception of such threats by decision makers and enterprises, attitudes towards using multiple approaches for the maintainance of "ethical" domains, and most importantly, the ability to couple and decouple mechanisms as the situation changes. Without such integrated thinking our ideas about information ethics in general and "ethical agency" in particular will remain a "cry in the desert", not implemented even if it is heared by someone because, simply, it is "scattered".

6. CONCLUSIONS

The question of information ethics is gaining momentum attention and importance within the context of global trasactions due to the complexities associated with the information-based migration of enterprises to "global trajectories". While such ethics are significantly and directly affecting some industries such as digital products (software, entertainment and libraries), their impact on others is also growing. However, the "isolated" implementation of technological and legal measures has been challenged by a wide range of considerations. The use of "intelligent agents" as a backbone concept for the implementation of global transactions, task coordination and information sharing among enterprises increases the importance of understanding "ethical agency" in a way that allows for an "acceptable" degree of integrated thinking that foucsses not only on "potential threats" and "unethical actions" but also to set the foundation for generating a process-technology matrix to guide implementation.

REFERENCES

1. D. J. Power (2000). Web based and Model Driven decision support systems: concepts and issues, proceedings of the Americas Conference on information Systems.
2. E. Elrod and M. Smith (2005). "Information Ethics", in *Encyclopedia of Science, Technology, and Ethics*, ed. by Carl Mitcham. Vol. 2: D-K (1004-1011). Detroit: Macmillan Reference USA.
3. Gabriela Kennedy. E-learning: Intellectual Property issues in E-learning, Computer Law & Security Report, Volume 18, Issue 2, 31 March 2002, pp. 91-98.
4. Harun Bulut and GianCarlo Moschini. Patents, trade secrets and the correlation among R&D projects, Economics Letters, Volume 91, Issue 1 , April 2006, pp. 131-137
5. Iglesias, C., Garrijo, M., Gonzalez, J, A survey of agent-oriented methodologies. In Muller, J. P.,, Singh, M. P., and Rao, A. S., editors, *Intelligent Agents V – Proceedings of the 1998 Workshop on Agent Theories, Architectures and Languages.*
6. J.J. Anton and D.A. Yao, Little patents and big secrets: managing intellectual property, *RAND Journal of Economics* **35** (2004) (1), pp. 1–22.
7. Manuel Castells, the Information Age: Economy, Society and Culture, Vol I: The Rise of the Network Society (Oxford: Blackwell Publishers, 1996).
8. Rafael Capurro. Ethical Challenges of the Information Society in the 21st Century, International Information & Library Review (2000), 32, 257-276.
9. Rudi Bekkers, Bart Verspagen and Jan Smits. **Intellectual property rights** and standardization: the case of GSM, Telecommunications Policy, Volume 26, Issues 3-4, April-May 2002, Pages 171-188
10. Tagelsir M. Gasmelseid. Web based Decision Support Systems for Global Enterprises: an architectural Blueprint", *Journal of Engineering letters,* 13:2, 2006, pp. 173-184.
11. V. Denicolo and L.A. Franzoni, Patents, secrets and the first inventor defense, *Journal of Economics and Management Strategy* **13** (2004) (3), pp. 517–538.
12. Wikipedia Website. http://encyclopedia.thefreedictionary.com/Information+ethics, accessed Oct 3, 2006.

The Impact of an ICT Project (Health Information Systems Programme) on the Work Practices of Health Workers in Primary Health Sector: A Case Study from India

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ABSTRACT

Health care sector is very complex and different from other sectors due to the high level of unpredictability in processes. For ex, an epidemic might break out, or emergency situation may suddenly occur and totally change the schedules of trajectories. The available resources in terms of drugs and equipments might also affect the articulation of work. Articulation here refers to collaboration and reaching common understanding(Strauss et al 1985) which is imperative in this field. Hence trajectories are not simple and linear. Introducing computers and implementing health information management systems requires new work routines and practices which are quite challenging(Boulus,2004). As pointed out by Nina Boulus(2004) changing work practices and improving management information systems are not singular elements but rather part of a large heterogeneous socio-technical network that includes arte facts, tools, people and other socio - cultural factors etc. Also she views the transformation process as a mutual, dynamic and reflexive transformation of both information infrastructures and situated practices of use. While the typical focus of training programs during the process of implementation of HIS is their technical content, many practitioners have demonstrated that social factors could be instrumental in the target system's success as the positive outcomes afforded by user training and adoption of the system are improved user attitudes, behavior, and performance. Thus to make the ICT projects sustainable it is essential that social factors along with technical issues are given importance during the process of implementation as ultimately the technology intervention has to get integrated into the existing work practices of the people in the organization thus leading to the establishment of new routines which will support the institutionalization of this technology- induced change. Using narrative method this paper will not only highlight the work culture that existed before the intervention of an ICT project but also how the work practices changed slowly during the process of an ICT intervention, and the different challenges (technical, social, geographical and political) faced both by the implementation team and the users in bringing about a change in the work culture of health workers based at the community level is described.

INTRODUCTION

Information and Communication Technologies, variously called ICT4D, i4D, or ICT, for Development interventions have demonstrated tremendous transformational potential for the developing world in e-government, telemedicine, e-learning, and other grass roots initiatives. (Sood, 2002).

There is enthusiasm in the development community over the great potential for ICTs as it is believed to alleviate the social and economic problems of the developing world (d'Orville, 2000; Allen & Thomas, 2000). A special challenge would be how to reach out to the poor and marginalised particularly women and make sure that they are not excluded from the emerging information society (Ekenberg & Asker, 1999). In order to bring about a realistic ICT profile particular to a rural community this implies that the starting-point for ICT use must be the people needs (d'Orville, 2000; Mansell, 1999) which can be identified by using a participatory approach.

Many approaches to using ICT for development have exposed the failure of top-down, one-way, non-consultative, technology-driven approaches to development communication (O' Farrel, 2000). Thus, developing appropriate ICTs (i.e. a framework) for sustainable development is, therefore, quintessential.

In health sector electronic information systems are revolutionizing health-care practice, research and education. Many health-care professionals realise the need for skills in finding and using information, and in assessing information systems since information is a critical ingredient for development. The more information that the poor and the marginalized possess, the greater their sense of empowerment.

With greater information particularly in health sector the health workers and the other staff based at the grass root level are better able to organize health care and take immediate and appropriate actions to improve the quality of health care services.

In this paper I try to describe how a contextual intervention of an ICT, Health Information Systems Programme (HISP) an action research project for mainstreaming and strengthening health information management at the district level is introduced to bring about changes in the work culture of health workers based at the community level.

Information and communication technology (ICT) continues to have a significant impact on the lives of people as its impact weaves through the cultural, psychological, political, sociological dimensions of human/social existence -- to spiritual and cultural values. The critical influence on people's responsiveness to change probably is its social attitudes, religious beliefs, and culture.

(In the present paper, the empirical data presented has been collected from Kuppam, a small area with nine Primary Health Centres(PHCs) spread over five mandals(administrative divisions) in Chittoor district in Andhra Pradesh, a site where the project was piloted and later was in the process of achieving sustainability).

The case study presented below apart from describing the impact of an ICT project on human behaviour also provides us a deeper understanding of the socio technical aspects of the complexities and challenges that emerge from the implementation of the HISP, an ICT project which is important from an anthropological perspective.

WORK CULTURE THAT EXISTED BEFORE THE INTERVENTION OF HISP

Before the intervention of the HISP it was found that PHCs which were supposed to provide both prevention and out reach services were instead burdened with achieving targets related to performance indicators such as immunizations, Ante Natal Care(ANC) registrations, ANC check ups, institutional deliveries,

sterlisations etc as there was an extreme pressure from the health authorities on health staff particularly on the Multi Purpose Health Assistant(MPHA)based at the grass root level to achieve the numbers fixed by them without taking in to account the ground realities.

Since the MPHA is the main link between the primary health care and the community in the rural areas extreme pressure is exerted at the health worker in fulfilling the targets. So, ultimately the health worker who is required to do outreach services and provide services to the communities instead neglects her duties and gets fully involved in completing the targets 'by hook or by crook'. As a result there is lot of manipulation in the data collected and collated at all levels.

Some of the elder MPHAs reminisces that during seventies and early eighties the focus of PHCs was only on providing services to the community. But in recent years with the focus on targets on important performance indictors the concept of primary health care has changed and the stress is only on figures that is, quantity and not on service.

For years the usual routine of work the MPHAs have been doing is that after performing the outreach services in the community the entries are made against the services provided in the field diary. And on reaching home instead of copying the figures from the diary in to the respective fourteen registers maintained for each service they postpone the above work to the day when review meeting is held in PHCs.

On the review meeting day the figures are entered in to the various registers maintained for each service and then they are culled out again to prepare different reports for different services though it is tedious and monotonous. More over in this pattern of work they find it quite easy to change the figures in the last minute to match the targets given by the medical officer before they can submit those forms to the supervisor on the review meeting day.

But during the intervention of the Health Information Systems Programme (HISP) commonly referred to as computer project among the health workers which was implemented in all the 9 PHCs of Kuppam, jointly done by University of Oslo, Norway and Government of Andhra Pradesh, the implementation team explained how HISP in the long run will benefit the health workers by reducing the work pressure by not entering data in to many registers but only in one or two forms in the DHIS(District Health Information Software) installed in a computer and how the data can be analysed and converted in to information.

INITIATING A CHANGE IN WORK PATTERN THROUGH HISP

Attempts to Mainstream Information Systems in Health Sector

Keeping in view the main objectives of HISP and the work pattern that exists within PHCs in the broader socio political context it became imperative to initiate efforts in changing the work culture of the health staff within PHCs and also to bring about the changes in the district medical and health office at district head quarters.

DATA ELEMENTS AND REPORTS

Before attempting to introduce change in the work practices of health workers initial months were spent in Chittoor district trying to understand the structure and functioning of both district and primary health units, information flows, different arte facts and tools used for data collection, reporting structure and formats. Based on the information attempts were made to develop minimum data sets by removing redundant data elements.

Similar to the redundant data elements was the practice with the reports. After discussing with officers in charge for various programmes and making them see the uselessness and waste of efforts of sending repeated reports containing duplicated data efforts were made by implementation team to reduce the number in the reports sent from district to state.

Simultaneously efforts were made to set up the necessary infrastructure by placing computers in all the 9 PHCs of Kuppam constituency for initiating change through DHIS (District Health Information System),an open source software for improving their routine health information processes since more than 60% of the time of health workers is spent on health information transactions (collection of data, collation of data in various forms and registers, and the transmission of data to upper levels of district and state). It was also considered that improving these processes will then directly have an impact on work, and the health staff can focus more time on providing care to the community as compared to filling

Figure 1. Map showing Kuppam constituency with five mandals and nine primary health centres

up endless forms that ultimately are marginal to their work of providing health care to the community.

So, keeping in view the above perspective 'On-site' and 'Off-site' training strategies were devised in order to build the capacity of health workers to work independently on the HIS software. Initially the trainers and the health staff had many problems on both sides -teaching as well as learning.

After lot of motivation and continuous training from the implementation team and the pressure from the officials at the different levels finally there were quite a number of medical officers and health staff including MPHAs, MPHS, pharmacist and lab technicians from different PHCs who managed to learn the computers, DHIS software and the generation of reports. Slowly this pattern of work became a routine and health staff enjoyed their new work culture as it not only reduced their work load and efforts but they were getting empowered with new skills. Moreover this training helped them to build capacity for dealing with health information, and enabling a culture of "use of information."

Both with peer pressure and through word of mouth the attitudes of their colleagues also changed and all the staff in their respective PHCs dutifully started using computers and DHIS software for entering data, doing analysis and generating reports.

Eight months after the project was initiated in Kuppam it was evaluated by the office of Commissioner of Family Welfare Department(CFWD) who gave instructions to the DM&HO to institutionalize HISP.

We assumed that as in any developing country more so in the rural areas the computers, free software and the free training on the software would be a welcome feature but there were many constraints and resistances which were not obvious initially but were very subtle and strong in nature to overcome them.

DIFFERENT CHALLENGES ENCOUNTERED WHILE INTRODUCING CHANGE IN THE WORK CULTURE OF HEALTH WORKERS

Apart from the different challenges faced by the implementation team such as power dynamics and social politics within PHCs not allowing the grass root workers learn computers and acquire new skills, too many meetings and workshops focused on achieving the targets sapped the time and energy health workers, hardware problems & problems of power supply which hindered the training programmes, gender concerns and the most important issue was that of the refusal of statistical officer in the DM&HO to learn computers and DHIS software thus putting all the efforts of HISP implementation team and the sanction from CFWD to institutionalize HISP at stake.

In spite of all the challenges faced both by the implementation team and the users in adopting the technology there was a positive outcome in terms of users adopting and using the technology in their work practices. The users particularly those based at the primary health centres (MPHAs, MPHS and in some cases medical officers, lab technicians and Pharmacist) started to use computers and DHIS in their daily work. The above case study delineates how new technology affects and interacts with the various actors and vice versa indicating a mutual interaction process.

But whether the impact of an ICT project lasted long enough in their work practice bringing about a change in their work culture is a point for discussion which needs to be discussed separately.

REFERENCES

1.Allen, T., & Thomas, A., (2000) Poverty and Development into the 21st Century, Oxford: Oxford University Press.

2..d'Orville, H., (2000) Knowledge and Information – New Levers for Development and Prosperity in the World Economy of the Future, IT for Development Programm Bureu for Development Policy, Choices,UNDP.

3.Ekenberg, L. & Asker, L. (1999) IT in Swedish Development Co-operation Suggestions for Ways of Including the Low-income Countries, The Swedish Ministry for Foreign Affairs and Sida, ISBN 91-586-7749-6, Stockholm.

4.Mansell, R. (1999) Information and communication technologies for development:assessing the potential and the risks, Telecommunications Policy 23: 35 – 50.

5.Nina Boulus (2004) Managing the Gradual Transition from Paper to Electronic Patient Record, Department of Informatics, University of Oslo, Norway(Unpublished Masters Thesis).

6.O' Farrel, C., Norrish, P. & Scott, A. (2000) Information and communications technologies for sustainable livelihoods, SD dimensions. Available: http://www.fao.org/sd/cddirect/CDre0055d.htm [March 19, 2003]

7.Sood, A, D (2002). "Guide to ICTs for Development", Center for Knowledge Societies, Bangalore

8.Strauss et al (1985) Social Organization of Medical Work, New Brunswick, NJ and London: Transaction Publishers,1997. First published in 1985 by The University of Chicago Press.

ENDNOTE

* The empirical material for the above case study was collected during my association with HISP project as Project Coordinator, HISP India from January 2001 to April 2005.

Dynamic Security Scheme for MANET

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ABSTRACT

Secured communication in mobile ad hoc network is a crucial issue due to dynamic nature of the network topology. Due to lack of centralized control, issuing certificates from a centralized certification agent is not possible in ad hoc network. The major problem in providing security services in such infrastructure less networks is how to manage the cryptographic keys that are needed In MANET any node may compromise the packet routing functionality by disrupting the route discovery process.. These unique characteristics of mobile ad hoc networks causes a number of nontrivial challenges to security design such as open network architecture, shared wireless medium, stringent resource constraints and highly dynamic topology. These challenges make a cause for building multi-fence security solution that achieves both extensive protection and desirable network performance. In particular, the absence of a central authorization facility in an open and distributed communication environment is a major challenge, especially due to the need for cooperative network operation. We propose a novel cluster based security scheme to protect mobile ad hoc network link layer and network layer operations of delivering packet over the multihop wireless channel. The dynamic network topology can be managed efficiently by the proposed cluster based architecture. A well-behaving node becomes a cluster member after the initial trust verification process. The membership validity period of a node depends on how long it has stayed and behaved well. Non overlapping clusters are created using the dynamic cluster creation algorithm. The cluster construction is fully distributed so efficiency is not degraded by node mobility.

Keywords: Cluster, Denial of Service, MANET Security.

I. INTRODUCTION

In ad hoc network every node is self-organized and each node can communicate directly with other nodes in the network through broadcast radio transmissions, i.e., transmissions that reach all the terminals within the transmission power range. However, due to radio range limitations, physical broadcasting does not cover all nodes in the network. In multi-hop scenario, packets are relayed by intermediate nodes to reach the destination. Applications of mobile ad hoc networks can range from military field communications, where networks must be deployed immediately without the support of base stations and fixed network infrastructures, to inter-vehicle communications, designed for both traffic safety enhancement and entertainment purposes. The ultimate goal of the security solutions for mobile ad hoc network is to provide security services, such as authentication, confidentially, integrity, anonymity and availability to mobile users. In order to achieve this goal, the security solution should provide complete protection. We seek to protect the network connectivity between mobile nodes over potentially multihop wireless channel, which is the basics to support any network security services. Security never comes for free. When more security features are introduced into the network, it increases the computation, communication and management overhead. In fact, both magnitude of security strength and network performance are equally important, and achieving a good trade-off between two extremes is the basic challenge in security design for mobile ad hoc network. Fully distributed cluster based security scheme provides secure peer to peer communication without compromising the network performance.

The rest of the paper is organized as follows. Section II discusses a review of related work. Section III describes the security issues in MANET. Section IV discusses the fully distributed cluster based security topology. Section V describes the dynamic clustering algorithm. Section VI discusses the performance issues. Section VIII concludes the paper.

II. RELATED WORK

The traditional key distribution protocols rely on infrastructure with online trusted third parties. When the users want to establish secure communication among them, each one of them has to obtain a new session key from the key distribution center. There is also number of schemes extending this approach to ad hoc network. [5] Present a hierarchical framework and key distribution algorithms for dynamic environment, with a focus on how keys and trust relationships are transferred when users move between so-called "areas" in the hierarchy. When distance vector routing protocols such as AODV [4] are used, the attacker may advertise a route with smaller distance metric than its actual distance to the destination or advertise a routing update with a larger sequence number and invalidate all the routing updates from other nodes.

Broadcast can be limited by adjusting the TTL value on each transmission is disused in [1]. The rapid proliferation of wireless networks and mobile computing applications has changed the landscape of network security. The traditional way of protecting networks with firewalls and encryption software is no longer sufficient and effective. The first key pre-distribution scheme is given in [6].

Carmen et al. analyzed a wide variety of approaches for key distribution in sensor network [3]. Study of recent literature reveals that reliable mathematical modeling of ad-hoc networks is gaining increased attention [7]. In [2], they considered the case when each node is its own authority and tries to maximize the benefits it gets from the network. Attackers are mainly outsiders of any security system, and such attackers can be resisted through authentication protocol [9]. Routing protocol intrusion detection has also been studied as a mechanism for detecting misbehaving routers [10]. Mobile agent based mechanism is used in [8] to detect the intruders.

In [10] fully distributed cluster based packet routing architecture is given. The feasible path to a destination is calculated using the QoS information available with each cluster members.

III. SECURITY IN MANET

In contrast to fixed networks a centralized certification authority is not feasible in ad hoc networks. Distributing the functionality of certification authority over number of nodes is a possible solution. This can be achieved creating n shares for a secret key and distributing them to n different node. Key can be generated by combining s shares using threshold cryptography technique.

Current ad-hoc routing protocols are completely insecure. Moreover, existing secure routing mechanisms are either too expensive or have unrealistic requirements. In ad hoc network, security solution should isolate the attackers and compromised nodes in the network. Proactively isolating the attackers ensures that they cannot continue to attack and waste the network resources in future. A security solution should have decreasing overhead over time when the network is in good condition without any attacks. By adopting the cluster based security scheme it cause less overhead as the network is in operation and proactively isolate the attacker as non cluster member.

IV. CLUSTER-BASED TOPOLOGY

We assume that self organized mobile networks are formed by a group of nodes having a valid identity (for example communication between the military officials or disaster recovery team). In our design each node is granted temporary admission into the network using an identity verification process. Each node generates a secret using the equation (1) and forwards it to the neighboring nodes. To verify the secret, neighboring nodes generates the covert using its identification number and compute the difference between the received value and the calcu-

lated covert. If the difference is less than the threshold value Sth, it accepts the sender as a valid member and add the sender node ID to set S. (S is the set of all valid neighbors and dynamic clustering algorithm uses set S to create non-overlapping clusters)

$$y = f(\vec{u}, cur - time) \quad (1)$$

After initial verification all nodes are continuously monitored by the neighboring nodes and credits are calculated based on the behavior of the neighbors. Watch-dog mechanism is used to monitor the neighboring nodes. A node accumulates its credits as it stays and behaves well in the network. The period of validity is propositional to its credits. Miss-behaving nodes credits are decremented; it will be denied network access when it reaches the minimum threshold level.

A. Probabilistic Clustering Model

It is possible to characterize this type of phenomena to which the poisson distribution is possible. T1, T2, T3 … Tn are the non-overlapping intervals, then the number of nodes entering into the cluster boundary in the interval is independent. There exists a constant q such that the probability of one event (exactly one node enters into the cluster boundary or leaves the cluster boundary) occurs in the interval of length dt is approximated to q*dt. The probability of two or more events will occur during an interval is approximately zero. So the experiment can be called as poisson experiment. For such experiment, if X counts the number of events occurs during any given interval, then it can be shown that X posses a poisson distribution. If the three poisson condition do hold and is X counts the number of events occurs during some specific time interval duration t, the X is poisson distributed with $\lambda = qt$.

$$P(X = x) = p(x; \lambda) = e^{-\lambda} \lambda^{x} / x! \quad (2)$$

The probability distribution function is

$$P(X \le x) = \sum_{k=0}^{x} p(x; \lambda) = \sum_{k=0}^{x} e^{-\lambda} \lambda^{k} / k! \quad (3)$$

E(x) is a parameter that carries information regarding the central tendency of the random phenomenon modeled by X. E(x) is often sufficient to give a partial description in terms of moments of the random variable. A moment generating function of a distribution can be employed to find the moments of the random phenomenon. Function of the variable t is defined as the moment of the random phenomenon X with respect to time t. The cluster topology changes can be represented using the random experiment X. The probability of nodes entering into the cluster boundary and nodes leaving a particular boundary can be calculated from the moment generating function.

Figure 1. Security architecture protocol stack

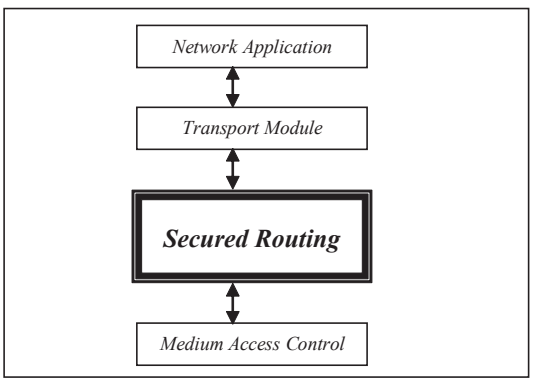


Figure 2. Framework of the network layer security

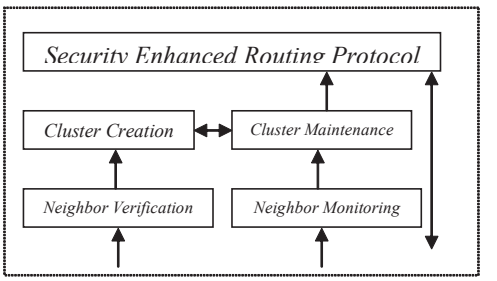


Figure 1 illustrates the protocol stack architecture of our security system. Figure 2 illustrates the composition of our security solution, which consists of five inter-related components.

B. Cluster Gateway Node Selection Process

MANETs can be modeled as an undirected graph with weight, G, G= [V, E] V, is the set of the mobile nodes and the E the set of the bidirectional wireless link. G and V are both dynamic set. An edge dominating set is a split edge dominating set if removal of D splits the graphs G1 and G2 into two sub graphs. The split domination number Dn is the cardinality of the dominating set.

Theorem 1

Let D be a split edge dominating set of G then

$$|E - D| \le \sum_{x \in D} \deg(x) \quad (4)$$

The equality holds if and only if the following conditions (a) and (b) hold.

a. D is independent
b. For each $x \in E - D$ there exits only one edge $y \in D$, such that $N^{I}[x] \cap D = \{y\}$, where $N^{I}[x]$ is the set of edges having exactly one vertex in common with x.

Proof:

Since each edge in $E - D$ is adjacent to at least one edge in D, it contributes at least one to the sum of degrees of the edge of D.

Hence $|E - D| \le \sum_{x \in D} \deg(x)$

Now let $|E - D| = \sum_{x \in D} \deg(x)$

Suppose D is not independent. Let x1 and x2 be any two edges of D having a common vertex. Then x1 is counted twice; once in deg(x1) and once in deg(x2). Then the sum of the degree of edges in D exceeds $|E - D|$ by at least two, a contradiction to the equality (6). Hence, D must be independent.

Now let $|E - D| = \sum_{x \in D} \deg(x)$ and (b) does not hold. Then $N^{I}[z] \cap D = \phi$ or $|N^{I}[z] \cap D| \ge 2$ for some $z \in E - D$. Since D is split dominating set the former case does not arise.

Let *x1* and *x2* belong to $N^{I}[z] \cap D$. Then $\sum_{x \in D} \deg(x)$ exceeds $|E - D|$ by at least one, since z is counted twice; once in deg(x1) and once in deg(x2), a contradiction. Hence if (a) and (b) are true then $|E - D| \le \sum_{x \in D} \deg(x)$.

If D is independent then D represent the set of gateway nodes that interlinks two clusters. So set of gateway nodes connecting two different clusters can be identified using equation (4).

Cluster creation module forms the non-overlapping clusters based on the valid neighbor set data. Gateway nodes are identified by the cluster maintenance module and all members maintain the list of gateway nodes. In dynamic network environment asymmetric keys can be used to encrypt/decrypt the data.

C. Cluster Maintenance

Cluster maintenance module proactively maintains the route information of all cluster members. There are three topology changes that requires cluster updation

Route discovery packets are forwarded only to the gateway nodes if the destination node is not in the same cluster. Our security system can operate in two modes. In normal mode route discovery packets are forwarded in plain text. Source announces its public key. Destination node can encrypts its data using source public key. For further data transfer symmetric keys can be used. In normal mode a passive attacker can view the path information during a data transfer. In fully secured mode in addition to data encryption the network layer packet header is also encrypted using the public key of gateway node along the path. In a shared wireless channel all neighbors hear the signal. But only the corresponding node can decode the coded signal using its private key. So information is never disclosed to unauthorized nodes.

V. IMPLEMENTATION

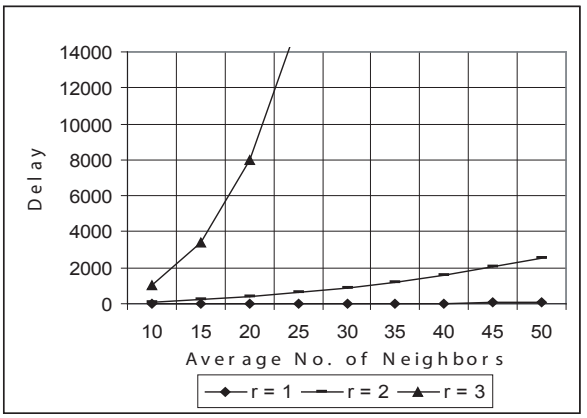
In order to provide scalability and to enhance the availability (by providing the service locally), the network is partitioned into a number of non-overlapping groups called clusters. In the conventional approach, each cluster has exactly one distinguished node, designated as cluster head, which is responsible for organizing and establishing the cluster. Cluster-head election algorithms are used to elect these cluster heads. The main bottleneck in this approach is the single point of failure (if the cluster head crashes, the entire QoS parameter table information will be lost), which forces the above procedure to be repeated for the construction of the QoS parameter table and subsequent election of the cluster head. To overcome the above problems, a fully distributed architecture is proposed. Clusters are created using a cluster creation algorithm and each cluster member maintains a QoS parameter table (about its cluster members) and a gateway table. Gateway nodes manage the communication with adjacent clusters. Routing is typically divided into two types: routing within the cluster (intra-cluster routing) and routing between different clusters (inter-cluster routing).

In this section, we present our algorithm and protocols that implement the localized security services and the self initialization of the mobile ad hoc networks. For the proposed clustering technique each node needs one or more hop connectivity information to execute cluster creation and maintenance algorithm. The cluster boundary or radius is adjusted based on the congestion factor of ad hoc network. The degree of the node is used as the congestion factor cf. If the congestion factor cf is grater than maximum threshold tmax (cf > tmax), it implies ad hoc population is very high consequently the hop count is set to one. If the congestion factor is between tmax and minimum threshold tmin (tmin <= cf <= tmax) it denotes the node is in a medium populated area consequently the hop count is set to two to create a strong connectivity. If the congestion factor cf is less than tmin (cf < tmin) it implies the node is in a sparsely populated area consequently the hop count set to three to maintain the strong connectivity.

Dynamic Clustering Algorithm

1. S: set of ID's of neighbors according to the hop count including the current node ID.
2. if (cur_id == msi(S))
   cluster_id = cur-id;
   forward to all nodes in set S (cur_id, cluster_id, location)
   S = S – {cur_id}
3. while (S != empty)
   on receiving neighbors(id, cid, loc)
   if (id == cid) and (cluster_id == UNKNOWN or cluster_id > cid) and (md == NOTSET or md > diff(cur_loc – loc)
   cluster_id = cid
   md = diff(cur_loc – loc)
   S = S – {id}
   if (cur_id == min(S))
   if (cluster_id == UNKNOWN) cluster_id = cur_id

Figure 3. Delay versus average no. of neighbors



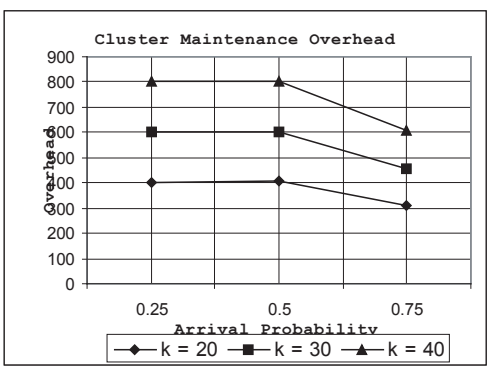
forward to all nodes in set S (cur_id, cluster_id, location)
S=S-{cur_id}

Using the above algorithm the non-overlapping clusters are formed based on the location of mobile nodes. The nodes, which are very close to each other, are grouped together. Each node maintains a route table with the QoS values and public key of all trusted cluster members. The algorithm is self-terminating and it leaves only the far-off isolated nodes as non-cluster members.

Neighbor monitoring is a lightweight process. It does not affect the normal functioning of a mobile node. For calculating the credit it simply listens to the packet forwarded by the nearby nodes. Using the message authentication code it checks whether the packets are relayed correctly by the neighboring nodes. Active attackers can be isolated using this mechanism. But another issue is in the shared wireless channel any node with in the transmission range of another node can receive the signals. So passive attackers can read all transmitted plain text data. To defend such types of attacks we propose a lightweight public key encryption method. The encryption and decryption process is done in the network layer. If network layer receives an encrypted packet, it decrypts the packet using its private key. If current node is the destination node, the data part is given to the upper layer. Otherwise according to the route table information find out the next node along the path to destination. Encrypt the packet using the intermediate node public key and send it. By this way we can protect the data from passive attackers also.

For cluster maintenance idle nodes periodically send a small alive signal to all trusted cluster members. If the update timer expires the corresponding node entry status in the route table is changed to down and it starts a wipe out timer. If the wipe out timer expires the corresponding entry is removed from the routable. If an alive signal or a data packet is received form that node before the timer expires then the status the node is revoked to up state and it restarts the update timer.

Figure 4. Cluster maintenance overhead



VI. PERFORMANCE EVALUATION

As the network topology changes dynamically, we considered a random topology for the analysis.

Let k denotes the average number of neighbors of a node. n is the number of mobile nodes in the network. c is the average number of members per cluster. Total number of messages replicated by a single cluster init message is

$$S_r = 1 + \sum_{i=0}^{r-1} k^i(k-1) \quad (5)$$

Where r denotes the radius of the cluster in number of hops. Rr nodes receive and process the cluster init message.

$$R_r = \sum_{i=0}^{r-1} k^i(k-1) \quad (6)$$

Figure 3 shows that as number of neighbors increases the processing overhead increases which in turn increases the packet transmission delay. Value of Rr is directly proportional to r and k. In ad hoc network topology changes dynamically. So k varies dynamically and it is not possible to control the topology change in ad hoc network. To have strong connectivity the cluster radius has to be increased. If r increases then the transmission delay increases exponentially. So without losing the connectivity we have to reduce the radius r. if number of neighbors' increases then r can be reduced without affecting the connectivity. If r decreases then transmission delay decreases. The cluster radius can be adjusted according to the value of k to maintain the connectivity and to reduce the transmission delay. If k is grater than the maximum threshold (tmax) then r can be set to one. If k is less than the minimum threshold (tmin) then r can be set to three. The maximum and minimum threshold values can set according to the other external parameters. If value of x is between tmax and tmin then rcan be set to two. The cluster initialization overhead can be maintained at an optimum level without losing the connectivity by adjusting the values of k and r.

For cluster maintenance each cluster member needs to forward the new information to all other cluster members. If a cluster member leaves the network, the trusted cluster member who identifies the change must inform this to all other members. A misbehaving node can also send a similar message to all other cluster members. But to prove the identity of the sender the trusted cluster member can encode the data using its private key. All other member maintenance the public keys of other trusted members and the data could be decoded using the corresponding public key. If a new node enters into the cluster boundary, it calculates the congestion factor. Based on the congestion factor it calculates the hop count and it executes the dynamic clustering algorithm. The cluster maintenance traffic overhead varies based on the arrival of new cluster member and departure of existing cluster members. Let Pnew is the new cluster member arrival probability. Let t is the traffic overhead per link. The overhead created by the arrival of new nodes is N.

$$N = Pnew\ [t(1 + 2\ r\ k)\ ] \quad (7)$$

Normally the probability of arrival of new cluster members increases as the node congestion increases. In our approach to maintain the connectivity, the cluster radius r is adjusted according to the congestion factor. So value of r decreased as Pnew increases. Figure 4 show that cluster maintenance overhead due to arrival of new cluster members does not increases as the new cluster member arrival probability increases.

$$c = r\ k \quad (8)$$

The control message traffic overhead for cluster maintenance is in o(c2). Even though the number of nodes in the network increases c remains almost constant because the cluster radius is adjusted according to number of nodes. c dose not increases as n increases. The control message traffic overhead does not increase as the number of nodes in the network increases. So this approach is scalable.

VII. CONCLUSION

Most of the proposed routing solutions are, as yet, incomplete when it comes to security issues. We can trust a routing mechanism only when it guarantees that all transmission will be protected. In this paper we proposed a novel security based routing protocol in which the packets are routed only through the trusted members. The trust factor of a mobile node is verified and monitored by neighbor verification and neighbor monitoring modules. Based on the calculated credits other cluster members maintain their routing table. In fully secured mode all transmissions are protected by encoding the network layer packet header in addition to data encoding. In the sheared wireless channel all neighbors hear the signal but only the corresponding router can decode the packet using its private key. Analysis shows that the secured cluster creation and maintenance overhead does not increase as the network size increases. This scheme is more efficient in terms of the resultant routes establishement, resource reservations, and computational complexity. If multiple malicious nodes collaborate, they in turn will be restricted and isolated by their neighbors, because they monitor and exercise control over forwarding RREQs by nodes. Hence, the scheme successfully prevents Distributed DoS (DDoS) attacks. Future works includes the implementation and testing of the algorithm in real environments.

REFERENCES

[1] E.M Belding-Royer, "Hierarchical routing in ad hoc mobile networks" Wireless Communication & Mobile Computing, vol. 2, no. 5, pp. 512 – 532, August 2002.

[2] L. Buttyan and J.P Hubaux, "Stimulating cooperation in self-organizing mobile ad hoc networks," ACM/Kluwer Mobile Networks and Applications, vol. 8, no. 5, pp. 579 – 592, Oct 2003.

[3] D.W Carman, P.S. Kruns and B.J Matt "Constraints and Approach for Distributed Sensor Security", NAI Labs Technical Reports, Sep 2000.

[4] Charles E. Perkins, Elizabeth M. Belding-Royer and Ian D. Chakeres. "Ad Hoc On-Demand Distance Vector Routing" Mobile Ad Hoc Networking Working Group, Internet Draft, Oct 2003.

[5] B. DeCleene, L. Dondeti, S.Griffin, T. Hardjono, D. Kiwior, J. Kurose, D. Towsley, s. Vasudevan and C. Zhang. "Secure Group Communication for Wireless Networks", in proc. IEEE MILCOM01, Oct 2001.

[6] Y. Desmedt and S. Jajodia, "Redistributing secret shares to new access structures and its applications," George Mason Univ., Tech. Rep., 1997.

[7] I. Glauche, W. Krause, R. Sollacher, and M. Greiner, "Continuum percolation of wireless ad-hoc communication networks," cond-mat/0304579, April 2003.

[8 C. Krugel and T. Toth, "Flexible, Mobile Agent Based Intrusion Detection for Dynamic Networks" Euro. Wireless, Italy 2002.

[9] K. Sanzgiri, B. Dahill, B.N Levine, C.Shields and E. Belding-Royer, "A secure routing protocol for ad hoc networks", in proc. 10th Int. Conf. Network Protocols (ICNP'02) 2002, pp 78-89.

[10] Nargunam A.S and Sebastian M.P "Fully distributed cluster based routing architecture for mobile ad hoc networks" In Proceedings of the first IEEE International Conference on Wireless and Mobile Computing, Networking and Communication (WiMob'2005) pages 383 – 389.

The Implication of Outsourcing Practices for Knowledge Management

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ABSTRACT

It is the aim of this paper to explore the nature of outsourcing and subcontracting practices and to identify the effects of using such policies for the accumulation and maintenance of knowledge in organizations. using evidence from, a case study research, conducted in three (3) medium size Tools industries, this study examines how outsourcing and subcontracting policies are set in practice and how the formation of such contractual inter-organizational relations affect the organizations as learning and knowledge entities) While it is argued that knowledge sharing between organizations requires mutual collaboration but also the construction of social environment, which promotes communication and sharing of cultures, it is shown in the research that contractors were not actually willing to share their expertise and their know-how. Additionally, the outsourcing of operations has affected the formation of people's identities in the organization and the will and ability of employees and managers to participate to the company's processes. It is therefore argued that outsourcing has reduced the absorptive capacity and the intellectual capital of the organization and has produced secondary negative effects such is organizational dependency from contractors and loss of the organization's ability to control and initiate innovation. The paper summarizes the findings within a model of 'vicious cycle' and suggests that outsourcing eventually leads to the addiction of .the organization to 'buy' expertise and knowledge, in order to fulfill short-term goals, instead of trying to acquire or create new knowledge.

Keywords: knowledge management, outsourcing, communities of practice

INTRODUCTION

The basic aim of the study is to show how the use of outsourcing policies (outsourcing, out tasking, subcontracting) affects the accumulation and circulation of knowledge in organizations and to elaborate a clear view .on how organizations deal with this relationship Although there is growing interest for the transformation of organizations into dynamic networks (Grandori & Soda, 1995) and the rhetoric of virtual enterprising gain attention (Hale & Whitlam, 1997), there is little interest so far for understanding the implications of the structural changes for knowledge management; organizational knowledge is treated in mos1 studies using the perspective of the traditional organizational boundaries despite the fact that· "it is certainly the case today that all organizations are being reformed and they an increasingly dependent on external sources of knowledge" (Quintas, 2002: 7). Despite the fac that some articles are concerned about the connection of outsourcing with organizational knowledge (Misawa & Hattori, 1998; Takeishi, 2002; Hendry, 1995) it can be argued that no much has been said about how outsourcing practices affect organizations, especially in term of knowledge management. The lack of such literature seems to be more important because c the increasing use of outsourcing and subcontracting by many enterprises (Chan, 199.::1 Hendry, 1995: 193; Johnson, 1997).

APPROACHING A DEFINITION FOR KNOWLEDGE MANAGEMENT AND OUTSOURCING POLICIES

Outsourcing

It is true that under the current neo-liberal model, in most capitalistic economies, organizations give a great importance in short-term results and neglect certain aspects of long-term planning (Whitley, 1999; Lazonick & O' Sullivan, 2000). Under this short-terms perspective, which has been often criticized as 'myopic', organizations have been increasingly using outsourcing and organizational networks in the last decade as a mean to manage their operations economically (Jarillo, 1988; 1993). It is actually shown in many studies that the reasons for using outsourcing policies are usually economic (Budros, 1999; Quinn, 1992; Jarillo, 1993) or knowledge oriented (Takeishi, 2002; see Chan, 1994 for a classification of outsourcing reasons).

By the word 'outsourcing', we mean the use of outsiders and contracted work or the use of an external agent's services in order to fulfill operations that should normally take place 'in-house' (Embleton & Wright, 1998; Laabs, 1997). As argued in Johnson (1997:4-6), the term 'outsourcing' can be considered as a big umbrella covering all forms of contracted work provided' by outsiders, although the word 'outsourcing' is usually used for information systems and facilities management projects (Vanson, 2001). Under this perspective, in this study the word outsourcing will be used to imply all forms of assigning work to outsiders such are formal outsourcing, out-tasking and sub-contracting. Summarizing the key elements from literature (Johnson, 1997; Hendry, 1995; Yakhlef, 2002).

Knowledge Management: The Social Dimension

This paper chooses 1£ adopt a social perspective of knowledge management. According to Sardari 2002 Tsoukas (1996), most Knowledge Management approaches are rather formistic. In fact, the streams of functional knowledge management (Nonaka, 1994; Nonaka & Takeuchi, 1995; Choo, 1998) or the supporters of intellectual capital theories (Boudreau & Ramstad, 1997; Bukh et al., 2001; Stewart, 2000; Edvisson & Malone, 1997).

Therefore, organizational knowledge is treated here as a projection of organizational life and as embedded in organizational norms and cultures (Teece, 2001: 126; Weick, 1995; see also Blackler, 1995 about encultured and embedded knowledge).

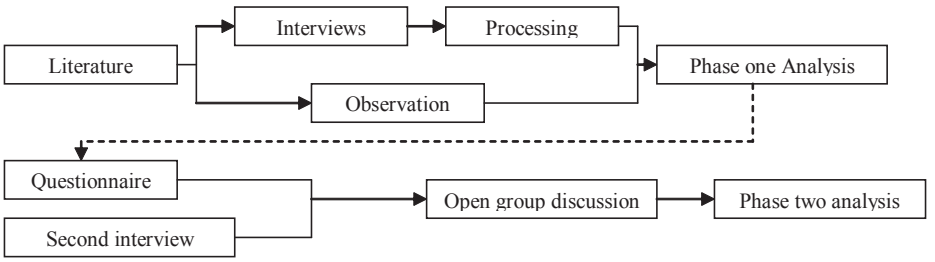
RESEARCH METHODOLOGY AND DESIGN

Our research was conducted following the principles of a 'case study' approach (Yin, 1994), and in fact it is based on a 'multiple case study' analysis (Eisenkhart, 1989). The case study approach has certain advantages, especially for knowledge management research. It provides the researcher great opportunities to explore deeply the organizational realities and to identify the reasons and causes of certain phenomenon (Yin, 1994; Blaikie, 2000:215). Additionally the case study approach allows the researcher to use a mix of qualitative and quantitative data (Yin, 1989; 1994; Stake, 1994), although "qualitative methods are of primary importance" (Gillham, 2000: 10). In practical terms, choosing to do a case study is to choose to search for an explanation of the organizational realities and phenomenon's and requires a process of reasoning. In fact, case study is not a technique but more or less a mode for organizing data and evidence (Goode & Hatt, 1952; Gillham, 2000), a perspective on how to see and explain social facts.

Amaratunga & Bauldry (2001) support the common idea that a complete case study research design should include a variety of research techniques, which could help the researcher, secure the conclusions and generalize the findings. In this research, the aim of the research design was to gather information from the interviewees from all tools companies and to return and cross check their first opinions with questionnaires and second interviews. Then a last open group discussion was designed to provide a final feedback from the organization about the issues that have arisen during the research.

Research has finally included three (3) medium sized tools companies and the sub- contractors. The subjects of research are summarized below:

Figure 1. Research process for all eleven Tools companies



OUTSOURCING PRACTICES IN THREE MEDIUM SIZED TOOLS INDUSTRIES

It has been seen that in all departments where operations are outsourced there has been a lack of effective communication (see Henrikssen, 1999 for similar case) between outsourcing companies' staff and the outsiders. In cases where contractors had to be present to the organization's environment (accounting consultants, software developers), sharing of knowledge was low while in cases where operations were taking completely outside the physical boundaries of the company, knowledge sharing was extremely low (sales and promotions, production). It is argued that geographical issues are also correlated with the low levels of knowledge sharing. It was also generally seen that all collaborations failed to be developed as partnerships of mutual interest and to assimilate a form of alliance (Doz, 1996; Mowery et aI., 1996). On the contrary it has been obvious that relations between staff and outsiders were focused on the contractual obligations; lack of time (McDermott & O'Dell, 2001) and the politics of contractors to protect their role and knowledge (Scarborough, 1995) lead to an important gap in communication. It is definitely the case that there was no will to exchange knowledge while the social environment would not assist such efforts.

A STUDY ON THE EFFECTS OF OUTSOURCING FOR ORGANIZATIONAL IDENTITIES AND KNOWLEDGE MANAGEMENT

Since knowledge management is treated as a social value and the accumulation of intellectual capital is well related with the quality of social capital (Stewart, 1997; Nahapiet & Goshal 1998),. In fact, the following diagram presents the effects that have been observed in the three (3) outsourcing companies.

INDIVIDUALS' IDENTITIES

A primary finding during the research in companies was that the outsourcing of certain activities had a dramatic effect on people and their identity in the organization. EmpJoye~5 and managers' role has become less important and people who were close to the processes ;n the past seemed to take a certain distance from the situation. Most of them expressed the concern that not only did they lose part of their power in the organization but that in a way they have been marginalized and have been unable to understand their role; a form. of alienation has been observed (Wheeler, 1996). It has been seen that the lack of effect communication with contractors caused the alienation of employees (Levinson, 1973)

Disintegration of Communication and Social Capital Pathology

It is arguable then that in PROEL, the traditional groups of people dealing with issues have been dissolved; teams with had the responsibility for doing the job have been replaced by teams from outside the firm (Lin, 2000). As analyzed in previous chapters, communities of practice require a certain degree of cohesion and must be concentrated on certain goals, to have a specific identity (Lave & Wenger, 1991). Previous sections` evidence presented, show that the individuals` identities have been affected and so were the identities of workgroups and items.

Addiction to Outsourcing: Losing the Absorptive Capacity

While outsourcing has affected identities and as a result the formation and the role of communities, it has also produced effects for organizational learning and for the maintenance of knowledge itself. What was found to be very important is that not only companies did lose parts of knowledge but that the disintegration of communities of practice, the lack of observation and experimentation (see Barley,1996; Orr, 1990) combined with the poor social environment created dynamics for further and continuous worsening of the situation. The disintegration of learning processes in the organization took the form of a snow slide.

SECONDARY EFFECTS: EXPLORING THE VICIOUS CYCLE OF KNOWLEDGE DEPENDENCE

The above situation produces secondary negative effects for the organization as a whole and it has been shown in our cases that the loss of absorptive capacity and the disintegration of knowledge in communities lead to further negative results. A main effect is the one of organizational dependence since the three (3) outsourcing companies are now relying on firms and outsiders to maintain their business activities. As argued in Fine (1998) and Takeishi (2002), relying to the knowledge of outsiders creates an expected level of dependence of the company. What was seen from our research was an increased dependence from the outsiders' knowledge and skills. During the research it was possible to identify certain cases where lack of organizational knowledge and the inability of the organization to have access to specific know-how costed a lot of time and money. Most incidents

Table 1. Matrix showing contractual relations of outsourcing among the eleven _ companies-subjects of research

Company/sub-contracts	Accounting & consulting	Promotion operations	Information system	Some Manufacturing Processes
PROEL SA	Thesis Ltd	Independent group of salesman(A)	Q-Logic SA	PH&T Iran
IA Tools Ltd	(In-house)		Infinitum Software Solutions Ltd	An Tools PROEL SA
MEDION Ltd	Large Auditing	Independent group of salesman(B)	(Mostly In-house)	PROEL SA

Figure 2. Pathology of knowledge management when outsourcing operations

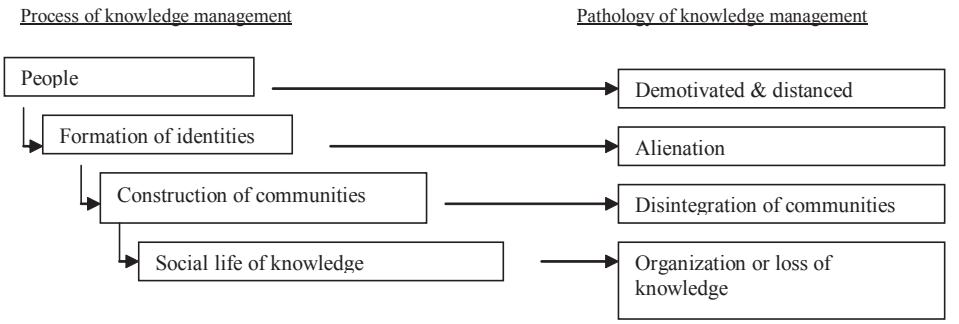
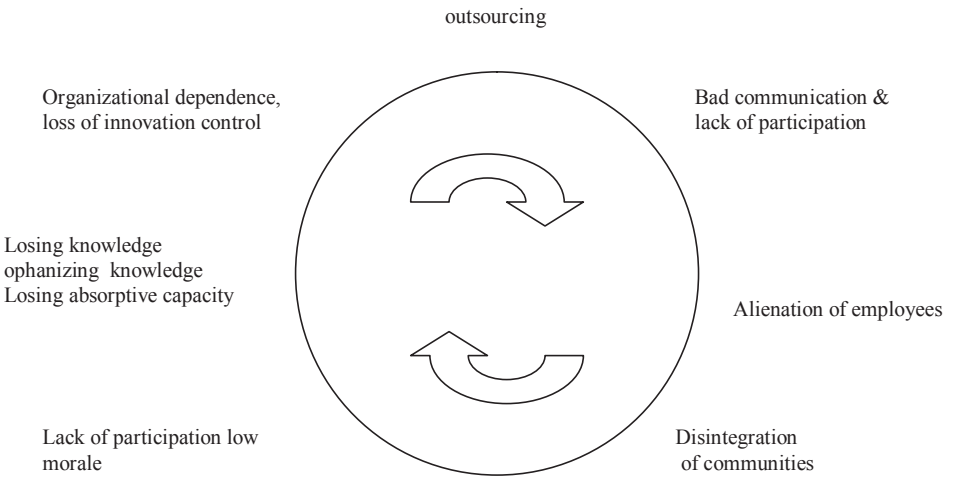


Figure 3. A summary of effects of outsourcing for knowledge management in organizations



have been presented to the companies in matrix forms. To a certain extent what was also observed, as a result of dependency, was a raising insecurity (Embleton & wright, 1998; Hendry, l995; Takeishi,2002) and a lack of trust in organizational capabilities to face problems; such situation is still creating an increasing dependence from those who know how to do the job. In other words, outsourcing has become a one-way process to import knowledge in the organizational boundaries and solve problems.

The above findings could be described as a `vicious cycle' of effects which have the form of a continuous chain reaction.

So, a main issue is that the use of outsourcing initiates further needs for outsourcing within the same department or even in different operations. Both organizational dependence and innovation outsourcing have created to most managers the impression that the company could not survive without the contractors' knowledge; an interesting issue coming but of the questionnaires is that most of them would approve more outsourcing because "it seems that we do a better job when being in position of control instead of doing things" (Sales Manager of lapharm). This idea of recycled outsourcing, missing from current literature, is very interesting and should be further studied and elaborated.

CONCLUSION

The vicious cycle of outsourcing effects should be considered as the main implication of this research. It has been shown that the use of outsourcing and subcontracting initiates certain social effect which finally produce further changes to the organizational life and to the intellectual capital of the organization. A continuous process of alienation (Erikson, 1990; Wheeler, 1996), disintegration of communities (Lave & Wenger,1991; Wenger, 1998) and organizational de-identification (Dukerich et al., 1998) takes place while the company is transformed from a learning entity (Easterby-Smith, 1999) into an expertise purchaser (Chan, t994) This study takes a negative stand against outsourcing, critically objecting the focus of management and shareholders on downsizing and reducing costs, neglecting important long-term aspects of organizational life (Lazonick & O'sullivan, 2000; Kasey, 1995; Whitley,

1999) and the importance of knowledge management and accumulation. It is argued that before transforming the policy of outsourcing into specific management decisions, a consideration of issues concerning the organizational culture, identities and finally knowledge should take place (Embleton & Wright, 1998; Chan, 1994; Vanson, 2001; Hendry,1995).

I argue that there are three typical approaches which can be followed:

a. Building and supporting inter-organizational mixed teams and communities.
b. Transforming the nature of relationship, several studies argue for a conversion of outsourcing contracts into strategic alliances.
c. Formalizing knowledge in order to achieve conversion of tacit and experience knowledge into typical, codified information flows.

Further research, currently conducted by the authors, focuses on specific organizational or functional mechanisms which would assist the company to preserve and accumulate knowledge while changing the internal structure, while outsourcing or downsizing.

The Effect of Information Quality on Surgery Process Variation

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ABSTRACT

This paper discusses the relationship between quality of care and information quality (IQ). The focus of the paper is on surgery process variation. The paper aims to identify the IQ dimensions that considerably affect surgery process variation. The research uses a case study approach and employs gap analysis and Delphi technique. Results indicate that accuracy, accessibility, completeness and timeliness are the most critical IQ dimensions that are affecting process variation.

Keywords: Delphi technique, gap analysis, information quality, process variation.

QUALITY OF CARE AND INFORMATION QUALITY

Quality of care is about meeting the physical, psychological and social expectations of the patients who search for care. According to the American Institute of Medicine, quality of care is "the degree to which health services for individuals and populations increase the likelihood of desired health outcome consistent with current professional knowledge" (Kupersmith 2003). The Advisory Commission on Consumer Protection and Quality in the Health Care Industry notes that there is a continuing pattern of variation in health care services, including regional variations and small-area variations (Advisory Commission, 1998).

Deming, who has developed a profound knowledge of quality, considers 'variation' as "the chief culprit of poor quality" (Evans and Lindsay 2005, p. 94). Deming observes that variation in quality characteristics exists in every process. Variation makes the process unstable and its outcome unpredictable because the variation that exists from one time period to the next is also unpredictable (Miller, 2005). Healthcare service is an information based service (McLaughlin 1996). Understanding the variation in information is the first step in reducing healthcare service variation and then stabilising the healthcare process. There are major variations in the conclusions of clinical observations and their interpretation (James et al. 1994). In fact, most healthcare quality problems can be attributed to variation or what is referred to as 'unwarranted variation" in healthcare delivery (Wennberg 2002). The term 'unwarranted' in relation to variation reflects a lack of necessary or quality information to conduct healthcare processes. This suggests that information quality is a critical factor in decreasing variations in the healthcare industry. Recognition the importance of data and information quality becomes a key area of both strategic and operations management in the healthcare industry (Lorence and Jameson 2002). The Lorence and Jameson study also emphasises that there is a shift from the traditional error-based approach to evidence-based data driven medicine. This allows the measurement of quality of care to be based on data rather than intensive, personal interaction with patients. As such, "the quality of data maintained by organisations becomes a critical factor in the ultimate delivery of care" (Lorence and Jameson 2002).

This paper discusses the information quality (IQ) dimensions and aims to identify the critical and decisive IQ dimensions affecting surgery process variation. The paper employs a case study approach. The paper uses gap analysis and Delphi technique (Linstone and Turoff, 2002) in order to define the critical dimensions affecting the process variation. The following section identifies the dimensions of information quality.

DIMENSIONS OF INFORMATION QUALITY

Evans and Lindsay (2005) stress that quality can be a confusing concept. They provide two main reasons for this assertion; (1) people view quality using different perspectives and dimensions based on their individual roles, and (2) the meaning of quality continues to evolve as the quality profession grows and matures. Similarly to product quality, IQ has no universal definition. To define IQ, it is important to comprehend both the perspective from which IQ is viewed and its dimensions. The Cambridge Dictionaries Online (2005) defines perspective as "a particular way of considering something" and dimension as "a measurement of something".

Individuals have different ways of considering the quality of information as they have different wants and needs and, hence, different quality standards which lead to a user-based quality perspective (Evans & Lindsey, 2005). This perspective is based on the Juran definition of quality which defines quality as 'fitness for intended use' (Juran and Godfrey, 1999). Thus, information and data can be regarded as being of high quality if they are fit for their intended use in operations, decision making and planning (Redman, 2004). Other related IQ perspectives are 'conformance to specifications' and 'meeting and exceeding consumer expectations' (Evans & Lindsay, 2005). While these perspectives capture the essence of IQ, they are very broad definitions and are difficult to use in the measurement of quality. There is a need to identify the dimensions that can be used to measure IQ.

IQ is a multidimensional concept. This means that organisations must use multiple dimensions and measures to evaluate the quality of their information or data. Several researchers have attempted to identify the IQ dimensions. Wang et al. (1995) list twenty six IQ dimensions, which in turn are classified into either internal view (design operation) or external view (use and value). Each of these classifications is divided into two subcategories; data-related and system-related (Wand & Wang, 1996). Wang and Strong (1996) conducted an empirical two-phase sorting study and provide the most comprehensive list of IQ attributes. Their list comprises 118 attributes. The 118 attributes are reduced to 20 dimensions, which in turn are grouped into four categories: accuracy, relevancy, representation and accessibility. Wang and Strong (1996) re-examine their four initial categories and relabelled the first two categories and the four categories become: intrinsic, contextual, representation, and accessibility. It should be noted here that Wang and Strong use the term DQ (rather than IQ) to represent both DQ and IQ. Recently, Lee et. al (2002) developed a two-by-two conceptual model for describing IQ. The model comprises 16 dimensions, which are classified into four categories; sound information, dependable information, useful information and usable information. Table 1 provides definitions of the most common IQ dimensions used in the literature and illustrates their categories.

RESEARCH METHODOLOGY

Case study approach can be used to provide a detailed description of a phenomenon (Yin, 1994). The finding of this research is based on a single case study which is used to explore the role of data quality dimensions in process variation. This case is also revelatory in nature. According to Yin (1994; 1998), the revelatory case approach is a single case study conducted under difficult circumstances not normally open for in-depth study.

The case study is part of a project initiated by the author and has been funded by the Faculty of Business at the University of Southern Queensland, Australia. The project includes two postgraduate students - an Honours Degree student and a Masters Degree student. The selected case is an Australian rural public hospital. The hospital comprises thirteen departments including; Surgical, Anaesthetic, Orthopaedic, Obstetric & Gynaecology, Paediatrics, Emergency, Critical Care, Medical Imaging, Medical, Renal, Public Health, Oncology, and Rehabilitation.

Table 1. Definitions of the common IQ dimensions used in literature and their categories. Adapted from several research works (Al-Hakim, 2006, p xiv-xv)

Dimension	**Definition**	**Category**		
		Wang and Strong (1996)	Wang et al. (1995)	Lee et. al (2002)
Accessibility	The degree to which information is available, easy obtainable or quickly retrievable when needed. Accessibility depends on the customer's circumstances.	Accessibility	Internal + External - Data / system related	Usable
Accuracy	The degree to which information represents real world state.	Intrinsic	Internal -Data related	Sound
Amount of Information	This dimension measures the appropriateness of volume of information to the user or task at hand	Contextual	Internal / External -Data related	Useful
Believability	This dimension measures the user assessment of trueness and credibility of information.	Intrinsic	Internal / External - Data / system related	Usable
Coherency	This measures how information "hangs together" and provides one meaning to different users.	Intrinsic + contextual	Internal -Data related	Sound
Compatibility	The level to which information can be combined with other information to form certain knowledge.	Intrinsic + Contextual	Internal -Data related	Useful
Completeness	The degree to which information is sufficient enough to depict every state of the task at hand or the represented system, that is, assesses the degree of missing information.	Contextual	Internal -Data related	Sound
Conciseness of representation	The compactness of information representation.	Representation	External -Data related	Sound
Consistency of representation	The degree of similarity and compatibility of information representation format.	Representation	Internal -Data related	Sound
Ease of manipulation	The applicability of information to different tasks.	Intrinsic	Internal - Data related	Useful
Ease of understanding	The degree of comprehension of information	Representation	Internal - Data/ system related	Useful
Free-of-error	The degree to which information is correct. This dimension measures the number, percentage or ratio of incorrect or unreliable information.	Intrinsic	Internal- Data / system related	Sound
Interpretability	The appropriateness and clarity of information language and symbols to the user.	Representation	Internal -Data related	Useful
Objectivity	This dimension measures information impartiality including whether information is unbiased and unprejudiced.	Intrinsic	External -Data related	Useful
Relevancy	Relevancy indicates whether information addresses the customer's needs. It reflects the level of appropriateness of information to the task under consideration.	Contextual	External -Data related	Useful
Reputation	The degree of respect and admiration of both information source and information content.	Intrinsic	External - Data related	Usable
Security	It indicates the level of either restriction on access of information or appropriateness of information back-up - protecting information from disasters.	Accessibility	Internal / External - System related	Dependable
Timeliness	This dimension measures how up-to-date information is with respect to customers' needs or the task at hand. It reflects also how fast the information system is updated after the state of the represented real-world system changes.	Contextual	Internal/ External - Data / system related	Dependable

The project is concerned with the surgical department. The department includes an operating theatre suite comprising six operating theatres. Four are used for elective lists that are run for two sessions per day. The two other theatres are dedicated to 24 hour emergency surgery services. There are eight recovery wards catering to the theatre patients.

A Delphi approach is used to collect, amend and reshape information regarding IQ dimensions affecting surgical process variation. The Delphi approach is characterised as a method for structuring a group of communication processes in a way that allows a group of individuals, as a whole, to deal with a complex problem (Linstone and Turoff, 2002). Semi-structured interviews were conducted with hospital officials including a senior registrar, senior nurse and elective surgery coordinator and other related officials and medical professionals. The officials were given an opportunity to provide feedback after initial assessment of the results.

The interviews are based on a questionnaire which aims to rate the expectation of the interviewee in relation to dimensions of IQ affecting process variation and the perceptions of the interviewee about the performance of the dimension. Each

question has two fields named as importance and performance. For the first field, the interviewee is asked to rate the expectation about critically or importance of the dimension on process variation. The second field considers the interviewee's perception of the performance of the dimension. If a dimension is not applicable to the process variation, the interviewee's is asked to tick N/A.

The Likert scale is used in the questionnaires to rate the importance and performance of IQ dimensions because it is the most popular method to measure attitudes and easy to administer (Sekaran, 1992). The Likert scales give the researcher a clearer understanding of the interviewees' perceptions on the key issues in the interviews (Yin, 1998). In this research a 7-point Likert scale is chosen to for two reasons. This scale can provide more accurate comparisons between different respondents as compare to the 5-point scale that is commonly used. Also, the odd scale is to allow the respondents to choose the neutral answer (point 3) if they are not sure of the answers. If the interviewee strongly agrees that a dimension under consideration is critical or performed well, he / she ticks '7'. The interviewee ticks "1" if he / she strongly disagrees.

IMPORTANCE-PERFORMANCE ANALYSIS

Healthcare officers dealing with a healthcare process may have different expectation about various IQ dimensions affecting process variation. The expectation from each dimension may also depend on the employee's performance and behaviour. They can also perceive or interpret the performance of an IQ dimension in their organisation. The expectation from a factor is referred to as "expected importance" and the interpretation of performance forms the "perceived performance" of a factor. A grid similar to the one shown in Figure 1 can be used to evaluate and analyse the importance-performance data (Evans & Lindsay, 2005; Keyt et al., 1994). An organisation should make a great effort to achieve high performance on factors of high importance and not to waste effort on factors of low importance.

Importance-performance analysis was first introduced by Martilla and James (1977). A gap between the perceived performance and the expected importance of a dimension may provide some indication as to whether the dimension is effectively implemented.

A gap between the importance and performance of each dimension is calculated. An IQ dimension is critical when the expectation is that the dimension is very important. However, when a dimension is critical and performed very well, that is, the importance-performance gap is insignificant, the dimension is not decisive.. A dimension is decisive only if it is satisfied the following two conditions:

1. It has a strong importance rate, that is, it is critical.
2. It has a significant importance-performance gap.

If an IQ dimension affecting the process is critical and has a positive value of importance-performance gap (expectation is higher than perception), then we have a potential problem in information flow and then with process variation. A negative value (expectation is less than perception) indicates an overestimation, which may result in wasting effort to increase performance in less critical factors (Al-Hakim and Xu, 2005).

FINDINGS

The initial round of interviews revealed that a considerable number of dimensions are considered critical dimensions with rating equal or higher than six (out of 7). These dimensions are accessibility, accuracy, believability, coherency, compatibility, completeness, free-of-error, interpretability, objectivity, relevancy, and timeliness. The meeting with the officers raised the question of whether the dimensions should be considered before or after the final decision to admit a patient to the operating theatre. The answer is that the research is concerned about process variability after the decision has been made to admit a patient to operating theatre. The officers emphasised the following issues:

- The dimensions accessibility, accuracy, believability, coherency, compatibility, completeness, free-of-error, interpretability, objectivity, relevancy, and timeliness are proposed to be analysed, verified or settled before the decision of admission of a patient to an operating theatre. However, except for the free-of-error dimension, there is no objective viable scale or metric that measures these dimensions. An IQ problem may happen regardless of the depth and level of effort.
- The surgeon who makes the decision to admit a patient is usually the surgeon who performs or supervises the surgery. Surgeons make decisions based on their assessment of trueness and credibility of information. Accordingly, the dimensions believability is not a decisive dimension. This assertion is true when more than one surgeon deals with the decision to admit a patient to the operating theatre.
- A supporting argument was that having doubts about source of information or on the trueness of information may unnecessarily disturb the surgery process and may considerably and unnecessarily increase costs.
- There are several recorded instances of a surgeon asking for information which he/she believed existed but no information actually existed. Such an event considerably affects surgery process variation. This makes the performance of completeness is relatively low.
- The officers emphasises that there are no problem in the performance of interpretability, objectivity and relevancy of information. However, with the high performance of these dimensions, surgeons may provide different meaning to the same information when they added to each others.

Based on the above discussion, the officers revised the importance-performance analysis as shown in Table 2.

Results (Table 2) indicate that accuracy and believability are extremely critical dimensions. Though the gap of importance-performance for accuracy is relatively small (0.43), there is a need to take further measures to ensure the accuracy of information received. The performance gaps for accessibility and timeliness and completeness are relatively high (1.29 and 1.00, respectively). This indicates the necessity to reengineer the information technology system in a way that allows real-time accessibility to the required data and information as well as timely and regularly updating data and information. There is also a considerable need to ensure the completeness of information.

CONCLUSION

The paper discusses the relationships between quality of care and information quality (IQ). It emphasises that the process variation is the main source of poor quality of care. The paper aims to identify the IQ dimensions that affecting the

Figure 1. Importance-performance comparison (Evan & Lindsay, 2005)

		PERFORMANCE	
		LOW	HIGH
IMPORTANCE	LOW	Who Care	Overkill
	HIGH	Vulnerable	Strength

Table 2. Gap analysis for some IQ dimensions

Dimension	Importance	Performance	Gap
Accessibility	6.14	4.85	1.29
Accuracy	6.71	6.57	0.43
Believability	6.85	*	*
Coherency	6.20	5.67	0.53
Compatibility	6.00	5.83	0.27
Completeness	6.43	5.83	0.60
Free-of-error	5.33		#
Interpretability	6.00	*	*
Objectivity	6.20	*	*
Relevancy	6.20	*	*
Timeliness	6.43	5.43	1.00

** The performance of these measures is considered up to the required standard and the importance-performance gap is insignificant.*

 # Non-critical factor

variation of the surgery process. It employs importance-performance gap and Delphi approach in order to identify the decisive IQ dimensions affecting surgery process variation. A dimension is a decisive dimension where it is critical (with high importance level) and does not perform well, that is, has a significant importance-performance gap. Results indicate that surgeons make decisions based on their assessment of trueness and credibility of information. However, surgeons may provide different meaning to the same information. In addition, there are several recorded instances of a surgeon asking for information which he/she believed existed but no information actually existed. Such events considerably affect surgery process variation. The analysis shows that the following IQ dimensions are decisive dimensions affecting the surgery process variation; accessibility, accuracy, coherency, compatibility, completeness, and timeliness.

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REFERENCES

Advisory Commission (1998). Advisory Commission's final report. Retrieved November 6, 2005, from http://www.hcqualitycommission.gov/final/execsum.html.

Al-Hakim, L. (2006). Preface. In Al-Hakim, L. (Ed.), *Challenges of Managing Information Quality in Service Organizations*, Hershey: Idea Group Publishing.

Cambridge Dictionaries Online. (2005). Retrieved December 6, 2005, from http://dictionary.cambridge.org/.

Al-Hakim, L. & Xu, H. (2005). Data Quality and work alignmrent: Do IT professionals think differently? In Sarmento, A. (ed.) "*Issues of Human Computer Interaction*", Hershey: IRM Press, pp. 291-320.

Evans, J. R., & Lindsay, W. M. (2005). *The Management and Control of Quality*, (6th edn). Cincinnati, Ohio: South-Western, Thomson Learning.

Juran, J. M., Godfrey, A. B. (1999). Juran's Quality Handbook, 5th edition, NY: McGraw-Hill, 2.2.

Keyt, J.C., Yavas, U., & Riecken, G. (1994). Improvement-performance analysis: A case study in restaurant positioning. *International Journal of Retail & Distribution Management, 22*(5), 34-40.

Kumpersmith, J. (2003). Quality of care in teaching hospitals: Executive summary. *Association of American Medical Colleges*. Retrieved August 15, 2005, from http://www.aamc.org/quality/surveys/start.htm.

Lee, W.Y, Strong, D.M., Beverly, K., & Wang, R.Y. (2002). AIMQ: A methodology for information quality assessment. *Information & Management,* 40(2), 133-146.

Linstone, H.A. and Turoff, M. (2002). The Delphi Method: techniques and Applications. http://is.njit.edu/pubs/delphibook/delphibook.pdf. Lorence, D. P., & Jameson, R. (2002). Adoption of information quality management practices in US healthcare organisations: a national assessment. *International Journal of Quality & Reliability Management*, 19(6), 737-756.

Martilla, J.A., & James, J.C. (1977). Importance-performance analysis. *Journal of Marketing, 41,* 77-79.

McLaughlin, C. P. (1996). Why variation reduction is not everything: a new paradigm for service operations. *International Journal of Service Industry Management*, 7(3), 17-30.

Miller, J. (2005). Information quality and market share in electronic commerce. *Journal of Services Marketing*, 19(2), 93-102.

Sekaran, U. (1992). The Hallmarks of Scientific Research: Research Methods of Business, John Wiley, USA.

Wand, Y., & Wang, R. Y. (1996). Anchoring data quality dimensions in ontological foundations. *Communications of ACM*. 39(11), 86-95.

Wang, R.Y., & Strong, D.M. (1996). Beyond accuracy: What data quality means to data consumers." *Journal of Management Information Systems*, 12(4), 5-34.

Wang, R. Y., Storey, V. C. & Firth, C. P. (1995). A framework for analysis of data quality research. *IEEE Transactions Knowledge and Data Engineering*. 7(4), 623-640.

Wennberg, J. E. (2002). Unwarranted variations in healthcare delivery: Implications for academic medical centres. Retrieved November 6, 2005, from http://bmj.bmjjournals.com/cgi/content/full/325/7370/961.

Yin, R. (1994). *Case Study Research: Design and Methods*. London. Sage.

Yin, R. (1998) *The abridged version of case study research: design and method,* Handbook of Applied Social Research Methods, Thousand Oaks, CA: Sage.

The Development of a Planning Model for the Content of Small Business Websites

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ABSTRACT

This paper reports on the development and refinement of a model that links business planning and analysis tools, such as the SWOT analysis, with the creation and maintenance of the small business website. Initially, a number of existing models are examined. The development of the model is traced through its early implementation as a spreadsheet through to its current incarnation as a handbook. An overview is provided of how the early stages of the model would operate in practice.

Keywords: website; development; planning; study; small business; model

INTRODUCTION

Some of the major issues facing small businesses in relation to their use of information technology (IT) are that they lack basic knowledge of how to use IT effectively, they do not know how to measure the benefits of IT and they lack the skills to plan for its long-term use in the business. These shortcomings typically translate to small business use of the Internet, particularly in relation setting up web sites. This paper reports on the development and refinement of a model that links well known business planning and analysis tools, such as the SWOT analysis, with the creation and maintenance of the small business website. The model, developed in 2002, is updated to take into account recent developments in the usage of Internet technologies and some models highlighted in the international literature that target small business website development.

SOME BACKGROUND

There are many studies that examine the adoption of IT by small businesses. Although they do not necessarily provide a 'forward looking' viewpoint from the standpoint of presenting a means by which small businesses can then effectively adopt a website, they can provide a useful set of antecedents to help small business policy makers, consultants and even owner/managers to put into place those factors that may best assist them. For instance, Mehrtens, Cragg & Mills (2001) developed a model of Internet adoption for small businesses using an innovation theory approach. Lee (2004) examined a number of models related to IT adoption by small businesses, and tested a model of eight antecedents to Internet adoption in small businesses with a survey of 71 US small retail businesses. From studies such as these we know that factors such as the size of the small business (and therefore the resources they have at their disposal), the drive and IT skills of the owner/manager and employees, the existing systems within the business and external factors such as the availability of suitable infrastructure and external pressures (placed by groups such as customers and competitors) can affect the adoption of Internet technologies. In addition to this, small businesses need to have an appreciation of the types of benefits that websites can provide. At this early stage of the paper, the argument is made that a model looking to advise small businesses on the development and maintenance of their websites should consider these factors.

EXISTING MODELS

There are many published models (too many to mention here) that document how a 'typical' small business might build its website over time. Many of these are known as 'staged' website development models. There is a deal of support for the notion that small business website development generally commences with a simple brochure-type web presence and evolves over time to incorporate different levels of sophistication and complexity. In describing staged models of adoption, Alonso Mendo & Fitzgerald (2005) suggest that they represent the early stages of Internet adoption by businesses gaining access via simple technologies (such as email) to dispense and gather information. Later stages refer to the creation of a basic web page, then the business moves onto publishing a wider range of information, marketing of products and possibly some after sales support. This is followed by e-commerce capabilities, where orders can be placed and perhaps paid for by customers. Finally, at the mature stages the business website is fully integrated with 'back office' systems. Levy & Powell (2003) do not necessarily support a 'stages of growth' model for Internet development and suggest that few small businesses even go beyond the early stages of website development. This is supported by Alonso Mendo & Fitzgerald (2005), who suggest that many small business web sites can remain in a 'dormant' state for months or even years. They criticise these 'staged' models on the basis that they are:

- Oversimplified
- Based on a (false) assumption that businesses progress from basic to more advanced use in a 'linear' fashion
- Lack validation
- Do not take into the diverse nature of small businesses
- Do not consider other theories (such as 'evolutionary' models)
- Focus too much at the industry level and not on individual instances.

Martin & Matlay (2001) refer to these types of models as 'linear' models and also argue that they may be too simplistic for the variety of small businesses in existence – suggesting that this variety can come in the form of business size, economic activity, location, resource availability and level of ICT adoption.

There are, however, some different approaches to developing models for website development and use. Alonso Mendo & Fitzgerald (2005) propose a multidimensional framework, that seeks to examine how small businesses change their websites (the process of change), what kind of changes they make (the content of change) and why they change them (the drivers of change) for the general purpose of understanding the evolution of their e-business practices. Fillis, Johannson & Wagner (2004) proposed a conceptual model designed to help understand why some smaller businesses implement and develop e-business activities and others do not. Their model considers a range of internal and external factors that may impinge on attitudes to e-business and the implementation (or not) of an e-business strategy. Initially, the business is affected by factors such as government policy and globalisation, then industry factors. Within this environment, factors such as the size of the business, the types of products or services they offer and the set of business competencies within the business will influence either positive or negative attitudes to e-business and its eventual adoption or non-adoption. The model recognises that an adopter may choose to revert from e-business back to conventional business processes, or a non-adopter may eventually become an adopter of e-business. Again, this is more of an 'explanatory' model, but does identify some useful factors that should be considered.

Chaston & Mangles (2002) propose a model to support and deliver an e-commerce marketing strategy. Decisions in this model are based on a hierarchy, with financial and operational competencies being determined by the strategic positioning options chosen by management.

Once the strategic position is determined, the business must be able to fund the level of investment required to support their online marketing strategy. This includes having appropriate systems, having the resources to update the website, ensuring appropriate integration with existing business systems and ensuring that the website is promoted at a level to attract visitors. When the strategy has been

determined and the finances allocated, Chaston & Mangles (2002) suggest that the business needs to examine new ways of improving their Internet products and processes, ensure that the workforce are skilled to carry out the online activities, ensure that a high level of quality in relation to products and services and customer service and efficiency in relation to logistics is provided (as customers can more easily switch to other suppliers). This model provides an indication of the type of model that the author has in mind, to provide a set of (top down?) steps that a small business can use to properly integrate its website activities with its business strategy.

AN ATTEMPT AT A FULL PLANNING MODEL

In order to address some of these problems facing small businesses that wished to use the Internet to interact with customers, particularly those relating to a lack of proper planning techniques, the conceptual version of a model to guide small businesses (refer to Figure 1) was proposed in 2002 (Burgess & Schauder 2002). The model was based upon the major steps in other IT and e-commerce models. It represented at the time an attempt to address the specific needs of small businesses by guiding them through a proper planning process that was relatively easy for them to comprehend.

As a prelude to developing the model, Burgess & Schauder (2002) identified a number of steps that are common to models that can be used to assist firms to identify strategic IT ideas (such as those identified by Porter & Millar (1985), Barton & Peters (1991), Osterle (1991) and for electronic commerce opportunities by Marchese (1998) and Al-Moumem & Sommerville (1999)). These steps included a need for an initial, thorough business investigation of where the business stood in relation to its own resources and as part of a marketplace involving customers and competitors. This exercise can increase the likelihood that decisions made later in regards to web content are based upon a sound knowledge of business activities. This step involves a SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis, which has traditionally been used for planning in the marketing or economics areas of the business. An analysis is performed on the various areas of the organisation to identify current or potential strengths and weaknesses when compared with other competitive forces. Then, actual or potential opportunities to gain strategic advantage or threats to the organisation's well being are identified (Kotler et al. 1989). This analysis provides the business with a picture of where it currently stands and the basis for making sound business decisions about the proposed website presence.

As part of the SWOT analysis, the firm's internal and (some) external forces the activities of competitors and expectations of customers) were to be examined. Internally, the firm's resources in relation to time, money and expertise were considered, as well as the characteristics of the firm's goods and services. The firm's overall strategy was also examined, as a firm wishing to grow in size may require a more 'aggressive' web strategy than a firm that is satisfied with its existing customer base. Finally, the Internet skill level of employees was determined. Externally, the web sites of competitors were examined, as well as the ability of customers to access the firm's web site and their expectations of the business.

Other steps of the model after the business investigation referred to identification of the firm's overall web site strategy, what web site features they were going to implement (facilitation), what method they used to implement these features, how they promoted the web site and how they evaluated its success.

It is important to note that this model is fundamentally geared towards the support of decisions about website content. Issues such as the selection of Internet Service Providers, security of the business website and design of the website are important considerations and will be included in later versions of the model.

RECENT DEVELOPMENTS AND A NEW MODEL

One shortcoming of the model is that it did not take into account the fact that many small businesses change their websites over time (the reader is referred back to the discussion of 'staged' models). Whilst they may not necessarily do this in the manner that many 'staged' models indicate (from 'brochure' through to full e-business integration) – there are often changes made in the website over time. Additionally, there are now many more options available to a small business when setting up their web presence. Many of these are associated with Web portals. For instance, a small accommodation business may wish to use the booking engine offered by specialised accommodation or regional portals, meaning that they can perhaps reach a wider market and will not need to concern themselves with the technology involved in online booking engines. In the case of small manufacturing firms, such as a winery, there may be attractions in using the online shopping cart features of a regional portal or industry portal. Again, this may provide access to more customers and lead to extra custom without having to be concerned about developing the shopping cart technology. A simpler example of an 'extended web' presence is when a small business provides its basic contact information to regional or industry portals. This can be quite inexpensive and, because the information does not change readily, is relatively easy to maintain. A more specialised example is where a business may wish to attract potential customers to a region, and realises that a regional portal has a listing of all of the tourist attractions and the latest events in the region. Why should they repeat these on their own website? They could rely on customers seeing this information as they link to the business through the regional portal, or perhaps more realistically provide a link back to the specific page on the portal. Let someone else worry about updating the information!

So – how can the model be updated to reflect the need to take into account that small businesses will probably change their website over time, and allow the business to consider what features of the 'extended web' will be used? **Error! Reference source not found.** represents the author's attempt to update the model to take these considerations into account.

The updated version of the model includes:

Figure 1. An initial model to assist small businesses to interact with customers on the Internet

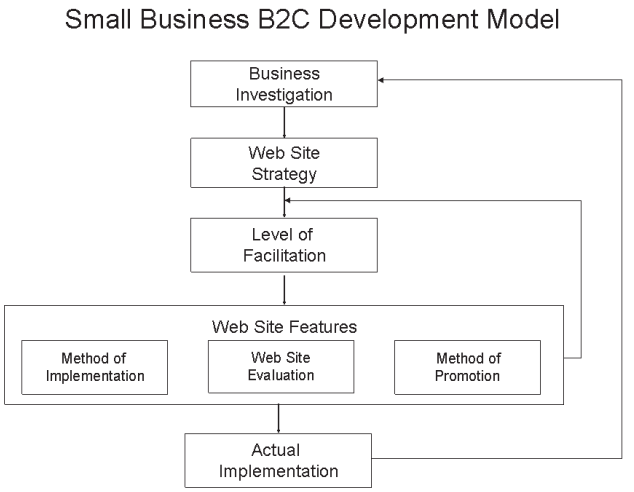
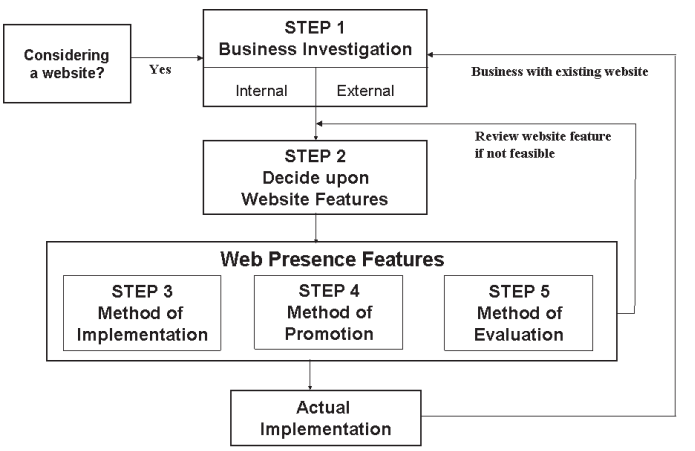


Figure 2. The revised, 'extended' version of the model



- The removal of the 'strategy' section from the earlier version of the model. This is now incorporated into the business investigation (SWOT).
- There are now two entry points into the business investigation phase. The first is where the business will be setting up a website for the first time. A detailed SWOT analysis will be needed here. The other entry is where the business has already been through the model and has already set up a website.
- The addition of a 'website audit' in the business investigation phase. This takes into account that the business may have already developed a website and may be considering changes to that website.

In the Website features stage, the decision of what features are to be placed on the website is re-evaluated each time the model is applied. The business may decide that it wants a particular feature on its website, but can also decide if it wants it NOW (or perhaps that it might be desirable in the future).

The 'method of implementation' phase has a step that includes consideration of the Extended Web. That way, if a business has decided to implement say, a shopping cart feature, it can use a shopping cart on an external portal if it decides it may not be suitable (or may even be too difficult) to implement on its own website.

MOVING FROM THEORY TO PRACTICE

[For this section of the paper I will move to discuss the development of the model in the first person]

One major problem faced in this project was how to take the theoretical model and turn it into a useful, applied model. The initial idea was to develop a manual or book that small businesses could work through and use to 'record' the results of the analyses that they carried out along the way. This would then lead to recommendations as to what web site features they should implement. There were two major concerns here if I was going to use a solely paper-based manual. The first was that if a small business person wished to go back and alter any of the data entered, he or she would have to use an eraser or liquid paper. The second was how to lead the person to the eventual recommendation at the completion of the analysis. I eventually determined that the spreadsheet package, Microsoft Excel, would provide the solution. Most small businesses that have computers use a spreadsheet package, and the majority of spreadsheet packages in use at the time were Microsoft Excel. The spreadsheet has long been recognised as a tool that can be used to support basic decision-making. It provides users with the capability to alter figures and to see the effects the alterations have on recommendations. In this case, it provided a means by which the path from analysis to recommendation could be handled automatically by the software. The programming language that is part of Microsoft Excel, Visual Basic for Applications, provided the flexibility to alter the software and the interface easily, based upon the suggestions of the micro focus group participants.

However, over time I realised that it was somewhat arrogant on my behalf to presume to make decisions about website content for small businesses, so the process has now been incorporated this into a handbook (the idea I originally shunned). I believe the best way to support small businesses with their decisions about their website presence is to provide them with as much information as possible and then let them make the decisions about content. The handbook contains many changes in the manner I approach the problem when compared with the spreadsheet – but the basic principles still apply – with the analysis carried out according to different website features. The following text is an extract from an early part of the handbook:

This handbook will encourage you to follow five steps in relation to planning and implementing your (or amending an existing) web presence. The analysis commences with a business investigation. If you do not have a web presence you will probably be performing much of this analysis for the first time. If you already have a web presence you may have performed some of this analysis before (perhaps without realising it) and you will certainly need to take an inventory of the website features you have already implemented. Either way, it is a good idea to perform these five steps on a regular basis, perhaps every 6-18 months.

After you perform your business investigation you will need to decide which website features you wish to adopt. After this, you will need to decide how and where you will implement your website features, how you will promote your web presence and how you will evaluate the performance of your web presence. Before you implement your web presence you may decide that some features are not suitable (perhaps due to cost or difficulty of implementation) – you should review all of your analysis to ensure that your proposed web presence fits your business strategy before you go ahead and implement it (or make major changes if you already have a web presence).

At this point it is important to point out that this review is for the purpose of which website features you will wish to add or remove from your web presence. As you will have read in the Introduction it is important that you keep the content of your website up to date. This is something you will need to do continually – MAINTAIN your website. This is why the upcoming analysis will discuss the two aspects of each website feature you adopt. How much effort it takes to SET UP and how much effort it takes to MAINTAIN each website feature.

The handbook then leads the small business owner through the business investigation. One of the main tools used during the analysis is the *Website Content Checklist* (refer Table 1).

This is designed to provide the business owner with a snapshot of the primary information needed to make decisions about website content. The reader is requested to imagine that this chart is printed on A3 paper, mounted on a wall and can be written on with an erasable felt pen. The first column of the checklist represents a particular strategy that the business may wish to adopt in its web presence. The second column lists the particular website features that can help to achieve these strategies. From here on each of the columns are numbered and refer to a different part of the analysis. If the business already has a web presence, the features that are already available can be listed on column 0 of the checklist. Columns 1 and 2 are for information only – and refer to the level of skills or how much effort is needed to setup the feature (column 1) and maintain the feature over time (column 2). In this instance, 'effort' can refer to the amount of employee time that is taken in setting up and/or maintaining the feature. In relation to employee skills, website features range from being quite easy to implement (for instance, just typing in text) to quite complex (requiring advanced programming skills). If a business wishes to implement a particular feature that requires more skills than those available, it may wish to build its own employee skills capacity (perhaps through training), access the skills outside the business (perhaps through a consultant) or host the website feature on an external site where the skills have already been employed (for instance, on a portal). In relation to capital, it is quite inexpensive to host a website with simple features – but some of these features may require more employee time (and thus cost more) to maintain. More complex features will also generally take longer, and be more difficult, to set up. In this instance it is probably easier to provide some examples.

Here is another extract from the handbook:

You may not want to do all of these things with your website. There are two things that you really need to know about each website feature:

- *They can range from being really 'easy' (quick, inexpensive and requiring only basic skills) to quite 'complex' (time consuming, expensive and requiring technical skills) to set up.*
- *Some features can be really easy to maintain over time, some may be quite difficult – perhaps taking up valuable labour hours to keep them up to date.*

So, when you are considering what features to have on your website you need to think about how much effort it will take to implement them and how much effort you will need to put in to maintain them. In some cases a feature that is easier to set up may be harder to maintain. Here are some examples of different website features and how they might differ in relation to setup and maintenance:

- *Business contact details: it is really easy to put these up on a website and, since the business location and contact telephone numbers rarely change, they also require little maintenance.*
- *Product catalogue: on the surface it appears that these are quite easy to put on a web site. You can just enter the product details and price as plain 'text' – which is quite easy to do. The problem occurs if your products and/or their details change regularly. Each time they change you will need to manually change them on the website. However, if you keep a separate products database it is possible to link this with your website. Whilst this can be quite costly and complex to set up, the benefit is that any changes you make are automatically reflected on your website. So – one option is easier to set up but harder to maintain. The other is more difficult to set up but easier to maintain!*

Table 1. Website content checklist

Type of feature	What goes on the website	Exist Web Site Feat	STEP 1 - INTERNAL			STEP 1 - EXTERNAL		STEP 2	STEP 3 – Where will the feature go?			
			Employee skills/ Capital		Product and/or Service	Competitors have?	Cust-omers want?	You want?	Your Web Site	External Website		
			Ease of setup	Ease of mtce						Directory Service?	Industry Portal?	Regional Portal?	Other
		0	1	2	3	4	5	6	7	8	9	10	11
Your Contact details	Physical location (address)		E	E									
	A location map		E	E									
	Telephone/ Fax number		E	E									
	Your Email address		E	E									
	Form for customers to fill in to contact you		E	E M									
Your product and/or service details	General product/ service details		E	E									
	Static product catalogue **OR**		E	E M C									
	Dynamic product catalogue		C	E									
Features for product and/or service support	A separate 'links' page		E	E									
	List local community events		E	E M									
	Frequently asked questions (FAQ)		E	E M									
	Instructions on how to use your product		E	E M									
	Provide a specific email address for direct contact		E	M C									
	Online bulletin board** (moderated?) for queries		C	M C									
	Frequently asked questions (FAQ)		E	E M									
	Instructions on how to use your product		E	E M									
	Special online promotions		E	E									
	Online form to fill in to receive newsletters		M	M									
Build online community	Online bulletin board** (moderated?) for discussion		C	M C									
Allow customers to place orders, pay for them and/or receive digital goods	Allow customers to print orders to then fax in **OR**		E	M									
	Allow customers to order via Online forms **OR**		M	M									
	Orders placed via a form and linked to a database of purchase orders **OR**		C	E									
	Customers can print a credit card payment form to fax in (combined with order form?) **OR**		E	M									
	Automated payment		C	E									
	Direct download		C	E									

Columns 1 and 2 can give a business owner an idea of the resources that they may need to devote to a particular website feature. It should be pointed out that in its published version the table is in code – with 'E' representing 'easy', 'M' representing 'moderate' and 'C' representing 'complex' to set up.

As part of the investigation, businesses are also expected to examine the particular characteristics of their products and services. For instance, do they produce products that can be easily mailed (such as books or CDs)? The business might consider implementing a shopping cart feature to allow customers to order their products online. Do they provide a service that involves digital goods (such as music)? There is already a significant market for online music delivery. Any particular features that the business identified might be suitable because of the products or services that they offer can be recorded on column 3 of the checklist.

Now the analysis moves to outside of the business. The model recommends that businesses examine the web presence of their competitors to see what features they are adopting. These can be recorded in column 4. Similarly, if customers have been requesting certain features to be added to the website (for instance, frequently asked questions) then these can be recorded in column 5.

Businesses are now in a position to make a decision about their website content. They know the basic types of websites features available and what they can do for the business from the first two columns of the spreadsheet. If they already have a web presence they know what features they have already implemented (column 0). They know how much effort they will need to put in to set up (column 1) and maintain (column 2) a particular feature. They know if their products or services are suited to a particular feature (column 3), what their competitors have on their websites (column 4) and what customers may be demanding from the website (column 4). They are now in a position to make up their mind about which features they would like on their web presence (and this can be recorded in column 6).

Although not the focus of this paper, the remainder of the columns (7 to 11) are there so that a business can represent *where* a particular feature is located – on its own website and/or on another website (such as a directory or a portal). Separate parts of the model examine promoting the website and evaluating its success.

Unfortunately the word limitations on this submission mean that the usual discussion about the implications of the model is somewhat curtailed here as the concentration of the latter part of the paper has been predominantly on its operation. The next phase of the development of the model is obviously to test it amongst small businesses – those new to implementing a website and those that have already done so.

CONCLUSION

This paper followed the development of a planning model for small business website development. The planning model, initially developed from models related to planning for effective use of information technology, has been refined after consideration of a number of recent small business website models (centred mainly around website content and adoption). When the antecedents to the successful adoption of Internet technologies in some of these models are combined with the idea that small businesses often change their websites over time and now have more options as to where to 'house' their website features, a newer version of the model has been proposed. A practical example of how the model might operate through a handbook and website content checklist has illustrated how information can be presented to the business owner so that they can make their own decisions about website content.

REFERENCES

Al-Moumem, S. & Sommerville, I. 1999, "Marketing for E-Commerce", *Proceedings of the 10th International Conference of the Information Resources Management Association*, ed. M. Khosrow-pour, Idea Group Publishing, Hershey, PA.

Alonso Mendo, F & Fitzgerald, G. 2005, "A multidimensional framework for SME e-business progression", *Journal of Enterprise Information Management,* vol. 18, no. 6, pp. 678-696.

Barton, P.S. & Peters, D.H. 1991, "A Synthetic Framework for describing the use of Information Technology for Competitive Advantage", *Proceedings of the 1991 Australian Computer Conference,* Australian Computer Society, , pp. 47.

Burgess, S. & Schauder, D. 2002, "Small Business E-Commerce Research: An Interpretivist Approach?" in *Skilling the e-Business Professional*, ed. A. Wenn, Heidelberg Press, Melbourne, Australia, pp. 105-123.

Davidson, A. & Burgess, S. 2006, *E-Commerce in Tourism: Use of Websites by Small Regional and Urban Enterprises*, CRC for Sustainable Tourism, Queensland, Australia.

Fillis, I., Johannson, U. & Wagner, B. 2004, "Factors impacting on e-business adoption and development in the smaller firm", *International Journal of Entrepreneurial Behaviour & Research,* vol. 10, no. 3, pp. 178-191.

Ghosh, S. 1998, "Making Business Sense of the Internet", *Harvard business review,* vol. 76, no. 2, pp. 126-135.

Kotler, P., Chandler, P., Gibbs, R. & McColl, R. 1989, *Marketing in Australia,* 2nd edn, Prentice-Hall, Victoria, Australia.

Lee, J. 2004, "Discriminant Analysis of Technology Adoption Behavior: A Case of Internet Technologies in Small Businesses", *Journal of Computer Information Systems,* vol. 44, no. 4, pp. 57-66.

Levy, M. & Powell, P. 2003, "Exploring SME Internet Adoption: Towards a Contingent Model", *Electronic Markets,* vol. 13, no. 2.

Marchese, L. 1998, "Brand Recognition", Internet World 98: Proceedings of the Australian Pacific ConferenceKirby Network Associates.

Martin, L.M. & Matlay, H. 2001, ""Blanket" approaches to promoting ICT in small firms: some lessons from the DTI ladder adoption model in the UK", *Internet Research,* vol. 11, no. 5, pp. 399-410.

Mehrtens, J., Cragg, P.B. & Mills, A.M. 2001, "A model of Internet adoption by SMEs", *Information & Management,* vol. 39, no. 3.

Osterle, H. 1991, "Generating Business Ideas based on Information Technology", *Proceedings of the 1991 Australian Computer Conference,* Australian Computer Society.

Porter, M.E. & Millar, V.E. 1985, "How information gives you competitive advantage", *Harvard business review,* vol. 63, no. 4.

Software Can Enhance Learning: A Case Study Evaluating the Implementation of an E-Learning Tool in a Multicultural, Tertiary Environment

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ABSTRACT

The past 15 years have seen a major increase in the numbers of full fee paying international students entering the New Zealand tertiary education sector. Accompanying this have been significant government policy shifts which have moved New Zealand Universities from a traditional to a corporate and research oriented model of operation. Both these factors have manifested themselves at the classroom level as opposing forces, those of reduced emphasis on faculty teaching time and, paradoxically, expanded need for teaching time for the increasing numbers of students with poor English skills. This paper evaluates a software-based approach to providing a solution to this teaching-time paradox. The author considers the pros and cons of the proposed solution in principle and also in practice using a specific commercially available software application and proffers some conclusions on the desirability and feasibility of such a project.

Keywords: Multicultural e-learning system, Multimedia and hypermedia, Online learning companion, virtual mentor, Robodemo, Captivate

INTRODUCTION

In 1999 there were just 675 full fee paying students (FFPS) in New Zealand. By 2001 the number had risen to in excess of 52,000. In 2002 over 80,000 international students came to New Zealand from 116 different countries, representing 8.4 % of tertiary enrolments (Asia2000, 2003). This is a phenomenal rate of growth which seems set to continue, despite slowing in 2003 due to market demand, institutional capacity, policy effects, the impact of tightening quality requirements and consumer behaviour.

Before quotas were lifted in 1999 there were very few FFPS from China in New Zealand, for instance the secondary school sector had just 43. In the three years after the quota was lifted following China's endorsement of New Zealand as an acceptable educational destination, the number had risen to 6,476. This ferocious Chinese demand for New Zealand education is driven by the esteem with which a tertiary qualification is held in China (only a small proportion of those applying can get into Chinese universities, thereby creating pent up demand), the easing of travel restrictions and fundamental economic growth. Today, China dominates with 39.6 % of total international students in New Zealand (Asia2000, 2003).

Even these figures, startling though they are, mask the real "on the ground" picture since recent immigrants form a large percentage of those who are not classified as international students. In short, the reality is that in New Zealand today, when walking into a class of undergraduate students one is typically looking at a sea of fresh, eager, young, Asian faces. These students currently face two significant disadvantages:

a. Their pre-tertiary education has been predominantly passive rote-learning, making them inept at raising issues with staff and seeking face-to-face advice during lectures.
b. Their lack of English skills.

Although New Zealand tertiary institutions all require fluent English language competencies for most undergraduate degrees [IELTS] (the universities state specified minimum levels of competence, such as 6.0 in the International English Language Testing System (IELTS) or 550 in the Test of English as a Foreign Language (TOEFL)), this does not appear to translate into actual ability with the English language in the classroom. Most certainly in any typical Information Systems student cohort there would be only a sprinkling of students capable of expressing abstract ideas, outcomes of client interviews, conceptual system designs or user interface justifications. Staff room polling indicates that, while most staff are sympathetic to the plight of these students, there is a significant philosophical debate about the approach which should be taken. There is a great reluctance to change the traditional teaching methods and a not inconsiderable irritation that courses have to be "dumbed down" to compensate for students' lack of comprehension. Lecturers complain of having to translate their lectures on the fly from their "normal" vocabulary into simple English. Such informal indications appear to reinforce Colleen Ward's research (2001) in which she concluded that, in general, educators involved with international students were unlikely to make any changes to teaching methods or course content despite there being need and/or opportunity to do so. In technology courses, which may involve the use of multiple complex software environments, students who are unable to resolve issues using online "help" systems face further disadvantages: shortage of time and lack of assistance. The latter factor due to reducing government funding per student, the resultant increasing financial pressures on Universities and the consequential increase in the student: staff ratio.

This situation is a frustration for staff who expect undergraduates to be more self-sufficient and pro-active, yet must repeatedly answer the same questions and an irritation for students, who are unable to interrogate the advanced and expensive software supplied because of their inadequate English. The students feel they "lose face" in the admission to staff of their language inadequacies and for many, this is a price too high to pay.

It should be emphasised that these students are not below average; in fact many of them achieve higher IELTS scores than the minimum the universities require. Rather, they lack a wide general vocabulary and have only a smattering of technical English. It is worth noting here, that a significant number of students who have English as a first language often suffer from the same incapacitating problem.

There are only a few solutions to this problem and if those which reduce University income are eliminated (raising the English requirements of students, or reducing and limiting the number of students on a course) the question arises how best to increase teaching resources without increasing the time allocated to faculty teaching. The implementation of a software-based solution seems immediately attractive; this paper forms an examination of both the desirability and the feasibility of such an exercise.

MOTIVATION

The motivation for this implementation stems not from a hoped for "silver bullet", nor from a submission to marketing hype, but from positive past experiences automating aspects of University undergraduate instruction and assessment. In 2000 a pilot study was carried out (Richardson, 2000) among students who used a purpose-designed computer-based tutorial and assessment package called SOAP

(Student Online Assessment Program, pre-Microsoft use of the term) developed with the following requirements in mind:

Quality of Testing
- Elimination of plagiarism
- Audit trail verifying student identification and completion of the test
- Automated marking
- Centralised result logging

Quality of Test Management
- Reduction in overall staff time
- More immediate results feedback
- More immediate performance feedback
- Improved student satisfaction
- Elimination of post test disputes

The student reactions to the introduction of the system were interesting and were summarised at the time as follows:

Running the pilot system gave some very valuable insights into the practicalities of system based tutorials and assessment. Overall, the computer literate students embraced the system and gave very positive feedback. They liked the ability to proceed at their own pace which the computer-based tutorial gave them. They were happy with the email help desk and computer-based practice test. The less computer literate students attended University-based tutorials and progressed more slowly, requiring more hand-holding to understand the interface and the principles of the exercise. (Richardson, 2000)

Among the conclusions reached in 2000 were:

Experience with the SOAP system highlighted the inability of students with poor English skills to understand a written query and translate that English sentence into SQL code. It was not use of computer-based learning or the lack of technical SQL skills that limited a significant number of students' performance; rather, it was their poor grasp of English that was their undoing. (Richardson, 2000)

While SOAP was a specific solution to a specific set of course issues, the general goals of a reduction in faculty time allocated to each student, increased student satisfaction and ubiquitous availability were inherited by the 2005 system requirements. In addition, the system evaluated here had a prime goal of circumventing the cultural and English language issues that proved to be the major stumbling block for students in the 2000 pilot study.

An additional motivation for the introduction of e-learning technology and one that is less quantifiable though nevertheless real is the student perception of what "up to date teaching methods and materials" actually means. Students now expect online, 24/7 access to teaching materials such as lecture notes, chat forums, streamed video, reading lists, web links and so on. In the current market-driven tertiary environment, such items are considered desirable features of a course and act as points of differentiation with other tertiary providers. These features are seen by students as pedagogical assets, necessary for the successful completion of a course and not, as is the view of many faculty members, merely technology which is convenient for and panders to lazy students.

TECHNOLOGY PLATFORM

With the 2000 SOAP experience in mind and the 2005 requirements set, several software packages were considered for evaluation. It should be emphasised here that the requirements called for a content generation and manipulation package rather than a delivery system. In fact the University had standardised on WebCT as its e-learning delivery platform and, for delivery of the 2005 e-learning content, would be an option, together with stand-alone web sites linked to individual faculty members. Although there were many generic screen-capture packages, available both for proprietary operating systems and as open source, none offered a feature set commensurate with the proposed system requirements (Table 1), proven stability and adequate support.

Table 1. 2005 system requirements

Features
Text entry boxes
Quizzes and scoring
Storyboard-based editing
URL and email branching
Audio creation and editing
Text and caption manipulation
High resolution video output
Streaming
Small output file size
Smooth mouse movements

After a comparison was made between the myriad of packages available and the proposed system requirements, the actual software options were reduced to two: Macromedia Robodemo and TechSmith Camtasia. Both TechSmith and Macromedia were viewed as well-established companies with proven track records and lists of well-respected corporations in their client base. The two rival products, Robodemo and Camtasia both had similar feature sets, were comparably priced, relatively easy to use considering their complexity and were well supported. A decision was made in favour of Robodemo due to its superior level of integration with Dreamweaver and Flash, both of which formed the chosen platform for web-development. A further consideration was the historic and continued satisfaction with Macromedia as a commercial software development company.

It should be noted here that shortly after this decision was made, Robodemo was re-launched as "Captivate" which included some enhancements to the Robodemo development interface and an improved feature set. For the purpose of this report both "Robodemo" and "Captivate" are synonymous.

Captivate offers a broad scope for experienced developers to generate e-learning systems with interfaces and content in synchronisation with the individual lecturer's style of presentation. It opens the door to the development of e-learning systems that reflect the personality and experience of the lecturer, including anecdotal examples and asides, rather than a clinical set of functional, point and click exercises that marginalise the student. This ability to personalise and link the multimedia tutorial with both the lecture content and the lecturer provides continuity for the student and a point of one-on-one contact. The 2005 system takes a learning-objects approach to its organisation in that, over time, a significant library of video/audio clips should be amassed, each dealing with a specific topic and able to be played and re-played under the students' control. These are significant benefits, being conducive to learning and providing a cross-cultural bridge for students who habitually use repetition as a lever to understanding. Similarly, using the lecturer's voice for audio tracks rather than third-party voice-over further cements an individual relationship with students and encourages them to relax in the presence of a familiar course "leader".

To summarise, the author expected Captivate to provide a flexible and comprehensive video screen capture, editing and manipulation tool, with the ability to record and synchronise audio tracks and produce small output files playable in a ubiquitous browser user interface. From a systems environment point of view, the author observe that this development and evaluation took place in a somewhat "Lone Ranger" atmosphere, where, though e-learning was seen by the University as generally a good thing, there was a dearth of specific goals or coherent strategies in place and no central, standards-based development model. As a result the project was staffed by academics throughout its entire life-cycle, the resultant conclusions therefore were based on real-world usage rather than remote laboratory evaluation by Information Technology technicians.

EVALUATION

Students and Delivery

The 2005 system was implemented initially on a computer graphics course. The students enrolled on this course had a very wide spectrum of English abilities; indeed a significant percentage could be classified as having very poor or negligible English communication skills. However, all students on the course had

similar issues understanding the somewhat arcane software specific terminology. Introducing the Captivate content as the main tutorial method attempted to address this specific issue.

An important difference between the students of 2000 and the students of 2005 is the non-academic work patterns. The pilot system developed in 2000 was laboratory based since students tended to attend University in semester time and be employed during breaks. The 2005 system had to be designed with a changed employment pattern in mind since some students worked part time all year round and required access to teaching materials accordingly. Robodemo addresses this service issue by providing output deliverable via web-browser 24-7. Students are able to benefit from the portability of a Robodemo movie and play the multimedia presentation at home or in a computer laboratory at a time to suit their work schedule. As Robodemo content may be output as Flash movies, the software required to view them is equally ubiquitous and also free to download.

More importantly, Robodemo content may be created for a variety of media. As noted by Tom Green (2005)

We are rapidly moving into a media development market where our work is no longer tethered to the desktop computer. The rise of cell phones, handheld devices and even tablets has expanded the reach of our development efforts.

Robodemo facilitates output to different devices, each device having its own screen size and playback requirement and, since Flash players are available for most handheld devices, content may be output to a plethora of different devices; with the proviso that it is correctly sized for the specific device during capture.

Students who lack English skills may be confronted by tutorial material they don't understand; nor do they have sufficient English conversation skills to appropriately question the tutor or lecturer. Often, afraid of losing face, they will send indecipherable emails to the lecturer rather than raise their hands in class.

Self-conscious about how they [Asians] are perceived by others, their questions and opinions may be geared to building relationships rather than expressing unique ideas. They tend to be reserved with people they do not know well, and they assume a power relationship with the teacher as an authority, so they may avoid the possible offence of even asking questions that they do have (McCarty, 2005)

Robodemo-based tutorials allowed the student to control tuition at their own pace, replaying content that was not understood. Many students schooled in Asian education, have experienced an environment that did not encourage an interactive learning style using Robodemo content. These students were able to watch and listen in their own time to explanations dealing with the use of graphics applications which reduced pressure on them in lectures. Robodemo can incorporate branching to applications and other interactive hypertexting, which leads students through application based upon their responses to questions and quizzes in the tutorial content. In this way the application is somewhat adaptable to the individual's e-learning style.

In Human Computer Interaction (HCI) there are many widely accepted guidelines that must be considered when developing user interfaces (Connolly 1996, Schneiderman 1987, Nielsen & Norman). One of the main guidelines is the need to make users feel in command rather than at the mercy of the system (Connolly, 1996). This can be achieved by keeping the user informed, clarifying each step and providing context sensitive help facilities. Robodemo facilitates this goal by using rollover buttons, dialogue boxes and other interface objects, as well as a fully integrated help generator called RoboHelp. To assist user navigation, Robodemo provides indicators of the points reached. Also, Robodemo-based content may exclude extraneous material, assisting student learning by 'only including what is necessary to the user' (Schneiderman, 1987). The creator of the content may remove or add parts of the screen capture – from mouse movements and keyboard sounds to quizzes and rollover buttons, leaving only the most relevant and useful actions and noises.

Management and Administration

The Computer Graphics course uses various software packages to teach the basics of 3d animation and multimedia production. Packages such as Bryce 3d and Poser are used extensively for landscape and human modelling. Each of these has a steep learning curve that students must surmount in order to gain understanding and confidence using the software package. Until the introduction of the 2005 system, the course had been organised as a series of five, three-hour "lectorials" (a mixture of lectures and tutorials) per week, delivered in a purpose built computer graphics lab. This labour intensive delivery method provided extra impetus for the introduction of an e-learning solution.

Creating Robodemo-based content for each tutorial normally delivered over the semester amassed a significant library of objects, which in turn has facilitated rapid and easy variation of the course structure. Indeed, the course delivery method was to some extent reshaped, as the content previously provided by lecturers as part of a presentation would be delivered instead by Robodemo. The tutorials needed no longer to be presented in a computer lab at set times; instead students could choose to view the tutorials at leisure in any lab or from home.

It was found, in general, that when creating movies, Robodemo helped concentrate the mind of the lecturer/creator such that oversights and sequence errors were mostly eliminated. As a consequence, rework was reduced or similarly eliminated.

From a course management perspective, Robodemo helped overcome the proverbial bus syndrome by providing a library of quality-controlled objects that lecturers could use to educate themselves and provide continuity for students.

Cultural Usability

Del Galdo (1996) comments that there are increasing numbers of products currently available concerning internationalisation, localisation and translation; that these usability issues have been placed at the forefront for many companies who want to move into the foreign market. Macromedia's Robodemo is no exception.

There is a great deal more to culture than just language. We cannot make exceptions about culture based on what is the norm in our own culture (Del Galdo, 1996).

Robodemo helps achieve internationalisation of tutorials with numerous toolbars to help customize the content, storyboarding and overall structure of the movie. This can be as simple as changes to the text in dialogue boxes or adding multicultural audio tracks to frames. Graphical metaphors in the movie can be similarly adjusted so that the use of a culturally unsuitable metaphor is not included. Unfortunately many of the software applications studied in the Graphics course do not also follow the same rigorous usability testing but by using Robodemo students can be educated to recognise the English meaning for a symbol or metaphor that has been used within the software package.

Observations

During the initial development of movies some observations were made regarding Robodemo's usability. There were irritations with certain aspects of the functionality and usability of the Robodemo package. However these were minor and became transparent with increased familiarity.

Adding audio to the movie was found to be one of the more time consuming components of the movie making routine. Whilst using a good microphone was essential, the frame by frame approach of adding a vocal soundtrack was slow going. The use of an additional software package to remedied this. Captivate has since improved this step.

Whilst initially the movies took longer to prepare, now the practiced hand can develop content in a quarter of the time taken to develop a normal lecture & tutorial (Table 2). The number of repetitive emails received regarding course content has significantly dropped as students spend more time using this elearning tool, and less time trying to replicate what they mistakenly saw or heard in class.

IS THERE A DOWNSIDE?

Many students do not have the motivation or skills to sit down and teach themselves by reading a manual or self-study guide. Manuals are usually more effective for reference than for learning. On the other hand, Robodemo attracts the student's interest and can even be enjoyable to use. It also has added benefits of being able to be developed for a diverse body of learners

Table 2. Break down of course work

	Before Robodemo	After Robodemo
Hours of Lectures/Tutorials per semester	5 x 3 hours =15 x 12 weeks = 180	12 x 2 hours = 24
Staff hours developing course	100	50 (first year)
Hours developing one tutorial	18	12 hours (initially), 8 hours now

It is argued that if e-learning is to be driven by the needs of the users, then diversity should be a driving force behind the use of e-learning technology (Minton, Boyle, Dimitrova, 2004).

E-learning has brought proven benefits to the course. It has encouraged students to take responsibility for their own learning and introduced flexible learning so that the tutorials can be taken to suit their circumstances. With e-learning there are options for learning at a place, time, pace and style to meet the student's needs.

E-learning assures standardization of training and content presented. Each student receives a consistent lesson – rather than a repeated version by a lecturer who may accidentally miss vital steps along the way. Students become productive more quickly and require less handholding to achieve results. It has saved time over traditional face-to-face courses as students only study what they need and at their own pace. Robodemo empowers learners with responsibility for their own learning experience.

The e-learning content must be designed and written in a quality manner for the students to keep interest and learn. A poorly designed movie can result in boredom or even confuse the person supposed to learn the material.

CONCLUSION

For the most part in tertiary education, students require lecturers and tutors to drive the instruction process. They are given content, are able to ask questions and are asked to memorize facts and synthesize material. However if their ability to do so is hampered by a lack of English skill or by a reluctance to show their lack of knowledge, students can fail to progress in their understanding.

E-learning refers to a broad range of activities that involve the use of information and communication technologies (ICT) to support and enhance learning. By introducing Robodemo as an e-learning tool, many of the difficulties that lecturers have coordinating and presenting a time intensive course can be dealt with and students benefit from the ever expanding library of interactive resources. Students are able to reinforce their knowledge as needed and at their own pace.

Whilst initially the time spent on developing the course may be significant as one learns the Robodemo system, the time and effort saved in the long term makes the shift to elearning worthwhile. Robodemo has helped support an increasingly large and diverse student population while at the same time reducing teaching time.

The key to improving the effectiveness and quality of student learning and making it worthwhile is to replace existing traditional modes of teaching with more active and engaging learning opportunities, delivered where appropriate by e-learning (Ashford, 2003)

Future work on this project will include quantitative analysis of student use of the Robodemo based system.

REFERENCES

Ashford, M. (2003). *E-learning Series No 3: A guide for teachers,* http://www.ltsn.ac.uk/application.asp?app=resources.asp&process=full_record&section=generic&ID=323

Berno, T. & Ward, C. (2003). *Cross-cultural and Educational Adaptation of Asian Students in New Zealand* http://www.asia2000.org.nz/about/programmes/research/various/Ward and Berno report.pdf

Connolly, J. (1996). Problems in Designing the User Interface for Systems Supporting International Human-Human Communication. In E. Del Galdo & J. Nielsen (Eds.), *International User Interfaces* (pp. 20-40). Canada: John Wiley & Sons, Inc.

Del Galdo, E. (1996). Culture and Design. In E. Del Galdo & J. Nielsen (Eds.), *International User Interfaces* (pp. 74-87).Canada: John Wiley & Sons, Inc.

Green, T. (2005). *Macromedia Captivate for Windows*. Berkeley, CA: Peachpit Press

International English Language Testing System (IELTS): http://www.ielts.org

McCarty, S. (2005). Cultural, disciplinary and temporal contexts of e-learning and English as a foreign language. *ELearn Magazine* Volume 2005, Issue 4, 1

Minton, L.,Boyle, R. & Dimitrova, V. (2004) If Diversity is a Problem Could eLearning be Part of the Solution? A case study. *Annual Joint Conference Integrating Technology into Computer Science Education,* **42-46**

Nielsen, J. & Norman, D. *Usability reports, user research and design guidelines.* **http://www.nngroup.com/reports/**

Richardson, A. (2000). Computer technology – keeping students honest. In IRMA 2000 conference proceedings pp 1010 – 1011

Schneiderman, B (1987) *Designing the User Interface: Strategies for Effective Human-Computer Interaction.* Reading, MA: Addison-Wesley Publishers.

Ward, C. (2001). The Impact of International Students on Domestic Students and Host Institutions: a literature review. Victoria University, Wellington 2001

Knowledge Pre-Processing: A Generic Approach Based on Compiler Function Concepts

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ABSTRACT
Knowledge extraction from semi-structured or unstructured documents and texts have become a significant research issue in today's context when knowledge is viewed as the crucial corporate asset and capturing tacit or implicit knowledge and converting them into some reusable form have therefore become necessary. In this paper, a concept called knowledge pre-processing is proposed, to adequately exploit certain latent structured-ness in specific areas of the knowledge sources. The concept uses the basic principles of compilers, namely the lexical and semantic analyzers, parsers and thesaurus.

Keywords: Knowledge, Clustering, Pre-processing, Context Free language

1. INTRODUCTION

Knowledge pre-processing can make knowledge extraction processes faster and more resource-efficient. The basic functions of a pre-compiler can be used as a pre-processing unit, as analogous to the Oracle- pro*C kind of combinations. In case of such pre-compilers like Pro*C with oracle, we see that the pre-compiler primarily acts as a filter and sends the classified inputs to different processing units or modules like a separate c compiler for processing the C programming sections and an SQL compiler for processing the 'exec SQL …" statements. Similarly, if this concept gets applied in pre-processing knowledge elements for creating re-usable knowledge repositories which can store integrated knowledge elements across various sources, types and structures, the knowledge extraction, capture, conversion/ translation(to the format acceptable to the repository) etc. i.e. the later steps become easier and faster.

In fact, many of the knowledge elements which are generally viewed as 'unstructured' or 'free-flowing texts' have some degree of explicit structured information for example embedded in their labels. Unfortunately, these already embedded 'semi-structured' information which can help any extraction module to do some 'level 0' or 'pre-classification', do not get adequately exploited if the whole document along with the semi-structured part also is input at the beginning itself to the extraction modules. For example, there can be limited amount of 'pre-classification' information embedded or available in the document headers, message headings, subject lines of letters or emails and so on. These, if adequately processed by a knowledge preprocessor before entering into the actual extraction phase, some classification information can already be made available through this pre-processing, to the extraction modules.

Therefore, the benefits of a knowledge pre-processing unit to be placed before the actual knowledge extraction and capture modules can be explained as follows:

- It can help the knowledge extraction modules, which are often extremely resource-hungry and slow (due to less availability of such computational resources), more efficient. The knowledge extraction modules tend to become slow because of their unavoidable and extreme logical and processing complexities. A pre-processed input can make the logic simpler to some extent.
- It also helps the knowledge extraction modules to exploit some amount of structured information that remained embedded in part of unstructured documents like headings etc.

In this paper, we propose a generic model for knowledge pre-processor using the concepts of compilers in programming languages.

However, the main difference between the two contexts (i.e. the programming language executable code generation vs. knowledge pre-processing) is essentially the fact that the output of the knowledge pre-processor is not any executable code etc. but some structured information about the knowledge source that is being input to a knowledge extraction module. The other significant difference which is a basic one is the fact that input for a compiler is a source code file with a specific programming language as using regular expressions and regular grammar, whereas in case of a knowledge pre-processor the input will be free flowing text strings for example as constructs in CFL(Context Free language).

There have already been some applications of compiler-related techniques for discovering classification information from unstructured text, like topic searching using lexical analysis, lexical chains etc. Here, our main purpose is NOT to extend any of these techniques or even enter into the searching algorithms, pattern search or thesaurus-based pattern matching algorithms which get applied to the entire body of the messages/ documents i.e. the whole of the unstructured inputs.

On the contrary, in this paper, we are proposing the concept of using a pre-processor based on similar concept like compilers, along with some explanations and examples of its possible use and benefits. Towards this end, we have first discussed some of the approaches for pattern discovery, subject identification, classification and clustering of unstructured/ semi-structured documents. Then we take a clean-slate approach with zero assumptions about the concept of knowledge pre-processing, and develop a new generic model for doing the same. Therefore, the authors' contribution starts from the section under heading "Generic model outline for knowledge pre-processor" which explains the basic framework of the knowledge pre-processor and its generic components, their roles and inter-relations.

2. UNSTRUCTURED TEXT HANDLING APPROACHES

There is various research issues related to unstructured/ free-flowing text. The issues range from highly theoretical, mathematical, logical and analytical dimensions like discovering cohesions and relations between various sections of body texts (e.g. paragraphs), discovering topics, searching for topics. Further issues are related to the practical or implementations-specific side of the problem e.g. storing the discovered/ searched information in a knowledge representation format which is more accessible, understandable, easy to implement, and easily retrievable to achieve the ultimate goal of re-usable knowledge repositories. These issues translate down to specific research questions like: text segmentation, topic tracking, topic detection, link detection, classification and clustering.

The background work for these issues have started since many years, starting from the machine readable dictionary-based approaches by McRoy(1992), Li(1995), then heuristics-based approached by McRoy(1992) etc. Topic segmentation issues have been worked upon by Hearst 1997 (topics boundaries discovered with slighting window-like systems), Kan 1998 (entity repetition-based concepts). Clustering techniques have also evolved over time, for example divisive clustering (Choi 2000), partitional and hierarchical clustering (He 2000). These works have culminated into further research work e.g. topic detection in unrestricted text using lexical cohesion(Chali 2001).

One of the methods for representing documents as networks using partitional and hierarchical clustering techniques is further explained in this section, to compare its strength and applicability with the proposed knowledge pre-processing model here. This section is based on the work of him (2001) and Chen (2001). The original research was aimed at classifying hypertext documents, but the process logic is appealing for applications to any unstructured text domain. The basics of this process are as follows:

- Any knowledge source/ input is treated unstructured documents
- Co-occurrence (He 2001) analysis is used to find the similarities and then consequently the dissimilarities between the documents. This is done as follows:
  Co-occurrence analysis converts data indices and weights obtained from inputs of parameters and various document sources e.g. email/text message bodies, into a matrix that shows the similarity between every pair of such sources.(He et al 2001,He and Hui 2002, Shneidermann 1996)
  When measured between two documents, say Ei and Ej,

$$Sim_{ij} = \alpha \{A ij / |A|2 \} + \beta Sij / |S|2 + (1- \alpha - \beta) Cij / |C|2 \quad (1)$$

  $0< \alpha, \beta$ (parameters) <1, $0 <= \alpha + \beta <=1$,

  where A, S, and C are matrices for A_{ij}, S_{ij}, and C_{ij} respectively. Values for A_{ij} will be 1 if Ei has a direct link/ reference/ hyperlink to Ej, else 0. S is the asymmetric similarity score Ei and Ej, and is calculated as follows:

$$S_{ij} = sim (Ei, Ej) = [[\sum_{k=1}^{p} d_{ki} d_{kj}] / [\sum_{k=1}^{n} d^2 d_{ij}]] \quad (2)$$

  where n is total number of terms in Ei, m is total number of terms in Ej , p is total number of terms that appear in both Ei, and Ej., dij = (Number of occurrence of term j in Ei) X log((N/dfj)Xwj)X(Termtype factor); dfj is number of documents containing term j; wj is number of words in term j; Termtype factor = 1 + ((10-2 X typej / 10), where typej = min 1 if term j appears in subject, 2 if it appears in body, 3 if it appears in 'note' etc.) and Cij is number of Es pointing to both Ei and Ej (co citation/ cross-referencing matrix).
- Document bodies which are very similar in terms of their contents i.e. many of the identified key-terms (i.e. Terms excluding the general terms like pro-nouns, prepositions, conjunctions etc.)are same, can be clubbed up together to form a cluster. Dissimilar document bodies can be created as other clusters.
- These clusters can then form a network using hierarchical and partitional clustering method to form a graph with the nodes as representative knowledge maps for a particular group of documents with high-similarity in their body text.
- Partitioning of a graph, say G, can be done in various ways, for example, by using similarity measures as below: (Rich and Knight 2001,Shi and Malik 2000)

$$\text{Normalized Cut } (x) = \{\text{cut between } (A, B)/ \text{ assoc}(A, V)\} + \{\text{cut between } (A, B)/ \text{ assoc } (B,V) \quad (3)$$

where, Cut between $(A,B) = \sum i \in A, j \in B \, Sim_{ij}$, Simij is similarity between nodes i and j of the graph. Assoc(A,V) and assoc(B,V) shows how on average nodes within a group are connected to each other. A cut on a graph G = (V, E) is defined as removal of a set of edges such that the graph is split into disconnected sub-graphs. (Chen et al 1998,Chen et al 2001)

Now, this approach can work fine when the whole document has no element of structure in it at all i.e. any headers / titles / subject lines etc., or these also are combined together along with the body text and are processed together as well, not separately. This property is the main strength as well as weakness of this approach in specific and these kind of clustering-based approaches in general. The strength is that it can handle the whole document as a whole. The weakness is, in doing so, 1) It fails to exploit whatever little structure-related information that is embedded in some part of the document structure itself e.g. label, headings etc., 2) the complex and repetitive nature of the algorithm makes it extremely resource-intensive and in absence of such intensive or dedicated resources, extremely slow.

Other approaches like lexical chains suffer from similar constraints. Lexical chains arise from concepts of lexical cohesion that may arise from semantic connections between words (Chali 2005). Deriving the cohesion structure of a text is equivalent to retrieving lexical chains like LC = $\{w_1, w_2, \ldots, w_n\}$. These approaches while working fine with entire text as inputs, as is the case of topic discovery, searching or matching, do not again exploit certain default structured properties of text documents.

The concept of LCs however, can be used appropriately within the context of this paper as well, i.e. we can create the first level of document identifiers or classifiers by applying these LC-discovery concepts to the document label information itself e.g. the heading/ subject lines etc. We have actually used the concept similar to that of Roget's thesaurus as explained by Chali 2005, in the lexical analysis equivalence part of our model.

3. GENERIC MODEL OUTLINE FOR KNOWLEDGE PRE-PROCESSOR

The generic model of knowledge pre-processor, as explained in the section above, is shown in Figure 1.

Explanation of the sub-modules of the knowledge-preprocessing module:

- Lexical information extractor: This is designed in line of lexical analyzer in compilers, the main differences being that in case of compilers, the output of a lexical analyzer is a symbol table with tokens, lexemes and patterns. But here the output of a lexical analyzer will be broken-down fragments of the subject sentence into nouns/ verbs/ adjectives/adverbs etc. (the identification of a noun/verb and its subgroups e.g. names/ objects/ functions etc. can be done by using pattern matching and thesaurus). If we represent this analogy as in Figure 3, we get the symbol table equivalent in knowledge pre-processor as shown in table 1 inside Figure 3.

Figure 1. Positioning the knowledge pre-processor in the context of creating a re-usable knowledge base/ repository with unstructured sources

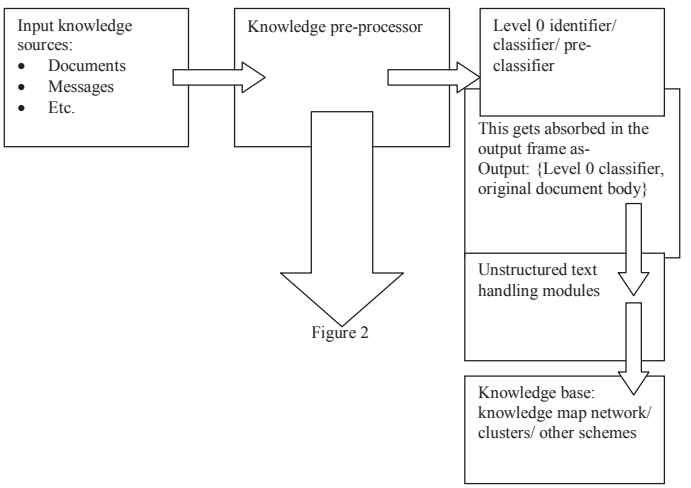


Figure 2. Knowledge pre-processor – basic building blocks and their outputs

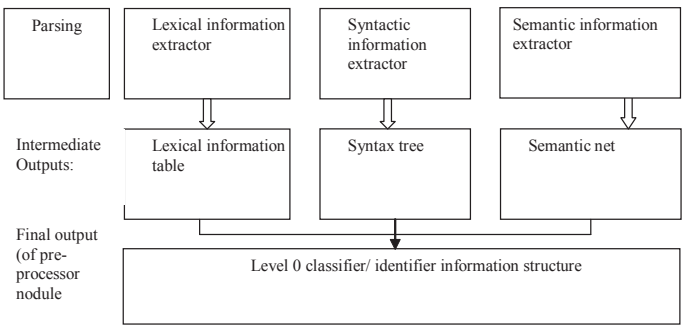
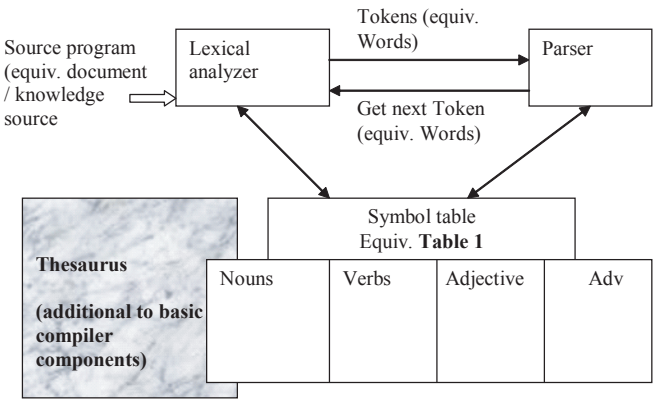
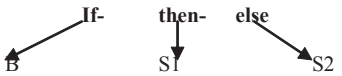


Figure 3. Lexical information extractor as an analogous equivalent of a lexical analyzer in a compiler



- Syntactic information extractor: The syntax extractor can draw it's equivalence to the syntax directed definitions including the annotated parse trees, dependency graphs, evaluation order-based graphs and syntax trees. A syntax tree can be thought as a condensed form of parse tree useful for representing language constructs. For example a production rule-type knowledge presentation scheme can appear as a syntax tree in the following form:



For a production rule: If B then S1 else S2.

- Semantic information extractor: Can be designed with an equivalence of semantic analyzer. The output can take form of a semantic network.

In the following section, we use a simple example drawn from a practical application situation and take this example through the initial steps in the knowledge preprocessor, basically onto up to the lexical analyzer equivalent part. This example can be further worked upon for generating the syntax trees as explained briefly above. And then it can be taken further to form it's semantic net equivalent.

AN EXAMPLE

Suppose there are two customer e-mail messages about rouble-shooting, to be input to a CRM knowledge base. The email messages have their subject lines in a fairly structured fashion, as they have used the pre-defined form fields of customer feedback forms on the company websites. These subject fields are considered as two inputs strings in this example. They are as follows:

InputString1: {Microwave model no. 2021 purchased in year 2002 not functioning: the table is not rotating}

InputString2: {Microwave model no. 4576 purchased in year 2005 not functioning: heating is not proper}

First level of lexical analysis on these two strings may generate output as follows:

InputString1: [Microwave model no. 2021 purchased in year 2002 not functioning]: (considered as connector) [the table is not rotating]

InputString2:[Microwave model no. 4576 purchased in year 2005 not functioning]: [heating is not proper]

2nd level: nouns (match from dictionary of nouns: can be made restricted to contexts: e.g. names (e.g. in case of customers complaining about service etc. by names), objects (as microwave in this example), place-names, function-names(e.g. 'heating' in the 2nd input string and so on)

InputString1: [[Microwave] [model no. 2021] purchased in [year 2002] not functioning] : [the [table] is not rotating]

InputString2:[[Microwave] [model no. 4576] purchased in [year 2005] not functioning]: [heating is not proper]

3rd level: verbs

InputString1: [[Microwave] [model no. 2021] [purchased] in [year 2002][not functioning]] : [the [table] is [not rotating]]

InputString2:[[Microwave] [model no. 4576] [purchased] in [year 2005] not functioning]: [heating] is not proper]

4th level: qualifiers/ adjectives

InputString1: [[Microwave] [model no. 2021] [purchased] in [year 2002][not functioning]] : [the [table] is [not rotating]]

InputString2:[[Microwave] [model no. 4576] [purchased] in [year 2005] not functioning]: [heating] is [not proper]]

Now, suppose we construct a table to store these strings as analyzed by the lexical extractor we get Table 1.

This table can be further fine-tuned, for example, by using a look-up table with index values for all these word-types and their sequential combinations e.g. 1 for nouns, and then 11 for names, 12 for objects, 13 for verb-type nouns e.g. function-names (like 'heating'), 2 for verbs(21 for auxiliary verbs, 22 for continuous tense …), 3 for adjectives, 4 for binary(yes/ no-not) response and so on. So, a phrase like 'Heating is not proper' can be expressed using this preliminary look-up table would be

Table 1. A minimal view of the lexical extractor output with two example input strings

Type of string component =➔	Noun	Verb	Adjectives	Adverbs
InputString1: substring1	[Microwave] [model no. 2021] [year 2002]	[purchased] [not functioning]		
InputString1: substring2	[table]	[not rotating]]		
InputString2: substring1	[Microwave] [model no. 4576] [year 2005]	[purchased] [not functioning]		
InputString2: substring2	[heating]		[not proper]	

<13>	<21>	<4>	<3>
[Heating]	[is]	[not]	[proper]

This whole string can be stored as an identifier with the numbers as indices for specific values as 13-21-4-3, just to remember the structure of the phrase. This information can be further added as the syntactic information for the phrases which would help in easy reconstruction of the phrases and subsequently easy and highly understandable retrieval. Also, the connectors may give valuable information, e.g. in this example case the symbol ':' depicts a further explanation of the problem, whereas in other cases the same symbol might mean different things e.g. cause-and-effect link between the two constructs. So, the connector along with its semantic role as a connector (e.g. a further explanatory/ a cause-and-effect link) will also have to be stored as part of the semantic extractor's job.

The rest of the example can be worked upon using further concepts on syntax and semantic analysis, as has already been mentioned before. Also, we can combine this model with the LC or co-occurrence analysis models as explained in earlier sections and can make the process more efficient.

4. CONCLUSION

This paper presents a fresh approach for knowledge extraction from unstructured sources using the concept of a pre-processor and the tried and tested concepts of traditional compiler construction in theoretical as well as applied computer sciences domain. The primary advantage of having a knowledge pre-processor, as has been explained in the first section of this paper, is the fact that a pre-processor can perform a level 0 analyzing and discover or present a basic identifier or classifier for an unstructured knowledge source by exploiting some amount of structured string-type information that are usually present in the source headers or document labels or message subjects/headings. This way it can reduce the workload of a knowledge extraction module which can then take the entire body-text of the document/ message/ knowledge source and apply the well-researched approaches of unstructured text handling on them. This way the entire process of knowledge extraction becomes faster and more resource-efficient. Further research possibilities include detailed design and implementation of the sub-modules under the knowledge pre-processor and exploiting the opportunities there again to use the tired and tested concepts of compilers, theory of computer science, theory of languages like regular grammar and CFL etc. With reference to the model presented in this paper, there are research issues in terms of scalability of the model e.g. the volume of unstructured data as well as heterogeneous source support-systems that can be handled by the model. Also there are issues related to the implementation, performance, resource utilization and tuning of any system based on this model which includes questions like which algorithms to choose for unstructured information handling, topic detection, preliminary information extraction, clustering etc., how to optimize the resource utilization for these algorithms, how to improve performance of an actual knowledge preprocessor and so on. Therefore, the model presented in this paper can be extended in multiple dimensions including theoretical aspects like algorithms design and analysis to implementation aspects including scalability and performance issues.

REFERENCES

Chen, H.; Fan. H.; Chau. M.; and Zeng, D.(2001) *Meta Spider: Meta Searching And Categorization On The Web*. Journal of the American Society for Information Science and Technology. 52(13). 1134-1147.

Chen. H.; Chung, Y.; Ramsey. M.; and Yang. C.(1998) A smart itsy bitsy spider for the Web. *Journal of the American Society far Information Science. 49*. 7, 604-618.

Chali, Y.(2001). *Topic Detection Using Lexical Chains*. Proceedings of the Fourteenth International Conference on Industrial and Engineering Applications of Artificial Intelligence and Expert Systems, Budapest, Hungary, Lecture Notes in Computer Science 2070, Springer-Verlag. 552–558.

Chali, Y. (2005) Topic Detection Of Unrestricted Texts: Approaches And Evaluations, Applied Artificial Intelligence 19(2): 119-135.

Choi, F. Y.(2000). *Advances In Domain Independent Linear Text Segmentation*. Proceedings of the 1st North American Chapter of the Association for Computational Linguistics, Seattle, Washington, USA , 26–33.

Hearst, M. A.(1997). *Texttiling: Segmenting Text Into Multi-Paragraph Subtopic Passages*. Computational Linguistics 23(1):33–64.

He, Y, and Hui. S.C. (2002) *Mining A Web Citation Database For Author Co-Citation Analysis.* Information Processing and Management. 38(4). 491-508.

He. X.; Ding. C; Zha. H.; Simon, H. (2001) *Automatic Topic Identification Using Webpage Clustering*. Proceedings of the 2001 IEEE International Conference on Data Mining. Los Alamitos. CA: IEEE Computer Society Press. 2(X)I. 195-202.

Kan, M.-Y., K. R. McKeown, J. L. Klavans. (1998). Linear segmentation and segment relevance. In Proceedings of 6th International Workshop of Very Large Corpora (WVLC-6), , Montre´al, Canada, 197–205.

Li, X., S. Szpakowicz, S. Matwin. (1995). *A Wordnet Based Algorithm For Word Semantic Sense Disambiguation*. Proceedings of the Fourteenth International Joint Conference on Artificial Intelligence, Montre´al, Canada, 1368–1374.

McRoy, S. 1992. *Using Multiple Knowledge Sources For Word Sense Disambiguation*. Computational Linguistics 18(1):1–30.

Rich E., Knight K.(2001), *Artificial Intelligence*, Tata McGrawHill Publishing Company Ltd, N. Delhi.

Shi. J., and Malik. J.(2000) Normalized cuts and image segmentation. *IEEE Transactions on Pattern Analysis and Machine Intelligence. 22.* S (2(X)0), 8S8-905.

Shneidermann, B.(1996) *The Eyes Have It: A Task By Data Type Taxonomy For Information Visualizations*. Proceedings of IEEE Symposium on Visual languages. Los Alamitos, CA: IEEE Computer Society Press, 336-343.

Automating the Business Process Case: Cairo Alexandria Stock Exchange

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ABSTRACT

Automating the business process in today's organizations is becoming a vehicle for competition and an important tool that helps provide a more effective and efficient service for its customers and employees alike. This paper demonstrates the findings of a market study[1] that was conducted in Egypt that focuses on the automation of the Cairo Alexandria Stock Exchange (CASE) and its implications on the operations of the exchange in terms of services offered, efficiency and effectiveness. The paper focuses on evaluating the trading process for brokers and investors both before and after the automation process of the exchange and identifying the impact of automation on the dissemination of information among the different stakeholders. Finally, the paper reports on a set of recommendations and conclusions that highlight the lessons learnt from the experience of the exchange in Egypt and provide guidelines for future implementations within similar environments.

INTRODUCTION

Stock Exchanges (SE) are the physical place, where stocks are traded, i.e. where they are bought and sold by brokers and dealers for other people's accounts who represent the investors. The stock exchange's main aim is to provide facilities for trade of company stocks and other financial instruments. Stock exchanges are usually found in central locations to keep it easy to record transactions. However, nowadays trade is much less connected by these physical places, as modern exchange stock markets are electronic networks with the evolution of information and communication technology infrastructures, which gives them speedy and less costly transactions (Helen, Hawkins and Sato, 1997). Such organizations are approved and regulated by the Securities and Exchange Commission (SEC). Stock exchanges are also called Bourses in European markets. Examples of famous stock exchanges are New York Stock Exchange (NYSE), which is probably one of the biggest stock exchanges in the world, London Stock Exchange (FTSE), Deutsche Börse (DAX), Tokyo Stock Exchange (TSE), and Cairo Alexandria Stock Exchange (CASE). The role of stock exchanges has been remarkably transformed over the last couple of decades due to the increasing and effective role information and communication technology platforms play.

Historically, stock exchanges first started in the 17th century. During that time, goods were traded and exchanged in central locations and the settlement of payments occurred at the end of the fair. Settlement days became more independent, eventually forming an autonomous market place. In the past, a number of steps as shown in table 1 used to take place in order to execute any transaction on the trading floor of stock exchanges (Helen, Hawkins and Sato, 1997).

However, the process of clearing and settlement became obsolete such that no more physical transfer of securities is required. Nowadays, the process became much easier when the automation of the process started. Figure 1 shows the traditional process of trading on NYSE trading floor.

Information systems have had a major influence on the different aspects of life leading to the integration of many processes and leveraging the performance of different organizations when properly designed and delivered. The capital market was not an exception and benefiting from the advantages that the information and communication technology infrastructure presents was a good opportunity to capitalize upon (American Chamber of Commerce in Egypt, 2004). There were several reasons behind automating the capital market on a global scale. This included a number of conditions such that having a perfect market would entail a strong automated capital market, which does not depend on the exchange of physical goods anymore as the digital transactions are dominating. Moreover, the fact that having an automated system transaction became very standardized made it easier to exchange securities all over the world and rendered the market more capable to compete and more effective in providing its services. Finally, having 24 hours access to information about the capital market became a priority and a necessity to compete in today's global environment and marketplace (Picot and Roehrl, 1995). It is important to note that with the information and communication technology evolution coupled with the growth of the digital environment, trading is becoming easy, accessible and a few clicks away from any potential trader.

The automation of stock exchanges started in the early 1970s, and the transaction of securities became electronically traded through the support of information and communication technology. Automating the capital markets did not only benefit one of the players of the financial trading game, however all the players in this sector gained from such technological breakthrough. After the automation, investors were not entitled to go and deal directly with stock exchanges, they did not have to go to a stock broker's office or deal with the hassles of calling him/her on the phone. As mentioned before, in the past, investors had to compete for the broker's time through regular and continuous access. The application of information technology allowed the investor to reach the information he/she requires any time anywhere. Moreover, investment decisions have become easier for the investor as more information became available around the clock (American Chamber of Commerce in Egypt, 2001). Post the automation process, the operation of the capital market transaction became classified as shown in table 2. The trading process post the automation of its components is demonstrated in figure 2.

As stated, all the players of the capital markets gained from the application of information technology in the stock exchanges. Generally, the automation process achieved a number of positive implications including; reduced interfaces, avoided media disruptions, and allowed disintermediation of middlemen like the agents on stock exchanges. Communication became more effective, efficient, faster, and wider and less costly in accessing information. As a result, transaction costs of trading were reduced. Automation allowed more transparency of information

Table 1. Traditional trading floor steps (Helen, Hawkins and Sato, 1997)

An investors calls a broker and orders the purchase of shares
When the order is noticed, the broker communicates with the relevant trader for order execution
Floor trader receives the order and calls a booth colleague who supplies the order to be executed
Floor trader goes to the pit in the middle of the trading floor where shares are traded and sends the order for execution
Execution is settled when the counterparty is found
Both parties record the transaction in their trading book
Simultaneously, the buyer reports the transaction to the trade reporting system and the trader makes a call to the booth to inform the broker to notify the client about the execution

Figure 1. Traditional process of trading at NYSE (Helen, Hawkins and Sato, 1997)

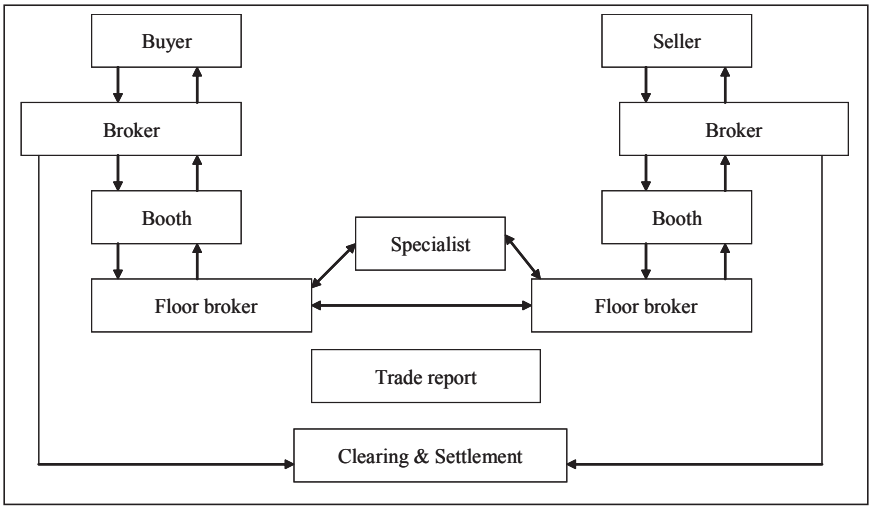
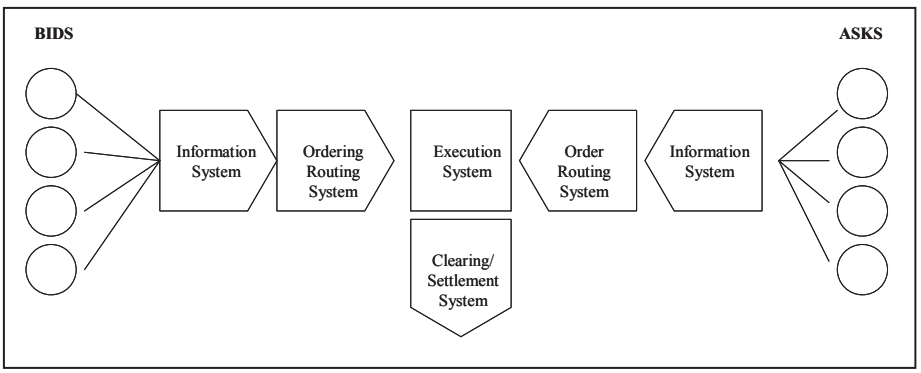


Table 2. Automation of the capital market (American Chamber of Commerce in Egypt, 2001)

Operational System	Definitions
Information System	Mainly electronic (digital) replacing the traditional "pink sheets" system with information available and accessible around the clock
Order Routing System	Electronic transmission of orders to relevant recipients replacing individuals using hand signals and moving back and forth on the trading platform, currently all transactions are transmitted via electronic networks leading to remarkable increase in the volume of trading
Execution System	Automation facilitated the process and rendered it more effective and more efficient
Clearing and Settlement Systems	Process became easier and faster

Figure 2. Process of trading (American Chamber of Commerce in Egypt, 2001)



and faster reaction time from both the investor and the broker ends. It is worth mentioning, that automation increased the volume of traded stocks in vast amounts and handled more trade faster. Moreover, automation improved and accelerated the decision making process for both investors and brokers. Overall, the operational efficiency of the market climbed after the automation and the transactions rates in terms of efficiency was remarkably improved.

From an investor's point of view, using the Internet is an invaluable advantage that supports the investment decision by getting quotes digitally and real-time from the World Wide Web (Parl and Yun, 2004). Investors can get extensive resources about the latest financial and stock news, search press releases and recognize any company declarations in a timely manner within a globally information-push environment. Investors as well can track the performance of the portfolios they create and continuously calculate the value of their investments and make changes as they see appropriate. Many of them use online brokers and execute their trading activities from home realizing another benefits and implications of the information and communication technology evolution and that is telecom-

muting with more expected to be introduced in the marketplace contributing to the diffusion to smart homes and users alike. Respectively, it became more convenient for investors to access huge amounts of stock market information at any time around the clock. Furthermore, investors are not subject to get outdated news like before from newspapers, radio and even television as financial news are available on the Internet instantly rendering the concept of information dissemination a way of life and helping the concept of information-push to become the way to do business.

The massive penetration of the Internet worldwide allowed investors to send trading orders in a few seconds instead of waiting for stockbrokers. Moreover, analytical tools for stocks are available for investors to evaluate their stocks and assist in the investment decisions on a real-time basis. Examples of such tools include graphs, charts; historical data, technical analysis, and portfolio tracking in addition to the possibility of an automatic execution of sale or purchase orders that are triggered by special events. However, it is important to note that although there were many positive implications for the introduction of automation to the exchanges, which led to the creation of many opportunities, there were a number of challenges faced globally. These challenges include regulating the exchange competition; regulating the costs incurred; regulating across-border trading; and security of the trading process since it became more difficult after the introduction of the automation process to control fraud and manipulative activities. Following is an overview of the research methodology deployed and the study conducted on the Cairo-Alexandria Stock Exchange with a focus on assessing the implications of the deployment of information and communication technology on the performance and productivity of the exchange.

RESEARCH METHODOLOGY

The methodology used was based on empirically testing the research questions through a field study instrumented via the use of a questionnaire and the conduct of a set of interviews. The process started with an in-depth interview with both the current and ex-chairman of CASE to get an understanding of the process of trading. Interviewing the ex-chairman was valuable since the process of automation occurred during his tenure. The questionnaire was distributed among different investors and brokers with an attempt to reach the largest sample of brokers and investors available. It should be noted that it was not easy to find many investors or brokers especially after filtering those who were busy, unwilling to cooperate, or do not have much knowledge about using information dissemination for trading. This is a problem in research in most developing countries; the availability of information and willingness of information holders to share it with others for research purposes.

The research team selected a sample of brokers from CASE itself, as well as sample brokerage firms including EFG-Hermes, Sigma Capital, HC Securities and Okaz brokerage, which are all local and regional firms operating in the financial market in Egypt and the region. Additionally, a number of banks that were involved in brokerage activities including the Commercial International Bank were also part of the study. In terms of investors, a random selection process was used through family, friends, and university professors and via brokers when facilitated. The sample used is not as large as anticipated, but it was sufficient to base the findings upon it and to deduct some insights to the workflow of CASE before and after the automation process. However, it is important to note that looking at the overall volume of individuals investing in CASE; it was an enormous challenge to find investors who are willing to collaborate. The research did not intend to study information dissemination for corporations since there was no single person responsible for the trading of corporations as well as the fact that the researchers believed that corporations are more privileged in attaining information, and might not be so willing to share as much or be as transparent in their feedback. After distributing and collecting all questionnaires and conducting all interviews, the process of analyzing data and coming up with findings, generalizations and conclusions took place. This was followed with a meeting with CASE chair and his senior staff. The purpose of the meetings was to focus on the vision for the future and the proposed recommendations and directions that can help CASE be more efficient and effective in information dissemination for all those stakeholders interested to use its services (www.egidegypt.com). It is important to note that this research represents phase one of a much-extended research that is currently addressing the needs and implications of information and communication technology on the stock exchange and its effects on the economy at large.

RESEARCH FOCUS

The focus of the research could be identified in four major directions and that included the following:

A. To evaluate how the use of information and communication technology allows and assists in the efficient and accurate dissemination of information to brokerage firms as well as to individual investors.
B. To assess the existing trading process at Cairo Alexandria Stock Exchange through in-depth interviews with its different stakeholders
C. To identify the drawbacks and the negative implications of automating CASE
D. To test whether the technology acceptance model (TAM) and theory of diffusion of innovation were applied throughout the process of automating CASE

The above-mentioned issues represented the basis for the research questions addressed through the study and leading to the assessment of the automation of CASE and the deployment of the state-of-the-art technology infrastructure. Following is a demonstration of the history of the Cairo Alexandria Stock Exchange (CASE) and the recent developments that took place in its management and functions with a focus on the deployment of information and communication technology.

OVERVIEW OF THE CAIRO ALEXANDRIA STOCK EXCHANGE (CASE)

During the last few years, the financial sector in Egypt including the capital market, the stock exchange market, the banking and insurance sectors went through a number of structural adjustments and reform programs to improve the overall national performance of the economy including massive investment in its information and communication technology infrastructure. Additionally, the government of Egypt had to stop intervening in the financial sector leaving the market to be determined according to the forces of demand and supply. According to the American Chamber of Commerce in Egypt, the state of the financial sector in Egypt can be summarized as follows; a) the stock market was ranked the 2nd in its size among the African and Middle Eastern stock markets in June 2000; b) the newly automated trading system that was introduced is capable of handling 100,000 transactions per day resulting in increasing the level of the trading volumes and increasing the liquidity; c) more encouragement to additional investments and decreasing the restrictions for the foreign access is underway; d) significant efforts are currently being exerted to boost the privatization process and various bonds were issued to facilitate the growth of the stock market (www.egyptse.com).

Moreover, the market experienced an increase in the activity of mergers and acquisitions during the last four years reflecting the interest of foreign firms in the market in Egypt, which was mainly reflected in the penetration of international banks in the local market. It is also important to note that there has been a remarkable improvement in the number of firms traded in the stock market where the capitalization used was estimated to be around 1.6 billion US dollars and increased dramatically over the last few years to 12.5 billion US dollars reflecting how the stock market is moving on the right direction and excelling in its performance as a result of a number of adjustments including information technology transfer and proper deployment in the financial sector (www.usaid-eg.org).

During the 19th century, Alexandria's futures market was one of the oldest in the world. The first local recorded cotton transaction took place in 1885 in Alexandria's Café de L'Europe where cotton merchants met and cut deals based on supply and demand for long and short staples. The first cotton dealmakers eagerly waited for the weekly arrival of the newssheets from Europe to guide future operations. Reputation counted for everything. From Café de L'Europe cotton dealmakers formulated the Association Cottoniere d'Alexandrie (later the Alexandria General Produce Association-AGPA) for trading in cotton, cottonseeds and cereals in the spot and future markets. In 1899, during the reign of Khedive Abbas Hilmi II, AGPA became the Alexandria Bourse and representing the focal point of the city's financial community.

Historically, the origins of the Cairo Alexandria Stock Exchange (CASE) goes back when Moise Cattaui Pasha, a renowned figure in investment and brokerage chose the old Ottoman Bank as an official headquarter of the newly incorporated Bourse and Banking Company of Egypt Limited on May 21st, 1903 (www.egyptse.com). Later on, an international competition started for the best design of a bourse to be located in the center of Cairo. When the process was completed

and the design was selected it was known as the Cairo Bourse (later became the Cairo Alexandria Stock Exchange-CASE) that was once among the world's top stock exchanges and leading the way in most of the times. During that time, the number of firms trading had reached 299 with a capital of 15.9 million US dollars. In Alexandria, the official stock exchange was established in 1888 indicating that it was even prior to the Cairo Stock Exchange that was established in the 1940s. The Alexandria stock exchange was ranked fifth worldwide in 1903. It is important to note that both exchanges were active and were functioning separately independent from each other. However, the adopted social and political polices in the 1950s led to huge reduction in the performances of both exchanges. This state remained declining from 1961 until 1992, where the stock exchange lost its position and status (www.egyptse.com).

As indicated earlier, both exchanges were working separately; each had its own chair and committees responsible for managing the stock exchange affairs. The chairs were appointed by the general assembly composed of brokerage offices and banks. Both were governed by the same rules and regulations. However, on 6 March 1997, the legal structure was redefined and both Cairo and Alexandria stock exchanges were merged becoming one operating in Cairo and Alexandria, headed by the same chair and governed by one board of directors. The new structure indicates that the chair is appointed by the prime minister for a period of three years. The board of directors includes 60% that are elected from brokerage firms and investment banks and the remaining 40% are chosen from the Central Bank of Egypt (CBE), the Capital Market Authority (CMA) and two additional members from the Bank's Association. CASE is a public person who has no shares that are issued or owned by others. Although the government has the ownership of CASE it is still managed as a private entity. On 14 May 2001, the exchange market started using a software trading system leading to having both exchanges using the same system for trading securities. It is important to note that CASE is the only registered stock exchange market in Egypt with a mission to become the leading stock market in the Middle East and Africa and to expand its role regionally and globally through technology links and cooperation agreements, thus increasing market liquidity and provide the fastest, cheapest and best execution of transactions.

CASE DEPLOYMENT OF INFORMATION TECHNOLOGY

Prior to the automation of CASE, the stock market was an auction, where everyone manually places his/her order, which was normal in the past because there was not so much activity, but later on there were so many transactions so there was a need for a comprehensive process that is efficient and that could be comparable to similar exchanges around the world. Therefore, during the period 1996-1997, CASE set the first basic framework of the vision of the new automated system which was a trading system where everyone places his/her order on the system and it automatically matches the trade. Later on, the system was replaced by a more advanced version with added features and capable of absorbing much higher capacity (up to 50000 transactions per day).

CASE set its plans to apply technology on its trading system and become an automated order-driven system. The process of automation was introduced through two main stages. First, the Capital Market Authority (CMA) was responsible for developing the automated trading system being the market regulator. The process included the regulatory framework, an automated trading system, a surveillance system and upgrading the clearance and settlement systems. The regulatory framework was developed in order to improve the market pace which required crucial amendments in the capital market law. These amendments led to the introduction of new rules and regulations to guarantee transparency, efficiency and fair competition in the capital market. The surveillance system built allowed online trading at CASE and offline surveillance system at CMA. One of the assignments of CMA was to establish a comprehensive database for the companies that are registered on the stock market. The database included; a) companies' statements and information about their status, growth, and activities; b) detailed daily reports on the companies' stock issuance and licensing; c) financial disclosure of registered companies and investment funds; and, d) other information that could benefit investors and brokers (www.mcit.gov.eg).

Additionally, CMA created a system to announce exchange rates and market reports on the exchange markets on daily, weekly and monthly basis. Furthermore, the CMA established for CASE an online presence through their website that provides different stakeholders with information on real-time basis. During the second stage of CASE automation, an agreement was concluded with a Canadian Software Company to handle the design and delivery of the automated trading system and to guarantee conformity to international standards and state-of-art information and communication technology. CASE started using EFA software trading system in 2001 allowing brokers to enter orders from either location or from the offices of licensed brokers. On the Cairo trading floor, there are 123 terminals and 19 more terminals in Alexandria in addition to 65 terminals in the brokers' offices. Orders are queued into the database to be automatically matched by the trading system (www.egyptse.com). The deployment of the new automated system required the establishment of an advanced information and communication technology infrastructure within CASE in addition to the development of state-of-the-art information network, training of staff and also organizes training sessions for brokers and individual investors interested amongst other activities. The system was gradually introduced during the period 1998-2000 through a testing phase with a lot of mocks, trainings to brokers until the first version of the system was installed at the end of this period (www.egyptse.com).

RESEARCH FINDINGS

The initial target sample of questionnaires was 200 for investors and 30 for brokers. However, after filtering out the ones that are not completed and ensuring that the ones used were valid and could be included in the analysis, the sample covered was reduced to 66 investor questionnaires and 20 broker questionnaires representing 33% and 66% respectively of the original plan. It is important to note that the total number of individual registered investors is one million however; the number does not reflect those that are actually active investors, which is around only 20% (200,000 active investors) of the total number of investors.

The demographics of the investors constituting the sample were mainly 85% males and 94% local citizens (Egyptians). The sample comprised of bachelor degree holders (65%), master degree holders (18%), high school degrees (3%) and PhD holders (2%). In terms of satisfaction of the newly installed automated process and its implications on information dissemination, the respondents were almost equally divided. Relating their satisfaction level with their educational achievement, it is observed that the more senior the respondents were and the more they were educated, the more their satisfaction level was confirmed. This can be attributed to being either a coincidence that occurred as a result of not having enough respondents or maybe because those with higher educations achievements have more access or sources of information and appreciate more its value and its contribution in rendering the investment decision making process more effective.

With regard to the actual sources of information that investors mainly relied upon, it was observed that most investors rely on their brokerage firms to provide them with information and updates about market trends and statistics. Investment banks trailed by far as the second most preferred source whilst CASE did not even make it to the fifth spot. This was indicated through the fact that while 70% of the respondents deemed various sources of information to be important, only 2% acknowledged accessing information through CASE due to various reasons. It is also interesting to note that word of mouth proved to play an important role as a source of information for investors which also explains why investors had a problem with the accuracy and reliability of the information. Table 3 demonstrates the sources of information as ranked by the sample examined in the study.

Although it was difficult to find investors who had invested before and after the automation of CASE, from those that were available, it was found that the

Table 3. Sources of information

Source of Information	**Percentage**
Word of Mouth	3.5%
Investment Banks	4.5%
www.yahoo.com	1%
www.gn4me.com	2%
Egypt for Information Dissemination	10%
EFG-Hermes	9%
Cairo Alexandria Stock Exchange	**14%**
Brokerage Firms	12%
Arab Finance Corporation	7%

automation process did not inflict real implications on the process of information dissemination. The culture of using information and communication was not yet well diffused within the marketplace. The findings indicated that those who were unsatisfied with the quality of information provided be it accuracy, speed of diffusion, timeliness or ease of use more or less did hold the same position post the installation of the automation process. Table 4 shows the factors preventing investors from making effective trading decisions as indicated by the responses of the sample. The main problem that was raised by the respondents was the time-lag between the time when events occur and the time when investors actually receive the information.

The responses of the investors showed little but gradual trust in the newly introduced system with 15% not really trusting the newly introduced automated system. This can be the result of a number of factors mainly related to the use of information and communication technology and the human resource capacities trained and prepared to use different automated applications. With respect to the responses of the brokers, the number of brokers has been steadily increasing since the introduction of the automation process due to the relative improvement in the process of information dissemination. The overall response seemed to be favorable of the new automated operation when compared to the traditional system which was confirmed by 90% of the responses. Brokers were more positive with respect to the role of the exchange as a primary and reliable source of information when compared to other sources. The findings of the research indicated that while CASE is not considered by most investors an important source of information, it is the main source of information for brokers who are themselves the main source of information for investors. This in reality implied that while CASE may actually be a good and valid source of information and knowledge about the financial market, investors do not really feel its presence or importance in terms of effectiveness and efficiency. Table 5 demonstrates the importance of information and its level of demand from the brokers and its transformation before and after the automation of the exchange.

With respect to the issue of investors relying mainly on brokers and their sources of information, the results were mainly moderate with no inclination to any major trends. Based on the interviews, the results were slightly different indicating that investors were gradually becoming more mature and less dependent on their brokers for information; alternatively, they seek information themselves and make their own decision. Table 6 shows the average investors relying on brokers for information to take a trading decision.

With respect to the span of time it took information to reach the investors, brokers indicated that in the majority of the cases 1-2 days were needed which may not seem that long. However, from an investor's point of view this duration could be the difference between a profit or a loss and they believed that there is an urgent need to cut down such duration substantially. Table 7 demonstrates the assessment of brokers of the duration it takes information to reach investors.

Table 4. Factors preventing investors from making effective trading decisions

Information Assessment Elements	Number of Respondents
Information not easy to use	26
Information is not useful	17
Unequal opportunity	19
Inaccuracy	28
Time-lag	47

Table 5. Levels of demand for information

Level of Demand	Findings
No demand	2%
Low demand	30%
Medium demand	35%
High demand	30%
Intense demand	3%

Table 6. Average investors relying on brokers for useful trade information

Level of Demand	Findings
Not at all	2%
Partially	28%
Mostly	52%
Entirely	18%

Table 7. Duration it takes information to reach investors

Duration	Findings
1-2 Seconds	0%
1-2 Minutes	12%
1-2 Hours	25%
1-2 Days	55%
1-2 Weeks	8%
1-2 Months	0%

RECOMMENDATIONS

Based on the number of issues discussed and the findings of the research conducted, one of the main debatable issues was the amount of time it was taking for real-time information to reach the investors to be able to take a trading decision. Therefore, the recommendation made relates to the development of a module for brokerage firms to help them overcome the information dissemination problem and at the same time serve both investors and brokers. The wealth of knowledge needed to be shared on a timely basis to capitalize on the benefits of information and communication technology. The model situation usually occurs when a broker gets feedback from a reliable source about any of the company's new decisions that would affect the stock prices and that appears to be important for their investors. Then the decision is to contact all investors at the same time to offer them the best opportunity to buy or sell stocks. It takes a very long time for the investors to be informed about the new changes in the stocks and when they start to react either by a decision to buy or sell, the price of the stock is usually altered. Therefore, investors have to be informed of changes that take place in order for them to be aware of their surroundings and be able to trust the brokerage firm when investing their belongings in the stock market.

The recommendation that was suggested was the development of an information base that can be used by brokerage firms and placed on a high-end server that is updated on a timely basis and linked to news networks that cover and relate to stock news and that can have implications on investors' decisions. News would automatically be updated into the information base which would instantly send electronic mails (email) and short message services (SMS) informing brokers that a change had taken place in the market that would be ultimately be important for investors and might result in them taking appropriate actions. With the diffusion of information and communication technology and media convergence, such inflow of information and knowledge and its timely and real-time access is becoming more of a reality. Respectively, brokers in seconds would inform their investors about all changes taking place through an email or an SMS (based on the investors' choice), giving him/her the opportunity to reply instantly and take an immediate action by either buying or selling. Such process is estimated to take a cycle of around 7-9 minutes taking the process to be as real-time as possible irrespective of time or distance barriers.

CONCLUSION

Based on the findings of the research, it is apparent that the current attitude of investors towards dissemination of information is relatively conservative with not much of a difference before and after the automation process in terms of information dissemination. There was an obvious difference between the impression of CASE senior management and various investors and brokers with opposing views on the role and effectiveness of the newly automated process. One of the major barriers faced was acceptance of technology especially by senior and relatively

older brokers and investors not really accustomed to the use of information and communication technology. The recommended solution should help realize and meet the requirements of the investors and cater for the need for information dissemination that was not addressed by the automation process of CASE. However, it is important to note that according to the findings of the research, the new automated process brought to CASE transparency, fairness, efficiency, higher volumes of transactions, a more user friendly environment, saved time and effort and became more capable of matching global market needs which was translated into having more foreign investors in the exchange.

To conclude, post the automation process of CASE, there has been a number of objectives realized indicating that more improvement of the process could be achieved with regular analysis of the market needs and continuously introducing customized services to the community of customers. Among the direct and indirect implications of the automation of CASE was providing a regulated and transparent market based on efficient and flexible technology and supply investors and brokers with reliable and real-time information services and attracting more investors from both local and international markets to increase the pool of liquidity in the economy. Moreover, it led to developing new products and services as bonds, raising the awareness campaign and introducing new trading practices that match the needs of investors, and aiding in the establishments of privately owned services that provide operational and technical support to registered brokers. Finally, it paved the way to working on creating the most effective and the best membership rules in the Middle East and Africa.

The awareness and diffusion of the use and benefits of information and communication technology led to the proper deployment of technology to serve the purpose and objectives of CASE. This has enforced the concepts based upon which the technology acceptance model is based. The easiness of using the services and the perceived usefulness were both critical elements contributing to the success of the automation process of CASE. The research study findings indicated, based on the sample covered, that with the automation process and the investment in human resource capacities including all stakeholders, information and communication technology tools will permit CASE to provide useful services to different traders while improving technology processes and infrastructure. Moreover, the analysis indicated that consistent with the technology acceptance model both perceived ease of use and perceived usefulness are playing important roles in defining the acceptance level of different CASE introduced technology-based services. It is important to note that this research study represents phase one of a much larger research work assessing the implications of the automation and the diffusion of information and communication technology on CASE, trading and the economy at large.

REFERENCES

American Chamber of Commerce in Egypt (2004) Proceedings of the Reform of the Financial Sector in Egypt Conference, December

American Chamber of Commerce in Egypt (2001) The Egyptian Capital Market, Business Studies and Analysis Center

Automated Trading System (2004) www.egyptse.com (website) last accessed 10 May

Capital Markets Program (2004) www.usaid-eg.org (website) last accessed 20 April

Egypt for Information Dissemination (2004) www.egidegypt.com (website) last accessed 5 May

Helen A, Hawkins J and Sato S (1997) Electronic trading and its implications for financial systems, BIS Papers, Number 7

History of the stock exchange in Egypt (2004) www.egyptse.com (website) last accessed 10 May

Ministry of Communications and Information Technology (2004) www.mcit.gov.eg (website) last accessed 28 April

Parl S and Yun G W (2004) The Impact of Internet-Based Communication Systems on Supply Chain Management: An Application of Transaction Cost Analysis, Journal of Computing Mediated Communication, Volume 10, Issue Number 1 (Special Issue on Electronic Commerce)

Picot A, Bortenlaenger C and Roehrl H (1995) The Automation of Capital Markets, Journal of Computing Mediated Communication, Volume 1, Issue Number 3 (Special Issue on Electronic Commerce)

ENDNOTE

[1] This paper is based on a research study conducted in Egypt in 2004 on the automation process of the Cairo Alexandria Stock Exchange. The research was conducted by Sarah Ayad, Nancy Benjamin, Nahla El Okdah, Hanan Ezzeldin, Mary Habib, Rafik Louis and Khaled Youssry

RFID Adoption: Issues and Challenges

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INTRODUCTION

Radio Frequency Identification (RFID) is an emerging technology that has been increasingly used in logistics and supply chain management in recent years, particularly in the US and Europe. World's largest retailers are increasingly requiring their suppliers to be RFID compliant. Although RFID is not a new technology, the term RFID has been popular for the past couple of years. We are seeing an increasing interest in this technology by companies (Prater and Grazier, 2005).

RFID tools can identify, categorize, and manage the flow of goods and information throughout a supply chain (Ngai et al., 2005). Rapid development of RFID combined with a major push coming from mandatory RFID tagging decree by Wal-Mart and the U.S. Department of Defense and others like European companies Metro AG and Tesco, has caused companies to take a hard look at what RFID can do for them and whether they should give further consideration to adopting the technology.

RFID has been around for decades. It is one such technology that we can embed into objects to track location, monitor security, and record the status of events or even environmental conditions (Stanford, 2003). RFID systems have emerged as new forms of inter-organizational systems (IOS) and are used to improve the efficiency of the processes in a supply chain. Because of their capability for use in real-time identification and tracking over long distances, some believe that RFID systems will fundamentally change the way companies do business (Smith and Konsynski, 2003).

The following are some of the current issues and challenges facing the RFID technology adoption in industrial applications.

CURRENT ISSUES FACING RFID ADOPTION

Globally Interoperable Standardization Problem

There is lack of global standards for RFID adoption. It is no doubt that the adoption of official standards, enabling interoperability between applications or devices, can significantly accelerate the adoption of RFID technology. The RFID industry has been mainly using two different standards. One is being developed by the International Standards Organization (ISO), the world's main developer of standards that has developed several standards around RFID which are used in Europe. The other is the Electronic Product Code (EPC) system, which is being commercialized by EPCglobal, a non-profit organization set up by EAN International and the Uniform Code Council. What standard should be used is one of the most frequently asked questions from the users. It is critical that the EPC and ISO standards can co-exist in order to ensure end-to-end interoperability of RFID systems to track goods through the global supply chain Finkenzeller (2003).

Environment

Currently, the most used frequencies for RFID implementations are – 13.56 MHz (i.e. "HF" for High Frequency) and 915 MHz (i.e. "UHF" for Ultra High Frequency). At these frequencies, transmissions are impacted by two environmental factors. The first one is water and other one is liquids which are hindrance to RFID system performance. Liquids can absorb the radio energy/signals and thereby limit range or prevent tag read/write operations altogether. Label media adhesives also can be an unexpected source of liquid. Some types of adhesive or label materials that absorb moisture from the environment, which could cause performance problems. This makes "reading" tags through liquids very difficult, if not impossible. Metals are another hindrance that generally reflect radio frequency signals and deflect the radio waves, thus altering their path. This is essential source of RFID interference and should be avoided if possible. This does not necessarily mean that metals prevent "reading" tags on objects or cartons that contain metal, but the radio waves must have a path into and out of the material.

The second technical problem is that one should watch out for the use of the other equipment of the frequency that is near the one used by the RFID solution. For example, the first generation of GSM phones transmits at 900 MHz, as do some handheld RF barcode scanners. This is near enough to 915 MHz to potentially cause interference. This problem can usually be overcome by shielding the RFID reader.

Security and Privacy

RFID technology has proven to be reliable, especially in supply chains, and is already showing tremendous advantages. But an automated supply chain mandates the necessity for data privacy, identity and non-refutability, and organizations should ensure the RFID technology they adopt supports their security requirements. Companies need to be aware of the security risks, such as profiling, eavesdropping, denial of service attacks and inventory jamming.

Education and training is the best way a business can ensure it understands the limitations and risks associated with RFID adoption. Businesses should not assume that the risks associated with RFID adoption are small because the RF footprint of current generation tags is constrained. Understanding the mean time to crack—access, alter or deny the use of—the tags is a prerequisite to ensure that tag selection embodies the objectives of the company's corporate security policy.

RFID has the potential to threaten consumers through intervention of their informational privacy, their physical privacy and security and their civil liberties (McGinity, 2004). Consumers are concerned the possible abuse of personally identifiable data (such as credit card number, security number) and sensitive data (such as prescription drugs) by the retailers when companies adopt RFID technology. A considerable driver of the fear of RFID to consumers is a lack of understanding about RFID technology. Companies should inform consumers that they use RFID tags on the products, and educating consumers of the true technological limitations of RFID.

Data Management

Many conversations about RFID inevitably end up touching on the presumed high volume of data and resulting data management issues that are expected to arise from tagging individual products. Data management is a key issue for any organization deploying RFID technology, and the robust middleware to handle that onslaught of data and route it to the right database is most concerned. To leverage this enhanced visibility of data captured, enterprises need to establish the right architecture to filter and translate RFID data into business relevant events and then to use these events to create and automate business process for providing quality service and better competitive advantages.

Generally speaking, RFID data management issues fall into several categories: RFID data collection and storage, data integration, data synchronization, data ownership and privacy, data interpretation and analytics, and execution of end-user business processes to sense and respond to RFID data. Companies need to address a couple of questions, for example: what RFID data should be collected and stored? How this RFID data is different from that is currently collected and stored? Who owns the RFID data, and what elements are subject to privacy or security considerations? What is the best way to visualize this RFID data collection and act upon key events? And most important, what business processes need to be changed to enable people to act upon this information?

Tag Failure Rate

As pointed out by the report of Deavours (2005) in the "UHF EPC Tag Performance Evaluation" – "Even tags of the same make and model vary significantly in their performance as this excerpt from the RFID Alliance Lab's report (http://www.rfidjournal.com/labreports). The tests showed that the range of under-or nonperforming tags can range from 0 percent up to 19 percent. Companies should screen out under or nonperforming tags. Even if tag producers will reimburse you for bad tags, you still need to do the screening yourself.

Focus on the worst case performance tags, not average or best case because your system will have to be designed to accommodate the worst performance. Currently, there is a high rate of first pass write failure, anything up to ~10%. Clearly, this failure rate is not the one that one could sensibly sustain in live operations. A Root Cause Analysis has thrown up two probably causes of this high failure rate:

1. A tag was mounted on a plastic base and multiple tags were then mounted on a plastic backing roll. Separating the two quickly set up an electrostatic discharge which damaged the chip.
2. When pulling the tag off the reel for manual application, the operators had a tendency to pull the tag across the centerline thus causing the antenna strip to separate from the chip.

Quality Assurance

An important part of the user's requirement is that the tags on all goods must be intact and readable. Considering the Wal-Mart as an example, pallet tags must be 100% readable at the receiving dock and case tags must be 100% readable on a conveyor moving at the speed of 600 feet per minute with a minimum spacing of 8 inches between cases (Deavours, 2005).

One should ensure that there are sufficient processes, checks and balances in place to guarantee that all RFID tags on pallets and cases have been written correctly and are intact at the point of shipment to the next location, be that a customer location or another distribution center. One should also ensure that all reasonable steps have been taken to prevent the damage or removal of the tag in transit.

RFID Expertise for Deployment

A recent survey by the Computing Technology Industry Association revealed that 80 per cent of the responding companies said there were not sufficient numbers of skilled RFID professionals. Two-thirds of them said training and educating their employees on RFID technology is one of the biggest challenges they face in order to succeed in the RFID market (Morrison, 2005). We believe that the problem is more serious in Asian countries. Like Hong Kong, there is a lack of strong expertise in RFID technology deployment. Local large-scale deployments are usually made by foreign companies. It is difficult to find local experts in the RFID field with large-scale deployment experience. Certainly, education through short course like an RFID certification program and a coordinated crash training program may be the best hope to fill the work force urgently need but for long time, the knowledge and skills related to RFID technology should be education in higher education.

CURRENT CHALLENGES FACING RFID ADOPTION

Along with the potential offered by RFID come the inevitable challenges that must be understood and overcome before companies can reap the benefits.

Management Commitment

Gaining management commitment is one of the biggest challenges in implementing RFID. Despite it can result in savings, it is always difficult to get senior management commitment because it is new to them. Return on investment (ROI) is an important consideration for management consider in assessing RFID investments before RFID project commitment. Gillette is using the RFID tags in one of the biggest EPC project, tagging all pallets and cases of its Venus women's razors that his vice president, Mr. Cantwell championed RFID technology internally at Gillette (Roberti, 2004).

Dual Systems

With RFID, not all partners will use it, and those who do may require it for only their RFID-ready distribution centers. Furthermore, not all the items or packages will be tagged. Another need for dual systems arises when you deal with small and medium businesses that can not afford RFID systems. You should assume that exceptions to the "all or nothing" ideal will always exist and be prepared to deal with this challenge from a technical and operational standpoint.

Cost Challenges

The biggest challenge companies faced with RFID is that it is the high cost of implementation. One of the challenges a company faces with the introduction of RFID technology is whether the business really needs the technology and how to justify the investment in the implementation. Cost-benefit analysis is critical to the successful adoption of an RFID project. At present, the cost of RFID adoption is the major investment in hardware, application software, middleware, tags and the cost of integrating RFID-based system with the legacy systems, consultancy fees and employee training.

Legal and Patent Challenges

Most of the companies overlook the importance of having a legally binding master agreement before adopting RFID. As most of us know that in the end there are no real winners in a trading relationship that ends up in litigation. RFID technology, should carefully discuss with vendor, each trading partner about the liability limitations that pertain to the data contained on tags (because it can mistakenly be overwritten). The intellectual properties (IPs) of some RFID technology is still not clear. Like in 2004, Symbol Technologies has filed a counter patent-infringement lawsuit against Intermec Technologies (http://www.rfidjournal.com/article/articleview/1443/1/58).

We believe that to make sure RFID technologies are widely adopted, RFID needs to be royalty-free. As some vendors are concerned about paying high royalty cost to develop RFID systems which is another barrier for widely development of RFID systems.

Operational Automation

Companies should evaluate their own needs and determine which processes can benefit from automation with the use of RFID and associated technologies. To aid in their operational evaluation, they must study the business operations processes in their company and determine the volume of information exchange. Which if your items are suitable for tagging? What are the types of tags will they need today and how quickly will those needs change in the future. Whether they need to combine that RFID tag with a bar code when they realize that the RFID system fails them too often and leaving them. Evaluate company's operations and determine how, where and when best to apply one or a combination of these technologies to benefit the organization, its customers and the entire supply chain. Those questions are the most frequencies asked questions by the users.

Selection of Hardware and Software

The challenges here include the choice of RFID solution including the hardware and software required. The choice of tag types in terms of read range, read/write capability, reader type, and middleware. The performance of hardware products in the market varies and a lot of efforts need to be devoted to hardware evaluation and testing. Also, the performance of RFID system varies in different environments. The solution is to tightly integrate the hardware equipment with the software system. The software system should be able to correct any problems due to the unreliable data captured via RFID.

Another consideration is whether to use the RFID tag alone or to tag it in addition to a bar code label. The advantage of the dual technology is, of course, that should one fail, and the other can serve as a backup. However, they can be sure about their implementation and maintenance costs will be higher as a result.

Technology Support for Adoption

At present, both RFID hardware and software in Asian markets are mainly from the US. Although RFID solutions are from foreign vendors with support of local distributors, which provide limited technical support, as most of their staff are marketing oriented. We have found that most RFID hardware providers in Asian markets lack technical support staff, and their RFID teams mainly consist of salesmen and marketing staff. This is due to the fact that RFID is just an emerging technology in most Asian countries.

CONCLUSIONS

Besides, the costs and technical challenges, we believe, the value of RFID, and how companies can implement this technology to enhance the quality of service, their production and eventually corporate earnings are crucial in RFID adoption. It is hoped that this paper will provide the readers to have a better understanding of the current issues and challenges facing the RFID adoption and be in a position to further investigate each issue and challenge discussed here best understand it before the implementation.

Technology researchers find out the ways to increase the range of RFID signals and reduce the radio frequency interference, standards organizations like ISO and EPCglobal unravel the standardization problem and make an open and compatible standard while stores determine how to make customers desire RFID in their lives (McGinity, 2004). However, as with other emerging technology, RFID technology is still not fully development. We see that the more research effort and development put into RFID study, the more successful RFID adoption we can see.

The following points out some research topics that are of interest for further research for RFID adoption:

- Social and economic impacts of RFID impacts of RFID adoption;
- Privacy, security, legal and cultural challenges of RFID adoption;
- Antecedents of RFID success adoption;
- Evaluation metrics and implementation of methodologies for RFID adoption;
- Barriers and critical success factors for RFID adoption; and
- Educational requirements and curriculum implications of RFID technology.

Finally, we quote a comment originally made by Mark Roberti, editor of RFID Journal that "Companies will have no choice but to use RFID, just as they have no choice but to use the Internet today".

REFERENCES

1. Deavours, D., EPC Tag Performance Evaluation, *RFID Alliance Lab*. May, 2005
2. Fao, A. and Gershman, A. The future of business services in the age of ubiquitous computing, *Communications of the ACM*, 2002, Vol.45, No. 12, 83 – 87.
3. Finkenzeller K., RFID Handbook Radio-Frequency Identification Fundamentals and Applications, *John Wiley & Sons, Ltd.*, England, 2003.
4. Morrison, J. (2005), "Help Wanted", *RFID Journal*, March/April, pp. 13 – 20.
5. McGinity, M. RFID: Is this game of tag fair play? *Communication of ACM*, 2004, Vol. 47, No. 1, 15 – 18.
6. Ngai, E.W.T., Cheng, T.C.E. Au, S., and K. H. Lai, Mobile commerce integrated with RFID technology in a container depot, *Decision Support Systems*, 2005 (Forthcoming).
7. Prater, E. and Grazier, G. Future impacts of RFID on e-supply chains in grocery retailing, *Supply Chain Management: An International Journal*, Vol. 19, No. 2, 134 – 142.
8. Roberti, M., Gillette sharpens its edge, *RFID Journal*, 2004, 12 – 16.
9. Smith, H. and Konsynski, Developments in practice X: RFID – An Internet for Physical Objects, *Communications of the Association for Information System*s, 2003, Vol. 12, No. 19, 301-311.
10. Stanford, V., Pervasive computing goes the last hundred feet with RFID systems", *IEEE pervasive Computing*, 2003, Vol.2, No. 2, 9-14.

Issues Affecting the Adoption and Continual Usage of Internet Banking Services in Semi-Rural Areas of South Africa

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ABSTRACT

In modern society, Information communication technology (ICT) diffusion is very rapid. However, ICT infusion is very slow. Several issues contribute to ICT infusion. They range from social, economic, demographic and political reasons. Internet banking is one such ICT contribution that is facing limited acceptance in some parts of South African society. This research looks at issues affecting the adoption and continual usage of Internet banking in a South African semi rural area, Mafikeng region. Although Internet banking has been receiving a lot of interest worldwide, very little methodical study has been done to determine reasons why many people in semi rural areas like Mafikeng do not adopt and make use of Internet banking services. Technology Acceptance Model (TAM) was used to guide the enquiry process into factors affecting Internet banking infusion. Internet Security was found to be a major factor contributing to Internet banking adoption and continual usage in Mafikeng.

Keywords: Internet Banking, Technology Acceptance Model, Internet Security, ICT diffusion, South Africa

1. INTRODUCTION

For banks to serve clients through the Internet can be very risk if security is not improved. The primary services provided through Internet banking are transferring money among one's own accounts, paying bills, checking account balances and sending and receiving confidential information between banks and their clients.

Information about financial institutions, their customers and financial transactions are considered very sensitive. Doing such business via a public network consequently introduces new challenges for information security. Internet banking system must solve issues of authentication, confidentiality, integrity and non-repudiation. The system must ensure that only authorized people can access an Internet banking account, the information viewed remains private and cannot be modified by third parties. Any transactions made should be traceable and verifiable. The behavior of people in a semi rural area of South Africa towards the adoption and usage of Internet banking will be the focus of this paper.

The rest of the paper is as follows: **Section Two** discusses the general Internet issues in South Africa. **Section Three** discusses the theoretical frameworks used to appraise the adoption of information systems in the society. **Section Four** looks at the research approach, **Section Five** discusses the results and **Section Six** concludes the discussion**.**

2. BACKGROUND TO INTERNET USE IN SOUTH AFRICA

South African Internet users have been increasing steadily since 2000 from 2.4 million to 3.6 million in 2005 (Internetworldstats, 2006). This is an average user increase of 50% and an average of 6.7% of users relative to the country's gross population. Table 1 shows the increase in the number of internet users from 2000 to 2005.

The Goldstuck report on "Internet Access in South Africa 2004", mentioned the introduction of high speed or broadband wireless by Sentech, and the good rand to dollar exchange rate as some of the factors that could contribute to increased internet access in South Africa. This is in addition to the introduction and licensing of a Second National Operator (SNO). The introduction of the SNO will remove Telkom monopoly and introduce competition in the fixed line industry. This may eventually lead to decrease in telecommunication costs which are rated highly as one of the factors hindering internet infusion in South Africa. In addition to broadband access from Sentech, introduction of ADSL and ISDN from Telkom will further increase internet speed and will positively contribute to reduction of internet costs.

2.1 Internet Banking Review

For customers, developments taking place in the banking world means cheaper, faster and convenient banking (Chan 2001). Nowadays, banks are installing automated teller machines (ATMs) in a bid to bring services to the people. Banking has been revolutionized (Standard Bank, 2004). Point of sale banking, where people are allowed to use debit and credit cards to pay for goods and services in addition to withdrawing money have also been introduced.

Advances in information technology (IT) have created cell phone banking and Internet banking as serving channels in the banking sector. Internet banking is

Table 1. Internet Users Growth Trends in South Africa, 2000-2005. (Source: Internetworldstats, 2006)

YEAR	Users	Population	% Pen.	Usage Source
2000	2,400,000	43,690,000	5.5 %	ITU
2001	2,750,000	44,409,700	6.2 %	IWS
2002	3,100,000	45,129,400	6.8 %	ITU
2003	3,283,000	45,919,200	7.1 %	Wide World Worx
2004	3,523,000	47,556,900	7.4 %	Wide World Worx
2005	3,600,000	48,861,805	7.4 %	Wide World Worx

"communication with the Bank and/or performance of Transactions through the Internet network"(ING Bank, n.d.). Some people refer to it as online banking. Generally, the two words are used interchangeably and defined as terms " used for performing transactions, payments etc. over the Internet through a bank, credit union or building society's secure website." (Wikipedia, n.d.).

Internet banking has changed the way banking is conducted areas such as, distribution, production, payment and trading (Llevwellyn, 1997). It also created new customer values, in content, infrastructure, and context (Methlie, 1998). Although the number of Internet users has increased significantly over the past decade, only a small number of those users have made actual purchases over the Internet. The failure of the Internet as a retail distribution channel has been attributed to the lack of customer trust in this electronic channel and web merchants (Stewart, 1999) as media of banking.

Customer trust can be related to customer loyalty and hence increased revenues for a firm such as a bank (Reichheld, 1993), High customer trust, low customer turnover and decreased costs can generate new business for a firm via word-of-mouth recommendations (Schlesinger and Heskett, 1991). Studies on factors that determine customer trust and loyalty in Internet banking are becoming extremely important.

2.1.1 Internet Banking in South Africa

According to World Wide Worx (2004), South Africa is one of the richest and economically important countries in Africa. Despite the country's sound economic framework, the apartheid legacy has prohibited South Africa from achieving its full economic potential.

South Africa's four main domestic banks offer Internet banking services. These are Standard bank, First National bank, ABSA bank and Nedbank. According to SA.Internet.com (2001), ABSA had predicted an Internet population of 3.2 million by the end of 2002. On the contrary, online banking only reached the one million mark in South Africa at the end of 2003. This implies ABSA's prediction went off the mark. World Wide Worx (2004)'s report, "Online banking in South Africa", the number of online bank accounts in South Africa grew by 28% in 2003.

However, about half of the country's Internet users have signed up for Internet banking (Webchek, 2002). This has encouraged banks to launch many new online banking offerings. Despite all these positive trends, few questions however remain unanswered. Two of such important questions are:

- Is there a great opportunity for growth amongst semi- rural Internet banking users in South Africa?
- What are the reasons contributing to the slow uptake of Internet banking services in South Africa?

This research paper covers an area that has long been neglected by many researchers in this field. It looks at a section of the society which falls between the urban elite and the seriously disadvantaged rural population, the semi rural society. This section of society has a great potential in adding value to businesses and must be considered as the next generation market niche especially in the banking sector. By its nature, the banking industry has traditionally focused on the urban elite as their revenue base. Market saturation is now forcing many banks to formulate new business strategies that are powered with new information systems strategies such as Internet banking strategies. These strategies can easily be realizable due to the fact that technology costs are ever going down and customers are ever looking for pervasive services.

2.2 Issues facing Internet Banking Customers

Internationally, banking is an information sensitive industry (Hoppe, 2001). There are a number of issues hampering the acceptance of Internet-based banking. These include customer satisfaction with existing service channels, security concerns, and a perceived lack of utility in the Internet channel. For newcomers to the Internet, issues such as security and privacy concerns are still the greatest barriers to entry.

2.3 Trust in Internet Banking

Trust is defined as "a willingness to rely on an exchange partner in whom one has confidence" (Mukherjee et al., 2003). Customer trust is depended upon Internet banking reliability and integrity. Trust plays a vertical role in building long-term exchanges between banks and customers. There exist many factors that contribute to Internet banking acceptance by users. Different models are used to study technology acceptance in organizations and society at large. The next section discusses some of these models.

3. FRAMEWORKS FOR EVALUATING IT ACCEPTANCE IN SOCIETY

Business-to-customer (B2C) commerce in the financial industry depends on the consumers accepting and recognizing online banks the same way they have accepted brick and mortar banks (Mattila, 2001). One of the objectives of this research is to investigate consumer adoption and usage of Internet banking. The research will help South African banks to understand the attitude of customers towards Internet banking. In order for banks to find out the attitudes of their customers towards Internet banking, indirect indicators such as verbal expression or overt behavior should be used to measure hypothetical constructs that show variables that are not directly observable.

3.1 Technology Acceptance Model

Technology Acceptance Model (TAM) proposed by Davis (1989) is derived from the Theory of Reasoned Action (Cho & Cheung, 2003). The goal of TAM is to provide a description of the determinants of technology acceptance that are competent of explaining user behavior across a broad variety of end-user technologies and user populations (Kamel & Hassan, 2003). TAM achieves this goal by recognizing a small number of basic variables suggested by other researchers dealing in the cognitive and sentimental determinants of computer acceptance (Chan, 2001).

TAM assumes that perceived usefulness (PU) and perceived ease of use (PEOU) are the primary significance for computer acceptance behavior. This model hypothesize that actual usage is determined by users' behavioral intension to use, which is influenced by their attitude and belief of perceived usefulness (Cho & Cheung, 2003). Users attitude towards Internet banking is determined jointly by perceived usefulness and perceived ease of use.

- **Perceived Usefulness (PU)** is whereby a potential user believes that his job performance would improve when using a particular system (i.e. Internet banking). How will Internet banking improve the way users do their financial transactions?
- **Perceived Ease of Use (PEOU)** is whereby a potential user believes that using a particular system (i.e. Internet banking) would be hassle free. Issues such as system's user interface design come to the fore.
- **External variables** of the system, such as documentation, and training are also considered here.

3.2 Development of Hypotheses

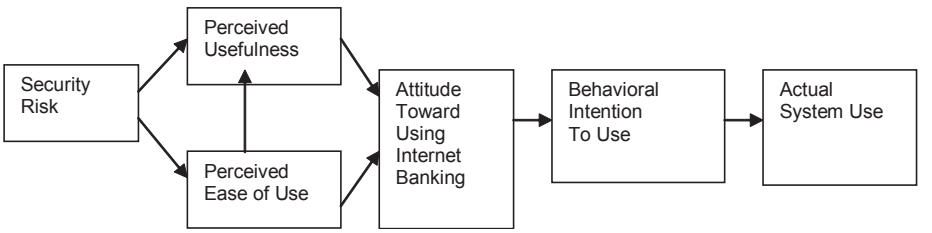
Hypotheses were developed based on the Technology Acceptance Model. According to Cho & Cheung (2003), perceived ease of use is a better predictor of attitude while perceived usefulness is a better predictor of intention of inexperienced users. The research considered the role of Internet banking security as an external variable affecting consumer adoption on Internet banking.

3.2.1 Internet Banking Adoption Model

Figure 1 shows the TAM based Internet banking adoption model. Perceived ease of use (PEOU), perceived usefulness (PU), attitude, intention, and the actual use are directly extracted from the technology acceptance model (TAM).

- **PEOU**: In this research, PEOU means the ease of login to the bank site and perform transactions. PEOU is positively related to attitude towards Internet banking security.
- **Attitude**: The research defines attitude as a person's positive or negative feeling about Internet banking. In TAM, attitude is directly related to intension. Internet banking security risk, PEOU, PU all influence attitude and they in turn affect the intention to use.
- **PU**: Perceived usefulness can be measured using security as a parameter. The perceived usefulness influences attitude towards using Internet banking. If Internet banking security is reliable and there exist Internet banking perceived usefulness, then people will have positive attitude towards using Internet banking.

Figure 1. TAM-based Internet banking adoption model



- **Security risk**: The effect of security risk on the adoption and continual usage of Internet banking was considered as an external variable. Security risk is the uncertainty users have on the fidelity of Internet transactions. This category includes issues pertaining to hackers, crackers, passwords, and the type of security protocols. Security risk may have negative impact on the PEOU and PU. If security risk on Internet banking web sites is reduced, users will be more willing to adopt and use the facility. The less the security risk, the higher PEOU, and PU.

3.2.2 Hypotheses Proposals

The following six hypotheses were proposed:

- H1: Peoples' attitude towards Internet banking is directly related to Perceived ease of use (PEOU)
- H2: Perceived ease of use (PEOU) is directly related to perceived usefulness (PU) of Internet banking
- H3: Perceived usefulness is positively related to users' attitude to use Internet banking
- H4: Users' intention to use is dependent on users' attitude towards Internet banking
- H5: Security risk is negatively related to Perceived ease of use of Internet banking
- H6: Security risk is negatively related to Perceived Usefulness of Internet banking.

4. RESEARCH APPROACH

This is a quantitative type of research. Quantitative research is based on the assumption that natural phenomena can be quantified in numeric terms. The development of metrics (numbers) that can be used to describe phenomena (objects and relationships) under study are the focus of this type of research (Cornford and Smithson, 1996). Because numbers (quantities) are the principal instruments to make a decision, this research becomes also a positivistic type of research.

Positivism is used to describe a philosophical position that can be discerned in research and can also involve crude and superficial data collection (Bryman, 2004). This type of research treats the subject of research as something capable of developing general theories of universal applicability (Cornford and Smithson, 1996). In some cases the theories need to be proposed and tested. The research will focus on a case of Mafikeng region. This case study exhibits particular characteristics that are not common to most of South African regions. It is a sample of participants from a semi rural background. The results that are found here may need to be supported with research from other representative areas of South Africa to make them more conclusive.

4.1 Research Design

A survey was conducted in the region of Mafikeng. The data gathering was done using a questionnaire. All the questions were of closed type. The intention was to collect information on people's perception of Internet banking and Internet banking security. The questionnaire had three parts. Part I dealt with Internet access issues and use of Internet banking. Part II questions looked at respondent's perception towards Internet banking. On a five point Rieckert scale, respondents were asked to indicate what they think about different aspects of Internet banking and security. Part III of the questionnaire included questions that gathered the demographic characteristics of the participants. Issues like age, gender and employment status were asked. Data collection took place between November and December 2005. Hundred questionnaires were distributed, fifty four (54) were completed and returned, and forty six (46) were not returned. All the data collected was analyzed using SPSS 13.1 version for windows.

5. RESULTS AND ANALYSIS

Comparisons were made between people who are using and not using Internet banking. Occupation, gender, access to Internet and Internet banking knowledge were considered. Table 2 shows the profile of the respondents. Of the returned 54 questionnaires, nineteen(19) were users of Internet banking, thirty three (33) were not using Internet banking and there were two missing data. Of these 54, twenty six (26) were males and twenty eight (28) were females.

Table 3 shows the distribution of respondents according to places they access the Internet.

The purpose of this question was to know which place is most used for Internet access. Of 54 observations, 9.3% access Internet from school, 70.4% access Internet from the work place, only 1.9% access it from home and 18.5% were missing data. This shows that from the sample chosen, very few people can pay Internet access at home.

Table 4 shows statistics of people who know about Internet banking. The purpose of this question was to give the researcher a guide of whether people have knowledge about Internet banking.

About 81.5% (44) of participants have knowledge of Internet banking and 16.7% (9) have never heard about Internet banking before. We have 1.9% (1) missing data. Table 5 shows results of people who are using Internet banking. These results will be used to judge Perceived Ease of Use and Perceived Usefulness of Internet banking.

Table 2. Respondent's profiles

Gender	Male	48.1%
	Female	51.9%
Occupation	Employed	81.5%
	Unemployed	18.5%
Age	17-21	7.4%
	22-30	29.6%
	31-40	24.1%
	41-50	25.9%
	51-60	11.1%
	61 and above	1.9%
Experience in using Internet banking	Yes	35.2%
	No	61.1%
	Missing data	3.7%

Table 3. Place of Internet access

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	School	5	9.3	11.4	11.4
	Work	38	70.4	86.4	97.7
	Home	1	1.9	2.3	100.0
	Total	44	81.5	100.0	
Missing	System	10	18.5		
Total		54	100.0		

Table 4. Knowledge of Internet banking

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	44	81.5	83.0	83.0
	No	9	16.7	17.0	100.0
	Total	53	98.1	100.0	
Missing	System	1	1.9		
Total		54	100.0		

Table 5. Internet banking users

Do you have experience using Internet Banking?

					Cumulative
Valid	Yes	19	35.2	36.5	36.5
	No	33	61.1	63.5	100.0
	Total	52	96.3	100.0	
Missing	System	2	3.7		
Total		54	100.0		

Table 6. Security perception

Advances in Internet security technology provide for safer Internet Banking.

					Cumulative
Valid	Disagree	2	10.5	11.1	11.1
	Neither	9	47.4	50.0	61.1
	Agree	6	31.6	33.3	94.4
	Strongly Agree	1	5.3	5.6	100.0
	Total	18	94.7	100.0	
Missing	System	1	5.3		
Total		19	100.0		

About 35.2% (19) of respondents have experience using Internet banking. This implies that out of 54, 61.1% (33) have no experience of Internet banking. There were two (2) missing data. Table 6 shows the Internet banking user's perception of Internet banking security. The Internet banking users are the ones who can give the Perceived Ease of Use and Perceived Usefulness from their experience in using Internet banking. Perceived Ease of Use is a better predictor of attitude and Perceived Usefulness is a better predictor of intention of inexperienced users (Cho & Cheung, 2003).

The respondents gave their answers using a five point Rieckert scale. As discussed in section 4.1, the range was from disagree (scale 1) up to strongly agree (scale 5).

The responses answered the research questions. The questions test our proposed model, where security was used as an external variable. The research questions concerns the most important elements of Perceived Usefulness (PU) and Perceived ease of Use (PEOU) in Internet banking. When respondents asked to provide their perception about security in Internet banking, Perceived Usefulness was considered the most important element of the PU construct.

Respondents were asked to indicate whether they think advances in Internet security technology provide for safer Internet banking. About 10.5% of the 19 who use the service disagree that advances in Internet security technology provide for safer Internet banking, 47.4% observations did not give their perceptions, 31.6% observations agree that advances in Internet security technology provide for safer Internet banking while only 5.3% observations strongly agree. We had 5.3% (1) missing data.

Table 7 indicates the distribution of responses with respect to the user friendliness of Internet banking. This question also was used in our proposed model, where

Table 7. User friendliness of Internet banking

Internet Banking is easy-to-use.

					Cumulative
Valid	Neither	2	10.5	10.5	10.5
	Agree	11	57.9	57.9	68.4
	Strongly Agree	6	31.6	31.6	100.0
	Total	19	100.0	100.0	

Table 8. Advice other to use Internet banking

I will not advice others about to use Internet Banking.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	3	15.8	15.8	15.8
	Disagree	4	21.1	21.1	36.8
	Neither	4	21.1	21.1	57.9
	Agree	7	36.8	36.8	94.7
	Strongly Agree	1	5.3	5.3	100.0
	Total	19	100.0	100.0	

security is also an external variable in Technology Acceptance Model (TAM). This research question also concerns an important element of Perceived Usefulness (PU) and Perceived ease of Use (PEOU) in Internet banking. In respondents' perception about ease of Internet banking, Perceived Ease of Use was considered the most important element of the PEOU construct.

About 10.5% (2) observations of 19 strongly disagree that Internet banking is easy-to-use, and 57.9% (11) agree that Internet banking is easy-to-use while 31.6% (6) observations strongly agree.

The focus of the question above was on the direct and indirect effects of PEOU and PU on the intention to choose Internet banking. Attitude construct has a larger direct effect on intention than PEOU and PU. The answer to the question above is that attitude mainly influences intention and behavior directly, but also indirectly through PEOU and PU.

About 15.8% (3) observations of 19 strongly disagree that they will not advice other to use Internet banking, 21.1% (4) observations disagree, 21.1% (4) did not provide their feeling, 36.8 %(7) observations agree that they will not advice others to use Internet banking, 5.3% (1) observations strongly agree.

5.1 Hypotheses Results

Using the analyses made on section 5, Table2 through to Table 7, the following deductions can be made about the proposed hypotheses.

H1: Perceived ease of Use (PEOU) is directly related to peoples' attitude towards Internet banking security.

The results of this hypothesis show that the majority of responses confirmed that attitude towards Internet banking adoption is directly related to Perceived Ease of Use and Perceived Usefulness. Attitude is also indirectly affected by security risks in Internet banking.

H2: Perceived ease of use (PEOU) is directly related to perceived usefulness (PU) of Internet banking.

Perceived ease of Use is directly related to Perceived Usefulness. This hypothesis was tested by the question "is Internet banking ease to use?". This hypothesis has been proven true as the responses where positive about the ease of Internet banking.

H3: Perceived usefulness is positively related to users' attitude to use Internet banking.

The result of the above hypothesis is true because the responses show that if the Perceived Usefulness is positive the user's attitude will also be positive.

H4: Users' attitude has a positive relation to the users' intention towards the adoption of Internet banking.

The result of the above hypothesis is also true because if the response of attitude towards Internet banking is positive, the intention to use will also be positive.

H5: Security risk is negatively related to Perceived Ease of Use of Internet banking

The hypothesis above explains that if the security risk is high in Internet banking, the possibility that user's see it to be Perceived Ease of Use is negative.

H6: Security risk is negatively related to Perceived Usefulness of Internet banking

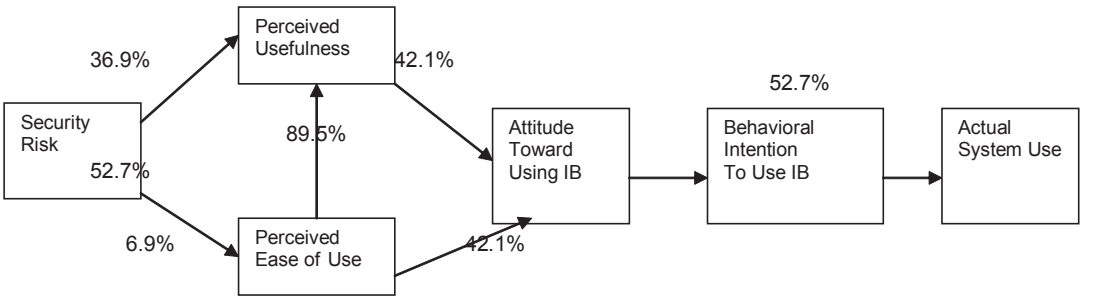
The hypothesis has been proved that it is true that security risk is negatively related to Perceived Usefulness.

Figure 2 shows the percentage distributions of the results obtained that justify the six hypotheses that were developed above.

6. DISCUSSIONS AND CONCLUSIONS

TAM as an appraisal technique for technology acceptance in communities can be applied effectively if other variables are kept constant. By focusing on the security parameter in Internet banking(IB), and ignoring other factors, the research has

Figure 2. Results for TAM-based Internet banking model



managed to show that Internet banking acceptance is directly related to both PU and PEOU but inversely related to the security issue. In other words, security as portrayed herein, is a major factor that reduces the uptake and continual use of Internet banking in Mafikeng.

The study has however shown that apart from security, in semi rural areas like Mafikeng, the following factors play a very important role in the acceptance and usage of Internet banking.

- Economic status of the society. Mafikeng is generally a poor society and prospective Internet banking users have no access to the Internet. Many of those using Internet access it from work places as indicated in Table 2.
- The people have no knowledge of the security systems in place in Internet banking. This has been indicated in the research by the fact that many respondents did not answer the security question, opting to abstain, Table 6.
- Implicitly, costs such as telkom costs, bandwidth and speed may also affect the uptake of a technology such as Internet banking. The research bases this argument on the fact that, if at all, a user has to use an Internet café to access the facility; the costs can be prohibitively very high. All these are a combination of Internet speed, bandwidth and telkom costs.
- The literacy level of a society play a major role in this type of research. Usually technologies such as Internet are associated with the educated, learned elite of the society. This factor was not properly followed in this research but considering that Mafikeng is a semi rural area, many people did not know what to answer on the questionnaire because they are semi literate. Table 2 statistics supports this fact.

The biggest limitation of the research is the fact that the number of respondents was very small. In studies like this, the sample could have been increased to about a thousand (1000) participants. This was not possible because of the financial and time constraints. Also, since this is a case study, the results may not be accepted at face value to be a general representation of all South African semi rural areas. The research intends to spread the investigation throughout South African towns so as to reach a general conclusion.

7. REFERENCES

BRYMAN, A. 2004. *Social Research Methods*. 2nd Ed, Oxford University Press, Oxford, United Kingdom.

CHAN S. C. 2001. *Understanding adoption and continual usage behavior. Towards Internet banking services in Hong Kong,* Lingnan University.

CHO, V. & CHEUNG, I. 2003. *A study of on-line legal service adoption in Hong Kong.*

CORNFORD, T. & SMITHSON, S. 1996. *Project research in Information Systems: A Student Guide.* Palgrave, New York

HOPPE, R., NEWMAN, P. & MUGERA, P. 2001. *Factors Affecting the Adoption of Internet Banking in South Africa*: a Comparative Study.

INTERNET WORLD STATS. 2006. South Africa: Internet Usage and Marketing Report. [Online]. Availbale: http:www.Internetworldstats.com/af/za.htm. Cited 6 September 2006.

ING BANK, n.d. General Terms and Conditions. [Online]. Available:http://www.ing.sk/sk-en/products_services/konto/new_natural/. Cited 10 September 2006.

STANDARD BANK, 2004. Self service online: Internet banking. [Online]. Available: http://www.standardbank.co.za/SBIC/. Cited 9 September 2006

KAMEL, S. & HASSAN, A. 2003.*Assessing the introduction of electronic banking in Egypt using technology acceptance model"* [Online]. Available: www.idea-group.com/downloads/excerpts/2003/1591400619.pdf

LLEVWELLYN, D.T. 1997. *Banking in the 21st century: the transformation of an industry, Bulletin Economic and Finance*, Vol.11 (49), pp.5-27.

MATTILA, M. n.d. Internet Banking Adoption Factors in Finland. [Online]. Available: http://www.arraydev.com/commerce/JIBC/MATTILA.HTM

METHLIE, L.B. 1998. *A business model for electronic commerce*, Norwegian School of Economics and Business Administration, Bergen, Norway.

MUKHERJEE, A. & NATH, P. 2003. A *model of trust in online relationship banking*, [Online]. Available: http://www.emeraldinsight.com/0265-2323.htm

REICHHELD, F.F. 1993. *Loyalty-based management*, Harvard Business Review, Vol.71 (2), pp.64-73.

SANER, R. 2003. *The effect of the Internet on South African youth in the next 5 years*: 2003 – 2008, [Online]. Available: http://www.sonlifeafrica.com/article06.htm

SCHLESINGER, L. & HESKETT, J. 1991. *Breaking the cycle of failure in services*, Sloan Management Review, Vol. 32(3), pp.17-28.

STEWART, K. 1999. *Transference as a Means of Building Trust in World Wide Web Sites, in Proceedings of the Twentieth International Conference on Information Systems.*

WEBCHEK. 2002. *Are there still growth opportunities in the Internet banking market?* [Online]. Available: http://www.webchek.co.za/library_growbanking.html

WIKIPEDIA, n.d. Online banking. [Online]. Available: http://en.wikipedia.org/wiki/Internet_banking. Cited 10 September 2006.

WORLD WIDE WORX. 2004. Leaders in Technology Research in South Africa, online banking in South Africa.[Online]. Available:http://www.theworx.biz/bank04.htm

Building Ensembles Using Decision Tree Metrics Based Meta-Trees

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ABSTRACT

Ensembles of classifiers have become one of the most popular techniques in machine learning research. The problem of selecting the most appropriate classifier for classification that is known from machine learning is also an important issue in the ensemble building methods. This paper tries to find a method that would select the best performing ensemble building method based on dataset characteristics instead of the most appropriate classifier. The proposed approach captures the characterization of the dataset from the metrics of the tree induced from the dataset. On 15 benchmark datasets, the proposed meta-tree based method discovered some strong and simple rules that could be used in future research in the field of basic ensemble building method selection.

1. INTRODUCTION

Combining multiple classifiers in ensembles is one of the standard and most important techniques for improving classification accuracy in machine learning. This paper compares performance of four different ensemble methods – Bagging [1], Boosting [2], Random Subspacing [3] and Random Forests [4]. There are numerous methods of combining different classifiers into ensembles, but there is no universal method of how to achieve the best accuracy on all datasets using only one ensemble creation method. The results of four above mentioned ensemble building methods are used to build meta-tree which would be capable of selecting the most appropriate ensemble building method based on the characteristics of the given machine learning problem. A variety of data characterization techniques have been developed, however their quality still needs to be improved. In our approach the idea of capturing the characterization from the metrics of the tree induced from the dataset is used [5].

The paper begins with the description of the ensemble building techniques in chapter 2 which is followed by chapter 3 on meta-tree building details. Next section describes our experiments and results of meta-tree learning. Conclusions and proposal of future work are discussed in the final chapter.

2. ENSEMBLE CREATION TECHNIQUES

To create an ensemble of classifiers two components are needed: a set of diversely trained classifiers and a mechanism that composes the single predictions into an overall outcome. This paper compares four most popular methods of combining the classifiers into ensembles which are described in more detail below.

2.1. Bagging

To compose ensemble from base classifiers using bagging, each classifier is trained on a set of n training examples, drawn randomly with replacement from the original training set of size m. Such subset of examples is also called a bootstrap replicate of the original set. Each such subset contains, on average, 63.2% of the original training set [6]. A set of classifiers is then used to classify the example using the majority vote of the ensemble.

The vital element of the bagging technique is the instability of the classifiers. If perturbations in the learning set can cause significant difference in the classifier construction, than bagging can improve accuracy of ensemble.

2.2. Boosting

Boosting is represented by the AdaBoost.M1 algorithm described in [2], which is the most commonly used algorithm for boosting ensembles. To use boosting it is assumed that the base classifier can handle weighted examples. In case where this is not possible we use sampling of the training set examples according to a weight distribution.

In AdaBoost algorithm classifiers are trained sequentially. Each classifier is trained on the dataset based on the misclassification of the previously generated classifier. Weights of the examples are updated according to the classification accuracy of the previous classifier by lowering weights of correctly classified examples and increasing weights of misclassified examples. After the training process is finished the predictions are made using weighted vote of the individual classifiers.

Boosting was tested by many researchers who proved that it can be declared as one of the best ensemble methods [7, 8, 9]. It was also applied to decision trees based ensembles and it can be considered as one of the best classification methods [10].

As each other classification method boosting also contains some drawbacks. One of the most important is overfitting although early literature mentions that boosting would not overfit even when running for a large number of iterations [11]. Recent research clearly shows overfitting effects when boosting is used on datasets with higher noise content [7, 12].

2.3. Random Subspacing

The ensemble method also called Random Subspacing was proposed by Ho in [3] and is based on multiple decision trees constructed systematically by pseudo-randomly chosen features from the training dataset. Each tree is constructed using randomly chosen features which cause higher diversity of ensemble members. Therefore Random Subspacing method can achieve nearly monotonic increase in generalization accuracy while preserving high accuracy on training data, provided that the features are sufficient to distinguish all samples belonging to different classes, or that there is no intrinsic ambiguity in the datasets [13].

2.4. Random Forests

Breiman upgraded the idea of bagging by combining it with the random feature selection for decision trees. This way he created Random Forests, where each member of the ensemble is trained on a bootstrap replicate as in bagging. Decision trees are than grown by selecting the feature to split on at each node from randomly selected number of nodes. Number of chosen features is set to $log_2(k+1)$ as in [4], where k is the total number of features.

Random Forests are the ensemble method that works well even with noisy content in the training dataset and are considered as one of the most competitive methods that can be compared to boosting [14].

3. BUILDING META-TREES

There was a lot of research done in the field of meta-learning methods based on data characterization in the domain of machine learning [5, 15, 16]. Meta-learning is based on set of meta-attributes that usually characterizes the dataset, and search for the optimal correlation between these attributes and the performance of learning algorithms. This paper focuses on research of the correlation between basic decision tree metrics as meta-attributes and performance of different ensemble building methods as learning algorithms.

To build meta-trees one should follow the three basic steps:

- describe the characterization of the dataset by definition of meta-attributes

- learn meta-tree using as much as possible different datasets to estimate the value of meta-attributes and measure the accuracy of different ensemble building techniques
- evaluate the results of built meta-tree

Many techniques extracting the characterization of dataset have been developed, such as data characterisation techniques (DCT) [17] including simple measures (e.g. number of attributes, classes et al.), statistical measures, and information theory-based measures. Inspired by work of Bensusan et al. [16] and Peng et al. [5] we use simple decision tree metrics to define meta-attributes, but two different decision tree algorithms are used – C4.5 [18] and Logistic Model Trees (LMT) [19].

Eight metrics were defined that consist of C4.5 pruned and unpruned number of leaves and number of nodes, LMT number of leaves and nodes and C4.5 leaves and node pruning ratio. Pruning ratio is computed as number of leaves divided by number of nodes in pruned tree by the same value in unpruned tree. Another two attributes that represent number of instances and features were added.

4. EXPERIMENTAL RESULTS

This section describes the experiments that were performed to build and evaluate meta-learning decision tree for ensemble method selection. Most of the experiments were done using WEKA toolkit for machine learning [20]. To train the meta-tree 10 UCI [21] datasets were selected and tested the built tree on 5 UCI datasets which are presented in Table 1.

Instance and feature sampling when learning the meta-tree were used to make learning datasets more diverse. This way each dataset consisted of 100 to 200 sampled instances and $n/2$ to n features for each experiment, where n represents the number of features of the original dataset. Ensemble building methods were run five times with five different settings of forest dimension for 20 times on 10 training set datasets. This way 1000 different datasets were used in the phase of learning the meta-tree.

A part of our experiment was also a classic comparison of four different ensemble methods using different number of decision trees. To observe the accuracy at different number of trees in ensembles five groups of experiments were selected. The first and smallest set of ensembles consisted of 6 trees and each next set consisted of the number in previous experiment multiplied by 2. Following this formula the size of ensembles equals $6 \cdot 2^i$, where $i=[1..5]$. The average accuracy of 10-fold cross-validation on 10 training datasets using different number of decision trees in ensembles is shown in Figure 1.

Table 1. List of datasets and their details

Training Set				
Dataset	Attributes	Continuous	Instances	Classes
cmc	9	2	1473	3
tic-tac-toe	9	0	958	2
segment	19	19	1500	7
balance-scale	4	4	625	3
ecoli	7	7	336	8
vowel	14	10	990	11
vehicle	18	18	846	4
dermatology	34	1	366	6
heart-statlog	13	13	270	2
liver	7	7	345	2
Test Set				
diabetes	8	8	768	2
glass	9	9	214	7
wine	13	13	178	3
hepatitis	19	6	155	2
sonar	60	60	208	2

It can be seen in Fig.1 that Bagging gains less on accuracy comparing to other methods when the number of classifiers increases. While on the other hand Random Forest method still increases significantly from when increasing the number of trees from 24 to 48. The later can be explained with the fact that Random Forest method produces the most diverse sets of classifiers as it is using Bagging and even some kind of Random subspacing when generating classifiers. At around 100 classifiers the accuracy of all methods becomes stable so the ensemble with 96 trees is used in most of experiments.

In the next experiment the first meta-learning tree was built using all 1000 runs of ensemble building on different datasets. Fig. 2 represents the number of wins for each method and number of experiments where two or more methods achieved the best results. Due to 10-fold cross-validation only 33 experiments ended with a tie of two or more methods that produced the same best accuracy. Those 33 experiments were excluded from the meta-learning training set which consisted of 967 examples, each containing 8 decision tree metrics and 2 statistical measures (number of instances and features). After this step the first C45 based meta-learning tree was built using all four ensemble building methods as decisions. The accuracy of this tree was 74.77%.

From Fig. 2 it can be observed that Boosting won in the majority of cases. These results can also be the consequence of the fact that Random Forest, Bagging and Random Subspacing methods share a lot of characteristics in the way they build ensembles of classifiers. Therefore an additional experiment was performed where Boosting method was compared to Non-Boosting methods (Random Forest was used as a representative of this group). The accuracy on training set was 84.4%.

Next experiment compares small (6 trees) and large (96 trees) ensembles and shows how ensemble methods are performing when the number of classifiers increases (Fig. 3).

Figure 1. Average accuracy for different ensemble methods using different number of decision trees

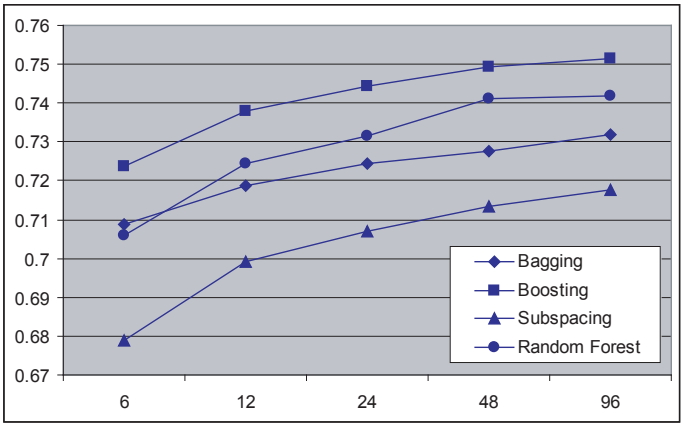


Figure 2. Number of wins and tied situations of four ensemble building techniques

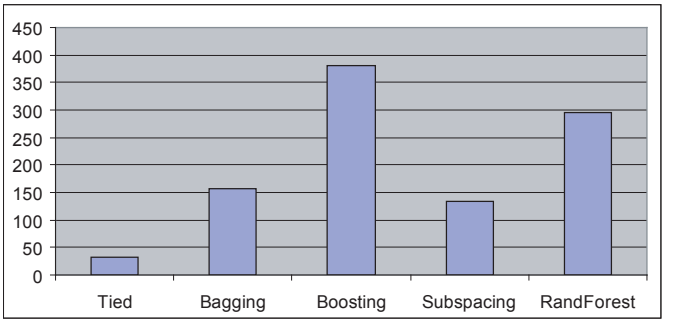
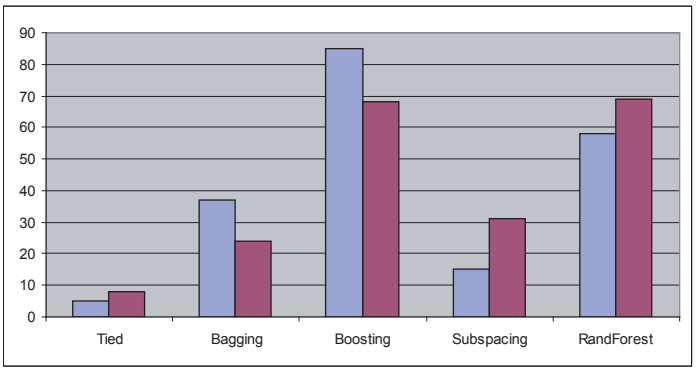


Figure 3. Comparison of four ensemble methods on small and large ensembles



It can be seen that Boosting is not dominant anymore when large number of classifiers is used. It is also interesting to observe a drop in accuracy of Bagging performance and an increase of accuracy at Random Subspacing method. This could again be due to the fact that Random Forest shares a lot of characteristics with Bagging and Random Subspacing. Therefore another observation was done where "Bagging – Random Subspacing" and "Boosting - Random Forest" comparison is done independently (Fig. 4).

Figure 4. Direct comparison of ensemble building methods (large ensembles)

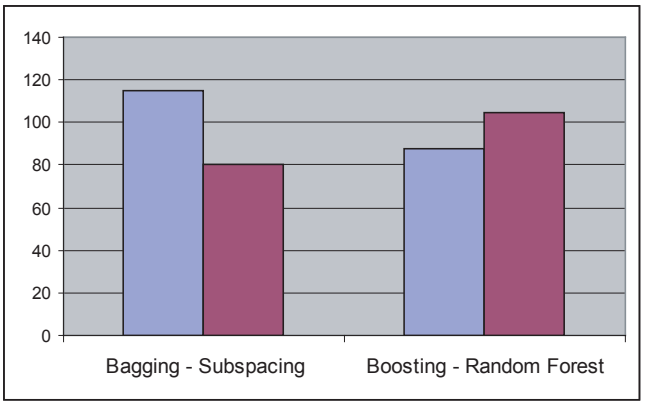


Figure 5. Simplified meta-learning tree (1-Boosting, 4-NonBoosting)

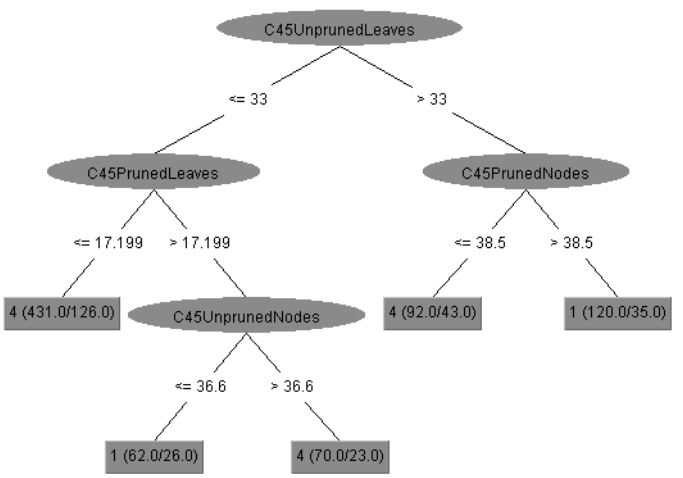


Fig. 4 shows that Random Forests in direct comparison even more evidently outperform Boosting in large ensembles. On the other hand Bagging outperformed Random Subspacing, but this comparison depends on the number of instances and the dimensionality of selected datasets very much. On average our training datasets had 14.2 features which could be to few for the Boosting method to perform better.

To simplify the observation of the large generated C45 meta-tree the number of instances per leaf is set to 60 and generated fairly simple meta-tree with the accuracy of 68%. The simplified tree (Fig. 5) shows two strong rules that characterize the main difference between boosting and non-boosting methods. Left and right most branch of the tree, which include more then 70% of training samples, can be transformed to the following rules:

- IF C45UnprunedLeaves <= 33 AND C45PrunedLeaves <= 17.2 THEN UseNonBoosting
- IF C45UnprunedLeaves > 33 AND C45PrunedNodes > 38.5 THEN UseBoosting

The above rules show that trees with lower complexity dictate use of non-boosting methods while trees with the higher measured complexity suggest using the boosting method of ensemble building.

Based on the observations from Fig. 5 it can be said that C45 metrics contribute the most useful information for the ensemble building method selection.

5. DISCUSSION AND FUTURE WORK

This paper presents the meta-tree approach to selection of the most appropriate ensemble building method for different datasets in machine learning domain. The accuracy of four most popular methods was measured for combination of classifiers into ensembles and were used for building C45 meta-tree based on C45 and LMT based decision tree metrics. This method of selecting the ensemble building technique enables assessment of the dataset complexity through decision tree metrics.

Our experiments show that some very simple rules can be extracted from the generated meta-trees which can help us understand which meta-features are the most important in the selection of ensemble building method problem. From the obtained results it is also obvious that there is no assurance that a single best ensemble building method can be found for all datasets.

There are still several open issues that have not been discussed in this paper. In particular more metrics could be included, especially the metrics of complexity in meta-datasets. In the future we will incorporate some ideas of fractal dimensions that can be used for the measurement of complexity and try to find some common points with the already used metrics. Another important aspect of the research would be the comparison of our proposed method with the similar methods that are in principle used for single classifier selection.

REFERENCES

[1] L. Breiman, "Bagging predictors," *Machine learning*, Vol. 24, No. 2, pp. 123-140, 1996.

[2] Y. Freund, R.E. Schapire, "Experiments with a New Boosting Algorithm," in *Proc. of the Thirteenth International Conference on Machine Learning*, Morgan Kaufmann, pp. 148-156, 1996.

[3] T.K. Ho, "The Random Subspace Method for Constructing Decision Forests," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, Vol. 20, No. 8, pp. 832-844, 1998.

[4] L. Breiman, "Random forests," *Machine learning*, Vol. 45, No. 1, pp. 5-31, 2001.

[5] Y. Peng, P. Flach, P. Brazdil, and C. Soares, "Decision tree-based data characterization for meta-learning," *in Proc. of the ECML/PKDD-02 Workshop on Integration and Collaboration Aspects of Data Mining, Decision Support and Meta-Learning (IDDM-2002)*, Helsinki University Printing House, pp. 111-122, 2002.

[6] P. Melville, R.J. Mooney, "Creating diversity in ensembles using artificial data," *Information fusion*, Vol. 6, pp. 99-111, 2005.

[7] G. Rätsch, T. Onoda, and K.R. Müller, "Soft margins for AdaBoost," *Machine learning*, Vol. 42, No. 3, pp. 287-320, 2001.

[8] E. Bauer and R. Kohavi, "An empirical comparison of voting classification algorithms: Bagging, boosting, and variants," *Machine learning*, Vol. 36, No. 1-2, pp. 105-139, 1999.

[9] T.G. Dietterich, "An experimental comparison of three methods for constructing ensembles of decision trees: Bagging, boosting, and randomization," *Machine Learning*, Vol. 40, No. 2, pp. 139-157, 2000.

[10] H. Drucker and C. Cortes, "Boosting decision trees," in *Advances in Neural Information Processing Systems 8: Proceedings of NIPS'95*, Vol. 8, pp. 479-485, 1996.

[11] R. Meir, G. Rätsch, "An Introduction to Boosting and Leveraging," *Machine Learning Summer School 2002*, pp. 118-183, 2002.

[12] A. Grove and D. Schuurmans, "Boosting in the limit: Maximizing the margin of learned ensembles," in *Proceedings of the Fifteenth National Conference on Artificial Intelligence*, pp. 692-699, 1998.

[13] T.K. Ho, "Random Decision Forests," in *Proceedings of the 3rd International conference on Document Analysis and Recognition*, Montreal, Canada, August 14-18, pp. 278-282, 1995.

[14] T.G. Dietterich, "Ensemble Learning," in *The Handbook of Brain Theory and Neural Networks*, 2nd ed., M.A. Arbib, Ed. Cambridge, MA: The MIT Press, pp. 405-408, 2002.

[15] P. Brazdil, C. Soares, and J. P. da Costa, "Ranking learning algorithms: Using IBL and meta-learning on accuracy and time results," *Machine Learning*, Vol. 50, No. 3, pp. 251-277, 2003.

[16] H. Bensusan, C. Giraud-Carrier, and C. Kennedy, "A higher-order approach to meta-learning," in *Proceedings of the ECML'2000 workshop on Meta-Learning: Building Automatic Advice Strategies for Model Selection and Method Combination*, 2000, pp. 109-117.

[17] C. Linder, and R. Studer, "AST: Support for Algorithm Selection with a CBR Approach," in *Proceedings of the 16th International Conference on Machine Learning*, Workshop on Recent Advances in Meta-Learning and Future Work. 1999.

[18] J.R. Quinlan, "*C4.5: Programs for Machine Learning*," Morgan Kaufmann, San Mateo, CA, 1993.

[19] N. Landwehr, M. Hall, and E. Frank, "Logistic Model Trees," in *Proc. of 14th European Conference on Machine Learning*, pp. 241-252, 2003.

[20] I.H. Witten, and E. Frank, "*Data Mining: Practical machine learning tools with Java implementations*," Morgan Kaufmann, San Francisco, CA, 1999.

[21] C.L. Blake, and C.J. Merz, "UCI repository of machine learning databases," 1998 [Online]. Available: www.ics.uci.edu/~mlearn/MLRepository.html

A Formal Approach to Semantic Mediation in SOA: Specification and Proof

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ABSTRACT

There are many situations in service provisioning scenarios that lead to conflicts and impasses. Very often consumers and providers do not share the same perspective about quality of service. These divergences become more pronounced when the involved parties use different vocabularies to show their interests. It has become commonplace since service providers use different ontologies to describe the offered services. In this paper we discuss the inclusion of a middle layer in the Service-Oriented Architecture (SOA), composed by mediators, in order to make closer the involved sides towards a service negotiation. Considering that mediation is a complex task which crosscuts all the service-related tasks (e.g. discovery and composition), it is proposed a formal approach to describe behavioral aspects of the mediator unambiguously.

Keywords: Mediators, Semantic Web Services, Service Discovery, Service Composition, Formal Methods.

1. INTRODUCTION

Service-oriented applications are potentially source of conflict, since there are two opposite parties: the *service requester* and the *service provider*. Divergences around the maximization of satisfaction with minimal cost (by the *service requester*), against the minimization of resource usage (by the *service provider*) may create impasses that require some external help. Mediators usually play that role bringing together these parties towards an agreement that explicitly considers individual needs but possibly admit reconsiderations. The development of such complex applications commonly requires the adoption of some structured guidelines to be observed.

The Service-Oriented Architecture (SOA) and Web Services technologies (Booth, 2004) have been largely used by developers of Web applications, which functionality is divided into self-contained units, the *services*. This architecture is made up by three entities. Besides the client and the provider, the *registry* is a fundamental part of this architecture. The basic dynamic tasks of SOA entities include: (i) the publication of the service inside the registry by the provider; (ii) the subsequent search for a specific services by the client; and (iii) the consequent execution of a web service and its corresponding result handling during the invocation phase. Eventually, a composition of services can occur when there is not a single service that can fully satisfy the client needs. An opposite situation can also occur, when many services fulfill the client requirements. In this case, it is critical to decide what service actually is the best, considering the client's viewpoint.

Situations like service composition and selection naturally encompass negotiation, although SOA does not explicitly treat this aspect. Indeed, mediators are generally treated as operational elements implemented by the applications (Wiederhold, 2004). However, considering the importance of mediation activity in a service scenario, it is reasonable to put mediators in the first-level of service-oriented architectures. It is precisely what this paper deals with.

Besides specific techniques for reconciliation, the mediator needs information in order to be efficient. It includes information about client and provider requirements, as well as information about the service itself. Although the use of mediators is not new (Wiederhold, 1992), (Wiederhold & Genesereth, 1997), (Mocan et. al, 2005), there is a gap to be fulfilled in the formalization of the mediator's behavior and the precise description of information treated by the mediator. The described proposal presents an architecture that extends SOA by the inclusion of the mediator as the fourth entity at the first-level. An important characteristic of the proposed architecture is the use of ontologies (Gómez-Perez et. al, 2005) that serve as a basis for meaningful information and context-aware activities related to the mediator.

This paper is organized as follows: Section 2 briefly surveys the state of the art in mediators and semantic web services technologies, mainly ontology and its use by mediators. Section 3 depicts the elements of the proposed architecture. Sections 4 and 5 present the translation of the proposed model into a formal specification, relating its static and dynamic aspects, respectively. Finally, Section 6 presents some conclusions and an outlook on our future work.

2. MEDIATORS AND SEMANTIC WEB SERVICES

In the Semantic Web, the information is given with a well-defined meaning through ontologies, which represent formal and explicit specification of a shared conceptualization of some knowledge domain (Berners-Lee, 2001). However, it is unrealistic to expect a global consensus between people and organizations onto a common, shared ontology.

Semantic heterogeneity represents a typical case in which mediation can be applied. In order to reconcile ontologies, it is necessary to analyze the mismatches between them (Sheth et. al, 2003). Mismatches might be present at a conceptual level, as well as at the terminological, taxonomical or purely syntactic levels (Hameed et. al, 2003). Different applications have different ontologies, different semantics, and different knowledge and data stores (Laskey et al., 2006). It is necessary to detect and resolve such discrepancies among them. Correspondences may have to be established among the source ontologies, and overlapping concepts need to be identified.

In the context of SOA, intelligent and active use of information requires a class of software modules that mediate between the service requester and service provider. Mediation simplifies, abstracts, reduces, merges and explains data (Wiederhold, 2004). Interoperability problems inevitably emerge from highly heterogeneous Web service descriptions (Paolucci et. al, 2004). For example, Web services functionalities may be described by different ontologies (e.g. WSMO or OWL-S), can use different protocols or they may have been designed with different goals in mind (Paolucci et. al, 2002). Semantic mediators identify implicit similarities, by the use of ontology reconciliation techniques, such as merging, alignment or integration (Hameed et. al, 2003). Therefore, mediators form a distinct middle layer, making the service requester queries independent of the service description semantics from registries. The translations needed in such layer and what form will have the modules supporting this layer are somehow interrelated.

Since there will eventually be a great variety of mediators, service requesters have to be able to choose among them. Alternate metamediators will have to exist that merely provide access to ontologies that describe available mediators and its properties. Since mediation occurs in different contexts and levels, metamediators synthesize intermediary mediations in order to compose a global mediation. Moreover, the use of ontologies to describe knowledge related to mediators themselves can improve the reuse of mediation functions. Applications may compose their subtasks as much as possible by acquiring information from the set of available mediators. Additionally, unavailable information may motivate the creation of new mediators (Wiederhold & Genesereth, 2004).

A lot of work has been done on mediation systems (Mocan et. al, 2005), (Garcia-Molina et. al, 1997), (Yan et al., 1997), (Tomasic et al., 1998). However, a proper conceptual setting for this task is largely missing. Formal methods, based upon elementary mathematics, can be used to create precise, unambiguous architectural descriptions, in which information is structured and presented at an appropriate level of abstraction. Hence, reasoning about a specification and attempting to construct proofs about its properties can help to detect problems at an early stage of system development. The process of constructing proofs leads to a better understanding about the requirements upon a system, and can assist in identifying any hidden assumptions.

3. AN ONTOLOGY-BASED ARCHITECTURE FOR MEDIATION

The conceptual elements of the extended SOA architecture proposal can be observed in Figure 1.

The first-level entities, i.e. *Service Requester*, *Service Provider*, *Mediator* and *Registry* are highlighted. The majority of other concepts are grouped into contexts. In the service requester context, the desired *functional requirements* are represented by the goal concept, while the user's subjective notion of quality is defined by *QoS Preferences* (what "includes" the service), *QoS Constraints* (what "excludes" undesirable services), and *QoS Priorities* (what "distinguishes" similar services). On the other hand, in the service provider context, the *capability* concept represents the provided functionality, while *QoS offered* abstracts a subset of *non-functional requirements* related to the service provisioning. It is important noting that the same service may be offered in different levels of quality, which causes an impact over resource allocation.

In a typical SOA scenario, the service requester accesses the registry in a direct manner, in order to discover potential services that accomplish the desired functionality. In this case, the mediator represents the entity that makes easy this search. This reconciliation process is made on the ontological level. Considering that ontologies are composed basically by related classes and properties, the role of mediator comprises an automatic verification of intersections in the concepts associated with these elements.

Mediators, as considered in this work, adopt a win-win approach to reach some agreement between the involved parties. Thus, in order to remain neutrality, mediators could be placed apart, in a namely semantic web server (Ribeiro et al., 2004), (Ribeiro et al., 2006), avoiding possible tendentious decisions that could possibly beneficiate either clients or providers. Another aspect to be considered is the fact that the whole mediation may be actually a composition of minor mediation processes. Hence, the concept of mediation in the proposed architecture abstracts several intermediary conflict resolutions, in different levels of complexity.

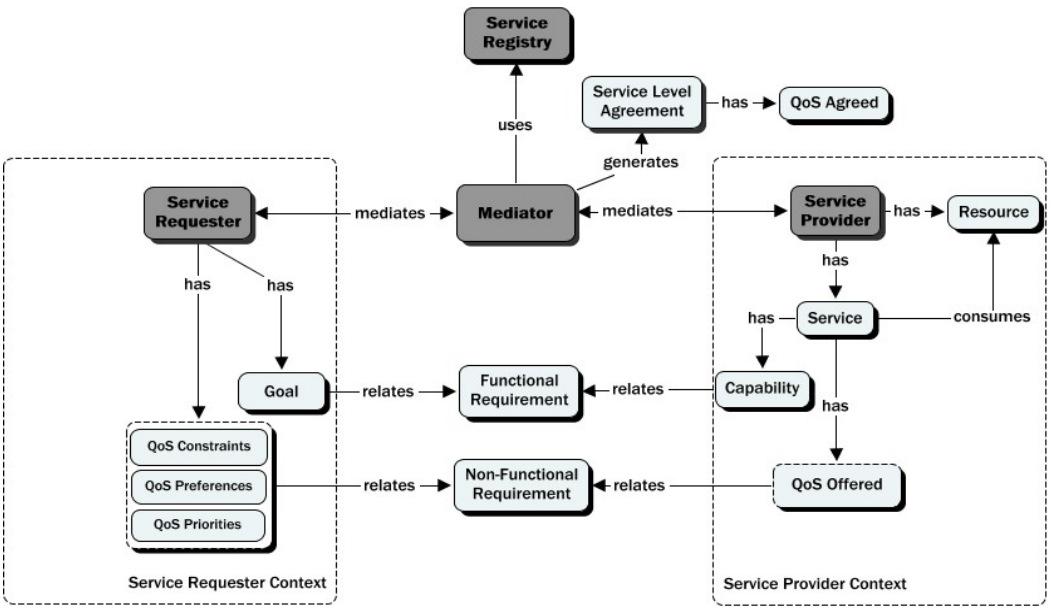
Despite knowing the importance of the role of discussions around implementation issues, this paper focuses on some universal aspects of mediators. For instance, mediators make use well-defined reconciliation laws, valid in some context or jurisdiction, in order to approximate different perspectives and possibly generating a contract that consolidates the conditions related to service provisioning. Hence, any mechanism that makes use of semantics (e.g. semantic web services, intelligent agents or matchmakers) could be used to implement mediators.

4. TRANSLATING THE CONCEPTUAL MODEL INTO A FORMAL SPECIFICATION

The use of formal methods in describing and verifying properties and behavior of systems is not new (Dong et al., 2002), (Dong et al., 2004). The Z notation (Spivey, 2004), for example, is a specification language based on set theory and predicate calculus. Some basic characteristics of Z notation guided its choice as the formalism in this work. The first one is related to its maturity level, recently conveyed into ISO standard (ISO, 2002). The second one refers to the availability of tools to support formal activities, such as type checking, theorem proving and animation of formal specification (Saaltink, 1997).

The fundamentals of Z notation and types are sets defined at the beginning of specification. A *given set* is a powerful abstract element of Z, represented by names inside brackets, from which a formal specification begins. *Enumerated* sets are also permitted in Z notation. In the following, some of the main given sets used to describe the related architectural elements are presented.

Figure 1. The extended service oriented architecture proposal



[Class, Instance, DataType, Parameter, Protocol, Resource, Registry, Preconditions, Postconditions]

Level ::= High | Medium | Low

OperationMode ::= Notification | OneWay | SolicitResponse | RequestResponse

OntologyReconciliationType ::= Alignment | Merging | Integration

ReconciliationResultType ::= ExactMatch | PluginMatch | SubsumesMatch | IntersectionMatch | Impasse

Other key element of Z specification is the *schema*. In analogous way, schema can be considered as class inside object-oriented paradigm. Like a class in OO paradigm, the schema includes a declarative part to encompass variables and a second part dedicated to the manipulation of variables, the predicate.

Schema

Variables

Predicate

Schemas in Z are used to describe both static and dynamic aspects of a system. The static aspects concern the global state of the system and the relationships between its components, namely the invariant. A rigid control over state integrity is accomplished by the invariant during any operation that changes the state. Dynamic aspects include all operations that manipulate the elements of the state (Spivey, 2004).

The *Ontology* type was composed by other types including power sets (P) of *Class*, *DatatypeProperties* (a partial function of *Class* in *DataType*), *ObjectProperties* (a relation between two classes) and *Individuals* (a function of *Class* in *Instance*). The *Mediator* is represented as a schema made up by *Description*, which is typed as an *Ontology* for mediators; a power set of *Techniques* and a *Context*, which represents a relation between two ontologies, i.e. the conceptualizations of involved partners.

Ontologies are built layer on layer. Since the proposed model relies upon them, it is necessary checking and validating its axioms, through the definition of Z semantics for the ontology language. This semantic model serves as a reasoning environment for verification using Z/EVES (Saaltink, 1997), which offers some powerful commands for theorem (e.g. *prove*, *rewrite* or *reduce*). In this section, only the static properties of ontologies are checked (Figure 2), which can be well captured by axiomatic definitions. Dynamic properties (e.g. *discovery* and *composition* phases) are detailed in Section 5. For the sake of space and simplicity, several ontology properties from the proposed axiomatic model were shortened.

5. GENERATING OPERATION SPECIFICATIONS

5.1 Mediation and Service Discovery

In general, service discovery comprises the matchmaking between *goals* (from the service requester context) and service *capabilities* (from the service provider context). The semantics of *goal* element, as well as Web service *capabilities* can be represented by a set of concepts described in a *functional requirement ontology*. The semantic mediator verifies possible similarities on the conceptual level. In order to consider goals and capabilities to match on the semantic level, these elements have to be interrelated somehow. Precisely spoken, we expect that some set-theoretic relationship between them has to exist. The most basic set-theoretic relationships that one might consider are the following:

- Exact match: goal = capability
- Subsumes match: goal c capability
- Plugin match: capability c goal
- Intersection match: goal I capability ë 0
- Non-match: goal I capability = 0

These set-theoretic relationships basically provide the basic means for formalizing an intuitive understanding of a match between goals and Web services in the real world. For this reason, they have been extracted from some extent already in the literature (Paolucci et al., 2002), (Paolucci et. al., 2004). The ideal situation can be represented when an *exact match* between requester desires and provider offerings occurs. Here the semantic mediator identifies that the offered service functionality coincides perfectly with the service requester goals (see Figure 3.a).

Subsumes match (Figure 3.b) occurs when the capabilities that are advertised by the service provider form a superset of relevant objects for the requester as specified in the goals. In other words, the service might be able to fulfill the desired

Figure 2. Formal definitions and proofs related to ontology and mediator concepts

theorem *IsObjectPropertyDisjoint*
local *ObjectPropertyDisjointness*
ObjectProperty ObjectProperty
◁objP1 ObjectProperty objP2
ObjectProperty▷
objP1 dom *ObjPropInstantiation*
objP2 dom *ObjPropInstantiation*

proof of *IsObjectPropertyDisjoint*
prove by reduce;
true

theorem *IsSubDatatypeProperty*
local *SubDatatypePropertyOf*
DatatypeProperty DatatypeProperty
◁dtP1 DatatypeProperty dtP2
DatatypeProperty▷
dtP1 dom *DtPropInstantiation*
dtP2 dom *DtPropInstantiation*

proof of *IsSubDatatypeProperty*
simplify;
prove by reduce;
true

theorem *isEquivalentObjectProperty*
local *EquivalentObjectProperty*
ObjectProperty ObjectProperty
◁objP1 ObjectProperty
objP2 ObjectProperty▷
objP1 dom *ObjPropInstantiation*
objP2 dom *ObjPropInstantiation*

proof of *isEquivalentObjectProperty*
prove by reduce;
true

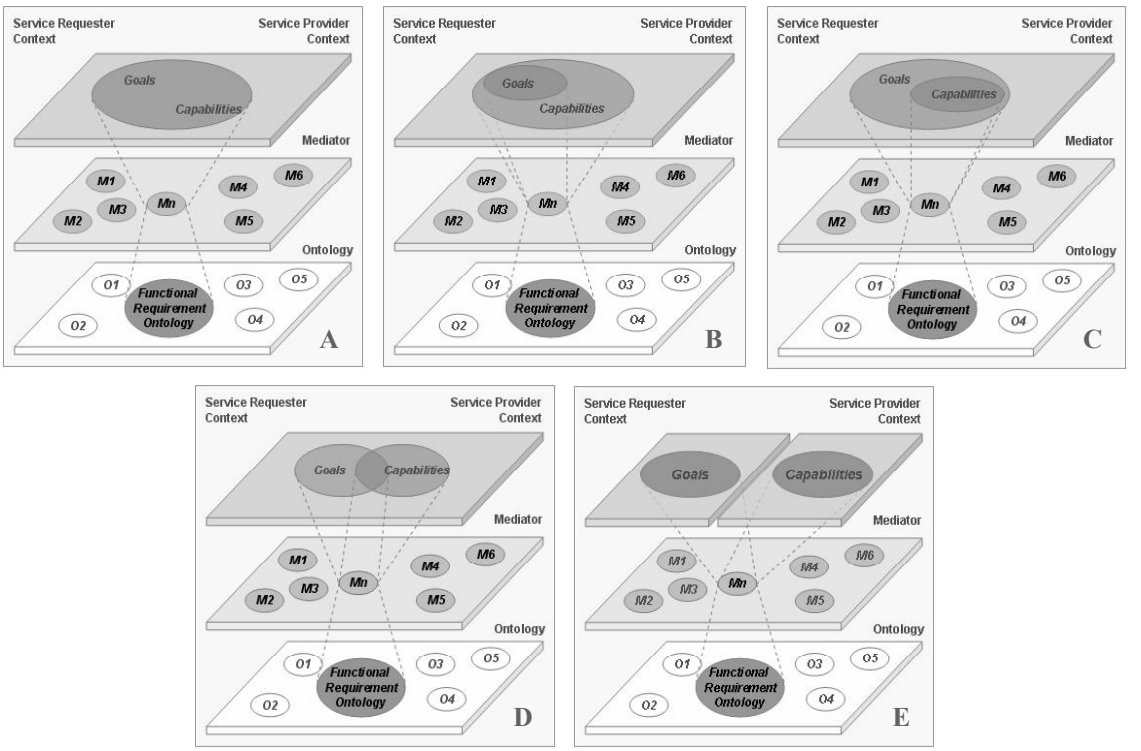
⋮

ObjectProperty: Class Class
DatatypeProperty: Class DataType

Individual: Class Instance
Ontology
Classes: Class
ObjectProperties: ObjectProperty
DatatypeProperties: DatatypeProperty
Individuals: Individual

Mediator
Description: Ontology
Techniques: OntologyReconciliationType
Context: Ontology Ontology

Figure 3. The set-modeling approach to ontology-based mediation: (A) Exact Match; (B) Subsumes Match; (C) Plugin Match; (D) Intersection Match; (E) Impasse



functionality. However it is possible that the service delivers objects that are irrelevant for the requester. When the service capabilities form a subset of requester goals, as illustrated in Figure 3.c, then a *plugin match* occurs. In other words, the service in general is not able to provide all the desired functionality, but there is a guarantee that no irrelevant objects will be delivered by the service.

There is a case when the set of service capabilities and the set of requester goals have an *intersection match* (Figure 3.d). Thus, the service is not able to deliver all the objects that are relevant for the requester, but at least one such element can be delivered. In this case a composition of services may be an alternative in order to achieve the desired functionality. Figure 3.e illustrates the case when the service capabilities description and requester goals are disjoint. That means there is no semantic link. Therefore, in the context of ontology reconciliation, it is also considered an *impasse* situation.

As mentioned before, semantic mediation is directly associated with ontology reconciliation techniques. This process involves the alignment of the two basic ontology structures: *classes* and *properties*. All the matching cases were formalized by two operation schemas, respectively *Goal2ServiceClassAlignment* (between classes), and *Goal2ServicePropertyAlignment* (between properties). Since these

Figure 4. Operation schema related to goal to service conceptual alignment

$$
\begin{aligned}
&\textit{Goal2ServiceClassAlignment}\\
&\Delta \textit{ARCHITECTURE}\\
&\textit{sr: ServiceRequester; m: Mediator; sp: ServiceProvider; s: Service; fr1,}\\
&\textit{fr2: FunctionalRequirement; o1, o2: Ontology; c1, c2: Class; i1,}\\
&\textit{i2: Individual}\\
&\quad \textit{sr} \quad \textit{ServiceRequesters} \quad \textit{sp} \quad \textit{ServiceProviders} \quad \textit{m} \quad \textit{Mediators} \quad \textit{s} \quad \textit{sp . Services}\\
&\quad \textit{c1} \quad \textit{o1 . Classes} \quad \textit{c2} \quad \textit{o2 . Classes} \quad \textit{i1} \quad \textit{o1 . Individuals} \quad \textit{i2} \quad \textit{o2 . Individuals}\\
&\quad \textit{fr1 = o1} \quad \textit{fr2 = o2} \quad \textit{o1} \quad \textit{sr . Goal} \quad \textit{o2} \quad \textit{s . Capability}\\
&\quad \textit{m . Context = m . Context} \quad \textit{do1} \cup \textit{o2}\circ\\
&\quad \textit{dc1} \cup \textit{c2}\circ \quad \textit{EquivalentClass} \quad \textit{di1} \cup \textit{i2}\circ \quad \textit{SameAs}\\
&\quad \textit{ReconciliationResult = ExactMatch}\\
&\qquad \textit{dc1} \cup \textit{c2}\circ \quad \textit{SubClassOf} \quad \textit{ReconciliationResult = PluginMatch}\\
&\qquad \textit{dc2} \cup \textit{c1}\circ \quad \textit{SubClassOf} \quad \textit{ReconciliationResult = SubsumesMatch}\\
&\qquad \textit{dc1} \cup \textit{c2}\circ \quad \textit{ComplementOf} \quad \textit{ReconciliationResult = IntersectionMatch}\\
&\qquad \textit{dc1} \cup \textit{c2}\circ \quad \textit{DisjointWith} \quad \textit{di1} \cup \textit{i2}\circ \quad \textit{DifferentFrom} \quad \textit{ReconciliationResult = Impasse}\\
&\quad \textit{ServiceRequesters}' = \textit{ServiceRequesters}\\
&\textit{ServiceProviders}' = \textit{ServiceProviders}\\
&\textit{ServiceLevelAgreements}' = \textit{ServiceLevelAgreements}\\
&\textit{Mediators}' = \textit{Mediators} \quad \textit{m}\\
&\textit{Registries}' = \textit{Registries}
\end{aligned}
$$

operations are very similar, only the class alignment is showed in Figure 4. The symbol (Δ) means that this operation changes the global state of the system. The predicate section instantiates some local variables, including ontological structures such as *DatatypeProperties* and *ObjectProperties*. The functional requirements are assigned to distinct ontologies followed by a logical concatenation of reconciliation preconditions.

The schema closes with a state change, by the inclusion of a new local mediator that was created to deal with the service discovery context, according to the *DatatypeProperties* and *ObjectProperties*. Considering these formal statements, the entire discovery phase could be represented by a sequential composition of the two before mentioned operation schemas. The following statement summarizes this aspect.

DiscoveryPhase ; *Goal2ServiceClassAlignment* ; *Goal2ServicePropertyAlignment*

5.2 Mediation and Service Composition

The partial response to the required functionality justifies the use of composite services. Composing Web services requires the description of each service, so that other services can understand its features and learn how to interact with.

A generalized model for Web service description is described with more details in (Medjahed et al., 2003). Figure 5 illustrates that, basically, the service description includes: *domain* information, represented by domain ontologies; a set of *operations,* which include aspects related to the message interchange; *bindings,* that defines message format and protocol details for service invocation; and *capability*, that describes the business functionalities offered by the service operations. Each element in the service purpose refers to the business functionality offered by a specific operation. In order to serve as a basis for workflow models that determine the behavior of composite services, other elements such as *inputs, outputs, preconditions* and *postconditions* are defined. Finally, the provider's notion of quality of service is represented by *QoSOffered* (a function of a set of non-functional requirements in a level of quality).

Service composition can also occur in different levels, from the binding level to the QoS level. A major issue when defining a composite service is whether its component services are *composable* (Medjahed et al., 2003). For example, it would be difficult to invoke an operation if there were no mapping between the parameters requested by this operation (e.g., data types, number of parameters) and those transmitted by the service requester. Hence the service composition is a complex task that involves both syntactic (e.g. binding) and semantic features (QoS Offered).

The proposed formal model aggregates the composition preconditions in two phases: *OperationCompositionPhase* and *ServiceCompositionPhase* (see Figure 5). The first one relates the mediation process in the reconciliation of the syntactic features (e.g. mode and message composability). The second one relates semantic features, in which an instance of a mediator verifies possible intersections in binding and domain aspects of the services, according to the context and reconciliation laws (e.g. *EquivalentClass* and *SameAs* axioms)

The entire *CompositionPhase* is defined by a schema that aggregates a sequential composition between *OperationCompositionPhase* and *ServiceCompositionPhase*.

CompositionPhase ; *OperationCompositionPhase* ; *ServiceCompositionPhase*

6. CONCLUSION AND FUTURE WORK

This paper presents an extended SOA proposal that explicitly includes the mediator as first-level entity. The main purpose of the architecture is to argue and reason about conceptual aspects related to the role of the mediator in service discovery and composition. It was investigated the use of ontological reconciliation techniques which serves as a basis for meaningful mediation. A formal set-based approach to describe the mediator behavior and related concepts was presented.

In particular, we investigate and analyze what kind of statements need to be formally checked and proven about relations between mediation and other service related tasks. These formal statements are called *proof obligations*. At the design stage, a proof can show not only that a design is correct, but also *why* it is correct. The additional insight that this affords can be invaluable: as requirements evolve and the design is modified, the consequences are easier to investigate. At the implementation stage, a proof can help to ensure that a piece of code behaves according to the specification. The practice of proof leads to better specifications.

In terms of future work, we intend to investigate and analyze what kind of statements need to be formally checked and proven in order to relate the mediation activity to the other service related tasks, including service selection, negotiation, agreement and monitoring. More specifically, we intend to extend the proposed formal model towards proof obligations in which QoS information can be used by the mediator to improve the process of reconciliation in the ontological level. These proof obligations, that basically comprise the formulation of theorems and automatic reasoning and simulation of the proposed architectural properties, will

Figure 5. Formal statements related to the operation and service composition phases

OperationCompositionPhase
ΔARCHITECTURE

op1, op2: Operation; m: Mediator; o1, o2: Ontology;
c1, c2: Class; i1, i2: Individual
m Mediators
(op1, op2) isModeComposableWith
(op1 . Input, op2 . Output)
isMessageComposableWith
(op1 . Output, op2 . Input)
isMessageComposableWith
o1 = op1 . Domain o2 = op2 . Domain
c1 o1 . Classes
c2 o2 . Classes
i1 o1 . Individuals
i2 o2 . Individuals
m . Context = m . Context (o1, o2)
(c1, c2) EquivalentClass (i1, i2) SameAs
ReconciliationResult = ExactMatch
(c1, c2) SubClassOf (c2, c1) SubClassOf
ReconciliationResult = PluginMatch
(c1, c1) ComplementOf
ReconciliationResult = IntersectionMatch
ServiceRequesters' = ServiceRequester
ServiceProviders' = ServiceProvider
ServiceLevelAgreements' = ServiceLevelAgreement
Mediators' = Mediator m

ServiceCompositionPhase
ΔARCHITECTURE

op1, op2: Operation; s1, s2: Service; m: Mediator;
o1, o2: Ontology; c1, c2: Class; i1, i2: Individual
m Mediators
op1 s1 . Operations
op2 s2 . Operations
(s1, s2) isBindingComposableWith
c1 o1 . Classes c2 o2 . Classes
i1 o1 . Individuals i2 o2 . Individuals
o1 = s1 . Domain o2 = s2 . Domain
op1 . Domain = s1 . Domain
op2 . Domain = s2 . Domain
m . Context = m . Context (o1, o2)
(c1, c2) EquivalentClass (i1, i2) SameAs
ReconciliationResult = ExactMatch
(c1, c2) SubClassOf
ReconciliationResult = PluginMatch
(c1, c2) ComplementOf
ReconciliationResult = IntersectionMatch
ServiceRequesters' = ServiceRequester
ServiceProviders' = ServiceProvider
ServiceLevelAgreements' = ServiceLevelAgreement
Mediators' = Mediator m

serve as the basis for a most complete framework for mediation in several levels in the context of service negotiation and provisioning.

REFERENCES

Berners-Lee, T., Hendler, J., & Lassila, O. (2001, May). The semantic web. *Scientific American, 284(5),* 34–43.

Booth, D. (ed.). (2004, February 11). Web Service Architecture,W3C Working Group Note. Latest version available at http://www.w3.org/TR/ws-arch/

Dong, J. S., Sun, J., & Wang, H. (2002, October). Z Approach to Semantic Web. In *International Conference on Formal Engineering Methods (ICFEM'02)*, Shanghai, China, LNCS, Springer-Verlag, 156-167.

Dong, J. S., Lee, C. H., Li, Y.F., & Wang, H. (2004, May). Verifying DAML+OIL and beyond in Z/EVES. In *Proceedings of the 26th International Conference on Software Engineering.*

Garcia-Molina, H. et. al. (1997). The TSIMMIS Approach to Mediation: Data Models and Languages. In *Journal of Intelligent Information Systems*, 117-132.

Gómez-Perez, A., Fernándes-López, M, & Corcho, O. (2004). *Ontological Engineering: with exemple from the areas of Knowledge Management, e-commerce and the Semantic Web*. Springer-Verlag,

Hameed, A., Preece, A., & Sleeman, D. (2003). Ontology Reconciliation. In Staab, S., and Studer, R. (eds.). *Handbook on Ontologies in Information Systems*, Springer- Verlag, 231-250.

ISO/IEC 13586:2002 – Z formal specification notation – Syntax, type system and semantics. Latest version available at http://www.iso.org

Laskey, K. J., Costa, P. C. G., & Laskey, K. B. (2006, November). A Proposal for a W3C XG on Uncertainty Reasoning for the WWW. Accepted to the *Proceedings of the second workshop on Uncertainty Reasoning for the Semantic Web (URSW 2006)*, to be held at the Fifth International Semantic Web Conference (ISWC 2006), Athens, GA, USA.

Medjahed, B., Bouguettaya, A., & Elmagarmid, A. K. (2003, November). Composing web services on the semantic web. *VLDB Journal*, *12,* 333-351.

Mocan, A., Cimpian, E., Stollberg, M., Scharffe, & F., Scicluna, J. (eds.). (2005, September 16). WSMO Mediators, Working Draft , latest version available at http://www.wsmo.org/TR/d29/

Paolucci, M., Kawamura, T., Payne, T. R., & Sycara, K. (2002, June). Semantic Matching of Web Services Capabilities. In *Proceedings of the First international Semantic Web Conference on the Semantic Web*. Horrocks, I., and Hendler, J. A. (eds.). *Lecture Notes In Computer Science*, *2342*., London: Springer-Verlag, 333-347.

Paolucci, M., Srinivasan, N., & Sycara, K. (2004). Expressing WSMO Mediators in OWL-S. In *Proceedings of the Workshop on Semantic Web Services: Preparing to Meet the World of Business Applications held at the 3rd International Semantic Web Conference* (ISWC 2004), Hiroshima, Japan.

Ribeiro, C. M. F. A., Rosa, N. S., & Cunha, P. R. F. (2004, March). Towards a Model for Personalized Communication Services. In *Proceedings of The IEEE 18th International Conference on Advanced Information Networking and Application* (AINA 04). *IEEE Press*, *2*, 99-102.

Ribeiro, C. M. F. A. (2006, April). An Ontological Approach for Personalized Services, In *Proceedings of The IEEE 20th International Conference on Advanced Information Networking and Applications* (AINA 2006). *IEEE Press (2006)*, *2*, 5 pp.

Saaltink, M. (1997) The Z/EVES System. In Bowen, J. P., Hinchey, M. G., and Till, D. (eds.), ZUM'97: Z Formal Specification Notation, *LNCS*, Springer-Verlag, 72- 85.

Sheth, A., Thacker, S., & Patel, S. (2003, May). Complex relationships and knowledge discovery support in the InfoQuilt system. *The VLDB Journal*, *12*, 2–27.

Spivey, J. M. (1992). *The Z Notation: A Reference Manual*. Prentice Hall International, 2nd edition.

Tomasic, A., Raschid, L., & Valduriez, P. (1998). Scalling Access to Heterogeneous Data Sources with DISCO. In *IEEE Transactions on Knowledge and Data Engineering*, *10*, 808-823.

Wiederhold, G. (1992, March). Mediators in the architecture of future information systems. *IEEE Computer, 25*, 38-49.

Wiederhold, G., & Genesereth, M. (1997, September-October). The Conceptual Basis for Mediation Services. *IEEE Expert: Intelligent Systems and Their Applications*, *12*, 38-47.

Yan, L., Özsu, M. T., & Liu, L. (1997, June). Accessing Heterogeneous Data through Homogenization and Integration Mediators. In *Proceedings of the 2nd IFCIS International Conference on Cooperative Information Systems*, South Carolina, USA, 130-139.

Taking a Back Seat? Integrating Trust in E-Government Service Delivery in South Africa

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ABSTRACT

The problem of citizen distrust for government is a growing phenomenon across Africa. The decline in citizen trust has major implications for e-government development in South Africa. Yet trust is considered a key ingredient for building quality e-services and citizen customer loyalty to e-government initiatives. The paper aims to examine trust in e-government service delivery, highlights key considerations in building "trust-based" e-government service delivery model for South Africa and recommends measures to promote a sustainable e-government service delivery. The paper is based on experiences, lessons and observations made from the Cape Gateway Project, a leading e-government initiative in South Africa. The study offers insights into our understanding of citizen trust, and how to investigate it in relation to e-government service delivery in an African context.

1. INTRODUCTION

The development of e-government process in its many guises is attracting increased attention from government, business and civil society in South Africa. Governments, businesses and increasing sections of civil society are now advocating that e-service delivery must be considered as a more viable, quick and efficient method for conducting transactions with the public sector and elected representatives Early efforts in e-government development in South Africa were driven by concerns to close the digital divide through the provision of the necessary back-bone infrastructure/hardware, (i.e. computers, internet, service provider infrastructure etc.), and the human capacity to mediate the new service delivery format (DPSA, 2001). Realizing that the gains made in the modernization of the technology infrastructure were necessary, but not sufficient, citizens have started to demand better quality services from their governments (Taylor, et. al. 2006). Fueling the new thinking globally is the "growing culture of rights," which attributes access to information as a basic human right (Parent, et. al, 2005).

The continent of Africa trails the rest of the world in e-government development with 14 percent of the global population, 2 percent of global internet users, or only 6 million out of more than 800 million people owning personal computers (Gebremichael, and Jackson, 2006). Even as South Africa adopts e-government, (Detolly, 2006) questions are emerging about its potential benefits and degree of sustainability of the e-service delivery revolution (Alexander et. al, 2006) . Additional questions linger around issues of how to promote equitable e-service delivery to citizen customers and generate long-term trust and loyalty to the new service delivery mechanism (Frazer-Moleketi, 2006). It stands to reason that to build the long term loyalty and customer base that is necessary for governments to achieve economies of scale in service provision, users need to trust not only the humans in charge, but the technology infrastructure that drives e-government in Africa.

Unlike in e-business, the question of trust in e-government in South Africa seems to have taken a back seat. Partly to blame is the fact that the "development of trust-based relationships" has been overshadowed by problems of pervasive government corruption across Africa (Sunday Times, 2006; City Press, 2006: Mail and Guardian, 2006). The incapacity or unwillingness to prosecute high crimes tends to betray citizen trust in government. In South Africa, the rising poverty levels and growing HIV and AIDs epidemic (UNAIDS, 2005) are oftentimes perceived as indicators of government inefficiency and failure. It is therefore not surprising that some ordinary citizens in Africa hold the perception that government is synonymous with "corruption," "poor service delivery" "uncaring attitudes" and "culture of empty promises" (Sunday Times, 2006). In contrast, governments in developed nations serve the civil society better, are held to account, and play a pivotal role in the delivery of quality services to citizens. Despite the fact that accountability in government remains somewhat an illusion, and information and communication technology (ICT) infrastructure remains appalling, some African organizations (e.g. African Information Society Initiative (AISI), NEPAD, etc.) are working tirelessly to promote ICT use, good governance credentials and trust.

Eliminating the "trust deficit" in Africa requires governments to "strategically integrate trust" in e-government transformation and e-value creation. Of concern to citizens around the world is the fear that "information security risks" could further erode any semblance of trust in e-service delivery. This paper therefore aims to examine the issue of trust in e-government service delivery, highlight key considerations in building a "trust-based" e-government service delivery model for South Africa, and recommend guidelines to deliver sustainable e-government trust. The study is based on our experiences, lessons and observations from the Cape Gateway Project, a leading e-government initiative in the Western Cape Province in South Africa.

The rest of the paper is organized as follows: the next section provides a brief background on trust and e-government service delivery in South Africa. This is followed by a framework for the development and integration of trust in e-government service delivery in South Africa. The third section reviews the literature on the role of trust in e-government development. In section 4, we conclude with insights on key considerations for integrating trust into e-value creation in e-government service delivery.

1.1 Background: Trust and E-Government Service Delivery in South Africa

In South Africa, the notion of *Ubuntu* and the principles of *Batho Pele* are the most significant attempts to build a "people-centered" culture in government service delivery. The term "*ubuntu*" embraces human values such as compassion, respect, kindness, inclusivity and the ideals of human life. It is a Zulu term that describes the fact that "a person is what he or she is because of other people in society." The *Batho Pele* principles are about customers expressing their rights. The term *Batho Pele* means "people first" and is a Government of South Africa (GSA) program that aims to re-brand service delivery in ways that promote the needs of the individuals in South Africa (DPSA, 2001). Government can show trust in its services when it demonstrates *Ubuntu* and *Batho Pele* in its operations and its relationship with citizens.

Trust can be perceived in the context of the socio-economic/political context facing a newly democratic South Africa. Recent press reports on demonstrations against poor service delivery by municipalities in South Africa indicates both rising levels of frustration, and the decline in trust about government's capability to deliver basic services to the people . Also, the claims by some religious constituencies that South Africa has lost her "moral bearings" are a further indication about growing frustrations with government conduct (Tutu, 2006). The effect of such negative perceptions not only lowers investor confidence, but locally it leads to a severe dissolution of trust between citizens and their government. In some countries,

distrust from citizens has slowed the erection of e-government structures and its deployment (Evans and Yen, 2006).

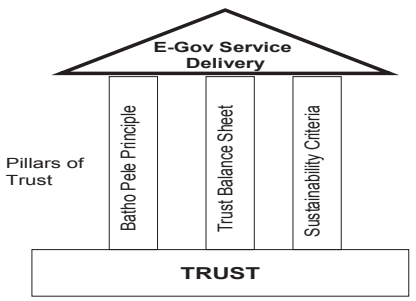
To what extent the adoption of the *Batho Pele* principles and "*Ubuntu*" ideology has succeeded in making service delivery customer focused in South Africa remains unclear. There are obvious signs of citizen disaffection with service delivery despite the on-going public service delivery transformation. This leads us to the argument that trust-based e-government solutions provide an alternative means to improve not only quality of service delivery, but also enlist the e-loyalty that is expected from satisfied citizen customers. If trust continues to take a back-seat, there are fears that the same problems (i.e., lack of trust, digital divide, etc.) that beset e-business could beset e-government (Mullen and Horner, 2004) in South Africa.

The e-government transformation in Western Cape Province is being driven by the Cape Gateway Project (DeTolly, 2006). To operationalize the Provincial Government of the Western Cape's vision, a multi-lingual and multi-channel e-government program was developed by the Center for e-Innovation. Despite its initial success, the moral basis for developing sophisticated e- government services amidst growing poverty is now being questioned (Alexander, et. al., 2006). To avoid the erosion of trust in this project, this issue needs to be addressed.

2. FRAMEWORK FOR THE DEVELOPMENT OF TRUST IN E-GOVERNMENT IN AFRICA

Trust is increasingly perceived as a significant barrier to the development of e-government services globally (Mullen and Horner, 2004; Tassabehji and Elliman, 2006). It is not different in South Africa. Because of its history of discrimination and apartheid, strenuous and purposeful efforts have been made by the GSA to engender trust in e-government services. From an analysis and examination of the different efforts, we have constructed the framework for engendering government e-service delivery in South Africa (see Figure 1).

Figure 1. Framework for engendering trust in e-government in South Africa, 2007



According to the framework in Figure 1, e-government service delivery in South Africa rests on a foundation of trust by citizens and organizations. Specifically, e-service delivery by the GSA is supported on three pillars (the Batho Pele Principle, a trust "balance sheet" and a set of sustainability criteria). These pillars, in turn, rest on the trust foundation. As can be deduced from the figure, e-government services are liable to be shaky and ineffective if one or more of these pillars are destroyed. In the rest of this section, we discuss these supporting pillars.

2.1. Batho Pele Principles: Conceptualizing Trust in the Public Sector in South Africa

Trust is the glue that binds the GSA to its citizens and organizations. This tie is fashioned from and cemented by the value-based aspects stipulated in the *Batho Pele Principle*.

The GSA adopted the *Batho Pele* principles in 1997, and this provides a good starting point to understand how South Africa has approached the question of trust in public service delivery. The *Batho Pele* principles cover eight key human valued-based areas (See Figure 2). The aim is to ensure that public service delivery provides all citizens an opportunity for effective consultation, technology solutions that promote broad-based access to services, the treatment of citizens with respect (i.e. courtesy), maintenance of service standards at all government levels (i.e. including security apparatus), transparency, complaint handling (i.e. redress) and value for money to all tax payers (White Paper, 1997). The *Batho Pele* principles are expected to be the first port of call to engender codes of trust in both citizens and businesses in their interaction with government.

As shown in Figure 2, it is important to note that trust is reciprocal, and is not a one but two way interaction (Schmid, 1987). Whilst civil society and business demand trust from government it should be a reciprocal process. The citizens experience trust when they encounter elements such as reliability, dependence and positive utility (Josang et. al, 2005) in their interaction with government. When trust prevails, policing costs are reduced (Schmid, 1987). The ability of GSA to "track" and "measure" the evolution of trust in e-service delivery depends on the extent to which its clients (businesses, civil society and other government departments) clearly demonstrate behavioral changes that are based on mutual trust-based relationships or reciprocity.

2.2 Building an e-Government Trust "Balance Sheet" for South Africa

In order to monitor the evolution of trust in e-government, we propose a" balance sheet approach" that tries to integrate the elusive concept of trust into

Figure 2. Batho Pele principles-setting government trust in motion in South Africa, 2007

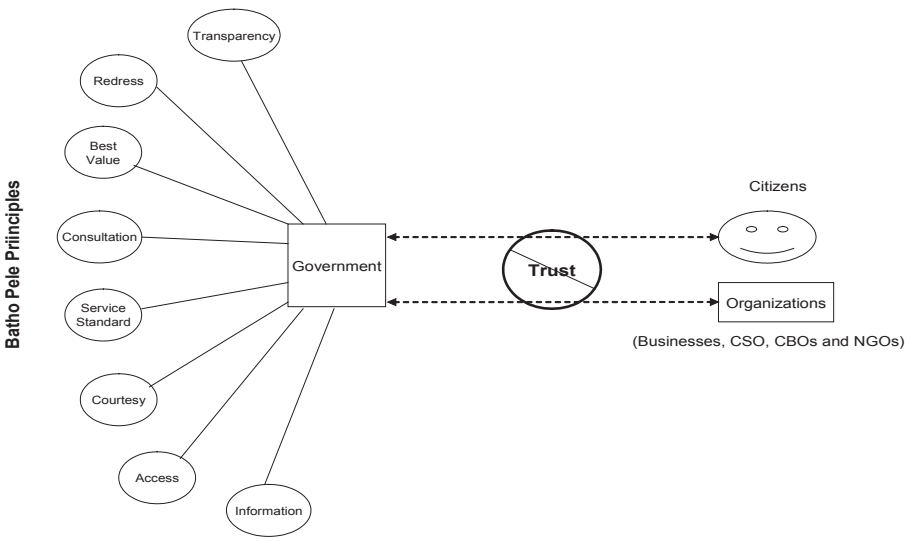
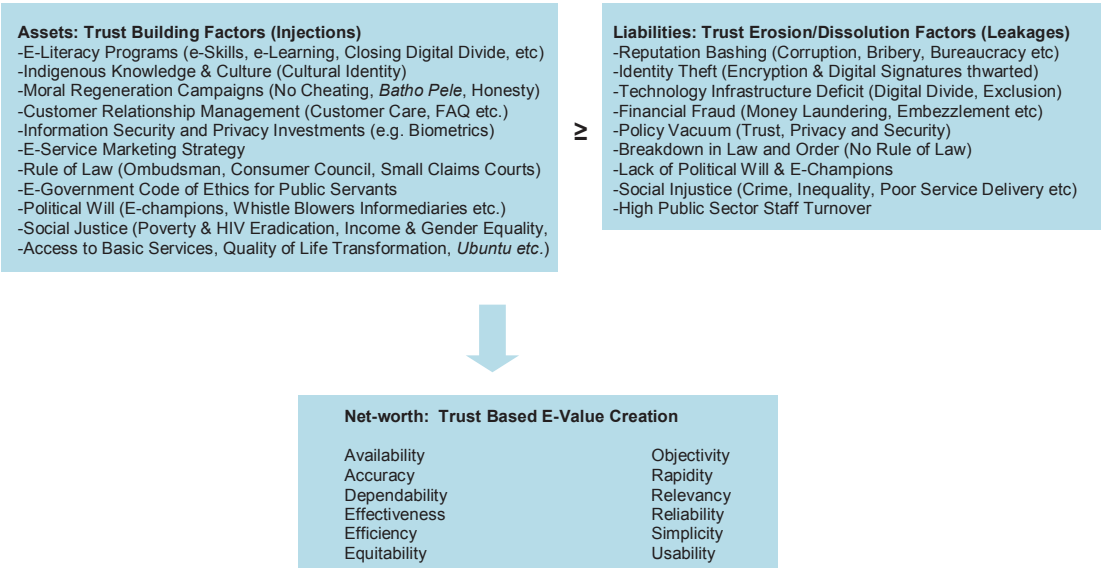


Figure 3. Proposed e-government trust "balance sheet" for South Africa, 2007



e-government program implementation. We perceive e-government trust as a form of socio-economic or political capital or asset. The challenge is to identify methodical ways in which trust can contribute to the "net-worth" of e-service delivery. Conceptually, the GSA should aim for a positive trust "balance sheet," one that consistently adds value to e-service delivery. This requires understanding clearly the difference between "trust building" and "trust dissolution" factors in e-government deployment. The "trust building factors" are what are traditionally referred to as the "assets" or "injections" while the "trust dissolution factors" are the "liabilities" or the "leakages" on an e-government trust balance sheet. The development of "trust building" initiatives ought to be treated as a key focal area driven by, and is largely part of, an overall e-government strategy.

As illustrated in Figure 3, trust building initiatives in South Africa can cover critical aspects such as (i) raising the confidence levels of citizens through e-literacy programs (ii) integration of indigenous knowledge and culture in e-government development, (iii) promotion of "moral regeneration" campaigns, (iv) innovative adoption of customer relationship management in the public sector, (v) investments in information security and privacy, and (vi) exercising the rule of law. For instance, the public may gain trust and confidence when they perceive their governments as serious in upgrading their e-skills base, expressing sensitivity to citizen-customer needs, and more importantly, demonstrating a commitment to prosecute high crimes perpetrated by public officials. The widespread problem of the break-down of the rule of law that characterizes many African countries unfortunately, is a recipe that "extinguishes any residual hope" that may be required to build trust-based relationships between government and civil society.

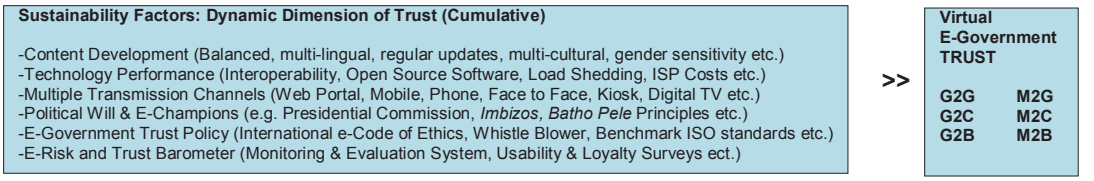
Likewise, it is important that GSA consistently monitor those factors that can be identified to cause "leakages" in trust between government, civil society and the business sector in both the first and second economies.. We identify among others (i) government image related characteristics, (ii) poor integrity of public officials (i.e., due to rampart corruption, financial embezzlement etc), (iii) lack of robust trust and privacy policy framework, (iv) weak technology infrastructure (i.e. urban-rural biases, class biases, etc.), (v) e-risks (e.g. identity theft, hacking, viruses, etc.) and (vi) high staff turnover rates of public officials as some of the key contributing factors to the dissolution of e-government trust in South Africa. The identification of "leakage issues" such as these in civil societal trust in government service delivery is a necessary first step in addressing the matters under discussion here. However, progressing the issue of building trust between the government and civil society, the GSA will need to take further steps to monitor any negative developments or liabilities in trust and should strive to promote "trust building" initiatives or "trust assets" that are related to e-government deployment as already mentioned above.

2.3 Building Sustainable Trust-based E-government Model for South Africa

The need to deliver on the opportunity to develop a "trust-driven e-government development model" requires policy makers to view trust not as a short-term gain, but as a long-term strategy for public service transformation. Unless the GSA realizes that trust gained in the short term can easily be lost, it will be difficult to grow the "trust dividend" in a sustainable way. To achieve longer term trust through a partnership based approach to participative governance there is need to identify issues that contribute towards building sustainable civil society trust for e-government which has extra dimensions in a 'virtual world' that are not evident in traditional service delivery approaches. In appreciating the "rainbow nation status" that South Africa prides itself on, it should promote a balanced e-government comprising (i) broad-based e-government content development (i.e. multi-lingual, multicultural, regularly updated, balanced in its coverage, etc.), (ii) the promotion of the widespread use of open software and multiple channels to make e-government accessible to majority poor (e.g. in remote rural locations, poor urban locations/townships, etc.) over time, (iii) the development and nurturing and retention of political will and e-champions, (iv) the crafting of an e-government trust, privacy and confidence strategy, and (vi) regular monitoring of trust and privacy issues to ensure an acceptable level of use of e-government services by critical mass of civil society.

The intrinsic value of "trust-building" assets must always exceed "trust eroding" liabilities in order to generate a desired positive "trust net-worth", considered a key part of the "e-value index" for a government web portal (Maumbe et., al., 2006). We envisage that improvements in e-government service delivery contribute to the "trust net-worth", and can be evaluated at three levels: (i) nature of the information (e.g. static web pages), (ii) transmission methods or communication channels and (iii) nature and sophistication of transactions (Evangelidis, 2004). Maumbe et. al., (2006), identify key internal, external and technical prime movers that contribute individually and collectively (i.e. through interactive mode) towards "e-value creation". The proposed e-value creation framework embeds, trust in the external environment (i.e. based on the cumulative interaction between intra-governmental agencies and strategic stakeholders, including business community and civil society). We expect that e-government information and service quality criterion such as (i) availability, (ii) accuracy, (iii) dependability, (iv) relevance, (v) rapidity and (vi) simplicity among others (see Figure 2), are key indicators that should represent an integral part of "trust-based" e-service delivery evaluation platform in South Africa. The effective development and tracking of such key performance indicators should help in taking the "pulse rate" of the e-government trust net-worth needed to generate the ultimate e-value-induced loyalty expected from satisfied citizen customers in a developing global information society.

Figure 4. Sustainable e-government trust: The dynamic nature of trust in South Africa, 2007



Furthermore, it is important for policy makers to realize that trust is a dynamic and not a static phenomenon (Figure 4). If the attainment of "virtual trust-based e-government sustainability" is the goal, it is crucial for the government to deploy multiple transmission channels that affords citizens and businesses, the opportunity to explore various e-service options offered via mobile technologies, especially in remote and poor regions where there is not sufficient 'back-bone' infrastructure to roll out Internet based online services. We therefore suggest the need for the development of some kind of "early warning system" that periodically gauges the status of an e- government trust factor. Without such a tool, inevitable break-down of trust between various service interaction mediums; Government to Government (G2G), Government to Consumer (G2C), Government to Business (G2B) and mobile-Government to Government (mG2G), mobile-Government to Consumer (mG2C), mobile Government to Business (mG2B), and mobile-Government to Business (mG2B) will result, and that will effectively undermine the goal of achieving trust-based e-value creation in the long term.

Currently, the GSA is undergoing an African Union and NEPAD Peer Review Mechanism that ranks African governments according to their economic sustainability, transparency, state of democracy and investment climate (www.aprm.org.za). Such a report is a barometer that could be used as a signal for and by the citizens to assess corruption and gauge their trust for the government. South Africa has passed the Access to Information Act and Protected Disclosures Act (i.e. also known as "Whistle Blowing Act" of 2000) (Camerer, 2001; www.pcaw.co.uk). The former Act aims to provide unhindered, equal access to government information to all the citizens while the later aims to promote whistle blowing on corrupt activities. Toll free lines are used to report serious crime in government and other sectors. Although, these mechanisms do not measure trust directly, they act as indicators for its monitoring. Examples of civil society organizations that advocate for public interest disclosure include Freedom of Expression Institute, Institute for Democracy in South Africa, Human Rights Commission, Black Sash and Office for Serious Economic Offenses.

3. TRUST AND E-VALUE CREATION IN E-GOVERNMENT SERVICE DELIVERY: LITERATURE REVIEW

Governments across the world confront the problem of eroding trust from their citizens (Evans and Yen, 2006; Parent et. al., 2005). The advent of e-government has fundamentally transformed relationships between government and citizens. A recent study revealed that citizens who regularly transact online with their governments reported significant positive changes in trust levels for the government (Parent, et al, 2005). Such findings provide a rationale for most e-government programs to become "citizen-centered" or "citizen-centric" in their e-service delivery approaches (Richter, 2004).

Nonetheless, the problems of technical implementation (i.e. system design), weak user participation (implementation), and lack of cooperation between different government departments still hinder numerous e-government programs (Stahl, 2005), and that calibrates the entry point for the need to cultivate trust. The effective integration of trust into e-government development demands public policies that reflect the thinking that e-service delivery is more than modern technology or systems design, but it is about putting people first (Richter, 2004).

Like any other technological activity, e-government development entails risks and uncertainties which require systematic assessment (Evangelidis, 2004). Trust influences the successful up-take of e-government information and services. A number of e-commerce adoption studies have identified the "trust element" as a significant factor in the uptake of e-services by citizens (Tassabehji, and Ellimann, 2006). Without a willing citizenship, e-government implementation can be problematic (Evans and Yen, 200). Trust is viewed as dynamic in nature and is not a static phenomenon. This argument suggests that trust can be cumulative, implying that it could rise or fall to new levels (i.e. just like investor confidence) depending on the presence/absence of trust-building or trust dissolving factors.

In an effort to preserve trust in e-government service delivery, questions are being raised about what is an acceptable moral behavior in electronic environments (Mullen and Horner, 2004). The authors argue that failure to establish coordinates about ethical behavior in cyberspace could undermine trust in e-government services. Others argue that in debating ethical problem in e-government, it is illogical to perceive citizens as customers as that assertion is more appropriate for commercial or e-commerce applications (Stahl, 2005).

The government's desire to forge close connections with civil society and its citizens, understand their unique preferences, and ultimately secure their trust provides a basis for customer relationship management (CRM) in the public sector arena (Pan et. al, 2006). The authors argue that CRM approach assumes that a customer relationship already exists, yet the creation of that customer relationship is as important as its management. Therefore, building e-government trust requires bridging the digital divide through e-literacy programs and raising ICT awareness. This of course recognizes the fundamental issue that many governments now confront and that is that the provision of access in and of itself is simply not enough. The technology needs to be socially appropriated in ways that not only understands civil society needs but provides a communication channel for structuration (Giddens, 1984) of service delivery systems to better meet civil society needs and elected government desires for participative governance that values social cohesion (Mbeki, 2006). Embedded in efforts to establish robust trust alliances between government and citizens in e-service delivery is the need to uncover the ethical problems of such technology deployment (Palm and Hansson, 2005). Attempts to ignore the ethical implications of technology (e.g. disability, ethnic minorities, gender issues, etc.) will undoubtedly introduce adverse consequences that will lead to a depletion of citizen trust across civil society, and will slow down the pace of e-government adoption in society.

4. CONCLUSION

South Africa has already embarked on the journey to transform its public service delivery to make it citizen-centered (DPSA, 2006). The deployment of e-government services has changed the nature of the relationship between GSA and its citizens (Detolly, et al, 2006, Alexander et. al, 2006). Civil society and citizens, like private sector customers, are keen to make informed decisions about e-government services. As concerns that government service delivery and capacity to manage the so called 'wicked issues' are getting worse emerge, the GSA needs to strategically integrate "trust-building" mechanisms in its e-government service delivery to the citizens. Trust in the new ICT enabled world i.e. the information society is the glue that holds government e-service channels and citizen customers together.

The adoption of the *Batho Pele* principles and the notion of *Ubuntu* by South Africa in 1997 triggered the first attempt to infuse trust traits in society through its "people first" approaches in service delivery. These issues have been strongly reinforced by government programs such as the Accelerated Shared Growth Initiative (ASGISA), the Strategic Plans of many Government Departments, ANC policy demands and the pronouncements of President Mbeki (2006). This paper attempted to provide a holistic view of the concept of e-government trust. To achieve that, we presented a framework that maps out key factors that contribute towards e-government "trust-building," "trust-dissolving," and "trust sustainability". We recommend the need for the GSA to regularly audit and strategically integrate citizen trust in e-government development, in order to meet the rising

"e-value expectations" from citizens who are utilizing e-services. Armed with such a tool, GSA will have an "early warning system" that will help send key signals to policy makers to make necessary and timely adjustments to advance e-government service delivery.

Although the paper does not advocate that e-government trust is a panacea for the implied deterioration in citizen trust, that it will play an increasingly important role is unquestionable. Therefore, trust can no longer afford to take a back seat in e-government development policy in South Africa. If awareness about need to curb government and private sector graft is raised, trust for GSA is bound to increase as more cases of corruption and unlawful activities will be exposed. Trust-based e-government has the potential to improve communication, enhance citizen participation, lower transaction costs and increase social cohesion (Taylor, et. al., 2006). Most importantly, it will promote a positive trust dividend (i.e. net-worth analogy) between civil society, citizens and their governments which is a crucial aspect for the emerging participatory democracy in South Africa. Finally, as this matter is of prime importance in the policy and delivery frameworks in South Africa, there is a critical need to develop a coherent research and evaluation agenda to bring out the relationship between civil society and citizen trust, building social cohesion and e-government service development and deployment in South Africa.

REFERENCES

African Peer Review Mechanism, APRM South Africa, available at www.aprm.org.za Accessed 29th January, 2007.

Alexander, H., Maumbe B.M. and K. Detolly, "Keeping Up with the Joneses: Questioning the Pace of E-government in the Developing World," In *Proceedings of the IST Africa Conference,* 3-5th May, 2006 CSIR International Conventions Center, Johannesburg, South Africa.

Camerer, L,(2001). " Protecting Whistle Blowers in South Africa: The Protected Disclosures Act, no 26 of 2000," Occasional Paper No 47.

City Press, "Department Has Lost Control of Prisons," 10th September, 2006, South Africa.

Detolly K., Maumbe B.M. and H. Alexander, "Rethinking E-government Development: Issues, Lessons and Future Prospects for the Cape Gateway Portal in South Africa," In *Proceedings of the IST Africa Conference,* 3-5th May, 2006, CSIR International Conventions Center, Johannesburg, South Africa.

Department of Public Service Administration, "Electronic Government; The Digital Future. A Public Service IT Policy Framework, 2001, Pretoria, South Africa. Available at http://www.dpsa.gov.za/documents/acts&regulations/frameworks/IT.pdf

Evans, D., and Yen, D.C. (2006)."E-Government: Evolving Relationship of Citizens and Government, Domestic, and International Development," In *Government Information Quarterly*, 23, 207-235.

Evangelidis, A. (2004)."FRAMES-A Risk Assessment Framework for E-Services," In *Electronic Journal of E-Government*," 2(1) , pp21-30.

Fraser-Moleketi, G.J. (2006). Report on the Government's Program of Action by the Governance and Administration Cluster, Pretoria, South Africa.

Gebremichael, M.D., and Jackson, J.W. (2006). "Bridging the Gap in Sub-Saharan Africa: A Holistic Look at Information Poverty and the Region's Digital Divide," In *Government Information Quarterly*, 23, pp.267-280.

Giddens, A. (1984). *The Constitution of Society*. University of California, Berkeley, California, USA.

Josang, A., R., Ismail, R., and Boyd, C. (2005), "A Survey of Trust and Reputation Systems for Online Service Provision," In *Decision Support Systems*, In press.

Mail and Guardian, "Democratic Alliance Slams Financial Mismanagement," 1st October, 2006, Johannesburg, South Africa.

Maumbe, B.M., Taylor, W.J., Erwin, G., and Wesso, H. (2006). "E-Value Creation for Government Web Portal in South Africa," In "Encyclopedia of Portal Technologies and Applications, Edited By Arthur Tutnall, Victoria University, Melborne, Australia. (forthcoming).

Mbeki, T. Nelson Mandela Memorial Lecture, University of Witwatersrand, 29th July, 2006. Available at http://www.dfa.gov.za/docs/speeches/2006/mbek0729.htm

Mullen, H., and Homer, D.S. (2004). "Ethical Problems for e-Government: An Evaluative Framework," In *Electronic Journal of e-Government*," 2(3), pp.187-196.

Palm, E, and Hansson, S.O. (2006). "The Case for Ethical Technology Assessment (eTA)," In *Technological Forecasting and Social Change*, 73(5), pp 543-558.

Pan, S., C, Tan, and E.T.K. Lim, E.T.K. (2006). "Customer Relationship Management (CRM) in E-Government: A Relational Perspective," In *Decision Support Systems*, 42, pp.237-250.

Parent, M., Vandebeek, C. A., and Gemino, A.C. (2005). "Building Citizen Trust Through E-Government," In *Government Information Quarterly*, 22, pp.720-736.

Richter, P, Cornfold J, and McLoughlin, I. (2004). "The e-Citizen as Talk, as Text, and as Technology: CRM and e-Government," In *Electronic Journal of e-Government*, 2(3), pp207-218.

Tassabehji, R and Elliman, T. "Generating Citizen trust in E-Government Using A Trust Verification Agent: A Research Note. In *Proceedings of the European and Mediterranean Conference on Information Systems (EMCIS)*, July 6-7, 2006, Costa Blanca, Alicante, Spain.

Taylor, W., G., Erwin and H. Vesso. "New Public Policies for the Emerging Information Society in South Africa-A Strategic View," *Paper Presented to the Government and Communities in Partnership Conference*, Center for Public Policy, University of Melbourne, Australia, 25-27th September, 2006.

Schmid, A.A. (1987). "Property, Power, and Public Choice: An Inquiry into Law and Economics," Second Edition, Praeger, New York, London, United Kingdom.

Stahl, B.C. (2005) "The Ethical Problem of Framing e-Government in Terms of E-Commerce," In *The Electronic Journal of e-Government*," 3(2), pp.77-86.

Sunday Times, " Why Criminal Are Walking Free," 1st October, 2006, South Africa.

UNAIDS, (2005). "AIDS Epidemic Update," Geneva, Switzerland, pp.92.

Whistleblower Protection, South Africa. Available at www.pcaw.co.uk. Accessed 30th January, 2007.

White Paper, (1997). "Transforming Public Service Delivery (*Batho Pele* White Paper), Department of Public Service and Administration, Pretoria, South Africa.

The Impact of Culture on the Adoption and Use of IT in the UAE: A Study Towards Bridging the Digital Divide Between the UAE and the Developed Countries

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ABSTRACT

Culture is thought to be probably the most difficult to isolate, define and measure in the adoption and use of IT. Consequently the impact culture on the adoption and use of IT does not feature prominently in the literature. As cultural factors may be important to the success of IT adoption and use, this research project was aimed at a focused study of its impact on the adoption and use of IT in the United Arab Emirates (UAE). The results of the study was compared along eight cultural dimensions and contrasted with a study (Hasan & Ditsa, 1997, 1999) on the adoption and use of IT in developing and developed countries. The results of this study were also used to identify issues of concern with the relationship of culture and IT and their implications for IT adoption and use in the UAE. The study results were further used to suggest ways of bridging the digital divide between the UAE and developed countries.

INTRODUCTION

Technology is believed to be culturally neutral and that the process of development, adoption and use of technology is uniform across countries, once basic economic and political conditions are satisfied (Review of the World Bank 1994). The review observed that many technology projects, including IT, in developing countries fail because the designs were not sufficiently tailored to those countries' history and industrial traditions. There are problems that cannot be attributed to the technology process, but rather the cultural differences between designers of the technology and the recipients. It is true culture may not be the only factor which influences the adoption and use of IT. Other such as economy, politics, social factors, education and skill levels may be deciding factors.

Hasan and Ditsa (1997, 1999) studied the adoption and use of IT in three regions of widely diverse cultures. They concluded that culture is an important ingredient in the identity of the IT products themselves and influences the impact of IT adoption and use in different cultures.

Following from the studies of Hasan & Ditsa (1997, 1999) and Ditsa (2005), this research carried out a focused study on the impact of culture on the adoption and use of IT in the UAE. The results were compared along eight cultural dimensions and contrasted with the studies of Hasan & Ditsa, (1997, 1999). The results of the study were also used to identify issues of concern for the relationship of culture and IT and their implications for IT adoption and use in the UAE. The study results were further used to suggest ways of bridging the digital divide between the UAE and the developed countries.

DEFINITIONS

Culture

Culture can be thought of as the beliefs, philosophy, shared values, attitudes, customs, norms, rituals, common practices, and traditions which govern the ways of living of a group of people. Macquarie Dictionary defines the culture of a society as:

"The sum total of ways of living built up by a group of human beings, which is transmitted from one generation to another."

Hofstede (1991, p.5) defines culture as: "the collective programming of the mind which distinguishes the members of one group or category of people from another". More simply, culture is shared values of a particular group of people (Erez & Early, 1993) and culture reflects the core values and beliefs of individuals, which are formed during childhood and reinforced throughout life (Shore and Vankatachalam, 1996). This implies that culture is all pervasive and has a strong influence on all our undertakings. It is not however easy to measure and hence is a difficult variable to use in a rigorous research.

Hofstede (1991) further looks at the manifestation of cultures as symbols, heroes, rituals and values, which he illustrates as the concentric skins of an onion, with the symbols forming the outer skin, followed by heroes, rituals and values in that order. Symbols are the most visible attributes of a culture, whereas values form its innermost and deepest manifestations and are difficult to change. Values, according to Hofstede, are broad tendencies to prefer certain states of affairs over others. That is, they are what make a group or a category of people distinguish between good and evil, clean and dirty, beautiful and ugly, natural and unnatural, normal and abnormal, logical and paradoxical and rational and irrational. According to psychologists these values are acquired unconsciously at an early age by the individual in a cultural group.

The Eight Cultural Dimensions

For the purpose of our study we adopted the eight cultural dimensions from Hasan and Ditsa (1999). Definitions of the eight dimensions are as follows:

- **Power Distance:** *The extent to which the members of a society accept that the power in institutions and organizations is distributed unequally.*
- **Uncertainty Avoidance:** *The degree to which members of a society feel uncomfortable with uncertainty and ambiguity.*
- **Individualism:** *Preference for a loosely knit social framework in which individuals take care of themselves and their immediate family as opposed to* ***collectivism*** *which is preference for a tightly knit social framework in which individuals expect their relatives or others in their group to look after them in exchange for unquestioning loyalty.*
- **Masculinity:** *Preference for achievement, heroism, assertiveness and material success as opposed to* ***feminism*** *which is preference for relationships, caring and quality of life.*

- **Time Orientation:** *A measure of people's consideration of the future.* Long-term orientation is characterized by people who persevere methodically toward results and save for the future whereas short-term orientation is characterized by people who expect quick results.
- **Monochrony and Polychrony:** *Cultural dimensions describing attitudes towards the use of time in performing tasks.* In Monchronous societies people focus on issues one at a time and emphasize schedules and procedures for task completion. In Polychronous societies people perform activities in parallel and focus on task completion rather than adherence to procedures.
- **Context:** *The amount of information that surrounds an event, inextricably bound up with the meaning of that event.* In a high context culture the information surrounding an event is already in the person, and very little is in the coded, explicit, transmitted part of any communication between participants. In low context cultures the mass of information is vested in the explicit code.
- **Polymorphic and Monomorphic:** *Cultural dimensions which relate to the influence of opinion leaders.* In polymorphic cultures, such as traditional villages and farming communities, the expertise of leaders or managers is assumed to span a wide range of issues, whereas in monomorphic cultures, such as modern industrialized societies, a manager's scope is limited to his or her explicit areas of expertise.

Digital Divide

There is growing disparity in the use of IT between the developed and developing countries. While developed countries are harnessing IT to revolutionize their operations of their industries, developing countries, on the other hand, appeared not to have the capabilities or the urge to do so. The disparity which exists in access to and use of IT between countries and between groups within countries is what is referred to today as the "digital divide". The growing disparity in the adoption and use of IT also results from the culture of a people (Ditsa, 2005).

THE STUDY

Methodology

The methodology used for this research is both qualitative and interpretive following the model proposed by Miles and Huberman (1984), which incorporates the four phases of: data collection; data reduction; data display; and the verification and drawing of conclusions. The data for analysis was collected from a set of organizations in each cultural region which were chosen to be as diverse as possible in size and industry type. The researchers took particularly care to select, where possible, representatives of the local IT community rather than foreign advisers or members of multinational corporations.

All the data was text-based and comprised of organizational documents and transcripts of semi-structured interviews with IT staff at both managerial and operational levels. In these interviews the researchers recorded answers to specific questions on: the history and use IT in the organizations; the method of acquisition and development of information systems; and the attitudes of operation and management staff involved in IT. The researchers also recorded any informal discussions that followed. As soon as possible after each interview, a full report was written based on the notes taken. Follow up interviews were conducted as soon as possible when we felt the need for further explanation for the data collected.

These reports and documents were then analyzed by using a process of data reduction with the selection and arrangement of relevant items. We extracted only that data which relates to culture as defined in this paper. The data was arranged along those dimensions and is displayed in Table 2 of this report. An interpretation of this data into generalized issues was then made and presented in the concluding sections of the paper.

Data Collection Methods

The data used for this study is descriptive in nature and the method of collection of the data is as follows. Interviews were conducted and observations made on the adoption and use of IT in two organizations in Al Ain, and one each in Abu Dhabi and Dubai. Before the data collection visits, preliminary contacts were made with these organizations. The organizations and interviewees were appropriately informed about our study. For obvious reasons, we agreed to guarantee the anonymity to some extent of all the organizations involved in this study.

In each organization, at least one interviewee was selected who had been involved in IT since its first introduction into the organizations. Evidence was also taken from the scarce literature of other case studies on the adoption and use of IT in the chosen organizations. Comparisons were then made with the wealth of data on IT in a Western developed country, Australia.

The Three Chosen Cultural Regions for the Study

Based on the studies of Hofstede (1983a, 1983b, 1984, 1991) and Hofstede et al. (1990), we have identified two distinct cultural regions in addition to the **UAE**, which is the focus of this study. The two are West Africa, which is in the developing world, and Australia, which is a developed country with Western culture.

Australia is one of the developed or industrialized nations which form about 25% of the world population but produce and consume about 12 times more per capita than the Third World countries (ABS, 1998). Australian companies play in specialized areas of IT. Most Australian organizations rely on IT for daily operations and strategic decision making.

Australian culture is very egalitarian resulting in an extremely low PD and a monomorphic structure where people are only respected for their own area of expertise. Australia culture is also individualistic and masculine and, perhaps being predominantly a nation of immigrants, Australians are generally venturesome and innovative. Per capita, Australia is a world leader in the use of new technology.

In contrast with Australia, the **UAE** represents the old and even ancient world, although the country can be considered as young. The UAE, like other countries in the Middle East, has some commonalities of culture, language and religion with countries of Northern Africa, and the other Islamic countries of the Levant and the Arabian peninsular. The use of IT in the UAE has grown tremendously in the last few years. Government IT initiatives appear to be towards making the UAE the technology capital of the region. These can be seen in establishment of educational institutions, the Knowledge Village, Dubai Silicon Valley, annual fairs such GITEX and Global Village to promote IT. The use of IT is widely encouraged in both public and private sectors. Examples are eGovernment initiatives in Dubai and Al Ain, and the police force. The presence in the country of giants in the IT industry (such as Oracle, Dell, IBM, Cisco, and Microsoft) attests to this. This is also evident in the use IT in the financial and other sectors.

Hofstede's (1991) cultural study in the **West African** region included Ghana, Nigeria and Sierra Leone and our study in this region focused on one country, Ghana. Apart from Liberia, which was created after the abolition of the slave trade, all other West African countries were once colonized. Ghana was at one time or another colonized by the Portuguese, the Spaniards, the Danes, the Dutch, the Germans, the French and, lastly, the British. The colonial legacies left in these countries are very obvious in their national and organizational administrative structures, languages and educational systems. For example, the official language of Ghana is English, as is that of Nigeria and Sierra Leone, whereas that of Burkina Faso, Cote d'Ivoire and Togo, is French.

According to Hofstede's (1991) study, the cultures of this region are very similar and despite the colonial rules which brought with them foreign cultures, the cultural identities of these countries still remain unique. Traditional cultures still permeate organizational cultures. The basic family values with extended family systems still dominate in this region.

DATA REDUCTION AND DISPLAY

Comparative Cultural Indices

Values of the eight cultural indices for each of the three cultures chosen were estimated from the literature. These values were also verified by representatives from the cultures used in the study and are shown in Table 1.

Summary Cultural Comparison of the Three Regions on the Eight Cultural Dimensions

From the analysis of the data collected in the study, a summary was made of instances where the value of each of the eight cultural indices was related to IT issues in each of the three cultures. These results were then verified with a representative from each of the three cultures and are presented below with a tabular summary in Table 2.

Table 1. Values of the three cultures along the eight cultural dimensions

	AUS	WA	UAE
Power Distance	Low	High	High
Uncertainty Avoidance	Moderately Low	Low	High
Individualist vs Collectivist	Highly Individualistic	Highly Collective	Collective
Masculinity vs Feminism	Masculine	Feminine	Masculine
Time Orientation	Long-term	Short-term	Short-term
Monochrony vs Polychrony	Poly	Mono	Mono
Context	Low	High	High
Polymorphic v Monomorphic	Mono	Poly	Poly

APPLICATION OF THE RESULTS TO THREE ISSUES OF CULTURE AND IT

From the results of this study we deduced three issues (Cultural identity of IT, Cultural Values of IT, and Impact of IT on Culture) that the eight cultural dimensions can be broken down into as summarized in Table 3.

It should be noted that most of the cultural indices of West Africa and the **UAE** are similar and in opposition to most of the values embedded in IT by Western culture, particularly along the dimensions of Power Distance, Individualist/Collectivist, Time Orientation, Context and Monochrony / Polychrony. The latter two dimensions are particularly interesting in regard to modern, interactive, windows-based systems which are becoming popular all over the world. These would seem to suit high context cultures and be at odds with the Monochronous nature of the work of a traditionally trained analyst-programmer concerned with structured algorithms and abstract data types.

IMPLICATIONS FOR THE IT INDUSTRY

The key area of concern for the relationship of culture and IT is the realization that many aspects of IT are not culturally neutral. Most of the popular commercially available hardware and software emanates from the US and similar Western cultures. Our study has focused on many of the issues that arise when people in different cultures use IT.

Of the eight dimensions of culture that we have used in this study, at least three could be thought of as inherent in the currently available technology, most probably because of its Western origin. These three are power difference, uncertainty avoidance and time orientation. Most IT products and projects suit cultures with low PD, low UA and long-term time orientation in the following ways:

- **PD** - Those in power in cultures with high PD are often fearful of the open nature of modern IT.
- **UA** - Adopting any form of IT is risky but there may be a greater risk of not joining the global IT community.

Table 2. Summary of the cultural comparison of the three regions on the eight cultural dimensions

	AUS	WA	UAE
Power Distance	IT has flourished in this low PD culture as networked organizations develop flatter management structures.	In this high PD culture, IT is often an imposition on organizations from the top without taking advice from IT staff.	In this high PD culture governments want to control IT and are concerned with its power to democratize society.
Uncertainty Avoidance	People here are prepared to take risks and ready to adopt new IT, resulting in successful innovation.	Also prepared to take risks but many unwise and risky projects are undertaken and a lot of incomplete IT projects are observed.	In this high UA culture there is almost no R&D. They accept only well established IT products from the developed world.
Individualist vs Collectivist	The individualist characteristic of this culture is exemplified in the typical solitary image of a dedicated computer programmer.	Here there is a collective attitude towards solving IT problems by teams of IT professionals. This has the potential to produce good IT solutions.	Most IT projects are initiated by people trained in the west who have individualist skills, whereas locals usually prefer to work in teams. This is a source of conflict in joint projects.
Masculinity vs Femininism	IT development has been predominantly technical and male oriented. Women are becoming more prominent as the number of less technical positions grows.	Both males and females vie for top jobs in the IT industry and people are more interested in what the technology can do rather than technical details.	Most jobs in IT are held by men but IT is providing jobs for women. This is welcomed by those trying to raise the position of women but is seen as a threat in conservative circles.
Time Orientation	Most organizations have a three to five year IT strategies and think reasonably long term.	Short-term planning is prevalent, so that only the results of today determine success and are rewarded	Management want quick results and do not appreciate the time value of money. Many organizations retain inefficient manual systems.
Monochrony vs Polychrony	Modern interactive, multi-tasking systems encourage polychronous work and are popular.	IT professionals prefer completing one job before taking another: a display of monochronous culture.	Batch systems were readily adopted and many have not been upgraded. This is indicative of a monochronous culture.
Context	System developers are good at low level development which requires detail and abstraction.	Interested in getting a system in place without much attention to details.	Seems to prefer modern high level end-user development tools which suit a high context culture better than traditional programming.
Polymorphic vs Monomorphic	IT management is separated from core business resulting in problems of communication: a display of a monomorphic culture.	IT managers are expected to have knowledge of every aspect of IT and the organization: a display of a polymorphic culture.	Managers are expected to deal with IT issues without being trained in IT: a display of polymorphic culture.

Table 3. Three aspects of IT and culture for each of the eight cultural dimensions

	Cultural identity of IT	Cultural Values and IT	Impact of IT
Power Distance	IT implies and supports a low PD culture.	IT can change the power base of organizations in high PD cultures giving skilled IT workers equity with managers.	IT can lower PD or be used to reinforce control.
Uncertainty Avoidance	IT is risky and has flourished in low UA. In today's world it is also risky not to adopt IT which poses a dilemma for high UA cultures.	High UA cultures may only adopt "safe" older IT and be less competitive in the global arena.	The global economic imperative of IT may have the effect of lowering UA as business are force to take the IT challenge.
Individualist vs Collectivist	Traditional IT suits Individualists but modern systems such as GSS and the Internet suit Collectivists.	IT can suit the individual or the group. It can support individual or cooperative work practices.	IT empowers individuals in collective cultures. It also creates groups across time and space.
Masculinity vs Femininism	IT has been male dominated, with a focus on the technology for its own sake. A Feminine attitude is people oriented and focuses on the end-user of IT.	Whereas the older IT systems fitted into masculine societies, feminist cultures feel more comfortable with modern user-friendly systems.	Older IT systems enforce a technological masculine way of working whereas the more modern usable systems promote feminine cooperative work practices.
Time Orientation	The changing nature of IT makes long-term planning difficult but critical. There is a need to plan long-term but also be flexible.	The need for long-term planning in a rapid changing environment can cause problems in cultures with short-term time orientation	The current climate of constant change is making people more flexible but also put more effort into anticipating future requirements.
Monochrony vs Polychrony	IT exhibits both these time aspects of work (eg Monochronous batch processing and Polychronous interactive multi-processing).	The popularity of modern windows systems in the West is in part because they support Polychronous work.	Older IT forced many into monotonous Monochronous jobs. Modern systems support Polychronous work and increase job satisfaction.
Context	IT has traditionally required explicit analysis and abstraction consistent with a low context culture.	The object oriented development approach may suit more high context cultures as it is more oriented to objects in the real world and integrates data and process.	Traditional IT has imposed its language and mode of operation on all users. It teaches problem solving skills and data abstraction with low context.
Polymorphic vs Monomorphic	IT works best when organizations combine technical and business knowledge. This is compatible with a Polymorphic culture.	Leaders in polymorphic cultures have problems with IT because it is such a specialized area of which they know little, yet they are expected to show leadership in IT adoption.	In the past IT has been run by IT specialists, however modern organizations are successful if the CIO has both business and IT expertise.

- **Time Orientation -** Some forward thinking and long-term strategy is needed to choose the best IT path for any country or organization.

Across the remaining five dimensions of culture, it is possible to choose appropriate technology for particular cultures. These could be:

- using groupware techniques in collective cultures, as opposed to single user systems which are more appropriate in individualistic cultures;
- more technical approaches to development in masculine cultures and more people oriented approaches in feminine cultures;
- using modern visual and object-oriented programming package for more high context cultures and more traditional algorithmic methods for low context cultures;
- highly interactive systems are easily accepted in polychronous cultures whereas linear systems suit monochronous cultures;
- monomorphic cultures readily accept specialists whereas in polymorphic cultures managers must have broader more generalist training, as they are expected to be experts in everything.

LIMITATIONS OF THE STUDY

More data is always desirable. It would have been useful to increase the number of organizations in the study and across the seven Emirate of the UAE. These would have required more time and resources, which in the current study were very limited.

CONCLUSION AND SUGGESTIONS FOR FURTHER RESEARCH

This study suggests that cultural impact on IT adoption and use cannot be ignored. Culture is an important ingredient in the identity of the IT products themselves and influences its adoption and use. Problems will arise when there are differences between the culture of an IT product and the culture of its user. We discussed this under the heading of three issues: the Cultural Identity of IT, Cultural Values and IT and the Cultural Impact of IT.

As the use of IT expands globally, there is need for further research into cultural aspects and implications of IT. A greater understanding of the various dimensions of culture, as applied to IT and the people who use it, will lead to more globally acceptable IT products and better choices for IT.

From the results discussed, suggestions can be made to the **UAE** government and the private sectors to encourage more use of IT in order to bridge the digital divide between the country and the developed countries. This may mean more provision of resources, education towards modernizing aspects of culture that inhibit the successful us of IT, providing tele-cottages to educate that section of the population that is computer illiterate. There will also be the need to encourage more use of IT at all levels of the educational sector. Teaching of IT at these levels should highlight the cultural aspects that inhibit the successful use of the technology.

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REFERENCES

ABS (Australian Bureau of Statistics) Web Site (1998) *http://www.abs.gov.au/*

Ditsa, G.E.M. (2005). "Issues of ICTs and Development in Less Developed Countries: A Case of Africa and A View Towards Bridging The Digital Divide", *IRMA 2005,* May 15-18, San Diego.

Edupage 1996 INFOSYS 3/19 July 4, 1996

Entsua-Mensah, C. (1996). Towards Effective Information Management: A View From Ghana. *IJIM,* 16:2 pp. 149-156.

Hall, E. and Hall, M. (1990). *Understanding Cultural Differences*. Intercultural Press.

Hasan, H. and Ditsa, G. (1997). The Cultural Challenges of Adopting IT in Developing Countries: An Exploratory Study. *IRMA 1997*, Vancouver.

Hasan, H. and Ditsa, G.E.M. (1999). "Impact of Culture on the Adoption of IT: An Interpretive Study", *JGIM,* Vol. 7, No. 1, pp.5 – 15.

Hofstede, G. (1984). *Culture's Consequences*. Sage Publications.

Hofstede, G. (1985). The Interaction Between National and Organizational Value Systems *Journal of Management Studies* 22:4 pp 347-355.

Hofstede, G. (1991). *Cultures and Organisations: Software of the Min.* McGraw-Hill.

Kamel, S. (1996). DSS for Strategic Decision Making. *IRMA 1996,* Washington.

Mensah, J. (1996). Science & Technology *http://www.uta.fi/~csfraw/ghana/articles/scit.html*.

Miles, M.B. Huberman, A.M. (1984). *Qualitative Data Analysis: A Sourcebook of New Methods*. Sage

Review of the World Bank (1994) "Lending for Industrial Technology: Lessons from Six Countries" # 70.

Shore, B. and Vankatachalam, A. (1996). Role of national culture in the transfer of information technology. *Journal of Strategic Information Systems* 5:1 pp 19-35.

Walsham, G. (1995). The Emergence of Interpretivism in IS Research. *IS Research*, 6.

The Role of Cybercafé in Bridging the Digital Divide

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ABSTRACT

Digital divide exists for those who do not have access and use Internet to fight the war against world poverty. Despite the remarkable advances in technology, more than 80% of the world population does not have access to telephone or Internet (Family Care, 2006). There are many international projects and efforts aimed at bringing the Internet to people in developing countries. Most of these projects are initiated and sponsored by international and governmental institutions. In this paper, we examine one way of bridging the digital divide based on private initiatives and yet yielding greater results and benefits to those who use it, to narrow the digital gap. There are over 100, 000 cybercafés in Nigeria. We examine the technology deployed and its advantage; discuss the operations of cybercafés in Nigeria and how they are helping to bridge the digital divide. The study involves a survey of cybercafés and the users of cybercafés. The result of the survey provides insight into what users of Internet in a developing economy use the Internet for.

Keywords: *digital divide, cybercafé, Internet, Nigeria, VSAT, economy*,

INTRODUCTION

The World Summit on Information Society in its declaration of principles, expressed its "desire to build a people-centered, inclusive and development-oriented Information Society, where everyone can create, access, utilize and share information and knowledge", and is "fully aware that the benefits of information technology revolution are today unevenly distributed between the developed and the developing countries" (WSIS, 2003).

Digital Divide is the term used for the unequal access to information and communication technologies by various communities. The digital divide exists at various levels between developed and developing nations. The implications of digital divide are very serious, because information and communication technologies propel economies of the rich countries.

In emerging economies, numerous projects have been launched to set up community access centers. Various strategies, actions and initiatives are being taken at all levels to bridge the digital divide. There are many international projects and efforts aimed at bringing the Internet to people in developing countries. Most of these projects are initiated and sponsored by international and governmental institutions. Despite all efforts, the digital divide persists, because of poor infrastructure among other factors resulting in inadequate access to affordable telephones, broadcasting, computers and Internet. (NEPAD, 2003)

The most overlooked solution to bridge the digital divide is the cybercafé phenomenon in the developing nations. The use of cybercafés to provide Internet access and connectivity to the populace is increasing and helping to close the digital divide. This study examines the cybercafé phenomenon, the technology deployed and its advantages, and how it is used to bridge the digital gap.

LITERATURE REVIEW

The implications of the digital divide has been documented in several reports (ITU, 2001, USIC, 2000, Bridges.org, 2001, OECD, 2001, Flor, 2003). Internationally, ICT is concentrated in the industrialized countries with little ICT in Africa. It is estimated that USA alone has over 183 million telephone lines while the continent of Africa has about 20 million telephone lines (ITU, 2001). In terms of the Internet, in 2000, there were about 137 million people with access to the Internet in USA and Canada (USIC, 2000). Africa has an estimated 274,742 Internet hosts with PCs shares of 7,558,000, representing 1.53% of the world total (Ya'u, 2002). By mid-2002, there were 1.7 million dial-up Internet subscribers in Africa with 1.2 million in North and South Africa, and the rest of Africa having about 500,000 subscribers (Jensen, 2003). In 2004, less than 3 out of every 100 Africans use the Internet compared with an average of 1 out of every 2 people in G8 countries. (ITU, 2004). In 2002, Nigeria has a 1,030,000 Internet hosts with 420,000 Internet users and a total of 853,000 PCs, with a population of about 125,000,000 (ITU, 2004).

Problems faced by Internet users in Africa are many. These include the cost of telephone connection to the Internet service provider, poor line quality slowing connection speed, frequent line drops, significant infrastructure problems and trained computers operators (Kenny, 2000). In his paper, Kenny (2000) discusses at length, the costs of Internet provision and access in Africa. Ya'u (2002) identifies four dimensions that affect the digital divide in Africa. Theses are the international dimension, the African's isolation from the cyberspace, the uneven distribution of telephone lines among African countries, the unequal access of ICTs between urban and rural people.

Schilderman (2001) believes that the establishment of sustainable ICT in developing countries is likely to take time and considerable efforts. The high cost of international bandwidth is a major constraint, with developing countries often having to pay the full cost of link to a hub in a developed country. Many developing countries have less than 10 Mbps of international Internet bandwidth (ITU, 2004). One of the challenges facing service providers in Africa is how to provide broadband connectivity in an unfriendly environment and make Internet connection affordable to the people. In most of the countries, the cost of one hour of Internet access can wipe out a day's wage.

There are many recent technological innovations that make ICT cheaper to the people. One of them is the VSAT technology, used for interactive voice and data broadcasting (Hudson, 1999). However, the reduction in the cost of Internet connection is not enough to reduce the digital gap. A new public access regime is needed. A Cybercafé provides a regime that provides both cheaper connection and easy access to Internet.

There is little research on what cybercafés are used for and who use them. (Callon, 1987). Since the early 1990, a number of people have undertaken researches on cybercafés (Wakeford, 1999). Stewart (2000) addresses the role of cybercafés in the general development of use and knowledge about multimedia and concludes that cybercafés are for technical access, for consumption of multimedia and serve as community and cultural spaces. Internet cafes are located world-wide and people use them to access web mail because it is more affordable than personal ownership of equipment.

The concept and name of Cybercafé was invented in 1994 by Ivan Pope in a proposal outlining the concept of a café with internet access from the tables. Inspired by this proposal, a cybercafé called Cyberia was opened on September 1, 1994 in London, England. In 1995, the first cybercafé was opened in East Village, New York City. (Sonia *et al*, 2003). There are over 100, 000 cybercafés in Nigeria. (The Guardian, 2006). Adomi (2005) did study the effects of a price increase on cybercafés in Abraka, Nigeria. But there is no reported study of the extent of the contribution of cybercafé in bridging the digital divide in a developing country.

THE STUDY AND METHODOLOGY

The study objectives are to determine the contribution of cybercafé in making Internet accessible to many people in a developing economy and to examine the patronage of cybercafés. The study also examines the various types of users of

cybercafés in terms of their professions and what they use internet for, while in the cybercafés. The study covers the surveys of cybercafés in Ibadan and Lagos, and a survey of users of cybercafés in the two cities. The two cities are selected because of their prominence in terms of Internet diffusion. Lagos is the commercial capital of the country with all major commercial activities. The population of Lagos Metropolitan is about 12 million. (Census, 2005). Ibadan is the major educational center with the first university in Nigeria, a prominent Polytechnic and a large student population.

The study also investigates the type of users of cybercafés and what they use the Internet connections in the cybercafés for. A questionnaire was designed and administered at about twenty cybercafés. Each user-client was given a questionnaire to complete as he/she comes into the cybercafé. Seven hundred questionnaires were distributed. Five hundred and forty-eight users were completed and returned the questionnaires. This represented about 78 percent that can be considered good for analysis (Babbie, 1979).

Part of the survey is for the users to rank reasons for using cybercafés and to rate the reasons. A rating between 1 and 5 indicates the nearness to most important or least important a reason is to the user. A questionnaire on rating important reasons is the traditional data collection tool which does not force respondents to confront the relationships between the reasons (Margado, *et al,* 1999). Rating method is used because important reasons could be termed to be homogenous considering the level of economic, political development and the environments within which the cybercafés operate. Rating is also used because it allows the evaluation of one reason at a time rather considering all reasons simultaneously. Simple descriptive statistics such as means are used to determine the ratings of the important reasons (Pinsonneault, *et al*, 1993).

RESULTS

The first observation of the cybercafés is the fact that no beverage is served in any of them. This is contrary to what is available in a typical cybercafé in Europe, Canada or U.S.A. A cybercafé in this study is purely an Internet center where a user can connect to the Internet. The center is also used to send and receive fax messages and to make telephone calls, especially, international long distance calls. Another observation is the fact that high tariff of dial-up connection for long distance and international calls makes it not feasible to use telephone dial-up facilities for Internet connections. It is also discovered that all the cybercafés surveyed use the same technology, VSAT, because it provides access to Internet at a cheaper rate to the users. VSAT technology is used for interactive voice and data broadcasting (Hudson, 1999).

VSAT (Very Small Aperture Terminal) is a device used to receive satellite transmissions. The "very small" component of VSAT refers to the size of the dish antenna mounted on a roof or wall or placed on the ground. The first component of a VSAT is the outdoor unit made up of the antenna, the low-noise blocker (LNB) which receives the satellite signal and the transmitter which sends signals. The second component is the indoor unit which is a PC containing receiver and transmitter boards and an interface for communicating with the existing in-house equipment – LANs, servers, and PCs. Connecting the indoor unit to the outdoor unit is a pair of cables.

VSAT is not limited by the reach of the cable since it can be placed anywhere that is the view of the satellite. VSAT is capable of sending and receiving all sorts of video, data and audio content at the same speed no matter the distance from the switching offices and infrastructure. VSAT technology is cost effective and provides quick implementation. Maintaining VSAT is limited to yearly maintenance.

A typical VSAT in a cybercafé has the following equipments;

- A 1.8 or 2.4 meter dish with 4W BUC and a satellite receiver mode for C-Band or KU-Band.
- A wireless access point and bridges
- 128/256 or 256/512 kbps bandwidth
- A server with appropriate operating system and other softwares for network administration and administration. Examples of the softwares are Windows NT, LINUX, Mikrotik, and Cyberclock

The cost of a VSAT start-up package, as revealed by the investigation, is shown in Table 1 in U.S. dollars.

The minimum computers available in a cybercafé surveyed are 10. While most of them have about 20 systems, one in particular has 30 computers connected to the VSAT. The connection fee is one hundred naira for an hour payable by a user (about $1.00). It is less than $1.00 if the user comes in after 10.00 p.m. The average number of clients in a cybercafé is 200 per day. If we considered that the number of Cybercafés across the country is 100,000, (The Guardian, 2006) then we have about 20 million people connecting to Internet daily. This represent about 16% of the population.

Table 1. Cost of VSAT installation

Purchase Options	Personal	Professional	Corporate	Commercial
Lease Purchase – 8 Months	1,800.00	2,500.00	4,500.00	9,100.00
Lease Purchase – 12 Months	2,000.00	3,000.00	5,200.00	10,000.00
Full Purchase	5,000.00	5,500.00	8,000.00	10,500.00
Bandwidth	32/128	64/256	128/256	128/512
# of Terminals Supported (Max)	5	10	20	30+
# of Voice Parts	1	1	1	1

Note: All start up packs include: Complete Indoor and Outdoor Equipment, 4 months bandwidth, quarterly software and maintenance installation charges. (Koochi Communications, 2004)

Table 2. Type of users by age-group

Age-group (Years)	Businessmen	Workers	High Sch Student	Univ./Poly Student	Professionals	Total
10-18	0	0	35	0	0	**35**
19-25	15 (4.3%)	92 (26.1%)	0	245(69.6%)	0	**352**
26-30	52 (58.4%)	2 (2.2%)	0	15 (16.9%)	20 (22.5%)	**89**
Above 30	0	0	0	0	72	**72**
Total	**67**	**94**	**35**	**260**	**92**	**548**

Table 3. Internet applications

Internet Applications	Percentage of Users
Chatting	74.8
E-mail	89.2
File Transfer	33.4
Research	53.5
Shopping	7.5
Information	69.3
Education	20.3
Others (entertainment, etc)	8.8

Table 4. Time connected to Internet

Age-Group	Average Time (Hrs)
10-18	**2.19**
19-25	**2.50**
26-30	**2.66**
Above 30	**2.04**

Table 5. ICT equipment usage

ICT Equipment	Percentage of Users
Telephone service	62.2
Mobile/Cell phone	80.7
Text/SMS Usage	63.7

Table 6. Reasons for using cybercafés

Reasons for using Cybercafés	Mean	STDV
Ease of using cybercafé	1.74	0.834
Cost of ISP Services	1.78	1.042
High Telephone charges	1.90	1.004
Affordable Cybercafé Services	1.93	0.872
Cost of Computers – expensive	2.14	0.924
Unreliable telephone services	2.33	1.380
Unreliable Power Supply	2.54	1.318
Lack of Computer Technicians	2.82	1.450

The study finds that 64.2% of the users of cybercafés are in the age-group 19-25 years, 16.2 % are in the age-group of 26-30 years, 13.1% are above 30 years old. Only few, 6.4% are in the age-group of 10-18 years. In the terms of the types of work the users do Table 2 shows the age-group by job types.

Eighty-seven percent of the respondents use computers at least once a week, with about ninety-two percent of the respondents use the Internet at least once a week. Of those connecting to the Internet, about eighty-six percent are connected for at least two hours at a time. Most of the users, 89.2% use the Internet for e-mail. Table 3 shows application areas of the respondents.

On the length of time connected to the Internet, the average connecting time by a user is 2.89 hours. Table 4 shows the average time connected to the Internet at a sitting by age-groups.

If the uses of other ICT (information and communication technology) equipments are considered, Table 5 shows the percentage of the respondents who owe or use the specific equipment and/or application.

Table 6 shows the ranking of the reasons why people use the cybercafé, from the most important using mean ratings and their standard deviations. The lower the mean of a reason the more important is it to the users. The higher the mean of a reason, the least important is the reason for using cybercafé. The standard deviations indicate the variability of the means – the higher the standard deviation of a given reason, the lower the level of agreement among the respondents on the issue

DISCUSSION

In discussing the results of this study, the following interrelated factors, adapted from Peters (2003), are applied to determine the effective utilization of Internet by the people:

1. Physical Access: The VSAT technology has made Internet available and accessible to many people
2. Appropriate technology: VSAT technology is appropriate to the local needs and conditions. There is little dependence on infrastructure, especially, power supply.
3. Affordability: Internet through VSAT technology is affordable to the people. The rate of one hundred naira (less than US$1.00) per hour makes it very affordable to the people. This rate is far less than the hourly rate of $5.40 for Nigeria in 2004 (Daub, 2004). Affordability is important in increasing the number of customers of cybercafé. A change in price regime usually exhibits this fact. (Adomi, 2005)
4. Socio-cultural factors: People are not limited in their use of Internet based on gender and religion. However, one noticeable factor is the paucity of the number of females using the cybercafés. Women have not taken advantages of opportunities available on the Internet.
5. Trust: It is not possible to determine the confidence of the people in the technology in terms of privacy, security or cyber crime. This is because few users use the Internet for any financial transaction
6. Legal and regulatory framework. There are no laws and regulations limiting the use of Internet.
7. Local economic environment: There is presently no local economic environment favorable to the use of Internet. But most institutions that required one kind of registration or other are now encouraging people to online or to make available information about their organizations.

This study reveals several things regarding the cybercafé phenomena. It shows that many people, hitherto, unrecorded, use the facilities in the cybercafés. While efforts are being made by institutions to close the digital divide, greater efforts are currently being undertaken by private individuals to close the divide. It is not uncommon to hear people who have no access to Internet to talk about receiving "mails" through Internet.

The age-group of users of cybercafés indicates that the youth of the country are now conversant with the Internet. This point to the fact that in the very near future, this group will continue to use the Internet

CONCLUSION

If the digital divide is to be bridged, efforts such as the establishments of cybercafés by the private entrepreneur should be encourage by the governments. This study reveals that the private can do more to bridge the gap than the public sector. The operations of cybercafés indicate sufficient understandings of local needs and conditions and attempts to satisfy theses needs through market forces. More people are connected to the Internet than before because of the operations of cybercafés. More people are now empowered in developing countries to overcome development obstacles.

This study is an initial effort to investigate the cybercafé phenomena and the VSAT technology to bridge the digital divide. In the near future, the results of the study shall be compared with similar study in other developing nations so as to understand the differences among the needs of Internet users. In addition, future researches can examine the economic impact of cybercafé in the local economy, and cybercafé and knowledge management in a developing economy.

REFERENCES

Adomi, Esharenana, E., (2005), "The effects of a price increase on cybercafé services in Abraka, Nigeria", The Bottom Line: Managing Library Finances, Vo. 18, N0. 2, pp. 78-86.

Babbie, E. R. (1979), "*The Practice of Social Research*", Wadsworth Publishing Inc., Belmont, CA.

Bridges.org, (2001), Spanning the Digital Divide: Understanding and Tackling the Issues, Bridges.org, South Africa

Callon, M. (1987). Society in the Making: The study of technology as a tool for sociological analysis. The Social Construction of Technological Systems. B.W.H.T AND P.T. Cambridge, MA

Daub, T. C. (2004). Cost of Cyber living, @ www.A:\Foreign Policy Cost of Cyberliving.htm

Flor, A.G. (2003), "ICT and Poverty: The Indisputable Link", Paper for Third Asia Development Forum on Regional Economic Cooperation in Asia and the Pacific, organized by Asia Development Bank, available online @ http://www.worldbank.org/html/extdr/offrep/eap/infoalexan.pdf

Hudson, H. E. (1999), "Global information infrastructure: the rural challenge", available at http://www.fao.org

Jensen, M. (2003) "The African Internet – A Status Report, July 2002" available at http://www3.sn.apc.org/africa/

Koochi Communications (2004), "VSAT Ownership just got easier", An Advertisement in The Guardian, Lagos, Nigeria, June 8, 2004, p. 17.

ITU (International Telecommunications Union), 2001, World Telecommunication Indicators Database, ITU, Geneva @ www.itu.org.

ITU (International Telecommunications Union), 2004, World Telecommunication Indicators Database, ITU, Geneva @ www.itu.org.

The Guardian, 2006, "Why Cybercafés Suspend Night Browsing", The Guardian Newspapers, 08/09/2006, page 37.

Family Care Foundation Computer Literacy Program found @ http//www.familycare.org/whatwedo/computer.htm

Kenny, C. J. (2000), "*Expanding Internet access to the rural poor in Africa*", Information Technology for Development, No. 9, pp 25-31

Margado, E. M., Reinhard, N., and Watson, R., (1999) "Adding Value to Critical Issues Research through Q-Sorts and Interpretive Structured Modeling", *Communications of the Association for Information Systems*, Vol. 1, January

NEPAD, (2003), "Bridging the Infrastructure Gap: Bridging the Digital Divide: Investing in Information and Communication Technologies", available online @ http://www.nepad.com

OECD, 2001, Understanding the Digital Divide, @ www.oecd.org/dsti/sti/prod/Digital Divide. PDF

Pinsonneault, A., Kraemer, K.L., (1993) "Survey research methodology in management information systems: An assessment", *Journal of Management Information Systems*, Vol. 10, No. 2, pp 75-113

Schilderman, T. (2001), "Can ICTs help the urban poor access information and knowledge to support their livelihoods?" Proceedings 4th International Conference on Urban Poverty, Marrakech, Morocco.

Sonia, L. and Laegran, A. S., (2003), Cybercafés: Debating the meaning and significance of Internet Access in a café environment, New Media & Society, Vol. 5 (3)

Stewart, J (2000), Cafematics: The Cybercafé and the Community, in Community Informatics: Enabling Communities with Information and Communications Technologies, Ed M. Gurstein, Idea Group, Toronto, Canada

USIC (United States Internet Council), 20000, Internet Report for the Year 2000 @www.usic.gov

Wakeford, N. (1999). Gender and the landscapes of computing in an Internet café. Virtual geographies: bodies, space and relations. M. Crang, P. Crang and L. May, London, Rutledge. Research at the University of Sussex and University of Teeside in 1999

WSIS (World Summit on the Information Society), (2003) Building the Information Society: A Global Challenge in the Millennium, @ http://www.itu.int/wsis/docs/geneva/official/dop.html

Ya'u, Y. Z. (2002), "Confronting the Digital Divide: An Interrogation of the African Initiatives at Bridging the Gap", @ www.clp@kabissa.org

The Challenge of Creating Virtual Communities

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ABSTRACT

The MySpace phenomenon and the increased use of virtual communities (VC) by large international organisations such as IBM and Procter and Gamble (P&G) confirms the importance of VC in today's society and the global economy. The holistic approach of using modern Internet tools and technologies with social networks presents both opportunity and challenges in the modern era. This paper addresses both the challenges and opportunities presented to communities wishing to establish a virtual cyber-presence. The research outputs are based on a review of academic literature in the area of VC. The research objective of this paper is to review current practices and success strategies as proposed in academic publications and studies.

INTRODUCTION

A virtual community is a community of people with a common interest but not necessarily a common geographic location (Sands, 2003). In their most basic form, virtual communities are websites that allow their users to interact with each other using tools such as discussion forums, 'Blog Spaces', real-time chat and trading areas.

Virtual communities allow companies to build stronger, more cost-effective connections between themselves, their partners and their customers (Roberts, 2006). If planned and executed correctly, VCs can benefit businesses by improving resource allocation, customer service and revenues, as well as lowering operating costs. Furthermore, virtual communities can act as bridges between companies and their customers by fostering product awareness, providing forums for questions and concerns and serving as conduits for feedback to improve future company products.

Virtual communities effectively allow the exchange of vast amounts of information between users scattered globally. Amazon.com, for example, utilises a virtual community to ensure that purchasing customers share information and opinions on their products, and this information can then be used to promote additional sales from other potential customers. This ensures that customers come back to Amazon for this free service that allows them to review what other customers have thought about products there.

The research objective of this paper is to review the challenges of virtual communities as highlighted in academic literature, and then look at suggested solutions to these. The paper will then summarise the findings and propose solutions to the challenges associated with virtual community implementations.

The research methodology employed in this paper will involve reviewing academic literature on the subject of virtual communities with a focus on problems associated with their implementation and uptake.

RESEARCH METHODOLOGY

A literature review was undertaken to obtain an in-depth understanding of the VC research area.

The methodology adopted in this paper is to firstly identify what virtual communities are from the extensive published academic literature. The paper shall continue by summarising the academic literature on the following topics:

- Why virtual communities are needed
- The various types of virtual communities
- Technologies for virtual communities
- Community member roles
- Virtual community life cycle

The paper will then discuss the various problems and challenges associated with virtual communities before outlining several success strategies from the academic literature that need to be followed in order to create a successful virtual community.

VIRTUAL COMMUNITIES

There are many definitions of virtual communities. Sands (2003) describes virtual communities as "*a community of people with a common interest but not necessarily a common geographic location*" that interact over the Internet.

Barnatt (1998) uses a similar definition, describing virtual communities as "*...any group of people who share a common bond, yet who are not dependent on physical interaction and a common geographic location in order to sustain their group affinity*".

Case et al (2001) describe the term 'community' in a traditional sense - i.e. a location where people with similar interests can share experiences, ask questions and collaborate. Members of a given profession can join a community bringing with them a large amount of critical information, knowledge and experience, which they share only occasionally at events such as conferences. Virtual communities, on the other hand, overcome this minimal interaction by connecting geographically disparate groups in real time, through an online environment. This allows them to share knowledge and information with speed, but with little expense. Like traditional communities, virtual communities also act as a repository of information for their members, but they can store a much larger amount of important data (Case et al, 2001). Another advantage for virtual community members is access to opinion leaders and industry experts with a mouseclick with whom they would otherwise never have contact.

One of the most widely used definition of VC is Communities of Practice (CoPs). These link together cross-functional teams that are focused on the same set of business processes (Hagel and Armstrong, 1997). A CoPs is a group of people that share a passion for something they specialise in and who interact on a regular basis in order to learn how to do it better (Wenger, 2004). Each one of us belongs to a number of CoPs (at work, at school, in our hobbies etc.) - we are core members of some communities and in others we are more peripheral (Wenger, 1998). CoPs improve the performance of their members, by allowing them to share the experience or advice of other members (Wenger, 2004).

According to Hagel and Armstrong (1997) the main types of Virtual Community are:

1. Customer-Focused Communities
   - **Geographic Community** - formed around a physical location of common interest, e.g. Amsterdam, South Africa, New York.
   - **Demographic Community** - focused on gender, life stage or ethnic origin. These communities may stimulate a good volume of high-value transactions from members such as teens, single parents, senior citizens etc.

- **Topical Community** - centred on topics of interest such as hobbies, pastimes, sport, politics, culture, etc. An example of this type is the Liverpool football club community.

2. Business-to-Business Communities
   - **Vertical industry Community** – these are widespread forms of early business communities, particularly in high-tech industries (e.g. forming software user groups). For example source forge is a community of open source developers contributing free software components.
   - **Functional Community** – these communities serve the needs of people in specific business functions, (e.g. marketing) and are useful for mutual support and access to information.
   - **Geographic Community** - similar to consumer-focused geographic communities described earlier, in that they are formed around a physical location of common interest. Small businesses may benefit from the ability to exchange information about their concerns and needs with similar companies.
   - **Business Category Community** – members of these communities include SMEs, franchises, and exporters, all of which have a similar need for information, and again a similar benefit from regular interaction with similar businesses. An example of this VC includes the Department of Technology and Industry (DTi) knowledge network.

VIRTUAL COMMUNITIES AND TECHNOLOGIES

Technology plays an important role in the life of many communities (Wenger et al, 2005). The technologies mentioned in this paper are regularly used not only by virtual communities, but also by communities of people that are able to meet face-to-face.

A community implies an experience of togetherness that extends through time and space (Wenger et al, 2005). Therefore recreating this behaviour of personal interaction through technology is vital for a VC to operate successfully.

In acquiesce Hagel and Armstrong (1997) also stress that members are the most important factor in the success of virtual communities - technology is merely the enabler that facilitates the delivery of value to end users.

Wenger et al (2005) state that there is no "perfect" technology configuration – it changes from community to community over time.

The technologies most relevant to virtual communities can be split into:

- Synchronous technologies - allow members of a virtual community to communicate and collaborate in 'real-time'. Instant messaging, video conferencing and whiteboard applications are good examples.
- Asynchronous technologies – allow members to communicate when there is a time difference involved. Examples include discussion boards and E-mail.
- Publishing technologies – allow members to collaborate through information exchange. Blogs, RSS feeds, newsletters, document repositories (including version control) and calendars are used to facilitate publishing.
- Transaction technologies – payment technologies allow members to securely purchase goods and services through the virtual community as well as identifying the parties involved in the transaction. (e.g. Paypal).
- Data Collection and Interpretation Software – allow community organisers to analyse member profiles and participation statistics, in order for them to continually re-engineer the community in order to meet the users' needs.

COMMUNITY MEMBER ROLES

Flavian and Guinaliu (2005) suggest that there are 5 types of roles required in

Table 1. Community member roles

Role Name	Role Function
Coordinators	• Understands the community's business area / industry / interest • Understands which members should talk to each other • Orchestrates community activities • Connects community members • Nurtures the community • Establishes new sub-communities • Optimises the community's structure and design
Moderators	• Respected members of the community • Channels debates in a suitable direction • Manages member-generated content (. bulletin boards, chat areas) and ensures it is suitable for the community • Manages member profiles • Builds up a library of member-generated content. Moderators work with Instigators to decide what content is kept and what is not from bulletin boards and chat areas
Instigators	• Evaluates and searches for useful resources for the community • Voluntarily and respectfully proposes conversational topics to encourage participation • Utilises member profiles from Moderators in order to understand which information is important to the users • Searches for new resources of interest to them
Support Team	• Understands the technical requirements of the community • Provides training for community members • Manages the technology infrastructure - ensures that community members have enough server capacity to store both content and profiles • Ensures that the community is secure • Liaises between the community members and the executive sponsor to ensure that the community delivers its goals • Responds to community's questions effectively without large expenses • Evaluates feedback from a number of sources (such as bulletin boards) in order to keep service levels high • Ensures that community transactions are secure
Executive Sponsor	• Responsible for staffing of the community • Gives investment, guidance and legitimacy to the community • Maximises the community's revenues from advertising and transactions and ensures that the products and services offered to community members are relevant to the their needs

Table 2: Development Stages of a VC (Adapted from Hagel and Armstrong, 1997)

Stage of Evolution Description Key Features
1 Virtual Villages Communities are highly fragmented but profitable businesses, each containing multiple, small sub communities. • Low barriers to entry • Many entrants • Companies participate across multiple communities • Network users sample across multiple communities • May become profitable niche businesses
2 Concentrated Constellations Concentration of core communities, and development of affiliate relationships with niche communities.. • Increasing returns lead to concentration within "core" topics, such as travel, teenage interests, the legal profession etc. • Niche communities benefit from affiliating with core communities
3 Cosmic Coalitions Core communities aggregate across complementary core topic areas (such as sports or music). They do so either because of the proactive efforts of one community organiser or because all see benefits in becoming a wider "co-operative". • Members find value in formation of coalitions, a common user interface and billing, for example
4 Integrated Infomediaries Communities and coalitions evolve into agents for members, managing their integrated profiles to maximise value to members. • Members themselves represent the most efficient location for capture of profiles • Members assert ownership over their profiles (and understand their value) • Specialised infomediaries can organise and maximise value of member profiles

order to keep a VC successful. Wenger et al (2005) believe that there are 3, whilst Hagel and Armstrong (1997) believe there are 9.

This paper builds on the assumption that there are 5 roles, summarised in Table 1.

VIRTUAL COMMUNITY LIFECYCLE

Hagel and Armstrong (1997) believe that in order to create a successful VC the organisers need to understand the possible evolution of both the structure of the community business and the relationships between communities themselves. As such Hagel and Armstrong (1997) proposed an evolutionary route for VCs (Table 2).

Wenger (1998) takes another view to the development stages of a virtual community, described in Figure 1.

BENEFITS FROM VIRTUAL COMMUNITY USE

There are several benefits for all parties using VCs. The main benefit is that VCs allow fast and inexpensive dissemination of knowledge and information between members whilst controlling information overload (Case et al, 2001). Members receive far more information than they would typically be able to access conveniently and cost-effectively in the past. Member's opinions and previous experiences are also disseminated throughout the entire community so benefiting all members (Hagel and Armstrong, 1997).

Benefits to Customers

VCs enable customers to exchange "word-of-mouth" experiences with each other, allowing other potential customers access to a critical evaluation of products or services they are interested in. Companies like Amazon.com have recognised this and built on it using a feedback system with customer comments. The company benefits from satisfied customers' comments to other members of the community. This gives customers the purchasing confidence and encourages return visits to the company. This feedback system works perfectly in a VC rather than in the offline world (Hagel and Armstrong, 1997).

Every new member of a VC increases the value of the community to both the new and existing members. The more members a virtual community has, the more attractive it will become to future members therefore creating a self-feeding cycle.

It is important to stress that the benefits of virtual communities are not related solely to financial transactions and commodities. They allow vital exchange of knowledge between experienced and inexperienced people that would otherwise be difficult to attain.

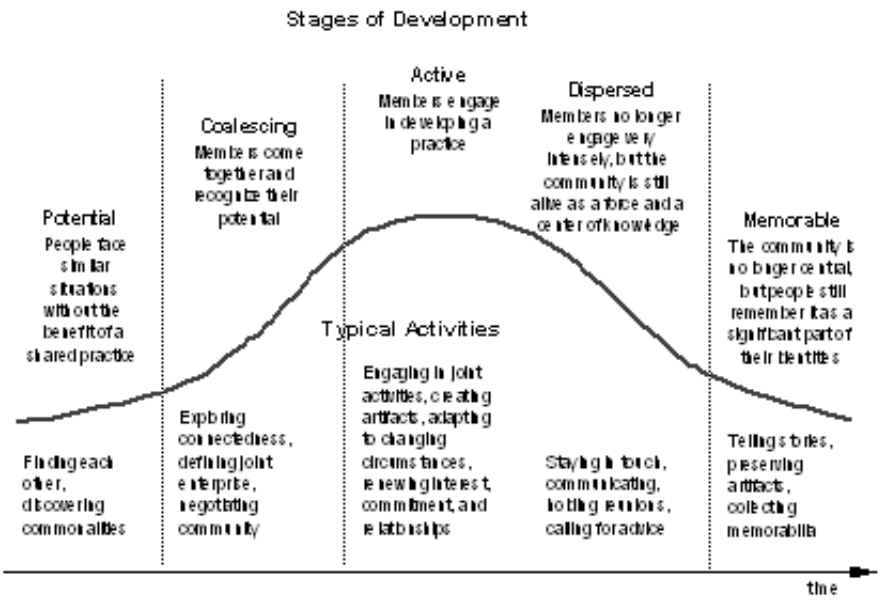
Benefits for Companies

Virtual communities' effectiveness at bringing companies and customers together enables small producers to have a national marketing capability for the price of an online advertisement. The customer feedback obtained from VCs is not only accurate and easy to obtain, it is extremely cost effective, with very little investment required. Companies could easily sponsor a VC in their area of business and converse with members in there to raise their awareness of their products (Hagel and Armstrong, 1997). These factors are all incredibly beneficial to Small to Medium Enterprises (SMEs) where it is vital that production mistakes are kept to a minimum.

Benefits for Individual Members

VCs create benefits for users at an individual level by enabling them to complete their job faster, more effectively, cheaper or even more enjoyably (Roberts, 2006). For example, an employee at a car manufacturer that works on the assembly line

Figure 1. Virtual communities development stages (Wenger,2005)



may have difficulty in one aspect of their job, but when they share this problem on the virtual community, other members can post suggestions to them for new ways of counteracting that problem.

CHALLENGES OF VIRTUAL COMMUNITIES

Despite the benefits there are numerous challenges that stand to impede the success of each virtual community. There is a critical short-term problem for all VC pioneers – the time it takes to establish the critical mass of members (Barnatt, 1998). It is unlikely that the virtual community will show anything but a financial loss in its early years, and attempts to raise short-term income from the new virtual community (such as subscription fees or the selling of members' information on to marketing organisations) are likely to fail.

Another challenge is that virtual communities have very low barriers for exit, meaning that it is difficult to keep that critical mass of members for long periods of time.

Hagel and Armstrong (1997) describe the threat that VC pose to larger organisations as the "piranha" effect. Just as piranhas reverse the principle that bigger fish eat the smaller fish, so too VCs become a threat to big corporations if they flourish in numbers. If more than a handful of these communities survive the first two or three years and are successful in wooing proportions of the customer base, they pose a long-term threat to larger organisations.

VCs will also not be eligible for every business application (particularly when the producer is also the distributor). For example, it is unlikely that many people will want to regularly visit a financial services virtual community. There is a challenge to this type of virtual community, as people are generally interested in each other (in areas such as gossip, news and sports), and not in the latest financial offerings or payment plans (Barnatt, 1998).

Maclaran and Catterall (2002) also raise the point that the discussion traffic on a VC is not evenly spread over 24 hours seven days a week. There may be long periods of inactivity followed by a surge of messages over a shorter time period. Different groups may also be active at different times, so there is a tendency for information overload.

Roberts (2006) highlights the fact that building VCs poses major challenges and risks to the organisers as well as the staff responsible for their design, launch and operation. The corporate landscape has become littered with VCs initiatives that failed to deliver tangible value. Poor preparation, unrealistic expectations and no clear sense of how the virtual community will support organisational goals are cited as reasons why virtual communities fail.

One of the greatest challenges is convincing both potential members and associated companies that participating in VCs is worthwhile. Hagel and Armstrong (1997) believe that the greatest challenge for management is converting traditional wasy of working to the innovative way that virtual communities operate. The company's business model changes from a "push" strategy (whereby companies push products or services onto potential customers) to a "pull" strategy whereby the newly empowered customers dictate the products stocked by the company. This shift in power (from companies to customers) is described as a "reverse market". Hagel and Armstrong (1997) also believe that failing to embrace VCs will result in a loss of opportunity and they will risk becoming squeezed by new players that understand this new phenomenon.

Technology can also be a challenge. Community technology is designed for communities, but is experienced by individual members (Wenger et al, 2005). Therefore, having to take into consideration so many users' needs, designing the appropriate technology is difficult. In fact this challenge is one of the reasons why large companies may avoid launching their own virtual community (Hagel and Armstrong, 1997).

Another issue is the return on investment is generally long term. Those who expect an immediate return on investment may become frustrated. Significant revenues are unlikely to be forthcoming until certain thresholds have been reached, and therefore, initial investments are generally made in an environment of uncertainty and risk. Revenue streams such as member fees are likely to slow the growth of membership substantially and other competing virtual communities may offer the same / similar service for free. Advertising and transaction commission is unlikely in the early years of the virtual community - companies are likely to wait until a critical mass of members has materialised (and usage profiles can be reviewed), which takes time (Hagel and Armstrong, 1997).

SUCCESS STRATEGIES FOR VIRTUAL COMMUNITIES

Despite these challenges, several strategies are proposed by academic researchers to maximise virtual community success. They are as follows.

1. Analyse User Needs

Successful VCs depend on accurate analysis of members needs. The community should be created according to its members' needs and not those of the company promoting it, their advertisers or any other group outside the community (Cothrel and Williams, 1999). The needs of the community members need to be constantly reviewed and refined to ensure that the community is fulfilling its purpose (Flavian and Guinaliu, 2005). Community organisers cannot assume that all their members have the same levels of commitment and therefore the same needs (Wenger et al, 2005). Roberts (2006) states that the following questions ensure the virtual community delivers its goals:

- Who are the intended users?
- How will they be introduced to your community?
- What is the "critical mass" required for the community to be cost-effective?
- How web-savvy is your intended audience?
- What do your intended users really think about the introduction of a virtual community? (Roberts, 2006)

Roberts (2006) cites the example of Mary Kay skin-care, who's IT department invested months of analysis of the company's sales force and back-office needs from every stakeholders' points of view before considering the solutions to meet those needs online. User surveys, industry newsletters and user discussions were all used to allow the organisation to explore what was important in their users' work lives.

Another idea is to review competitors' sites periodically in order to keep abreast of new developments as they occur (Hagel and Armstrong, 1997).

2. Get Members Involved and Strengthen Community Feeling

The key to becoming a successful community organiser over time is their ability to aggregate members, retain them and even encourages them to transact (Hagel and Armstrong, 1997). Flavian and Guinaliu (2005) suggest that the VC should be formed around individuals who are highly motivated and willing to participate in the group - creating a higher commitment to the community. Members should also be able to locate or be directed to relevant people and stored information (Case et al, 2000) therefore fostering a community spirit and so improving members' loyalty to the VC.

The VC which fails to provide immediate, tangible benefits, will fail to impress users. Successful VCs empower users with the ability to perform their current job more effectively (Roberts, 2006).

Hagel and Armstrong (1997) believe that aggregating members, as well as aggregating relevant resources are vital for success. From these, member profiles can be analysed enabling organisers to better understand the needs of their members.

3. Don't Control Members

Freedom to choose the topics of discussion will allow the community to grow freely as will leaving members to resolve their disputes wherever possible. (Flavian and Guinaliu, 2005). A moderator interfering will only result in limiting the amount of information discussed, and eventually drive members away.

Marketers need to create discussion boards and risk allowing members discussing freely not only the company's products but those of its competitors. The results can then be analysed objectively and result in increased trust (Hagel and Armstrong, 1997).

4. Use Suitable Technologies and User Interface

Hagel and Armstrong (1997) propose 4 key guidelines to create a successful technology strategy:

- Use proven technologies
- Use robust technology for information capture and analysis
- Avoid developing any technology in-house, and
- Use a modular technology architecture.

Flavian and Guinaliu (2005) suggest systems that can transmit complex messages (e.g. combining text with images and sounds), in a simple way similar to the way in which members interact offline. Members should be able to locate or be directed to relevant people and stored information with ease (Case et al, 2001). Members should also have access to all the information they require without feeling overwhelmed - the amount of communication and information flow should be intelligently regulated so that the burdens of membership do not outweigh its benefits.

Roberts (2006) suggests starting with a small functional system to deliver results and quickly create a critical following which can then be built upon. The more effective the VC becomes, the more it will impact on its members. Therefore, scale and capacity to perform at the promised level should be considered (Roberts, 2006).

In a community that depends on technologies for interaction, tending to the technology becomes an important role. Wenger et al (2005) state that organisers must keep abreast of the latest technologies - they must then decide which new technologies would apply to the evolving needs of their members.

5. Assign Roles

As described earlier, different roles within the community allow for an increased level of dynamism (Flavian and Guinaliu, 2005). The roles allow the members to concentrate solely on their area, thus promoting a high level of focus within the community.

6. Community maturity

Management of the virtual community is essential. Timely, accurate and relevant content will attract users and make them return (Roberts, 2006). Interesting, provocative material is vital to maintain the conversations. Successful virtual communities require regular monitoring for problems and modifying for the evolving needs of their members (Snyder, 2000). Even the most successful virtual communities are works-in-progress, and user feedback should be used to redesign the web interface (Roberts, 2006).

CONCLUSIONS

This paper has demonstrated that although there are many benefits to adopting virtual communities, there are also several challenges involved that may deter potential community managers from VC implementations. Getting the critical mass of members remains the biggest challenge, due to the low barriers for exit that virtual communities operate within. Without this critical mass, it is difficult to attract members and investment for the community. Other challenges include selecting the correct technology, ensuring continual participation from members, convincing business managers that virtual communities are worthwhile and the fact that virtual communities are not applicable to every type of business application.

The challenges can be overcome, however, by using the success strategies mentioned in this paper. Analysing user's needs (both before development and throughout the lifetime of the virtual community) is a must if the virtual community is to deliver value to the end-user. Encouraging participation, selecting appropriate technologies, allowing members to contribute freely, and assigning roles to community members all aid in making the virtual community a success.

A future research area would be to measure the challenges (and their respective impacts) for each type of virtual community and also classify the importance of each of the success strategies for each type.

REFERENCES

Barnatt, C., (1998), "Virtual Communities and Financial Services – On-line Business Potentials and Strategic Choice", International Journal of Bank Marketing, Vol. 16, No. 4, p. 161-169

Case, S., Azarmi, N., Thint, M. and Ohtani, T., (2001), "Enhancing E-Communities with Agent-Based Systems", Computer, Vol. 34, No. 7, p. 64-69

Constant, D., Kiesler, S. B. & Sproull, L. S., "The Kindness of Strangers: The usefulness of electronic weak ties for technical advice", Organization Science, (1996), vol. 7, no. 2, pp. 119–135.

Flavian, C. and Guinaliu, M., (2005), "The influence of virtual communities on distribution strategies in the internet", *International Journal of Retail & Distribution Management*, Vol. 33, No. 6, p. 405-425

Hagel, J. and Armstrong, A., (1997), "Net Gain: Expanding Markets Through Virtual Communities", Harvard Business School Press, Massachusetts

Jones, S. G. (ed.), (1995), "CyberSociety: Computer-Mediated Communication and Community", Sage, Thousand Oaks, CA

Kendall, L., (2002), "Hanging Out in the Virtual Pub: Masculinities and Relationships Online", Berkeley, University of California Press

Kippenberger, T., (2000), "The Phenomenon of Virtual Communities", Strategy and Leadership, Vol. 5, No. 1, p. 22-25

Lesser, E. L., and Storck, J., (2001), "Communities of Practice and Organisational Performance", IBM Systems Journal, Vol. 40, No. 4.

Maclaran, P. and Catterall, M., (2002), "Researching the Social Web: Marketing Information from Virtual Communities", Marketing Intelligence and Planning, Vol. 20, No. 6, p. 319-326

Rheingold, H., (1993), "The Virtual Community: Homesteading on the Electronic Frontier", Addison-Wesley, Reading, MA,

Rheingold, H., "SmartMobs: The Next Social Revolution", Perseus Books, New York, (2003)

Roberts, P., "Creating E-Communities", (2006), http://www.unisys.com/products/es7000__servers/insights/articles/articles.htm?insightsID=48400

Romm, C., Pliskin, N. and Clarke, R., (1997), "Virtual communities and society: toward an integrative three-phase model", International Journal of Information Management, Vol. 17 No. 4, pp. 261-70.

Sands, M., (2003), "Integrating the Web and e-mail into a push-pull strategy", Qualitative Market Research: An International Journal, Vol. 6, No. 1, p. 27-37

Snyder, J., (2000), "E-Community Platform Ups Site Stickiness", InfoWorld, Vol. 22, Iss. 24, p. 78

Snyder, W., Wenger, E. and de Sousa Briggs, X., (2004), "Communities of Practice in Government: Leveraging Knowledge for Performance", http://www.ewenger.com/pub/index.htm

Wellman, B., Salaff, J., Dimitrova, D., Garton, L., Gulia, M. & Haythornthwaite, C., (1996), "Computer networks as social networks: collaborative work, telework & virtual community", Annual Review of Sociology, vol. 22, pp. 213–238

Wenger, E., "Communities of Practice: Learning as a Social System", The Systems Thinker, (1998), Vol. 9, No. 5, available at http://www.ewenger.com/pub/pub_systems_thinker_wrd.doc

Wenger, E., (2004), "Knowledge Management as a Doughnut: Shaping your Knowledge Strategy through Communities of Practice", Ivey Business Journal, http://www.iveybusinessjournal.com/article.asp?intArticle_ID=465

Wenger, E., White, N., Smith, J. and Rowe, K., (2005), "Technology For Communities", http://www.ewenger.com/pub/index.htm

The Web Service-Based Combination of Data and Logic Integration in Federated ERP Systems

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ABSTRACT

ERP systems become more complex and financial expenditures that are connected to the application of such systems increase. ERP systems consist of many software components which provide specific functionality. However, these ERP systems are designed as an all-in-one solution, often implementing functionality not needed. The paper presents the reference architecture of a federated ERP system which allows the distribution of ERP system components on the basis of Web Services. This architecture draws upon a hierarchical standardization model of data and service types. The model advances the reusability of data types and reduces the necessity of data transformation functions in business process descriptions.

Keywords: ERP, FERP, Web Services, Web Service Standardization, WSDL, SOA

1. INTRODUCTION AND MOTIVATION

An *ERP system* is a standard software system which provides functionality to integrate and automate the business practices associated with the operations or production aspects of a company. The integration is based on a common data model for all system components and extents to more than one enterprise sectors [1, 2, 3, 5].

Modern ERP systems consist of many software components which are related to each other. Currently these components are administered on a central application server. In connection to the ERP system complexity several problems appear:

- Not all installed components are needed.
- High-end computer hardware is required.
- Customizing is expensive.

Due to the expensive proceedings of installation and maintenance only large enterprises can afford such complex ERP systems. One solution to face these problems is to develop a distributed ERP system where the system components are reachable over a network (e.g. internet). This component ensemble (federated system) still appears as single ERP system to the user, however it consists of different independent elements which exist on different computers. Based on this construction it is possible for an enterprise to access on-demand functionality (components) as services[1] of other network members over a P2P network. This approach solves the mentioned problems as follows:

- Due to the separation of local and remote functions, no local resources are wasted for unnecessary components.
- Single components are executable on small computers.
- Due to decreasing complexity of the local system also installation and maintenance costs subside.

A *federated ERP system* (FERP system) is an ERP system which consists of system components that are distributed within a computer network. The overall functionality is provided by an ensemble of allied network nodes that all together appear as a single ERP system to the user. Different ERP system components can be developed by different vendors [1, 4].

Figure 1. Architecture of a conventional ERP system

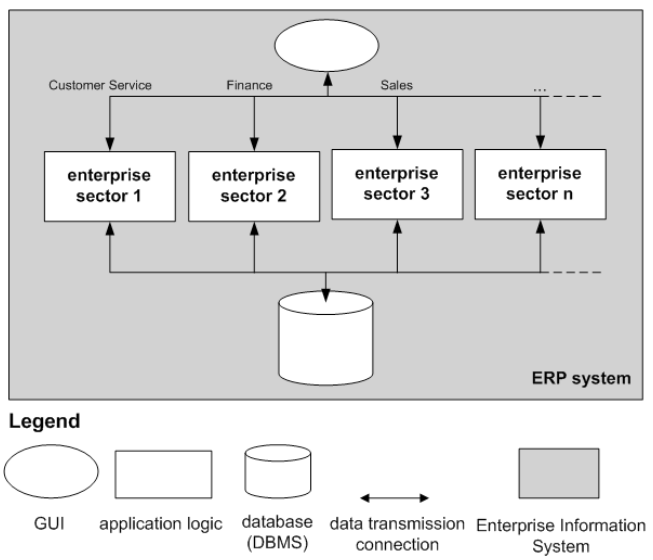
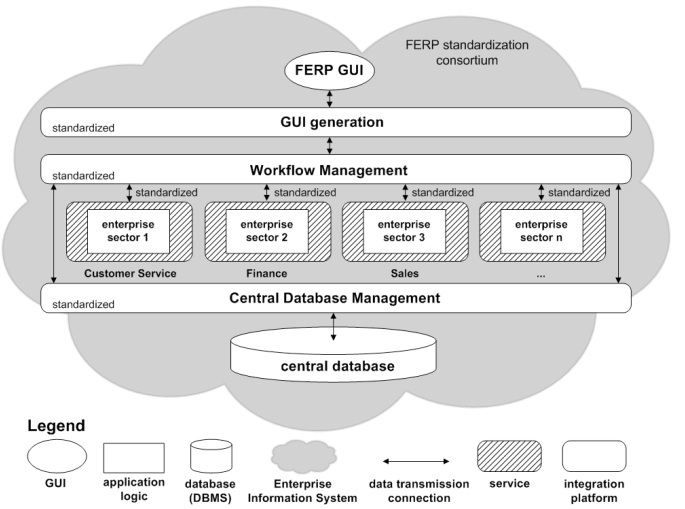


Figure 2. Vision of a Federated ERP system



In this paper we present an FERP system based on Web Services. The main idea follows the multi-layer paradigm of modern information systems which aims at the separation of the application logic from the presentation layer and the database layer. In our approach the application logic of ERP systems is encapsulated in a multiplicity of Web Services which can be provided either locally or remotely. The vision of this approach is to allow the application of business logic components in a distributed manner. In order to facilitate a vendor-independent development and provision of those components the approach considers the standardization of Web Services as well as GUI descriptions and database interactions. The standardization process is supposed to be advanced by a consortium of ERP vendors, utilizing enterprises and scientific institutions (*FERP standardization consortium*). Figure 2 shows the abstract architecture of the presented approach.

2. REFERENCE ARCHITECTURE

Figure 3 gives a survey of the reference architecture of a Web Service-based FERP system. The architecture consists of several subsystems which are interconnected. Because one of the main objective of an FERP system is to integrate business components of different vendors, all components have to comply with standards. In this approach these standards are described as XML schema documents. In order to separate the three different layers of a typical layered architecture of conventional ERP systems each layer is assigned to its own standard.

The subsystems of the proposed architecture are the following:

FERP Workflow System (FWfS)
The FWfS coordinates all business processes which have to be described in an appropriate XML-based workflow language. A workflow in this context is a plan of sequentially or in parallel chained functions as working steps in the meaning of activities which lead to the creation or utilization of business benefits. Workflows implicitly contain the business logic of the overall system. The function types a workflow in FERP systems can consist are the following:

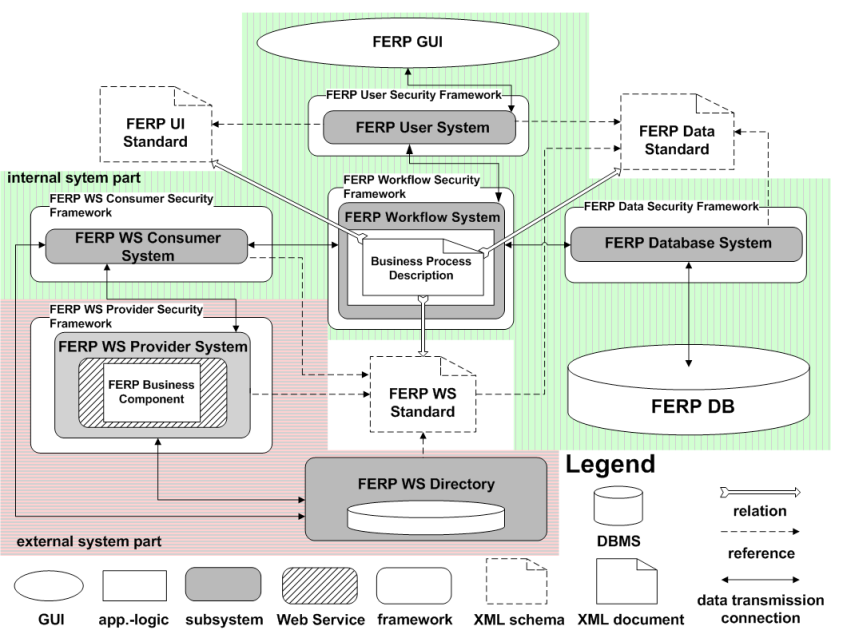
- model based user interface functions, e.g. show, edit, select, control
- database access functions, e.g. read, update
- application tasks which are connected to Web Service calls

FERP User System (FUS)
The FUS is the subsystem which implements functions for the visualization of graphical elements and coordinates interactions with end users. This subsystem is able to generate user screens at runtime. Screen descriptions which have to comply with the *FERP UI standard* are transformed to an end device-readable format, e.g. HTML in case of web browsers.

FERP Database System (FDS)
The FDS is the subsystem which implements functions for the communication with the FERP database. This subsystem is able to interpret XML structures which comply with the *FERP data standard*. The interface differentiates between two kinds of requests. Database update requests contain object oriented representations of business entities as XML trees. Database read requests contain X-Path or X-Query expressions specifying portions of data to be extracted. In both cases the request parameters have to be transformed into different types of request statements that vary depending on the type of database management system (DBMS) which is used. Assumed that a relational DBMS (RDBMS) is used the underlying data model also has to comply with the FERP data standard which means that the corresponding table structure has to reflect the XML-Schema specifications respectively. The java.net project *hyperjaxb2*[2] provides a solution to generate SQL statements on the basis of XML schema definitions. Another solution is the application of native XML databases or XML-enabled RDBMS.

FERP Web Service Consumer System (FWCS)
The business logic of FERP systems is encapsulated in so called FERP business components which are wrapped by a Web Service. The FWCS is the subsystem which provides functions for the invocation of Web Services. All possible types of FERP Web Services are specified by the *FERP WS standard*. This standard contains XML schema definitions which describe Web Service operations as well as input and output messages. A Web Service references these types in its description which is expressed in the Web Service Description Language (WSDL) which is the common standard for the description of Web Services and is already well supported by tools. Furthermore this subsystem is able to search for Web Services which are defined by a unique identifier. By this it is possible that different Web Service providers implement the same business component type as Web Service. Beside the implementation of Web Service invocation and search functions this subsystem is responsible for the interpretation and consideration of non-functional parameters. Examples for those parameters are: security policies, payment polices or Quality of Service (QoS) requirements on the part of Web Service consumers.

Figure 3. Reference architecture of an FERP system



FERP Web Service Provider System (FWPS)
The FWPS is the subsystem which implements functions for the provision of Web Services which comply with the FERP WS Standard. The subsystem includes a Web Server which is responsible for the interpretation of incoming and outgoing HTTP requests which in turn encapsulate SOAP requests. The subsystem provides business components of the FERP system as Web Services. A connection to the *FERP Web Service Directory* allows the publication of Web Services. Furthermore this subsystem is responsible for the negotiation of common communication policies such as e.g. security protocols or usage fees with the requesting client.

FERP Web Service Directory (FWD)
The FWD provides an interface for the publication and the searching of FERP Web Services based on the UDDI standard. The structure of this registry leans on the FERP WS standard. In this standard Web Services are assigned to categories mirroring the predetermined functional organization of enterprises.

3. HIERARCHICAL XML SCHEMA STRUCTURE

The proposed architecture is dependent on the specification of different standards. The next two paragraphs focus on the standardization of FERP data types and Web Service operations in the context of FERP systems. Because of the complexity of enterprise data models and the difficulty to standardize a completed data model we propose a hierarchical standardization model which allows different abstraction levels. This model uses XML namespaces for the representation of hierarchical levels and XML schema documents for the definition of data types and their relationships. The reason for the usage of XML schema documents is

Figure 4. Extract of the hierarchical Easy Access® menu of an SAP/R3® system[3]

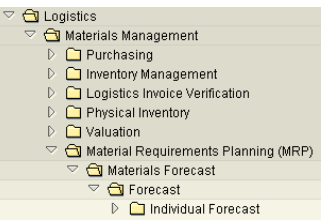
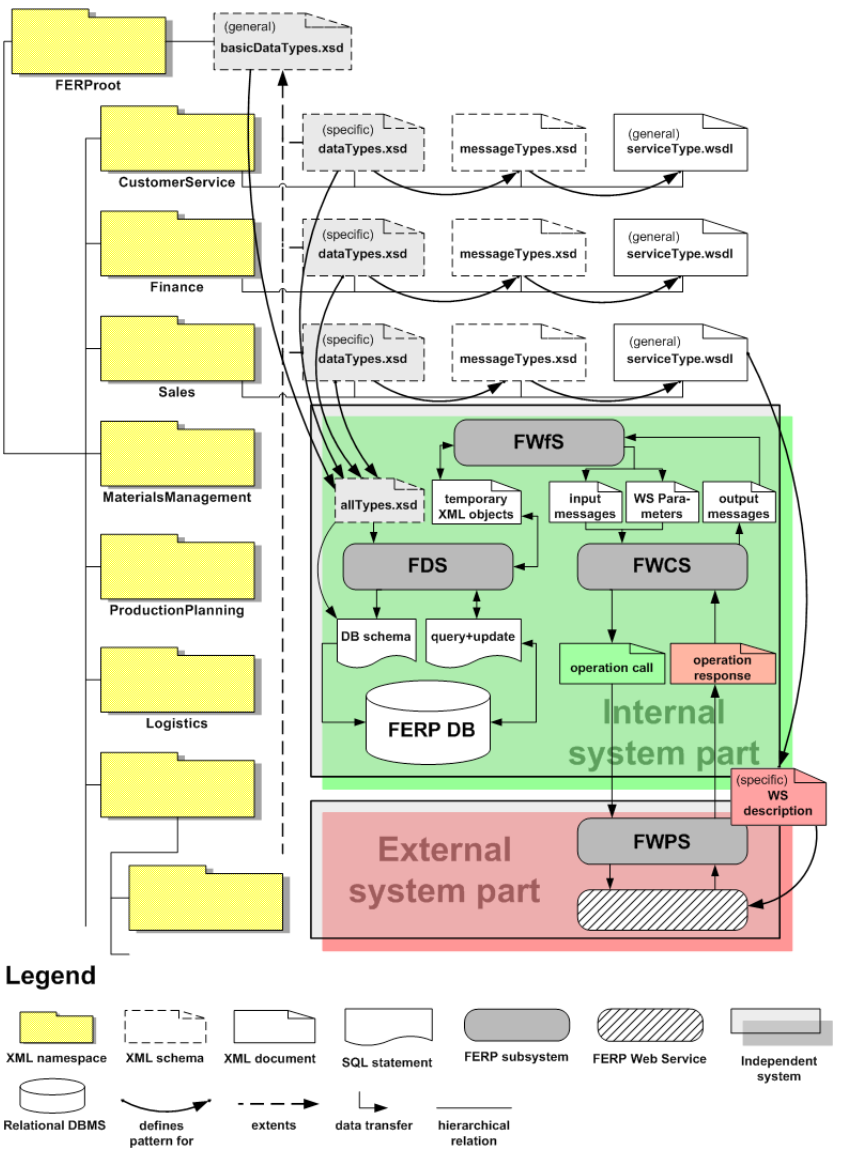


Figure 5. Hierarchical XML schema structure of an FERP system



their compatibility with WSDL. The interoperability between FERP Web Services and the FDS is achieved by a transformation of XML schema-based data model descriptions to SQL-based data model descriptions. Web Service Descriptions in WSDL reference the FERP data standard by including the appropriate XML schema documents of the standard. In order to standardize the input and output messages of FERP Web Services we propose the usage of XML schema documents as well.

Figure 5 shows the hierarchical XML schema structure of an FERP system and shows the influence on the systems activities. The left hand side represents different enterprise sectors which are assigned to XML namespaces. This hierarchy can be compared to the internal structure of the application logic of conventional ERP systems which is often mirrored to the navigation structure of their GUI. Figure 4 shows the function hierarchy of the Easy Access® menu of an SAP®/ R3® system.

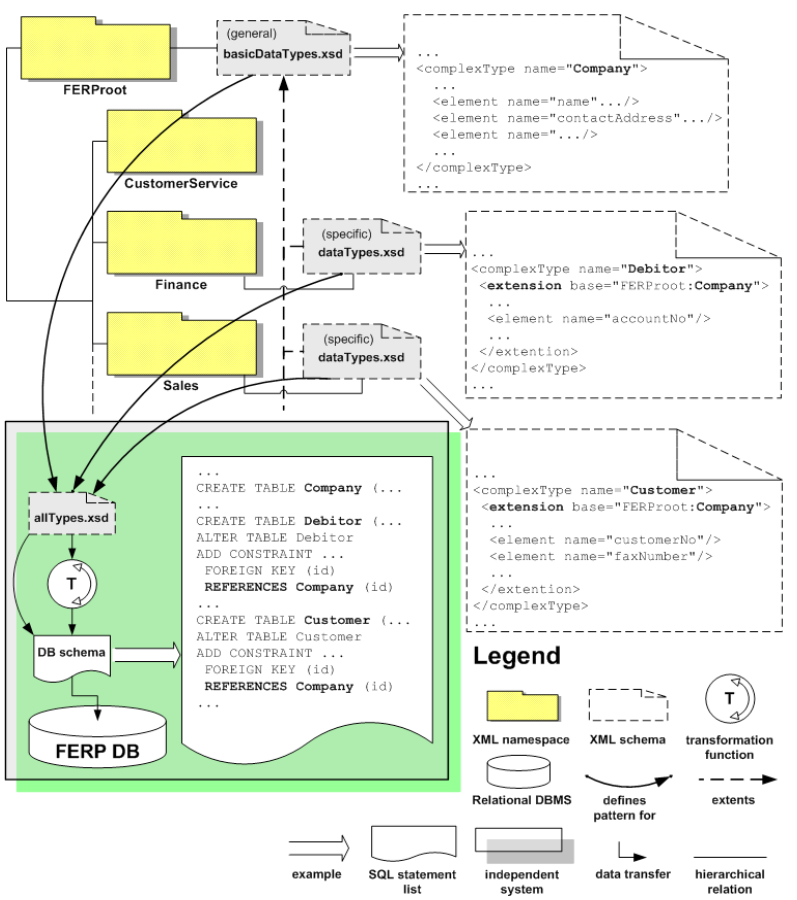
The upper half of figure 5 shows the relationships between XML schema documents and concrete Web Service descriptions. Standardized Web Service input and output messages (defined in *messageTypes.xsd*) build the basis for the standardization of Web Service types (described in *serviceTypes.wsdl*). The lower half of figure 5 shows the interactions between the different subsystems of the FERP system. The system internally creates a new XML schema document (*allTypes.xsd*) which includes a copy of all standardized data types that are used in process definitions. The system has a connection to the server of the FERP standardization consortium and will be notified in the case that the standard changed. Those changes are only allowed in terms of extensions. Thereby old versions will be supported during the whole lifetime of the standard. The hierarchical structure provides a useful foundation for this requirement because it is already field-proved in the context of object oriented programming paradigms like polymorphism, generalization and specialization. The local XML schema representation will be transformed to a relational representation of the data model as SQL statement list (see the example in figure 5 in the next paragraph). In addition to the schema transformation the FDS is able to transform SQL result sets to XML documents that comply with the FERP data standard in the case of *DATABASE_LOAD requests*. On the other hand XML documents will be transformed to SQL INSERT or UPDATE statements in the case of *DATABASE_STORE requests*. Both LOAD and STORE functions are provided by the FDS and can be used by the FWfS.

Web Service calls are initiated by the FWfS as well (see figure 5). Therefore the FWfS sends a standardized XML representation of the appropriate input message to the FWCS. A second XML document contains configuration parameters which specify the concrete Web Service provider to be chosen by the FWCS. Those parameters include either a URL for a static Web Service call or requirements for a dynamic call like e.g. a maximum price. An alternative way for the specification of requirements for dynamic calls is a centralized mapping between Web Service types and requirements. Once the FWCS chose an appropriate Web Service provider it will repack this message to a *SOAP operation request* which includes the standardized name of the Web Service operation to be invoked. This request will be sent to the FWPS. After having finished the processing of the business logic the FWPS will return a SOAP operation response which includes a standardized response message. Figure 5 shows how this response message is going to be sent back to the FWfS that primarily initiated the Web Service call.

4. DATA INTEGRATION OF DIFFERENT ENTERPRISE SECTORS

One of the main reasons why ERP systems have been achieving success in the past is their data-driven view towards the integration of different enterprise sectors. As defined above "*this integration is based on a common data model for all system*

Figure 6. Example for the hierarchical enterprise data integration



components and extents to more than one enterprise sectors" (see paragraph 1). The presented architecture of a Web Service-based FERP system reaches this integration by the hierarchical XML schema structure which is mirrored to the relational data model. Figure 6 shows an example for this hierarchical XML schema structure. In this example the general type *Company* has two specialized representations, *Debitor* and *Customer* which define additional elements. These elements can be seen as individual properties of the assigned enterprise sector. Because the FERP DB uses separate database tables for the management of these records, updates will also influence related enterprise sectors which share the same table for all general elements. We tested this functionality by the application of the *hyperjaxb2*[4] framework which draws upon *JAXB*[5] and *Hibernate*[6].

5. RELATED WORKS

The intra-enterprise integration of business application systems is commonly abbreviated as EAI[7]. According to the 3-tier architecture of business application systems today's EAI platforms support the integration over all three tiers. Enterprise portals mainly provide a basis of the consolidation of existing software systems on the user interface level which means that portals feature a user-centric orientation [8]. The Web Services paradigm implements a Service-oriented architecture which presupposes a middleware for the management of services. Search and publication requests are processed by this middleware. Business Process Management (BPM) platforms support the orchestration of such services. Thus it is possible to centralize Web Service accesses in business process definitions. In some cases EAI platforms support both a portal functionality and a BPM platform in combination with each other.

Disadvantages of domain-independent BPM platforms as foundation for the implementation of Web Service-based ERP systems are the following:

- XML object representations have to be transformed to different data models (XML schemas) when independent Web Services are used in one process because in most cases no common standard[8] is referenced in independent Web Service descriptions.
- XML object representations of Web Service return values have to be transformed to SQL statements[9] in the case that return values have to be stored in an external database. This transformation has to be part of the business process definition. Because of this problem Web Services often are assigned to their own database which is directly accessed by the business logic of a Web Service. The problem of this solution is that Web Services cannot be exchanged if they are provided externally[10] because the connected database will be not available anymore. Another problem is that such a solution would not comply with the definition of an ERP system (see paragraph 1) where the integration of different enterprise sectors is achieved by the usage of a common data model. Therefore conventional ERP systems use a central DBMS whereby also the management of database transactions is simplified.
- Input values for Web Services which have been extracted from the enterprise database have to be transformed from a database result set representation to an XML object representation which complies with the respective Web Service description.

The presented approach of a Web Service-based FERP system offers the following advantages that all together address actual challenges of business process modelling approaches[11]:

- Output values of Web Services can be directly used as input values for other Web Services because all Web Service definitions reference the same standard.
- Output values of Web Services can be transmitted to the FDS directly because both implement the same data model.
- XML object representations which have been extracted from the FDS can be used straightforward as input values of Web Services because both, the data model of the FDS and the parameter description of each Web Service comply with the same standard.

Another neighbouring working area is represented by Federated Database Systems [9] which are a type of Meta-DBMS. Those systems integrate multiple autonomous DBMS to a single system. This integration is achieved by schema mapping techniques. One solution for the data integration in Web Service-based ERP systems could be the utilization of a Federated Database System in order to consolidate independent DBMS which are directly assigned to Web Services. The Federated Database System would represent a central entry point to a decentralized DBMS structure which in turn would comply with the definition of an ERP system. This solution has the following disadvantages in comparison to the presented approach:

- Enterprises are dependent to Web Service providers who also provide one part of the database federation. In the case that different providers offer the same Web Service type a migration from one provider to another implicitly necessitates data migration.
- A global schema[12] indeed can define a normalized data model but redundancies in the overall network of independent DBMS are possible anyway. Because Web Services would directly access their local DBMS duplicate entries in the DBMS federation could lead to complications when a process or another Web Service accesses the central Federated Database System.

In comparison this approach, an FERP-system has the following advantages:

- A migration from one Web Service provider to another does not influence the data view because all data is stored in a central database which can only be accessed by a local[13] process. Web Services have no direct database connection.
- Because the hierarchical FERP standard considers the combination of Web Services' duties and affected data each level in the hierarchy is assigned to unique operation and data types. Furthermore the inheritance support allows a reutilization of general data types. Thereby redundancies in the database can be avoided because on the one hand existing data type definitions can be reused for new Web Service definitions and on the other hand standardized Web Services which use existing data types will create redundancy-free[14] data.

6. CONCLUSIONS AND OUTLOOK

Comparing distributed ERP systems and ERP systems running on only one computer, the distributed systems offer a lot of advantages. Particularly small- and medium sized Enterprises (SMB) benefit from using shared resources. However, the design of distributed system architectures is subject to a number of problems. The paper addresses the problem of redundant data in business application systems of independent vendors presents a basis for the standardization of ERP system components that are provided as Web Services. A standardized data model builds the basis for message and service standardization. The hierarchical structure of the presented standard advances the reuse of existing data types. Furthermore we presented a reference architecture of FERP systems which reduces the necessity of data transformation functions in business process descriptions.

The standardization of the syntactic level is only the first step. Behaviour, synchronization and quality of Web Services must flow into the definition of an overall ERP system standard. The future work must pick up these problems to realize the vision of a loosely coupled ERP system which allows the dynamic outsourcing of applications [5, 7] and the combination of software components of different providers.

ACKNOWLEDGMENTS

This paper has drawn upon opinions and views of many colleagues. In particular we acknowledge the review of Lars Gersmann who defined his practical position as an experienced software engineer and highlighted practical advantages of our approach which even influenced the title of this paper. Furthermore we thank Inty Saez for his review which gave us more ideas for the prototypical implementation of the presented reference architecture which is still in progress. Last but not least, also a special thanks in this order to the students of the University of Oldenburg who jointly performed lots of test implementations which delivered the foundation for many architectural design decisions. At the moment we are testing YAWL[15] as basis for the prototypical implementation of an FWfS.

REFERENCES

1. ABELS, S., BREHM, N., HAHN, A. & MARX GÓMEZ, J. (2006) Change management issues in federated ERP-systems – An approach for identifying requirements and possible solutions. *International Journal of Information Systems and Change Management (IJISCM),* 1, 318-335.

2. BREHM, N. & MARX GÓMEZ, J. (2005) Secure Web Service-based resource sharing in ERP networks. *International Journal on Information Privacy and Security (JIPS),* 1, 29-48.
3. BREHM, N. & MARX GÓMEZ, J. (2005) Standardization approach for Federated ERP systems based on Web Services. *1st International Workshop on Engineering Service Compositions.* Amsterdam.
4. BREHM, N. & MARX GÓMEZ, J. (2007) Federated ERP-Systems on the basis of Web Services and P2P networks. *International Journal of Information Technology and Management (IJITM)*.
5. BREHM, N., MARX GÓMEZ, J. & RAUTENSTRAUCH, C. (2005) An ERP solution based on web services and peer-to-peer networks for small and medium enterprises. *International Journal of Information Systems and Change Management (IJISCM),* 1, 99-111.
6. CUOMO, G. (2005) IBM SOA "on the Edge". *ACM SIGMOD international-conference on Management of data.* Baltimore, Maryland, ACM Press.
7. DAN, A., DAVIS, D., KEARNEY, R., KELLER, A., KING, R., KUEBLER, D., LUDWIG, H., POLAN, M., SPEITZER, M. & YOUSSEF, A. (2004) Web services on demand: WSLA-driven automated management. *IBM SYSTEMS JOURNAL,* 43, 136-158.
8. SHETH, A. P. & LARSON, J. A. (1990) Federated database systems for managing distributed, heterogeneous, and autonomous databases. ACM Computing Surveys (CSUR), 22, 183 - 236.
9. SMITH, M. A. & (2004) Portals: toward an application framework for interoperability. Communications of the ACM, 47, 93 - 97.
10. VERNER, L. (2004) BPM: The Promise and the Challenge. *QUEUE (ACM Press),* **2,** 82-91.

ENDNOTES

[1] In this term, a service is a software component that encapsulates one or more functions, has a well defined interface that includes a set of messages that the service receives and sends, and a set of named operations [6].

[2] Hyperjaxb2 – relational persistence for JAXB objects: https://hyperjaxb2.dev.java.net/ (last visit October 2006)

[3] Easy Access® and SAP/R3® are trademarks or registered trademarks of SAP AG

[4] We tested the inheritance support of *hyperjaxb2* in version 0.4.

[5] Java Architecture for XML Binding (JAXB): http://java.sun.com/webservices/jaxb/ (last visit: October 2006)

[6] Hibernate, Relational Persistence for Java and .NET: http://www.hibernate.org/ (last visit: October 2006)

[7] Enterprise Application Integration (EAI)

[8] No common standard means that the BPM platform is domain-independent and transformations have to be included in the process definition.

[9] In case of using an RDBMS

[10] Externally means that Web Services can be provided outside the enterprise's intranet by independent software vendors.

[11] Currently business processes include both abstract business logic and technical constructs in an unstructured manner which complicates traceability [10].

[12] In the Local as View (LaV) mapping direction the local schemas of independent DBMS are defined in terms of the global schema. In the Global as View (GaV) mapping direction the global schema is defined in terms of the underlying schemas.

[13] Local in this context means that the FWfS is directly connected to the central database.

[14] New Objects update old objects of the same type and the same identity because a central DBMS is used.

[15] Yet Another Workflow Language (YAWL): http://sourceforge.net/projects/yawl/ (last visit: October 2006), YAWL was released under the GNU Library or Lesser General Public License (LGPL)

Study on Factors Underlying Students' Ethical Decision Making in Music File Sharing

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ABSTRACT

Business ethics is at a high stake in view of a rash of recent unethical business scandals. Business schools are defensive in a barrage of blames for not teaching business ethics effectively to their students. The college of business at SHU is particularly sensitive to this issue since it has been proud of its Catholic intellectual tradition and has been doing its best to comply the requirements by AACSB for the accreditation. This study will help us to understand factors underlying in our business students' ethical decision making and to address those factors effectively in the business curriculum so that they will behave more ethically by respecting others' intellectual properties. One limitation of this study is that we measure our students' ethical behavior based on only one matter, music file sharing.

INTRODUCTION

Concerns on business ethics are raised very high nowadays in a wake of a series of recent business scandals caused by high-profile executives in well known companies such as Enron, Anderson, Tyco, ImClone, Boeing. Some of those misconducts are often attributed to the excessive compensation structure with stock options that tempts top executives to manipulate business results for option holders' short-term interests at the cost of everyone else. Desire for high achievements in today's hyper-competitive business environment may also pressure profit-obsessed top managers to make unethical decisions to maximize economic benefits. As a way of remedy, there are various discussions on corporate-governance reforms (Hannafey, 2003; Tipgos, 2002; Watkins, 2003). For instance, top executives' compensation may be linked to a company's long-term achievements to alleviate the pressure for short-term profits. New York Stock Exchange would require companies to have a majority of independent directors as a better way to supervise top executives. Certainly, those governance reforms may help thwart some fraudulent conducts. However, many of misconducts are rooted in the socio-cultural and behavioral factors such as greedy personality, lapse of business ethics, unhealthy organizational culture.

Can managers learn how to behave ethically? If possible, who can teach them? For decades, business schools have taught business ethics in various ways to their students. Also, accreditation bodies like the Association to Advance Collegiate Schools of Business (AACSB) require an ethical component in their curricula. However, recent ethical lapses in business circles put business schools under close scrutiny. Media put blames on lax ethics education in business schools that are busy teaching core and tangible materials (Etzioni, 2002; Merritt, 2003; Wall Street Journal, 12/30/2003). There are several researchers who studied business students' perception of ethics. Elm, et al (2001) claims that "business students have lower moral reasoning levels than students in other fields." Angelidis and Ibrahim (2002) reported that there was no significant difference between business students at secular and non-secular uniervities. Richards, et al (2002) urges business schools to assess ethics education needs in their own MBA programs, particularly if they have not added significant ethical content to their curricula. Sankaran and Bui (2003) measured ethical attitude among accounting majors and compared with other business majors and non-business majors. While reviewing the trends in ethics education, Farnsworth and Kleiner (2003) assert "Ethics should be a required course in US colleges and universities because the study can initiate the process to address these challenges." Procario-Foley and McLaughlin (2003) and Stablein (2003) agreed that business students should be more exposed to ethics in their business education.

ETHICS EDUCATION

In 2003, the college of business at the Sacred Heart University (SHU) its core curriculum for undergraduate students to properly address the AACSB guidelines as part of its self-study for the long-awaited accreditation. One of the focal issues was whether a business ethics course should be required as a core course for all business undergraduate students like the MBA curriculum. A majority of the undergraduate curriculum committee members voted not to do, but to ask instructors to teach the concept of business ethics in their courses since each disciplinary area such as accounting, marketing, finance, human resource management, sport management may better address its own ethical decision making cases. However, the faculty voted to require a business ethics course for all business students when the dean insisted to do as a way to show the college's strong commitment to ethics particularly in compliance with the SHU's Catholic intellectual tradition, which is reflected in the college's newly drafted mission statement, as follows:

"Our values are within the Catholic intellectual tradition: …We stress ethical decision making … We strive to develop professionals who will act ethically, morally, and responsibly." (Mission Draft, 2004, p. 1).

Learning business ethics is one thing and doing ethical decision making is another thing. The lingering question is how positively a business ethics course affects a business student's ethical decision making. As a way to answer this question, we decide to see any difference in business students' ethical decision making before and after taking a business ethics course. Rather than developing some ethical decision making scenarios, we pick a real issue, music file sharing, which many college students have been participating in though they know that it's illegal and unethical. It is reported that at least two SHU students have been named for inclusion in an RIAA (Recording Industry Association of America) lawsuit brought against computer users who download and share copyrighted materials. If students knowingly participate in this kind of unethical behavior, how can we expect them to respect intellectual properties when they become managers later? We want to know what excuses they have so that we can better address those in our business ethics education.

Business ethics is at a high stake in view of a rash of recent unethical business scandals. Business schools are defensive in a barrage of blames for not teaching business ethics effectively to their students. The college of business at SHU is particularly sensitive to this issue since it has been proud of its Catholic intellectual tradition and has been doing its best to comply the requirements by AACSB for the accreditation. This study will help us to understand factors underlying in our business students' ethical decision making and to address those factors effectively in the business curriculum so that they will behave more ethically by respecting others' intellectual properties. One limitation of this study is that we measure our students' ethical behavior based on only one matter, music file sharing.

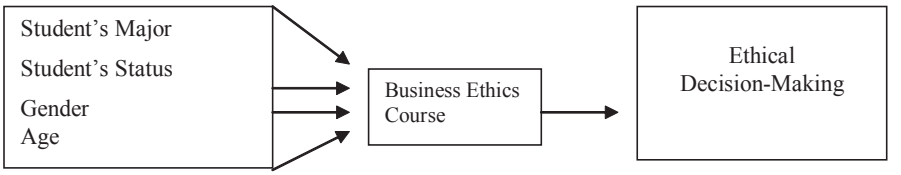
RESEARCH METHOD

The conceptual framework of the study is shown in Figure 1.

There are five research questions, as follows:

- Research Question 1: Ethical decision making of business students becomes different after taking a business ethics course.

Figure 1



- Research Question 2: Ethical decision making of business students is different by major.
- Research Question 3: Ethical decision making of MBA students is different from that of business undergraduate students.
- Research Question 4: Ethical decision making of female students is different from that of male students.
- Research Question 5: Ethical decision making of old students is different from that of young students.

To find answers to those questions, we developed a questionnaire as shown in the appendix 1. The section 1 is to collect demographic data and the section 2 is for a respondent's perception on the issue. In the section 3, we listed two questions for each of the six ethical principles explained in an MIS textbook: (1) The Golden Rule, (2) Immanuel Kant's Categorical Imperative, (3) Descartes' rule of change, (4) Utilitarian Principle, (5) Risk Aversion Principle and (6) Ethical "no free lunch" rule (Laudon & Laudon). Data has been collected form SHU students who are business school undergraduates and MBA students. Computer science major students are included in order to compare the effect of their major (business management vs. computer science). Since the registering of the survey is included by selection rather than by manipulation, it is not an experimental research design. Therefore no causal relationships can be inferred. Instead, descriptive statistical analysis will be reported. According to the research questions 1 through 5, there are four independent variables in the study: students' major, status (undergraduate vs. graduate), gender and age.

Reliability is defined in practice in terms of internal consistency of the responses from the participants. Internal consistency is the extent to which the individual items in the questionnaire correlate with one another or with the instrument as a whole. To demonstrate the reliability of the instrument, Cronbach's alpha will be calculated. Construct validity of the questionnaire will be demonstrated by factor analysis. For the research question 1 through 4, Chi Square test of Independence will be performed based on data for section 2 in the survey, and t-test based on data for the section 3. Qualitative data for the section 4 in the survey will be gathered and analyzed. For the research question 5, One-way Analysis of Variance (ANOVA) — treating the dichotomous criterion variable (yes or no) as dummy variable — will be performed based on data for the section 2 in the survey. One-way ANOVA with one-between groups design will be performed based on data for the section 3.

DATA ANALYSIS AND DISCUSSION

(Will be done later)

SUMMARY AND RECOMMENDATIONS

(Will be done later)

REFERENCES

Angelidis, J.P. and Ibrahim, N.A. (2002). Practical Implications of Educational Background on Future Corporate Exceutives' Social Responsibility Orientation. Teaching Business Ethics. 6(1). 117-

Etzioni, A. (Aug 4, 2002). When It Comes to Ethics, B-Schools Get an F. The Washington Post. B.04

Farnsworth, J.R., and Kleiner, B.H. (2003). Trends in ethics education at U.S. colleges and universities. Management Research News. 26(2-4). 130-

Hannafey, F.T. (2003). Economic and moral criteria of executive compensation. Business and Society. 108(3). 405-

Hilton, T.; Oh, S.H.; and Al-Lawati, H. (2006). Information Systems Ethics in the Triad. J. of Computer Information Systems. 46(4). 78-102.

Laudon, K.C. and Laudon J.P. (2006.)Management Information Systems, 9th edition, p.154.

Manuel A Tipgos, M.A. (2002). Why management fraud is unstoppable. The CPA Journal. 72(12). 34-

Merritt, J. (Jan 27, 2003). WHY ETHICS IS ALSO B-SCHOOL BUSINESS. Business Week. 105-

Mission Draft (2004). College of Business. Sacred Heart University.

Procario-Foley, E.G. and McLaughlin, M.T. (2003). A Propaedeutic for a Framework: Fostering Ethical Awareness in Undergraduate Business Students. Teaching Business Ethics. 7(3). 279-

Richards, C.H., Gilbert, J., & Harris, J. R. (2002). Assessing ethics education needs in the MBA program. Teaching Business Ethics. 6(4). 447-

Sankaran, S. and Bui, T. (2003). Ethical attitude among accounting majors: An empirical study. Journal of American Academy of Business. 3(1/2). 71-

Stablein, R. (2003). Teaching business ethics or teaching business ethically? Management Communication Quarterly, 17(1). 151-

Watkins, S.S. (2003). Ethical conflicts at Enron: Moral responsibility in corporate capitalism, California Management Review. 45(4). 6.

A Data Mining Approach Using Geographic Information Systems Data for Predicting Voting Behavior in the Presidential Election of 2004

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ABSTRACT

Throughout the last few decades, the state of North Carolina has voted to put both Republicans and Democrats in elected positions. The election of 2004 was no exception. North Carolina voted for a Republican president and a Democratic governor. This research seeks to understand the reasons for this voting pattern by focusing on one the largest counties in North Carolina, Guilford County. Guilford County was used for this study since it was one of the few counties in North Carolina that votes democratic. This research is an attempt to discover pattern and insight on voting habits based on the demographics of homeowners, house values and the age of property. This research will be beneficial not only to political parties but also to the citizens of Guilford County who want to see the data and unique comparisons between voting records and housing information

INTRODUCTION

Throughout the last few decades, the state of North Carolina has voted to put both Republicans and Democrats in elected positions. The election of 2004 was no exception. North Carolina voted for a Republican president and a Democratic governor. Since 1964, North Carolina has only given its electoral votes to the Democratic Party twice – 1964 (Johnson) and 1976 (Carter). 2004 continued this same voting behavior from previous elections. George W. Bush (R) garnered 1.96 million votes while Mike Easley (D) won nearly as many votes as the president with 1.94 million. Guilford County is one of few counties in North Carolina that voted Democratic in both the presidential and gubernatorial 2004 elections. Overall exit polls for North Carolina indicated that income and demographics played a strong role.

A County-by-County election return data from *USA Today* (Vanderibei, 2004) together with County boundary data from the US Census' Tiger database. Blue for Democratic, red for Republican, and green is for all other. Each county's color is a mix of these three-color components in proportion to the results for that county (Vanderbei, 2004). Clearly this map indicates that there are pockets of voters who are more likely to vote one way of the other solely based on their locations. It is also interesting to see that the density of voter participation is also closely related to what is shown in Figure 1. In Figure 2, the voter density of most urban areas shows a distinct propensity to vote democratic. It is interesting to note that the concentration of minority voters in urban areas is much higher than that of rural area and as seen in both figures 1 and 2, these voters tend to vote democratic.

This research, we were interested in understanding the voting patterns for a specific southeastern county in the United States and to see whether the broader presented reached earlier holds for this county as well.

Specifically we were interested in:

- Map and validate the North Carolina exit poll data to Guilford County for the 2004 election

Figure 1. County-by-county election returns in Presidential Election of 2004

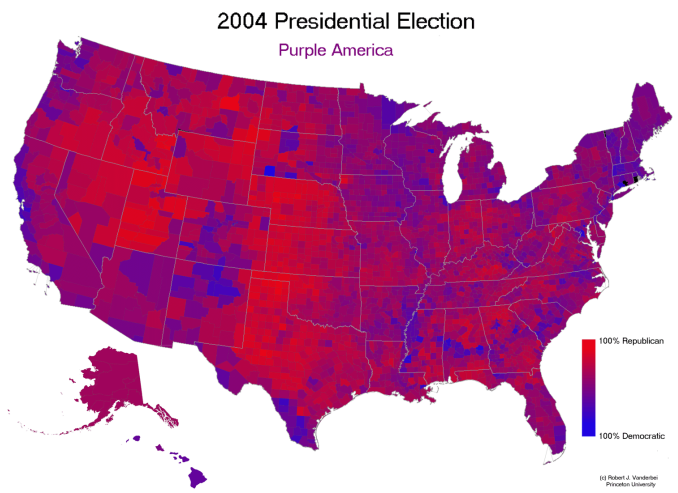
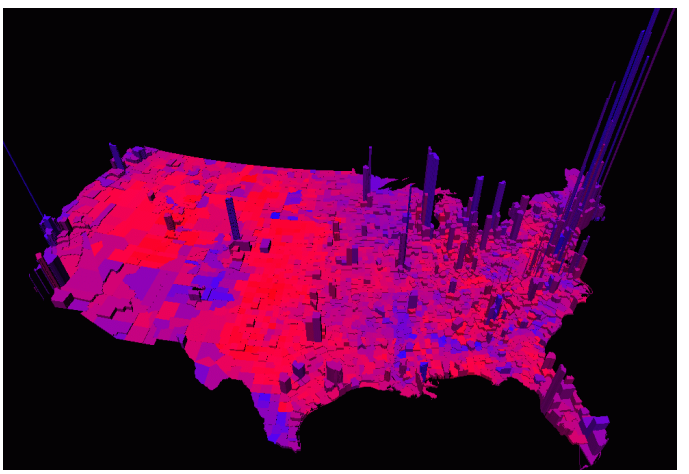


Figure 2. Voter density in 2004 Presidential Election



- Determine presidential and gubernatorial voting behaviors for precincts in Guilford County
- Map home values in precincts to voting behaviors
- Map age of the home to voting behaviors

In 2004, Guilford County broke from the "North Carolina pattern" in a slim fashion to vote for John Kerry, the Democratic challenger. Guilford County was one of a minority of counties in the state to vote for Kerry over George W. Bush. In addition, Guilford County was one of the 14 counties that made up 50% of the presidential vote in 2004. In addition to Guilford County, Orange County and Durham County were three of these fourteen counties that voted for Kerry (Guillory, April 2005). It has been widely held that Guilford County tends to lean democratic due to the combination of several factors Paul Shumaker, a political consultant for the Republican Party, states "Large urban counties and counties with a large public university presence provided the best results for Democrats." (Shumaker, April 2005). It can certainly be argued that Guilford Country has a strong educational infrastructure with schools such as UNC-G, NC A&T, Guilford College and Greensboro College. In addition, an argument can be made that this county has an active Democratic contingent and did an excellent job of promoting early voting. Most importantly, Guilford County has a sizable minority population. But what are other factors that impact this pattern of voting. According to 2004 exit polls conducted by Edison/Mitofsky, it appears that in general, suburbs in North Carolina vote strongly Republican while urban areas tend to vote evenly for both sides. In addition, voting by income reveals that incomes under 30K vote democratic versus incomes over 30K that vote republican (*Southnow*, April 2005). Is there a relationship between the value of a house and the voting behavior of the homeowner? Are there correlations between the voting behaviors of precincts and the value of the homes in those precincts?

Focusing on present housing statistics, voter demographics and votes cast in Guilford County in the 2004 election, this research project will seek to validate the exit poll results from Edison/Mitofsky as they pertain to Guilford County? Our research group intends to validate these findings in Guilford County by matching home value to income through a 40% rule of mortgage to income as well as define precincts as being in the city of Greensboro – urban – or outside of Greensboro but within Guilford County - rural. We anticipate that while most of the results match this exit polling, our research will also support the data that "In terms of electoral politics, the attitudes of both groups of voters (Republicans and Democrats) reflect the divided nature of an electorate in which neither major party commands a majority of popular support" (*Southnow*, April 2004).

This research is an attempt to discover pattern and insight on voting habits based on the demographics of homeowners, house values and the age of property. This research will be beneficial not only to political parties but also to the citizens of Guilford County who want to see the data and unique comparisons between voting records and housing information

DETAILED DATA MINING USING GIS DATA

In order to validate that North Carolina exit poll data (Edison/Mitofsky 2004) applies to Guilford County, this research project will focus on the following data points:

- present housing statistics
- voter demographics
- votes cast in Guilford County in the 2004 election

In addition the data mining of the GIS data would allow us to have a better understanding to the following questions:

- Do higher home values translate to Republican votes?
- Do lower home values translate to Democratic votes?
- Do precincts that are considered urban or metro vote democratic? Are there strong levels of home ownership in these districts and do they vote democratic as well?
- Do the "rural" precincts in Guilford County – outside of Greensboro city limits – vote republican?
- Do residents of identically valued houses in different neighborhoods vote the same or different?
- Are there particular precincts that split their votes or vote straight ticket?
- Are there particular home values that split their votes or vote straight ticket?
- Is there a correlation between home values and presidential and gubernatorial election results?
- How should precincts with lower numbers of homes for sale be scrutinized for other forms of housing such as rental apartments?

Our research intends to validate these findings in Guilford County by matching home value to income through a 40% rule of mortgage to income as well as define precincts as being in the city of Greensboro – urban – or outside of Greensboro but within Guilford County - rural. We anticipate that while most of the results match this exit polling, our research will also support the data that "In terms of electoral politics, the attitudes of both groups of voters (Republicans and Democrats) reflect the divided nature of an electorate in which neither major party commands a majority of popular support" (*Southnow*, April 2004).

Through this analysis, we intend to prove that in addition to the more widely understood, race and as predictor of voting preference, home value also plays somewhat of an indicating role in how precincts vote. Certain home value ranges will prove to be a wash. Precincts with lower home values will prove to vote democratic. Precincts with higher home values will prove to vote republican.

There are several assumptions that need to be considered in this project. We assume that:

- 40% of the combined income of individual or family translates to the assumable mortgage of a home
- The value of a house translates roughly to a home mortgage financed at 90%
- The value of a home is a close indication of the income of the owner
- Cities with universities tend to vote Democratic
- Precincts within the city limits of Greensboro will be considered urban
- Precincts within Guilford County but outside of the city limits of Greensboro will be considered rural

We were interested in studying whether using the age of the house, the tax value of the house and demographics of the homeowner can be used to predict the voting behavior of the homeowners.

We used the following commonly understood relationship between the value of the house and the income of the occupants. Based on the formula:

Value of house = 40% of (combined) income

Using this formula, we construct the following propositions:

- **< $30,000 income translates to $75,000 home and these voters tend to vote Democratic**
- **$30,000 – $50,000 = $75,000 - $125,000 home with no differentiation between parties**
- **$50,000 –$ 75,000 = $125,000 - $187,500 home with no differentiation between parties**
- **$75,000 – $100,000 = $187,500 - $250,000 home with no differentiation between parties**
- **> $100,000 translates to $250,000+ house and these voters tend to vote Republican**

IMPLEMENTATION

The data was analyzed and mined to determine the validity of the conventional wisdom. In addition to using Microsoft Excel, the project team also used mining tools provided by Microsoft Analysis Services in the SQL 2005 suite. In combination with these analysis tools, the project team also relied on data visualization tools through the use of GIS – geographic information system.

A data warehouse was developed using dimensional modeling approach to be the feeder for our data mining tools. This data warehouse is used to store:

- Precinct data including precinct ID, city, county, and precinct name,
- Voter registration statistics including voter registration, sex and ethnic background
- Presidential and gubernatorial voting data from 2000 and 2004
- Housing data including the average home value in the precinct, average value per square foot, age of home, and average year built.

Figure 3. Dimensional model used for data warehouse

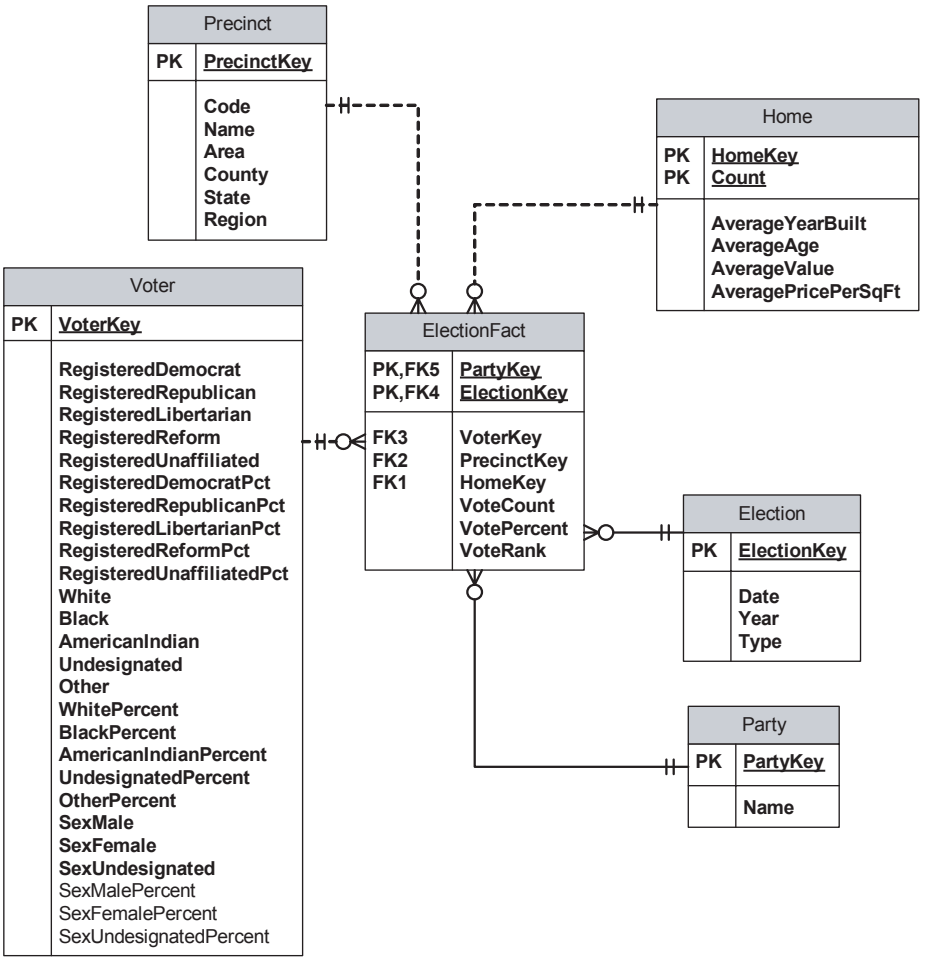


Figure 3 depicts the dimensional model used for this data warehouse.

To populate this data warehouse, the data was collected from various sources including:

- Triad Multiple Listing Service (MLS) – This is a powerful real estate listing site that provides detailed data on the local housing market
- Guilford County Taxation Department
- U.S Census Bureau
- Guilford County Board of Elections
- North Carolina State Board of Elections
- Triad MLS – A detailed report containing the fields in the previous section was created. A search was performed on active and pending houses in Guilford County for all areas of the county. Approximately 3692 records were created and displayed in the report. The report was exported from the site as a tab-delimited text file.

Data on the 2004 General Election Results were obtained from the Guilford County Board of elections. This data was in the form of a spreadsheet. Unfortunately, the 6 precincts were split into two precincts after the Precinct TIGER shapefile was created. Data for these two precincts was manually combined prior to further processing. A VBA routine was created to copy the appropriate data from the results into the database. This routine also generated and populated calculated data such as percent of vote. Data on Precinct Voter Registration was obtained from the Guilford County Board of elections. Finally a routine was developed to move the data to the data warehouse. This routine generated and populated calculated results such as translating counts into percentages. Data on Home Values was imported into the data warehouse. This method generated and populated the average home price, the average price per square foot, number of homes in the sample for the precinct, average age, and average year built.

GEOGRAPHICAL INFORMATION SYSTEMS

Data visualization provides a graphical interpretation of a data so that it can be analyzed from different perspectives. This study will combine data warehousing analysis techniques with spatial analysis to generate visual ads to assist in data visualization. Spatial data is data describes a location (point), line, or a shape (polygon) such as. A point object could represent a poll location, a line object could represent a street segment and a polygon could represent an area such as an election precinct. Spatial Analysis allows for the analysis based on the spatial feature as well as the relationship between two or more objects. For example what is the greatest distance from a polling location to the edge of the precinct.

The primary software package used for this phase was ESRI's ArcGIS ArcMap function. This application enabled the project team to:

- Load and view spatial data stored in a variety of formats.
- Manipulate and modify spatial objects and their attributes.
- Manipulate display graphics by symbolizing, classifying, and labeling spatial objects.
- Identifying, selecting, and finding features by attributes or location.
- Preparing data for analysis by removing unwanted features and combining others.
- Analyze spatial data by buffering and overlaying features.
- Generating the final output Maps

Figure 4. Guilford County 2004 Presidential Election results

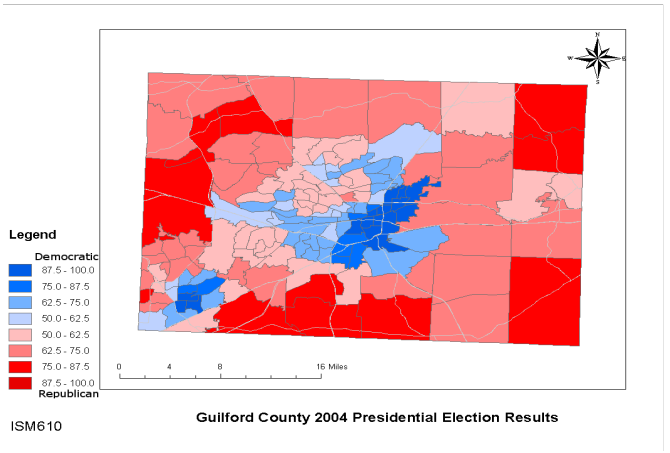


Figure 5. Guilford County registered minority (2004)

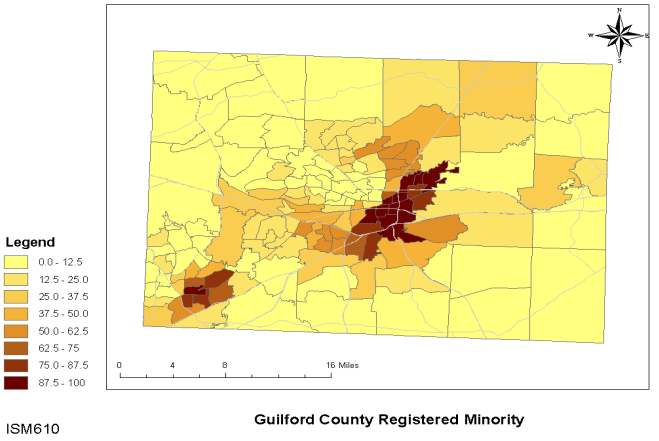


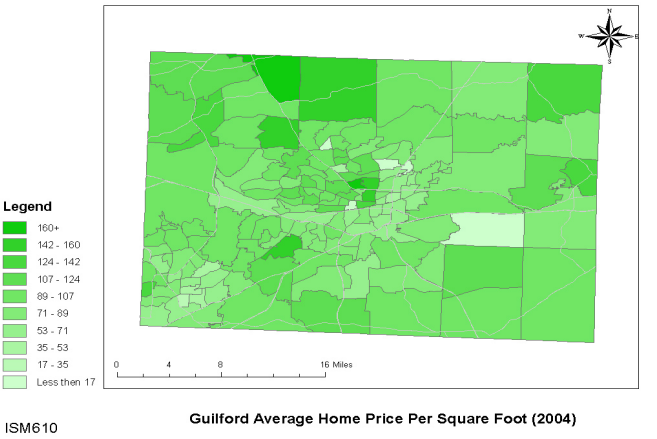
Figure 4 shows Guilford County 2004 presidential election results and Figure 5 shows Guilford County Registered Minority in year 2004. This Figure depicts the percentage of minority voters in each precinct based on voter registration information obtained from the Guilford County Board of Elections for 2004. Precincts rendered with darker values have a higher percentage of voters identifying themselves as being of minority background. As one can clearly see, the two figures are almost identical, indicating a high correlation between the two.

On the other hand, Figure 6 features the average value per square foot of the homes sold in the precinct during the study period. This information was imported into the data warehouse and rendered in ArcGIS application and the resulting map generated. Precincts with lighter shades of green experienced home sales of lower average value per square feet compared to those areas with darker shades of green. In this case, the relationship between the voting pattern and home prices per square foot is not clear.

Home Values

The group also analyzed housing data from MLS by grouping listings and data into the corresponding precincts. The group could not collect housing data for 4 of the 151 precincts. These precincts are Greensboro 28, Greensboro 45, Greensboro 8 and Jefferson 4.

Figure 6. Guilford average home prices per square foot (2004)



Average home value for the county from the sample was $140,583.89. We gathered housing information on 1,353 homes in Guilford County. Removing the four precincts where we did not have information, the average number of homes to precincts was 9.2.

Average age – 35 years.

Average $ / sqft - $91

No precinct that voted democratic had an average home value more than 211,200. The following graph represents how precincts with various average home values voted in the 2004 presidential campaign. The y-axis represents average home value per precinct. Each blue dot is a precinct. 0 represents a precinct that voted republican and 1 represents democratic ones.

NAÏVE BAYES DATA MINING BASED ANALYSIS

In analyzing the GIS data, we used the Naïve Bayes approach for data mining. Naïve Bayes is a classification and prediction algorithm that calculates probabilities for each possible state of the input attribute, given each state of the predictable attribute. This can then be used to predict an outcome of the predicted attribute based on the known input attributes. In order to better understand how precinct housing price data plays an indicating role in how precincts vote, our group needed to analysis the available data from several vantage points.

In combination with the voting data and voter demographic data, we looked to combine housing data from MLS. Through this analysis, we intended to prove that home value plays somewhat of an indicating role in how precincts vote. Although certain home value ranges would prove to be a wash, the group sought to prove that precincts with lower home values would prove to vote democratic while precincts with higher home values would prove to vote republican.

Based on the formula: *Value of house = 40% of (combined) income*

We analyzed the data within the following parameters. The analysis is included with each part.

< $30,000 income translates to $75,000 home and these voters tend to vote Democratic

40 precincts fell in this category. 34 of the 40 precincts voted democratic (85%) in the 2004 presidential campaign. The data strongly supported this position.

$30,000 – $50,000 = $75,000 - $125,000 home with no differentiation between parties

39 precincts qualified in this category. 23 of these precincts (59%) voted democratic. There did not appear to be a significant differentiation between this income range and voter outcome.

$50,000 –$ 75,000 = $125,000 - $187,500 home with no differentiation between parties

32 precincts composed this category. 6 of these precincts (19%) voted democratic. It appears that our data disproved this part. 4 out of 5 precincts with incomes in this range voted republican.

$75,000 – $100,000 = $187,500 - $250,000 home with no differentiation between parties

19 precincts fall in this category. 3 of these precincts (16%) voted democratic. Similar to the previous income range, the data that we collected disproved our initial thought that this range would be a wash. In fact, this income range strongly supported the republican candidates.

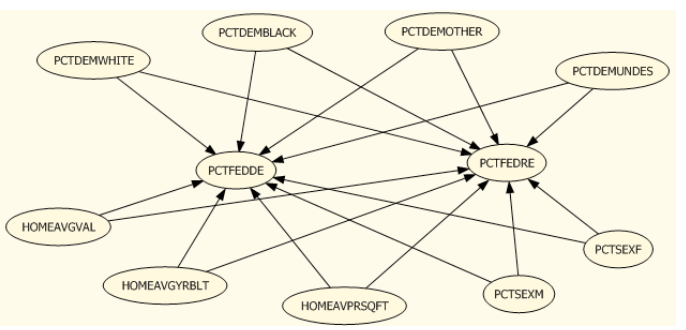
> $100,000 translates to $250,000+ house and these voters tend to vote Republican

17 precincts fall this category. Every one of these precincts voted republican. In this range, the data clearly supported the initial premise.

The Naïve Bayes algorithm was used to analyze the relationships between various voter attributes and the percentage of votes for each political party. The collected input variables included:

- Ethnic Background
  - o PCTDEMWHITE - percentage of registered voters identified as White.
  - o PCTDEMBLACK - percentage of registered voters identified as African-American.
  - o PCTDEMUNDES - percentage of registered voters undesignated.
  - o PCTDEMOTHER - percentage of registered voters identified as other.
- Male/Female
  - o PCTSEXM - percentage of registered voters designated as Male.
  - o PCTSEXF - percentage of registered voters designated as Female.
- Housing Information
  - o HOMVAVPRSQFT – Average home value per square foot.
  - o HOMEAVGVAL – Average home value.
  - o HOMEAVGYBUILT – Average year that home was constructed

The following diagram series of figures represents the dependencies between input values and output values that were used in the algorithm.



IMPORTANCE OF EACH DATA ELEMENT:

Each of the following graphics depicts the critical relationship between each of the attributes and the precinct percentage of votes for the democratic presidential candidate. These graphics are presented in order of significance from most to least. Based on analysis the importance of each input data type ranks as follows:

1. Percentage of registered voters identified as African-American.
2. Percentage of registered voters identified as White.
3. Percentage of registered voters identified as Female.
4. Percentage of registered voters identified as Male.
5. Average Home Value
6. Percentage of registered voters identified as other.
7. Average Home Value per Square Foot
8. Percentage of registered voters of unidentified Ethnic Groups
9. Average Age of Home.

The Naïve Bayes analysis closely follows the general analysis above in terms of the strong influence the race and gender have on precinct voting. Housing data does not play as strong a role with average home value being a stronger attribute than home value per square foot or average age of home.

ATTRIBUTE DISCRIMINATION VALUES

Attribute Discrimination indicates the importance of a particular attribute category in determining the output values. The following charts show how the most important data attributes play a part in the final output values – the percentage votes for the republican and democratic parties.

The attributes favoring *high* democratic vote results in a precinct include:

- Home average value less then 95,000
- Percent of white voters in precinct of less then 17%
- Percent black voters greater then 85%
- Average home value per square foot of less then $67

The attributes favoring *low* democratic vote results in a precinct include:

- Percent African-American voters of less then 13%
- Percent White voters greater then 85%
- Registered male voters greater then 47%

Because there are only two major parties, the factors that favor one party tend to be ones that work against the other as indicated in the Attribute Discrimination chart for the Republican Party. The following graphics depict the information in the preceding bulleted lists:

CONCLUSION

As stated in the introduction, Guilford County was one of a minority of counties that voted not only for the Democratic candidate for governor but also the democratic candidate for president. The intent of this paper was to answer the question – why? In order to tackle this question, we needed to gather not only the basic information such as the voting data from 2004, but we also wanted to gather housing data to determine if there was a significant correlation between housing data and voting data.

The data supports one of the group's premises that higher home values translate to republican votes. Conversely, lower home values translate to democratic votes. In addition, there appears to be a strong correlation between home values and the presidential election results. Gubernatorial results are not as clear as the presidential results.

In terms of gender and racial demographics, our analysis supported the traditional thoughts around Guilford County. Race and gender play a critical role in determining voting trends in precincts. Housing played a complementary role in determine democratic and republican voting behaviors. Voters from precincts with an average home value of less than $70,000 strongly supported democratic candidates. Voters from precincts with an average home value of more than $125,000 voted more republican. All precincts with an average home value of $250,000 voted republican. In fact, no precinct that voted democratic had an average home value of more than $211,200.

In conclusion, our project team successful merged two sets of seemingly disparate data to reveal intriguing connections between voter demographics, voting results and housing statistics. While race and gender were the strongest attributes in the overall study, Naïve Bayes analysis revealed some strong connections between housing and voting results.

REFERENCES

Census TIGER/Line Data. 2000. http://www.esri.com/data/download/census2000_tigerline/

Edsall, Thomas B. "Voter Values Determine Political Affiliation". Washington Post. March, 2001. http://www.washingtonpost.com/ac2/wp-dyn/A56905-2001Mar25?language=printer

Gautschi, Eric. "Suburban Thirty-Somethings Make the Difference". Southnow, April 2005. http://southnow.org/pubs/ncdn/ncdn38.pdf

Guilford County General Election Results. 2000. http://www.co.guilford.nc.us/government/elections/gen11-07-00.xls

Guilford County General Election Results. 2004. http://www.co.guilford.nc.us/government/elections/vt110204.xls

Guillory, Ferrel ."Straight-Party and Split-Ticket Voting" Southnow, April 2005. http://southnow.org/pubs/ncdn/ncdn38.pdf

North Carolina Voter Registration Statistics. April 1998. http://www.app.sboe.state.nc.us/voterreg/vr0498p.pdf

Quinterno, John. "New Voters Altering Political Landscape" Southnow. April 2004. http://southnow.org/pubs/ncdn/ncdn36.pdf

Shumaker, Paul. "The Republican Base and Cross-Over Appeal". Southnow, April 2005. http://southnow.org/pubs/ncdn/ncdn38.pdf

U.S. PRESIDENT / NORTH CAROLINA / EXIT POLL. CNN. 2004. http://www.cnn.com/ELECTION/2004/pages/results/states/NC/P/00/epolls.0.html

Vanderbei, Robert J. 2004. http://www.princeton.edu/~rvdb/JAVA/election2004/

VR Statistics By Precinct. 2005. http://www.co.guilford.nc.us/government/elections/st053105.pdf

Internet Commerce Adoption in the GCC Countries

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ABSTRACT

The purpose of this study is to determine the status of Internet and e-commerce adoption by the countries of the Gulf Cooperation Council (GCC). The research is designed to help local governments and the corporate sector formulate more effective strategies and make efficient resource allocation decisions. Surveying 189 companies' Web sites, the study uses the three-level model of Internet commerce adoption (MICA) to assess Internet adoption rates for firms in the various industries and shows variability in adoption rates among the different industries in the region. Many industries are lagging with the adoption of the Internet indicating a need for education and training. According to Burgess, Cooper and Alcock (2001), the central tenet of the MICA model is that in developing commercial web sites, organizations start with the establishment of a simple presence on the web and these sites get more functionally complex as the expertise of these organizations in the use of Internet technology increases and they incorporate more modules to these sites.

Keywords: Internet Adoption, MICA, GCC, Website Maturity, Developing Countries

INTRODUCTION

Over the past 15 years, countries of the Gulf Cooperation Council (GCC) have taken quantum leaps in the direction of liberalizing their economies and diversifying them away from the oil-based sector. Leaders in the six countries have realized that in the Internet era, it is important to effectively move in the direction of e-commerce and e-government in order to create competitive advantage. In order to assess their success/failures rates, both governments and firms need to learn the status of e-commerce adoption, especially when establishing policies and devising strategies. The results benchmark the internet adoption status of the GCC countries will yield statistics to support policy formulation for future industry development.

Internet technology has changed the world's supply chain by enhancing cooperation and adoption efficiency as well as adding value to products and enterprises. In recent years, electronic commerce has increased the sharing of business information, has built business relationships, and has enhanced business transactions by means of telecommunications networks (Zwass, 1997). According to recent studies, internet-based e-commerce provides a fast and efficient way of obtaining comprehensive market information, feedback from industry and supplier performance (Soliman and Youssef, 2003).

Many research projects are being conducted to document successful e-commerce processes. One such study finds that there are many processes critical to the success of e-commerce including order fulfillment, revenue generation, financial control, web management, monitoring, order generation, call center integration, and consumer behavior (Duffy and Dale, 2002). New business models are needed to conform to the electronic commerce of today's economy. Defining the customer's expectation in e-business is important as well as the need to invest adequately in the improvement of services (Rotondaro, 2002). The critical dimensions such as finance, legal issues, logistics, marketing, operations, security and technology, as well as strategy must be considered when planning new e-commerce ventures (Kao and Decou, 2003). Regardless of the benefits that can be gained from e-commerce, or the critical issues solved, the first thing for modern enterprise should do is to go online and adopt the Internet.

GCC AND THE INFORMATION/KNOWLEDGE SOCIETY

The Gulf Cooperation Council (GCC) was established in accordance with an agreement concluded in 1981 in Riyadh, Saudi Arabia between: Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and UAE. These countries declared that the GCC is established in view of the special relations between them, their similar political regimes and geographic proximity (Karake-Shalhoub, 2006). The author evaluated the countries individually and collectively using three international indicators and standards developed by multinational organizations: The Economic Freedom Index, The Information Society Index, and Digital Access Index. The findings revealed that the GCC countries display the highest penetration rates in mobile phones, fixed lines and Internet users. Mobile phone penetration in the GCC stands at 26.16 percent while average Arab world penetration stands at 7.92 percent. GCC mobile phone penetration is also well above the world average, at 17 percent. While fixed line penetration in the Arab world stands at 7.95 percent and Internet penetration at 2.69 percent, the GCC enjoys a much higher fixed line penetration of 16.52 percent and Internet penetration of 9.48 percent (Karake-Shalhoub, 2006). Further, the study found that some of the GCC countries have emerged as forerunners and are among the 50 top information technology (IT) users in the world. In terms of the Digital Access Index (DAI), which includes variables, such as education and affordability, four of the GCC countries (UAE, Bahrain, Qatar and Kuwait, were classified in upper access category, and the remaining two (Saudi Arabia and Oman) were classified in medium access category (Karake-Shalhoub, 2006).

All indicators, then, point to the fact that the GCC countries are ready to engage in e-commerce transactions. Based on a study done by Ernest and Young, in 2002 it was estimated that the current total B2B trade in the region was between $3.5-4.2 billion, of which the automotive industry, the oil industry and IT industry accounted for the bulk of the online transactions. They also estimate that considering the ongoing initiatives in various other segments, particularly in the Oil, Petrochemical and Government sectors, it is likely that the B2B trade in the region could grow to $7.25-9.15 billion in 2005. Overall, eCommerce trade (B2C and B2B) in the GCC region can consequently be expected to amount to between $8 -10 billion in 2005.

A main indicator of the level of diffusion of electronic commerce is the rate of credit card penetration in a country/region (Karake-Shalhoub et al, 2006). According to the latest statistics of Visa International, daily use of debit and credit cards in the GCC countries continue to grow strongly. According to this report, for the 12 month period ended March 2005, an average of 730,000 purchases were made per day on Visa debit and credit cards in the GCC, or more than eight transactions every second, representing a 30 per cent growth over the previous 12-month period (Credit Cards News, 2005).

This year, shopping spending increased by 32 per cent to $10.5 billion from last year. While the rise in volume and value of card payments is pleasing, what is perhaps more significant is that the majority of purchases being made by Visa cardholders in the GCC are everyday, small value purchases. This indicates that these societies are moving away form the cash-based format, and that credit and debit cards are starting to challenge cash in societies of the GCC as the preferred way to pay.

Based on analysis of spending by geographic region, it is stated that more than a third of the shopping spend in the GCC was generated by Saudi cardholders. In addition, markets such as the UAE are already showing clear signs of cards replacing cash, with the numbers of purchase transactions by UAE cardholders being higher than the number of ATM cash withdrawals.

INTERNET COMMERCE ADOPTION MODEL

The rapid adoption of the Internet as a commercial medium has motivated firms in the Gulf Cooperation Countries (GCC) to experiment with innovative ways of marketing to consumers in cyberspace. Previous research has shown that that innovation, organization and external factors can influence a firm's decision to adopt e-commerce as a marketing and selling strategy (Lin et al, 1998). Using a survey of 162 SMEs, the authors found that the drivers of firm Internet adoption are different from those of traditional information system adoption, and the degree of internet adoption by firms in the study was strongly related to the owner's perception of the relative advantages of using information technology. Another study found that the degree of information system adoption can be related to the firm's previous innovation experience (Lee and Runge, 2001). Previous research has evaluated e-commerce adoption by firms from different perspectives. Wen et al (2003) employed a data envelopment analysis (DEA) model evaluates e-commerce adoption, diffusion and performance of firms using various measures such as financial and operational. A study by Davidson (2002), though a search of the literature, shows Web sites are classified in different ways: Web Typology, Scoring System, and Stages of Development.

THE SAMPLE

This study, and for the first time, covers a sample of Web sites in a group of developing economies in the Middle East, namely the six countries of the Gulf Cooperation Council. The author evaluated 183 popular commercial Web sites. These Web sites were identified and classified based on the Standard Industrial Classification (SIC)/North American Industry Classification System (NAICS), as classified by the AMEinfo Business directory. AMEinfo adopted the SIC/NAICS classification because it is the most comprehensive overall industry classification system found when AMEinfo restructured its database of more than 200,000 companies in January 2005. Table 1 contains the distribution of the sample by country.

As can be seen from Table 1, Saudi Arabia and the UAE comprise close to 75 percent of the websites examined. This is consistent with the fact that the two countries have the largest numbers of registered Internet hosts (ITU, 2003).

The distribution of websites per industry is depicted in Table 2. The classification was based on the 1997 North American Industry Classification System (NAICS), which was updates of the original Standard Industrial Classification (SIC) (OMB, 1997). The industry classifications "Finance and Insurance" and Retail Trade" account for more than 53 percent of the total companies in the sample.

Based on the above Table and assessing the viability of the sample size within each industry, it was deemed appropriate to concentrate our research on industries represented by more than 10 firms reducing our sample size to 157; hence, the following sample (Table 3) will be analyzed.

This paper utilizes the model of Internet commerce adoption (MICA). The Model of Internet Commerce Adoption (MICA) advocates that in developing commercial web sites, private and public sector entities normally start by creating a 'presence' on the Web and add more and more functions and applications over time. As such, the sophistication and comprehensiveness of the sites will expand as the site provides more applications (Burgess and Cooper, 2000). This staged approach to the development of web sites that is embraced by MICA is well recognized within the Information Systems (IS) history that acknowledges that growth and development is caused by adding more functions (Burgess and Cooper, 2000).

According to the MICA model, a website goes through three stages of development, from infancy to maturity; these are promotion, provision, and processing (Table 4). During the promotion stage, companies start simply by establishing a "presence" on the Web; the main objectives here is to establish websites which make customers acquainted with their products and services. In doing so, they provide basic information covering business scope and post news relevant to their operations; some use animation and multimedia to draw visitors' attention toward an important promotion offered. Users, however, users cannot send anything to the site and can only receive information from promotion web sites. The second stage of website development is the provision stage; here the web site offers users the functionality of sending and receiving information. Users of a "provision" website receive information, access to search engines, and even choices of languages. The hope here is that these value-added applications will help maintain existing customers and cultivate new ones. More complex applications are also embedded as integral components of interactive Web sites. Users can search for information and use functionalities such as e-mail; they can also register online and take part of message boards. Interactive websites encourage and entice visitors to inquire, request, complain, challenge, or make recommendations; they also help companies adopt a sense and respond strategy, however, an imperfect one.

In the processing stage, customers play the most influential role. One of the main utilities here is customer relationship management, from initiation to maintenance. Other electronic services such as online orders or inquiries are all completed

Table 1. Distribution of sampled firms among the six countries

Country	Number of Companies	Percentage
Bahrain	10	5.46 %
Kuwait	16	8.74 %
Oman	11	6.01 %
Qatar	9	4.92 %
Saudi Arabia	74	40.44 %
UAE	63	34.43 %

Table 2. Web sites classified by industry

Industry Type	Number of Sites
Accommodation and Food Services	6
Administrative and Support and Waste Management and Remediation Services	0
Agriculture, Forestry, Fishing and Hunting	2
Arts, Entertainment, and Recreation	2
Construction	5
Educational Services	3
Finance and Insurance	36
Health Care and Social Assistance	14
Information	11
Management of Companies	0
Manufacturing	21
Mining	6
Other Services (except Public Administration)	0
Professional, Scientific, and Technical Services	0
Public Administration	16
Real Estate and Rental and Leasing	0
Retail Trade	41
Transportation and Warehousing	2
Utilities	18
Wholesale Trade	0

Table 3. Web sites analyzed

Industry Type	Number of Sites
Finance and Insurance	36
Health Care and Social Assistance	14
Information	11
Manufacturing	21
Public Administration	16
Retail Trade	41
Utilities	18

Table 4. Web site classification scheme

Item Name	Description
Promotion Stage	
1. enterprise information	background and business scope
2. product information	product catalog and names
3. news of enterprise	important news such as new product releases
4. animation and multimedia	attract user's attention; focus on major targets
Provision Stage	
5. recruitment info.	list of open jobs and job requirements
6. technical info.	detailed info on existing product/services or advanced info on new product or services
7. email hyperlink	users' interaction
8. search functionality	assist users in finding info. quickly
9. language choice	provides service to an international audience
Processing Stage	
10. online resume	functionality to fill in relative information
11. e-service	ability to query, analyze, or download technical information
12. online order or inquiry	functionality of making purchases or inquiring about products and services.

online through the website. For example, a CV can be filled out using a template provided by the site and then submitted by an applicant; users and visitors are able to download technical information, and complete their orders online. More mature transaction sites incorporate ordering, purchasing, and delivering functionalities. Developing these web sites requires high levels of sophistication in programming.

DESIGN OF THE RESEARCH

Previous research has demonstrated that larger companies are more likely to adopt e-commerce and to implement e-business applications (Macher et al, 2002). In terms of diffusion in the industry, the service sector shows greater internet commerce adoption and greater e-commerce maturity than other sectors, largely due to lower capital and manpower investment.

In our research the Burgess and Cooper MICA model (2000, 2001 and 2002) is used to assess the stage of e-commerce adoption by each of the 159 GCC websites identified in the previous section. Each website was evaluated and assessed using the MICA 12-code scheme (Table 4). Following previous research, if a MICA item was found, it was assigned the code "1" on the MICA sheet, and "0" if the item was not present. As in previous research, if a website had items including online resume, e-service, and online order or inquiry, it is categorized as belonging to the processing stage. A website is categorized in the processing stage, if any code "1" could be found from item 10 to item 12 (Peng et al, 2005). If the website does not qualify to be in the processing stage category, then it is checked for appropriateness to the provision stage. If there was any code "1" found for item 5 to item 9, then the website was classified into the provision stage. Finally, we would confirm that a web site was in the promotion stage if any code "1" was found from item 1 to 4, but not having any in item 5 to 12. To measure the maturity of website design, the ratio of items coded one to the total number of

Table 5. Classification of Websites according to MICA stages of development

Stage	No. of Sites	Percentage
Promotion	0	0.00%
Provision	98	0.62%
Processing	61	0.38%

Table 6. Classification by industry type

Industry Type	Number of Sites	Percentage
Finance and Insurance		
• Promotion	0	0.00
• Provision	16	0.44
• Processing	20	0.56
Total	36	1.00
Health Care and Social Assistance		
• Promotion	0	0.00
• Provision	9	0.64
• Processing	5	0.36
Total	14	1.00
Information		
• Promotion	0	0.00
• Provision	8	0.73
• Processing	3	0.37
Total	11	1.00
Manufacturing		
• Promotion	0	0.00
• Provision	17	0.81
• Processing	4	0.19
Total	21	1.00
Public Administration		
• Promotion	0	0.00
• Provision	3	0.19
• Processing	13	0.81
Total	16	1.00
Retail Trade		
• Promotion	0	0.00
• Provision	30	0.73
• Processing	11	0.27
Total	41	1.00
Utilities		
• Promotion	0	0.00
• Provision	13	0.72
• Processing	5	0.28
Total	18	1.00

items in each stage was computed. For example, the processing stage has three items (items 10 thru 12), if only one item was coded "1" then the relative maturity of the site within each stage would be computer as 1/3 or 0.33.

ANALYSIS AND RESULTS

A content analysis was performed on the 159 websites included in our sample. Based on the MICA 12-code scheme, all the websites were classified into one the three stages. Table 5 presents the classification of the sites by stage of development; as it is indicated, no site was classified in the "promotion" stage; this is not surprising since the countries of the Gulf region were early adopters of e-commerce and digital technologies. The majority of the sites, or 62 percent, were classified in the "Provision" category, and 38 percent were classified in the "Processing" stage.

Table 6 shows the MICA classification of the sites by industry type. The results show that the Finance and Insurance and Public Administration industries have the lion share of 'processing' websites, and 56 percent and 81 percent respectively. These were followed by the Information industry (37 percent), Health care and Social Assistance (36 percent), Utilities (28 percent), Retail Trade 927 percent), and Manufacturing (19 percent). These results are not surprising since the Financial and Insurance sector is dominated by global, well established firms such as Citigroup, HSBC, Bank of Canada, and bank of America, among others. In addition, the Local banks in the region are at a very advanced stage, and compete head to head with their foreign counterparts. Results of the Public Administration are explained by the fact that at least three of the six GCC countries (UAE, Bahrain and Qatar) have well established and well developed e-government programs supported by top political leaderships that encourage, and in some instance mandate (as is the case of the UAE and Bahrain), e-services, e-payments, and e-solutions.

The study also revealed several additional findings: (1) none of the websites offered chatrooms or discussion forums; (2) only fifteen (15) of the websites featured online resume functionality; (3) none of the website had a currency converter; and (4) sixty-one sites had language options (mainly Arabic and English). These findings are surprising, especially since these websites are geared toward promoting international and global orientation of the businesses.

CONCLUSION AND RECOMMENDATIONS

This benchmark study provides a framework for evaluating the status of Internet and e-commerce adoption by the countries of the Gulf Cooperation Council (GCC). The twelve items of MICA were used to evaluate the development stage of the seven main industries with Web presence in the region; namely, Finance and Insurance, Health care and Social Assistance, Information, Manufacturing, Public Administration, Retail Trade, and Utilities. The research shows that none of the 159 websites under examination are in the 'promotion' stage, sixty-two (62) percent are in the 'provision' stage and thirty-eight (38) percent are in the 'processing' stage.

The results reveal that two industries had a large dominate the 'processing' stage; these are Finance and Insurance and Public Administration; these results are not surprising and might be justified by the fact that the Finance and Insurance sector is dominated by large, global companies which have the knowledge, resources and expertise in website development; and that the Public Administration sector is supported by successful e-government initiatives in the region.

The results for the other remaining industries can be explained by the fact that online ordering is currently not very popular, but will hopefully increase dramatically in the near future as awareness among providers and clients increase. The current strategic direction for the governments in the GCC region is very promising and is that of encouraging the use of e-commerce.

Definitely, more awareness programs are needed; and more education and training is needed to encourage the internet adoption. Further, the government should help enterprises become familiar with the use of the internet and research is needed to measure the impact of incentives and training on adoption.

REFERENCES

Burgess, L. and Cooper, J. (2000). "Extending the viability of model of internet commerce adoption (MCA) as a metric for explaining the process of business adoption of internet commerce." Paper presented at the 3rd International Conference on Telecommunications and Electronic Commerce, Dallas, TX.

Burgess, L., Cooper, J. and Alcock, C. (2001). "The Adoption of the Web as a Marketing Tool by Regional Tourism Associations (RTA's) in Australia." *Proceedings of ACIS2001*, Coffs Harbour, Australia, pp. 493-502.

Credit Card News (2005). "Saudi Arabia leads GCC in usage of credit, debit Cards." Available at www.creditcardsmagazine.com/managearticle.asp.

Duffy, G. and Dale, B.C. (2002), "E-commerce process: a study of criticality", Industrial Management & Data Systems, 102(8): 432-41.

International Telecommunication Union (2003). ITU Digital Access Index: World's First Global ICT Ranking. Published by ITU, Geneva: Switzerland.

Kao, D. and Decou, J. (2003). "A strategy-based model for e-commerce planning." Industrial Management & Data Systems, 103(4): 238-52.

Karake-Shalhoub, Z. and Al Qasimi, L (2006). The Diffusion of E-commerce in Developing Economies: A Resource-based Approach. Edward Edgar Publishing, New York, N.Y.

Karake-Shalhoub, Z. (2006). "Trust, privacy, and security in electronic business: The case of the GCC
countries," Information Management & Computer Security, 14(3): 270-283.

Karake Shalhoub, Z. and Al Qasimi, L. (2003). The UAE and Information Society. a 40-page report prepared for ESCWA, United Nations and presented in February 2003, United Nations. Published by the United Nations, Geneva, Switzerland.

Lee, J. and Runge, J. (2001). "Adoption of information technology in small business: testing drivers of adoption for entrepreneurs." Journal of Computer Information Systems, 42(1): 44-57.

Lin, L.H., Can, B. and Wei, K.K. (1998). "An integrated model on the adoption of internet for commercial purposes." Paper presented at the Hawaii International Conference on System Science (HICSS-31), pp. 403-12.

Macher, J.T., Mowery, D.C. and Simcoe, T.S. (2002). "E-business and disintegration of the semiconductor industry value chain." Industry and Innovation, 9(3): 155-81.

Office of Management and Budget. (1997). North American Industry Classification System, United States.

Peng, Y.C.; Trappey, C.V.; Liu, N.Y. (2005). 'Internet and e-commerce adoption by the Taiwan semiconductor industry,' Industrial Management & Data Systems, 105(3/4): 476-91.

Rotondaro, R.G. (2002). "Defining the customer's expectations in e-business." Industrial Management & Data Systems, 102(9): 476-82.

Soliman, F. and Youssef, M.A. (2003). "Internet-based e-commerce and its impact on manufacturing and business operations." Industrial Management &Data Systems, 103(8): 546-52.

The Heritage Foundation/WSJ (2005). Economic Freedom Index. Published by The Heritage Foundation, NE Washington, DC.

Wen, H.J., Lim, B. and Huang, H.L. (2003). "Measuring e-commerce efficiency: a data envelopment analysis PEA) approach." Industrial Management & Data Systems, 103(9): 703-10.

World Times/IDC (2004). Information Society Index: Measuring the Global Impact of Information Technology and Internet Adoption. Published by World Times, USA.

Zwass, V. (1997). Foundations of Information System, McGraw-Hill, New York, NY.

Education Portal Strategy

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ABSTRACT

Education portals promise to be an integrated point of entry that provides all stakeholders of an education body, frequently referred to as campus or university, with a single, personalized, web interface to all information and application resources in a secure, consistent and customizable way. They also promise to be the means by which multiple devices and multiple access methods can be utilized to retrieve all appropriate information and learning resources anytime, anywhere, with anything. Therefore, developing an education portal can be a key strategic technology decision since it can impact the entire campus community in the way it learns, teaches, communicates and interacts. This paper presents the major issues for portal strategists in the preparation and implementation of education portals, and looks at the development approaches, lessons, comments and concerns from concrete projects. A generic approach towards portal strategy is being derived from the international portal experience which implies four subseqent stages that determine the way portals can be embedded in an institutional context: emerging, applying, infusing, transforming.

INTRODUCTION

Education portals promise to be an integrated point of entry that provides all stakeholders of an education body, frequently referred to as campus or university, with a single, personalized web interface to all information and application resources in a secure, consistent and customizable way (Kavavik, 2002) through multiple devices and multiple access methods can be utilized to retrieve all appropriate information and learning resources anytime, anywhere, with anything. Hence, they allow more interaction and collaboration among students, faculty, staff, and alumni (Barratt, 2003). Properly implemented, portals can be a strategic asset for the institution. In that sense, they do far more than a traditional web site of static information ever could (Strauss, 2002).

The promising opportunities notwithstanding, developing an education portal can be a key strategic technology decision since it can impact the entire campus community in the way it learns, teaches, communicates, and interacts. Therefore, the primary challenge for educational institutions in prior to the implementation of a portal solution is to develop a deliberate *portal strategy* based on a careful analysis of long term and short term needs, and a clear vision with concrete strategic goals (Katz, 2000, 2002).

However, the international portal experience in the educational sector over the past decade shows that various strategies have been pursued in very different institutional environments and with very different objectives (Perraton, 2000). This has been driven to some extent by the fact that the portal concept as other technologies in open and distance learning (ODL) has been first applied and adapted to higher education and professional training environments, but establishes gradually also in primary and secondary education institutions (Owston, 1997; UNESCO, 2000).

Therefore, looking at the development approaches, lessons, comments and concerns from concrete projects, it is primarily the diversity that stands out. This article sheds light on those aspects that can serve as a common basis for an integrated, generic approach towards portal strategy. It understands the four directions of impacts on *learning*, *teaching*, *communication* and *interaction* of education portals as strategic dimensions along which strategic goals are set and embedded in an institutional context.

The generic approach may guide portal strategists in governing bodies of education portals through the delineation of strategic success factors and development priorities at different stages of portal development independent from the educational sector. Therefore, the terminology of this article refers in a common sense to teachers and students instead of differentiating these broader categories into professors, faculty staff, trainers or pupils. Educational institutions such as universities, colleges, schools are collectively termed campus.

FOUNDATIONS OF EDUCATION PORTAL STRATEGY

Portals in the field of education are a widely discussed, but nonetheless often misunderstood term. Therefore, the view on education portal strategy should not lack a brief explanation of the conceptual foundations and the terminology. The general portal concept is based on three essential features: personalization, customization and standardization. The main purpose of personalization is to provide information tailored to the needs of a visitor such as given through the different teacher and student roles these visitors might have in the portal environment. The individual must be able to customize, thus, have complete control over the information displayed on the portal pages. Standardization refers to the user interface as single sign-on (SSO) access point to a variety of tools and resources (Kavavik, 2002).

Portal related initiatives exist at many campuses, but formal strategies for a portal, its use, and its benefits have not been created. Most of the development has occurred in the form of small, targeted projects designed to enhance the functionality of existing web sites. These projects have been prompted by specific educational or administrative needs (Gleason, 2001). An essential contribution to make the education portal concept more consistent throughout the variety of different institutional and educational specificities is the pyramid model of Oblinger and Kidwell (2000). Based on this approach, success factors for the implementation of education portals can be classified at three levels: *governance*, *services* and *infrastructure*.

In this sense the designation of leadership and a concentration of decision-making responsibility are keys to the development and implementation of a portal, providing confidence to campus that it can place the responsibility and trust in the hands of a knowledgeable individual or an informed and dedicated group of individuals. This governing body must be capable to conceptualize the entire portal organization and processes, and to control the technical, policy and financial portal infrastructure. Community involvement and input can play an important role in finding a deliberate balance of necessary competencies.

The service level presents the educational core of the portal. It addresses all aspects of learning, teaching, administration that a campus intends to capture by electronic means. The service orientation can be both teacher-centred and student-centred according to different teaching and learning models, types of learning content and applications. Hence, such models and different types of education portals, in a gradual implementation process also referred to as different stages of portal implementation, are duals of one another (UNESCO, 2002a).

At the infrastructure level, the technology architecture, the financial endowment and the policy framework delineate the vital environment of education portals. The choice of the appropriate overall technological infrastructure is a make-or-buy decision. On the one hand this depends on resource constraints in terms of in-house development capacity and financial resources. On the other hand, regarding the expediency and the uniqueness of existing file systems and the risk to lock the campus into a single proprietary vendor, the decision must be based on clear requirements on flexibility and adaptability of purchased solutions and legacy systems (Looney & Lyman, 2000). Efficiently, an education portal implementation must consider all requirements at the infrastructure level in order to assure its accurate, long-term operation (Gleason, 2001).

STRATEGIC SPACE OF EDUCATION PORTALS

Looking at the factors classified by Oblinger and Kidwell (2000), the prerequisites for a successful education portal implementation and the global portal environment of campus-specific variables may very well differ from institution to institution and may shape the educational opportunities of portals in very different ways. Whereas, governance and infrastructure appear to play more of a role as determinants of the institutional environment in which a portal strategy is embedded. Thus, the greatest source of strategic development opportunities of education portals is the service level.

The focus on services realigns the discussion of education portal strategies to the core of education portals - open and distance learning (ODL). Katz (2000, 2002) specifies four dimensions that capture the strategically most significant aspects in this field: teaching, learning, communication and interaction.

TEACHING AND LEARNING

Teaching and *learning* are best thought of as interconnected and interrelated. However, the subject falls into two dimensions when it is regarded in the context of portal strategies and concrete strategic decisions on the design of e-learning systems (ELS), organizational and processes-related issues. The primary interest here is how far and how consistent a campus intends the portal to support and enhance teaching, learning and related administrative processes (Oblinger, 2001).

The distinct dimensions differentiate the common terms *e-learning* and ODL towards a strategically meaningful view, and put the ELS concept in the focus of education portal strategies. This is key to create a beneficial learning environment with a positive impact on both effectiveness and efficiency of the teaching and learning process. Whereas, effect refers to qualitative educational objectives on certain competencies or knowledge. Efficiency relates to the time or effort needed to achieve this objective. The wide ELS spectrum can roughly be divided into the areas learning management systems (LMS) to administrate learning and teaching processes, and learning content systems (LCS) to provide adequate support in the acquisition of knowledge or competencies (Becker & Knackstedt, 2004).

Courses and curricula define the educational profile of a campus as well as a portal. Therefore, content development and the implementation of appropriate applications to deliver this content are crucial issues in LCS. Comprehensive, well designed resources may stimulate students' self-directed learning. Whereas, to achieve an optimal online resource pool it is essential to recognize that existing conventional content cannot be transferred directly into technology supported courses (UNESCO, 2002b). Therefore, the quality, scale and scope of the portal resources is at least to some extent a question of the design and development capabilities of teachers who are often considered as the content producers (Alpar, Grob, Weimann & Winter, 2002). Another important aspect of ELS relates to the administrative support of students and teachers. LMS may replace formerly separate staff functions so that teachers or students themselves can perform administrative tasks with little effort and parts of the original campus administration become obsolete (Hawkins, Rudy & Nicolich, 2005).

COMMUNICATION AND INTERACTION

Education portals provide an enhanced platform for communication and interaction as facilitators and enablers for teaching and learning processes (Oblinger, 2001). Both areas represent target dimensions of portal strategies.

A central principle of learning, *communication* in an education portal environment involves teachers, students and supporting administrative staff. The portal can provide its users with easier access to information as well as with information that is more relevant to them. In so doing, it manages the application framework which distributes information resources in multiple forms and media. Such resources can be communicated either synchronously or asynchronously, pushed by broadcasting or accessed on demand. As these applications change, so the quality and nature of the resources and the impetus on the learning process will change (Pickett & Hamre, 2002). Thus, the sophistication of communication channels of a portal controls the quality of the information, and the resource flow and exchange.

Another key principle of learning, the emphasize of *interaction* underlines that in the education portal concept learning is not just about covering content, and it is not technology alone. The purpose of technology is to effectively support good pedagogy (Dede, 2005). Interaction means connected, collaborative generation of knowledge and acquisition of skills between students and teachers and among students and students (Oblinger, 2001).

The education portal creates an interaction space, on the one hand, for larger numbers of students to share a common learning experience, or on the other, to enable an individual student to have a unique, personal interaction with a teacher or with another student, no matter where located. More importantly, these learning experiences can be of much higher quality than they would be possible without an advanced, virtual communication and interaction platform (Collins, 2003).

INTERDEPENDENCIES

While learning content is the central resource, applications supporting communication and interaction in practices, experimentation, simulation and project work facilitate the transfer of content into knowledge and capabilities. A portal may cover a broad range of corresponding features that all imply different levels of sophistication of the ELS which embeds the entire teaching and learning process and related administrative activities. Furthermore, as teaching and learning techniques will change along with more interactive, self-directed approaches of student involvement in the education process, so the fundamental roles and the relationship of teachers and students will do (Oblinger, 2003).

The connections between these subjects show the way for a strategy concept that must understand all dimensions from teaching and learning to communication and interaction as interdependent aspects of digital education services. The strategic goals along these dimensions must reflect the interdependence.

In a straight forward approach towards more advanced education concepts on ELS, interaction becomes more and more an integral aspect of portal applications and the teaching and learning process. Students will not only benefit from the unified interface to courseware and required information about courses, easier communication with teaching and administrative staff, but also access to communities of interest and community services, and enhanced learning opportunities tailored to specific learning needs and preferences, following an increasingly student-centred view (Oblinger & Oblinger, 2005).

Hence, also ELS features require gradual or continuous adjustments in order to meet educational standards based on learning behaviour, and preferred communication and interaction processes. In this context reference models on such behavioural aspects may be helpful (Becker, Delfmann & Knackstedt, 2004). In terms of curriculum and application development, they may be obtained from integrated just-in-time student assessments and program planning in order to better understand the learning effect of different courseware (Olds, Moskal & Miller, 2005).

Furthermore, a corollary of changing patterns of teaching, learning, communication and interaction, the redefinition of ELS roles in furthering and adapting the education process present a strategic issue in portals since it is based on the three features personalization, customization and standardization, and closely linked to clear and distinct role schemes. The strategy must acknowledge that depending on the focus of the education concept teachers may act as architect, consultant, expert, guide, lecturer, resource, reviewer. A student may be apprentice, builder, listener, mentor, peer teacher, publisher, team member, writer (Oblinger & Oblinger, 2005).

Eventually, the technological opportunities to adapt an ELS to concrete needs according to different principles of learning and role models appear to be unlimited (Dede, 2005). The great opportunities notwithstanding, an education portal strategy will hardly succeed without the consideration of capabilities of both teachers and learners to make use of the technology (UNESCO, 2002a).

STRATEGIC APPROACHES

The four dimensions teaching, learning, interaction and communication constitute the strategic space in which the education portal strategy pursues objectives, determines the scale and scope of a portal solution, educational services and features. The remaining question is the strategy formation itself.

UNESCO (2002a) identifies four broad approaches through which educational institutions adopt and use information and communication technology (ICT), termed emerging, applying, infusing, and transforming. These categories reflect the specificities of campus environments with different institutional determinants for the adoption process.

On the application of the strategic dimensions outlined above, it is possible to derive a compatible concept of equivalent approaches that all imply a certain strategic posture of education portals. Thus, the approach a campus pursues towards

Table 1. Generic approaches towards education portal strategy

Strategy appraoch	Emerging	Applying	Infusing	Transform-ing	Virtual campus
Interaction			collaborative learning, learning content systems adopted to teaching practice, integration with non-ICT content, increasing student responsibility	strong leadership, clear governance models, ICT is integral to overall curriculum development, web-based learning, interaction spaces	if upon education concept implementation no transformation is needed but rather an ad-hoc concept of an entirely virtual organization and corresponding processes
Communi-cation	didactic pedagogy, focus on learning management systems, basic communication	Factual knowledge-based learning, learning management systems, learning content systems developed by specialists, content applied in discrete subjects			
Education concept	**Teacher-centred**			**Student-centred**	

education portal strategy can be understood as generic. However, the institutional preconditions, technological opportunities and capabilities, and education concepts present the starting point of a campus-adequate strategy.

The *emerging approach* is firmly grounded in traditional, teacher-centred practice. The curriculum reflects an increase in basic communication functionality. This way the campus community develops an awareness of the benefits of portal technology. The vision reflects individual benefits so that interactive pedagogy is rather a minor aspect in the portal concept than a part of an integrated e-learning program. Teaching and learning processes follow conventional didactic patterns.

The *applying approach* replaces offline tasks formerly carried out in the campus administration and in the curriculum through online portal applications. Whereas, the development of applications and features is driven by ICT specialists. Teachers largely dominate the learning environment that is mainly designed for factual and knowledge-based learning. Direct interaction between students and teachers takes still place offline.

The *infusing approach* involves integrating and embedding the curriculum in the portal, and is seen at those campuses that already employ a broad range of computer-based technologies in laboratories, classrooms, and administrative offices. Teachers explore new ways in which the portal can change and optimize their professional practice, and the effectiveness and efficiency of learning processes. Driven by subject specialists the curriculum begins to merge resources with comprehensive ELS functionality. The student focus increases along with the availability of more collaborative applications.

The *transforming approach* is appropriate for campuses that use technology to rethink, modernize and innovate their entire organization. The education portal becomes an integral part of daily personal productivity, teaching and learning practice. The focus of the curriculum is student-centred and integrates a variety of resources in sophisticated applications that support multi-sensory, experiential learning and different preferred learning styles. The ELS incorporates all areas of teaching and learning, and related administrative activities. Collaboration and mentoring concepts play a key role. The governing body demonstrates strong leadership and requires an advanced level of community involvement. Through a consistent transformation, a campus can become a completely virtual education centre.

The international experience shows that the adoption of ICT and the transition of conventional campus environments is usually a gradual process (UNESCO, 2002a). Therefore, the generic approaches can be seen either as a continuum of stages for the implementation of portal technology or as ad-hoc concept to guide a portal strategy in the definition of a deliberate balance of strategic goals in order to leapfrog certain stages. Whereas, necessary resource commitments at the portal service and infrastructure level will increase the greater the step is from an existing institutional framework, its educational objectives and its technological readiness towards a more *virtual campus* approach (UNESCO, 2003).

CONCLUSIONS

Eventually, it is obvious that the challenge of an education portal strategy is no less than the challenge of bringing a campus into a wave of technology. The generic approaches can assist the delineation of strategic success factors and development priorities for portal development. They provide a framework to further the teaching, learning, communication and interaction capacity of existing portal solutions in systematic way, adapted to the specificities of a campus. Table 1 illustrates the multi-dimensional picture outlined above and its interdependencies.

REFERENCES

Alpar, P., Grob, H. L., Weimann, P., & Winter, R. (2002). Anwendungsorientierte Wirtschaftsinformatik - Eine Einführung in die strategische Planung, Entwicklung und Nutzung von Informations- und Kommunikationssystemen, 3. Braunschweig-Wiesbaden, Germany: Vieweg.

Barratt, W. (2003). Information technology in student affairs. In S. R. Komives, D. Woodard Jr., & Associates (Eds.), *Student services: A handbook for the profession* (pp. 379-396). San Francisco: Jossey Bass.

Becker, J., Delfmann, P., & Knackstedt, R. (2004). Adaption fachkonzeptioneller Referenzprozessmodelle. *Industrie Management, 20(1),* 19-21.

Becker, J., & Knackstedt, R. (2004). Referenzmodellierung im Data-Warehousing. State-of-the-Art und konfigurative Ansätze für die Fachkonzeption. *Wirtschaftsinformatik, 46(1),* 39-49.

Collins, H. (2003). Enterprise knowledge portals: Next generation portal solutions for dynamic information access, better decision making and maximum results. New York: Amacom.

Dede, C. (2005). Planning for neomillennial learning styles. *Educause Quarterly, 28(1),* 7-12.

Gleason, B. W. (2001). Institutional information portal - key to web application integration. In Information Technology (Ed.), *White papers* (document reference january 2001). Bosten, MA: Bosten College.

Hawkins, B. L., Rudy, J. A., & Nicolich, R. (2005). Web portals. In *Core Data Service - Fiscal Year Summary Report* (pp. 57-61). Washington, DC: Educause.

Katz, R. N. (2000). It's a Bird. It's a Plane. It's a Portal? What is a campus portal strategy and why do you need one? *Educause Quarterly, 23(3),* 10-11.

Katz, R. N. (2002). *Web portals & higher education*. San Franscico: Jossey Bass.

Kavavik, R. B. (2002). E-business in higher education. In R. Katz (Ed.), *Web portals & higher education* (pp. 41-67). San Franscico: Jossey Bass.

Looney, M., & Lyman, P. (2000). Portals in higher education: What are they, and what is their potential? *Educause Review, 35(4),* 28-36.

Oblinger, D. G., & Kidwell, J. (2000). Distance learning: Are we being realistic? *Educause Review, 35(3),* 31-38.

Oblinger, D. G. (2001). Will e-business shape the future of open and distance learning? *Open Learning, 16(1)*, 9-24.

Oblinger, D. G. (2003). Boomers, gen-xers, and millenials - Understanding the new students. *Educause Review, 38(4),* 37-47.

Oblinger, D. G., & Oblinger, J. L. (2005). *Educating the net generation.* Washington, DC: Educause.

Olds, B. M, Moskal, B. M., & Miller, R. L. (2005). Assessment in engineering education: Evolution, approaches and future collaborations. *Journal of Engineering Education, 94(1),* 13-25.

Owston, R. D. (1997). The world wide web, a technology to enhance teaching and learning? *Educational Researcher, 26(2),* 27-42.

Perraton, H. (2000). *Open and distance learning in the developing world.* London: Routledge.

Pickett, R., & Hamre, W. (2002). Building portals for higher education. *New Directions for Institutional Research, 113*, 37-55.

Strauss, H. (2002). All about web portals: A home page does not a portal make. In R. Katz (Ed.), *Web portals & higher education* (pp. 33-40). San Franscico: Jossey Bass.

UNESCO. (2000). *Informatics for primary education. Recommendations.* Moscow: Institute for Information Technologies in Education, International Federation for Information Processing, & Institute of New Technologies of Education.

UNESCO. (2002a). *Information and communication technology in education -A curriculum for schools and programme of teacher development* (UNESCO document symbol ED/HED/TED/1). Paris: Division of Higher Education.

UNESCO. (2002b). Open distance learning - Trends, policy and strategy considerations (UNESCO document symbol ED.2003/WS/50). Paris: Division of Higher Education.

UNESCO. (2003). *The virtual university: Models and messages.* Paris: International Institute for Educational Planning.

MIS Recruitment and Retention Factors: Some Preliminary Cross-Cultural Comparisons

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ABSTRACT

With the growing internationalization of businesses, and the increasing mobility of IS/IT professionals there is a need to understand the aspects of the work environment and the job that motivates these professionals. As more and more organization employ professionals from a range of different cultural backgrounds, the question arises as to whether or not the incentives structure, work features and motivators are the same for different cultural groups. This paper reports the results of a pilot study comparing attitudes of computing professionals from three countries (Australia, China and the Philippines) into those work environmental factors and motivators that act as incentives to join a company, and to remain. Exploratory factor analysis identified eight factors that attracted individuals to join and stay with a company. These factors when converted to composite variables results compared for the three countries. The similarities and differences are compared suggesting that a "one size fits" all approach to recruitment in IS may not be justified.

Keywords: Motivators, Incentives, Information Systems, Cross-cultural, International Comparisons

INTRODUCTION

During the late 90s and early 2000, the worldwide shortage of IS/IT professionals caused serious concern in economies around the world. This shortage seems to have abated, maybe temporarily. With the growing internationalization of businesses, the interdependencies of the world economies, and the increasing mobility of IS/IT professionals there is a need to understand the aspects of the work environment and the job that motivates IS professionals. As more and more organization employ professionals from a range of different cultural backgrounds, the question arises as to whether or not the reward structure and motivators are the same for different cultural groups.

The study reported in this paper explores the features of the working environment that firstly attracts an IS/IT professional to join an organization and secondly whether the views have changed since joining. This will be of benefit to employers of IS/IT professionals recruiting from widely differing cultures in understanding in some way what may motivate their staff.

OTHER STUDIES

Gill and Pidduck (2001) showed that work challenge and work environment were far more important to IS professionals than issues of compensation. The Gartner Group (Morello, Zidar, McNee & Smith 1998) predicted that enterprises relying on financial compensation alone were likely to have a high staff turnover. Goles (2001) reporting on student perceptions of IS/IT job attributes, suggests that financial and other benefits are not used to select jobs but rather to eliminate them. Goles further suggests that the learning of new skills in the job is of significant interest amongst students. Smits, Tanner & McLean (1995) found that salary was only an indicator of career progress and was not a significant indicator of job satisfaction of organizational commitment. Lee (2002) provided some interesting insights regarding career strategies, job and career plateauing, and job satisfaction among IT professionals. Paré, Tremblay & Lalonde (2000) presented a model to explain turnover intentions of IT staff and identified several factors covering HR practices, remuneration and organizational behavior & commitment that influence turnover intentions. A slightly more recent study by Horwitz, Chan and Quazi (2003) addressed the issues of attracting then motivating and retaining qualified knowledge workers. They separated the approach into three separate strategies. The most popular motivation and retention strategies had some common overlap covering challenging work, management support, work freedoms and bonuses which also were the more effective strategies for retention whereas strategies such as flexible work practices and funding for studies and conferences were the least effective. More recently King, Xia, Quick & Sethi (2005) demonstrated there were complex mediating relationships involving socialization tactics, role adjustment and organizational attachment which made IT professionals different from other professionals.

Several authors have suggested that training was an important factor in both the hiring and retention of IT professional staff (Gjestland, Blanton, Will & Collins 2001; Paré, Tremblay & Lalonde 2001; Acton & Golden 2002). Paré et al. in particular noted that IT employees are sensitive to the importance of skill development when it comes to deciding whether to leave an organization. They also noted that training is too often regarded by employers as a perk rather than an investment in intellectual capital. Lash & Sein (1995) presented a theoretical framework where organizations and IT professionals are motivated by different expectations. Organization, they suggest, have specific needs leading to jobs that must be filled whereas IT professionals are concerned with career anchors. Thatcher *et al*. (Thatcher, Liu & Stepina 2002) developed a path model examining that showed intrinsic motivation that was positively related with job attitudes and found hygiene factors were important in motivating IT workers.

A study of new information systems professionals King & Xia (2001) found that socialization of new employees was an important factor in retaining newly hired IT employees. They proposed that organizations make a special effort to assist new IT employees adjust via socialization processes to help them change from "outsiders" to "insiders" including mentoring schemes. Lee (2002) found that social support is significantly associated with job satisfaction and turnover intentions.

Little has been reported concerning the issue of cultural differences involving MIS professionals' career anchors. Wormley and Igbaria (1991) reported on differences experienced by Afro-American MIS employees, found less job discretion, and career support than their white counterparts. Further they found less career satisfaction, lower performance ratings and earlier career plateaus than whites. Igbaria and McClosky (1996) surveyed 90 MIS employees in Taiwan. They found that job security, service and challenge were rated highest whilst technical competence and autonomy were rated lowest. They noted a number of differences towards entrepreneurship, challenge and autonomy between Taiwanese and American MIS employees with Taiwanese MIS employees exhibiting a lower career orientation.

METHOD

Based on a review of the literature a questionnaire was prepared addressing issues relating to features of the job, working envirnment and surrounding matters which might initially attract someone to join a company and which might provide incentives to stay. Participants were asked to indicate what attracted them to join their company and if these efatures motivated them to stay after they had joined. Given the concerns often expressed anecdotally by employers over the

churn of highly skilled personnel these are important questions needing answers. Demographic details were also requested including age, gender, years employed in the present position.

Both paper based and web-based survey distribution were used. Mehta and Sivadas (1995) demonstrated that e-mail based surveys generated response rates comparable to those of postal surveys but significantly faster, at lower cost and of a higher quality. On the other hand, Tse, Tse, Yin, Yi, Yee & Hong (1995) in an internal survey of Hong Kong University staff experienced a much lower return rate for e-mail surveys (6%) compared with conventional mail (27%) that they attribute to the possibility of participant identification with e-mail. Comley (1996) found comparable response rates from the two methods. Comley also indicated that electronic data collection methods are often self-selecting due to recipients irregularly checking email messages and consequently have the potential to introduce bias. He points out however that although this is a problem for representative samples it is less of a problem for targeted groups as in the case of the present research. Electronic surveys, by their nature are accessible only by those with access to the appropriate technologies and we would expect that this problem would be lower amongst IS/IT professionals than in the general population because of the nature of the work they do.

The questionnaire was set up using Microsoft FrontPage 2000. Data were captured using Microsoft Access 2000. Electronic surveys have the advantage being pre-coded and free of ambiguity of response in that only one response per item can be selected. They have the disadvantage that they risk missing those who do not have access to computers and the web, although this was not seen to be a problem for the group being surveyed. During the first half of 2003, invitations to participate were sent by email to 365 IS professionals throughout Australia. A total of 40 usable replies were received from Australian participants representing an overall response rate of 11 percent – acceptable for unsolicited surveys of this type but lower than was hoped. In China and the Philippines paper based surveys were distributed by local contacts and distributed numbers are not available. However the selection was based on convenience sampling. Analysis of the data was carried out using SPSS R14.

The survey was sent to IT workers seeking their views on those aspects of the job or organization that appealed to them. Respondents were those who were actually working in an IT environment in a professional capacity. It specifically excluded contractors, self-employed people or those in managerial roles as the study was expressly aimed at IS professionals who are employees.

Participants were asked to rate the importance of incentives offered by employers to IT career professionals. They were asked to rate the importance of 31 items using a Likert scale of 1-5 (where was 1 irrelevant to 5 essential). The incentives considered included opportunity for promotion, travel, a friendly work environment, challenging work assignments, ongoing training provided by the employer, an industry competitive salary, flexible working conditions, reliable internal communications, supportive superiors, scope for individual skills development, and economic fringe benefits such as company vehicles and shares.

RESULTS

As can be seen from Table 1, in each country the majority of IS professionals were male, accounting for nearly 73 percent of respondents from Australia, 80 percent from China and just over 55 percent for the Philippines.

Table 1. Gender distribution

Country (P14)		Frequency	Percent
Australia	Female	11	27.5
	Male	29	72.5
China	Female	6	20.7
	Male	23	79.3
Philippines	Female	21	44.7
	Male	26	55.3

Table 2. Age distribution of respondents

Country (P14)	Age Group	Frequency	Percent
Australia	20-29	18	45.0
	30-39	11	27.5
	40-49	10	25.0
	50-59	1	2.5
China	20-29	18	62.1
	30-39	5	17.2
	40-49	5	17.2
	50-59	1	3.4
Philippines	30-39	43	91.5
	40-49	4	8.5

Table 2 shows the age distribution of respondents. Over 62 percent of the Australian respondents are below 40 years of age, from China 79 percent and from the Philippines nearly 92 percent. As might be expected, fewer respondents were in the above 40 age group presumably because older respondents are more likely to be in senior positions.

Respondents were asked how long they had been employed in their present position. Two people did not answer this question. Of those who did answer the average was 2.7 years, the shortest two months and the longest 10.7 was years. The majority had held their position between 3 months and five years.

Results from the questionnaire containing 31 questions relating to employment aspects are presented in Table 3. Cronbach's α was used to test the reliability of the questions. For pooled results, the Cronbach value was 0.91 for responses concerning "joining" the organization and 0.92 for "staying" with the organization. These each comfortably exceed the benchmark value of 0.7 normally chosen for item reliability. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity were used for testing the suitability for applying factor analysis. The value for KMO was 0.83 and Bartlett's test indicated a significant result indicating the questions were suitable for factor analysis. Principle Components Analysis using a Varimax rotation was applied. Those questions that returned a loading of less than 0.5 and which load on more than one factor were excluded. The final factors with low loadings suppressed for clarity are presented in Table 3.

Eight latent factors were isolated that accounted for just over 70 percent of the variance. The eight factors isolated relate as follows Factor 1 – Job Challenges, Factor 2 – Recognition of self, Factor 3 Non-financial rewards, Factor 4 – Financial rewards, Factor 5 – Company reputation, Factor 6 –Support culture, Factor 7 – Risk aspects and Factor 8 - People related. Composite factors created from these groupings were according to the methods outlined in Hair, Black, Babin, Anderson & Tatham (2006). As the number of component variables was different in each case, an average score was computed from the component variables for each composite factor. The same factors were also applied to responses concerning the reasons for staying with a company. Questions relating to on-going training were confounding variables and loaded onto more than one latent factor. Treated separately they showed no significant differences regarding joining and staying but there were significant differences for the provision of on-going training. This feature was substantially less important for Chinese worker; Australian and Philippine workers were similar in their responses.

Joining Factor Comparisons

The results for desirable features joining the company are presented in Table 4. The composite variables were compared for the three countries using the Kruskall-Wallis test. All but one factor displayed significant differences at the 0.01 level or better. Rewards and company status are much more important to the Philippine group than for either the Chinese or Australian group. The Australian group appears more influenced by stability concerns that do either the Chinese or Philippine groups. Job challenges are slightly more important to Australian IS workers than the Philippine group and much more than the Chinese group.

Table 3. Final rotated factor scores (joining)

	Component							
	1	2	3	4	5	6	7	8
J20 Variety of challenging work projects	.730							
J4 Challenging work assignments	.714							
J5 Provision for on-going training to gain new skills	.702							
J16 The company IT/IS culture	.656							
J10 Opportunities to expand personal skills	.630							
J21 Opportunities for job mobility within the company	.539							
J24 Recognition of my skills by my superiors		.859						
J25 Acknowledgment of effort by superiors		.823						
J23 Recognition of my skills by my co-workers or peers		.789						
J2 Opportunities for sponsored travel			.819					
J28 Opportunities for international work			.767					
J1 Good promotional prospects within the company			.550					
J11 Fringe benefits (eg company shares, car etc)				.796				
J31 Good bonuses based on performance				.715				
J6 A high salary for the industry				.546				
J13 Company reputation nationally					.822			
J14 Company reputation internationally					.716			
J8 Reliable internal communications						.874		
J9 Supportive superiors						.646		
J29 Proximity of company to my home							.782	
J27 There are few opportunities in IT at present							.739	
J17 Company size								.768
J30 Organization is socially active								.646

Extraction Method: PCA.
Rotation Method: Varimax with Kaiser Normalization.
a Rotation converged in 9 iterations.

Staying Factor Comparisons

The results for staying with the company are presented in Table 5. All factors exhibited significant differences across the three samples with the Chinese group clearly rating their views much lower than the others. Rewards, reputation and recognition factors are more important to the Philippine group but risk factor are more important to the Australian group.

Differences

Table 6 summarizes the differences in composite responses for joining and staying with a company. In all cases the z-scores are negative suggesting a lessening of attitude towards their employing company. However there are no significant differences for the Australian group for any of the factors at the 0.05 or 0.1 levels. For the Chinese, "people issues" are significantly different with an increase in the positive ranks. For the other groups there was also an increase but the results were not significant. For the Philippine group the situation is quite different with four factors showing a significant difference between the joining and staying responses covering job challenges, recognition of self, financial rewards and risk factors. Non-financial rewards, company reputation and the support culture factors are not significant for the Philippine group at the 0.05 level but are at the 0.1 level. Only the people factor is not from significant at these levels. However these results display a lessening in the reasons for staying compared with those for joining with the exception of company reputation.

DISCUSSION

These preliminary indicators show that there are some differences in expectations of IS/IT professionals based on cultural origins. It appears from the results that remuneration are less important to both Chinese and Australian IS workers than for Philippine IS workers and similarly for non-monetary rewards. Company reputation is more of an attraction for Philippine staff. Australian staff appear to favor broad recognition of to motivate them to join a company. Australian IS workers also indicate factor such as job availability and proximity to home as important and this may indicate a concern for the current job market in Australia

The differences when asked whether the same items that attracted them to join a company also were important in their staying with the company displayed interesting cultural differences. The responses from Australian participants did not show significant changes. People issues were less and significant for the Chinese group but the remaining factor bore no significant differences. For the Philippine IS workers there were several factors that were significantly different at the 0.05

Table 4. Composite factor mean ranks for each country (joining company) (significant for p<0.01; # not significant p>0.05)*

	country	N	Mean Rank
job challenges *	Australia	40	68.61
	China	29	42.03
	Philippines	47	60.05
recognition *	Australia	40	69.74
	China	29	37.03
	Philippines	47	62.18
non-monetary *	Australia	40	52.84
	China	29	44.52
	Philippines	47	71.95
remuneration *	Australia	40	56.65
	China	29	42.40
	Philippines	47	70.01
company status *	Australia	40	53.41
	China	29	38.88
	Philippines	47	74.94
support culture *	Australia	40	63.91
	China	29	41.31
	Philippines	47	64.50
risk factors *	Australia	40	75.83
	China	29	33.28
	Philippines	47	59.32
people factors @	Australia	40	59.93
	China	29	48.76
	Philippines	47	63.30
	Total (all)	116	

Table 5. Composite factor mean ranks for each country (staying with company - all significant at p<0.01)

	Country (P14)	N	Mean Rank
job challenges stay	Australia	40	61.98
	China	29	41.47
	Philippines	47	66.05
recognition stay	Australia	40	57.98
	China	29	39.66
	Philippines	47	70.57
non-monetary stay	Australia	40	51.21
	China	29	45.14
	Philippines	47	72.95
remuneration stay	Australia	40	52.19
	China	29	41.33
	Philippines	47	74.47
company status stay	Australia	40	57.15
	China	29	41.05
	Philippines	47	70.41
support culture stay	Australia	40	60.93
	China	29	42.22
	Philippines	47	66.48
risk factors stay	Australia	40	75.64
	China	29	31.52
	Philippines	47	60.56
people stay	Australia	40	60.84
	China	29	41.60
	Philippines	47	66.94
	Total (all)	116	

level or better. Factors that became more important included Challenges, Recognition, Rewards ($p<0.1$), Remuneration, Support ($p<0.1$) and Risks; Company reputation was less important ($p<0.1$).

The study has its limitations. Firstly, the number of respondents is quite small and this limits the ability to generalize the results. The differences in responses concerning reasons for joining and reasons for staying with a company were obtained at the same time. This of course relies on the ability of the respondent to remember what aspects were the attractions to join the company and this is problematic for those with a longer service. The data were collected in the respondent's home country. The same outcomes may not be present if collected from people working in a foreign country.

The research reported here is preliminary in nature but does suggest that cultural differences may affect IS/IT staff preferences when it comes to rewards and incentives. With the growing internationalization of companies, the increased mobility of staff, and a growing number of staff from different cultures, it should not be assumed that a homogeneous reward/incentive structure is going to satisfy all. More research into this appears warranted.

The instrument used is available on request.

REFERENCES

Acton, T. & W. Golden (2002). Training: The way to retain valuable IT employees? InSITE - "Where parallels Intersect". Cork, Informing Science: 12.

Table 6. Differences in response joining vs. staying

Test Statistics[c]

		Asymp. Sig.		Asymp. Sig.		Asymp. Sig.
challstay - job challenges	-.26[a]	.80	-1.21[a]	.23	-2.45[a]	.01
recogstay - recognition of self	-1.61[b]	.11	-1.61[a]	.11	-3.06[a]	.00
rewardstay - non-monetary extras	-.15[a]	.88	-1.05[a]	.29	-1.81[a]	.07
finstay - remuneration	-.78[a]	.43	-1.25[a]	.21	-3.28[a]	.00
reputstay - company status	-.71[a]	.48	-.36[a]	.72	-1.74[b]	.08
supportstay - support culture	-.20[b]	.84	-1.36[a]	.17	-1.81[a]	.07
riskstay - risk factors	-1.00[a]	.32	-.25[a]	.80	-2.50[a]	.01
peoplestay - people factors	-.61[b]	.54	-2.18[b]	.03	-.06[a]	.95

a.

b.

c.

Comley, P. (1996). The use of the Internet as a data collection method. URL http://www.sga.co.uk/esomar.html.

Gill, B. & A. B. Pidduck (2001). IT staffing and retention: A success story. Association for Computing Machinery Special Interest Group on Computer Personnel Research (SIGCPR), San Diego CA.

Gjestland, C., J. E. Blanton, R. Will & R. Collins (2001). Assessing the need for training IT professionals: A research model. Association for Computing Machinery Special Interest Group on Computer Personnel Research (SIGCPR), San Diego CA.

Goles, T. (2001). A View from the Entry Level:Student Perceptions of Critical Information Systems Job Attributes. SIGCPR 2001, San Diego CA.

Hair, J. F., W. C. Black, B. J. Babin, R. E. Anderson, et al. (2006). Multivariate Data Analysis. Upper Saddle River, NJ, Prentice-Hall.

Horwitz, F. M., T. H. Chan & H. A. Quazi (2003). "Finders, keepers? Attracting, motivating and retaining knowledge workers." Human Resource Management Journal 13(4): 23-44.

Igbaria, M. & D. W. McCloskey (1996). "Career Orientations of MIS Employees in Taiwan." Information & Management 17(2, April): 3-24.

King, R., W. Xia, J. Quick & V. Sethi (2005). "Socialization and organizational outcomes of information technology professionals." Career Development International 10(1): 26-51.

King, R. C. & W. Xia (2001). Retaining IS talents in the new millennium: Effects of socializing on IS professionals' role adjustment and organizational attachment. Association for Computing Machinery Special Interest Group on Computer Personnel Research (SIGCPR), ACM.

Lash, P. B. & M. K. Sein (1995). Career paths in a changing IS environment: A theoretical perspective. Association for Computing Machinery Special Interest Group on Computer Personnel Research (SIGCPR), ACM.

Lee, P. C. B. (2002). The Social Context of Turnover Among Information Technology Professionals. Special Interest Group on Computer Personnel Research Annual Conference, Kristiansand, Norway, ACM.

Mehta, R. & E. Sivadas (1995). "Comparing response rates and response content in mail vs email surveys." Journal of the Market Research Society. 37(4): 429-439.

Morello, D. T., E. Zidar, B. McNee & C. Smith (1998). IT staff retention and recruitment: Addressing a critical problem for the IS organisation, Gartner Group.

URL: http://gartner11.gartnerweb.com/public/static/hotc/00072957.html.

Paré, G., M. Tremblay & P. Lalonde (2000). The impact of human resources practices on IT personnel commitment, citizenship behaviors, and turnover intentions. International Conference on Information Systems, Brisbane.

Paré, G., M. Tremblay & P. Lalonde (2001). Workforce retention: What do IT employees really want? Association for Computing Machinery Special Interest Group on Computer Personnel Research (SIGCPR), San Diego, ACM.

Smits, S. J., J. R. Tanner & E. R. McLean (1995). Herzberg Revisited: The Impact of Salary on the Job and Career Attitudes of I/S Professionals. SIGCPR95, Nashville, TN, ACM.

Thatcher, J. B., Y. Liu & L. P. Stepina (2002). The role of the work itself: An empirical examination of intrinsic motivation's influence on IT workers attitudes and intentions. SIGCPR '02, Kristiansand, Norway, ACM.

Tse, A. C. B., K. C. Tse, C. H. Yin, K. W. Yi, et al. (1995). "Comparing two methods of sending out questionnaires: E-mail vs mail." Journal of the Market Research Society 37(4): 441-446.

Wormley, W. M. & M. Igbaria (1991). "Organizational experiences and career success of MIS professionals and managers: An examination of race differences." ACM CPR 91: 119-139.

Ontology Negotiation in an Intelligent Agents Dynamic System for Military Resources and Capabilities Planning

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ABSTRACT

The division Concepts of the Assistant Chief of Staff Evaluation (ACOS Eval) of the Belgian Ministry of Defence is making a study on the subject of "management by costs" based on an approach of capabilities. The original idea was based on the generation of future capabilities (investments and planning) and later extended to the operational use of the existing capabilities. In this paper an intelligent agents framework is proposed to simulate the possible scenarios of capabilities. Central to this subject is the ontology issue, where the Ontology Negotiation Protocol, as explained by Bailin and Truszkowski [Bailin 2001], is one of the solutions that should be further developed to resolve the problems related to the ontologies.

Keywords: Intelligent agent, strategy, capabilities, resources planning, ontologies, ONP (Ontolgy Negotiation Protocol), Military

1. INTRODUCTION

The division Concepts of the Assistant Chief of Staff Evaluation (ACOS Eval) of the Belgian Ministry of Defence is making a study on the subject of "management by costs". The purpose of the study is not only to develop a system to manage the costs, but also to provide a decision support system (DSS) to the leaders and managers, based on information about costs.

The original idea was based on the generation of future capabilities (investments and planning) and later extended to the operational use of the existing capabilities. The challenge is that the political (and social) environment is changing fast, which has a considerable influence on the (political) way of using Defence in such a fast moving world.

Flexibility and quick adaptability to new situations are very important in the planning and acquisition of resources for military capabilities. Therefore a system to support the process of acquisition and operational use of capabilities should be dynamic and agile. Scenarios must be quickly and thoroughly evaluated without ignoring the impacts on existing programs and performances.

The study has three phases. The first one is to define an ideal system where different kind of techniques are used like operational research, commercial-of-the-shelf software, benchmarking and intelligent agents. The latter is the subject of this paper. The second phase is to distillate the necessary conditions of "the management by costs" and confront them in a third phase with the existing (dispersed but not integrated) systems to propose the change management, which implies the implementation of the new system.

This paper will treat a conceptual model of "management by costs" to plan the acquisition of future resources and to follow up the operational use of the actual resources, by using intelligent agents (pieces of software which can determine their own strategy to obtain their given objectives). In the following paragraph, the global context of capability approach is described. Paragraph three discusses the framework of intelligent agents for the configuration of future capabilities and the issues around ontologies. The operational use of capabilities is described in paragraph four. This paper ends with possible extensions of this framework, further research and conclusions.

2. CAPABILITY APPROACH

The political leaders would like to have some effects on the society (outcomes) by using the military power, which will then perform actions (output) to obtain these effects. The wanted effects will be described in a number of scenarios ([Bernard 1978], [Géré 2000]) . Therefore the Military Command will configure capabilities to perform actions for all scenarios. However due to budgetary and operational reasons, not all scenarios can be covered at the same moment. The political leaders have to express which will be the maximum deployment of forces (capabilities) at the same time. Military Command can propose different configurations, each with the costs. Or the political leaders can decide a maximum budget, for which the Military Command can optimise the configuration of capabilities. Rabaey et al. [Rabaey 2006b] describe a model of the capability approach based on semantic web technologies, however this model uses only web services and concerns more the business processes necessary in a framework of capability approach.

Modules deliver the necessary capabilities, where one module can serve multiple capabilities. These modules are composed of resources. In the process area of capabilities generation, modules and/or resources are acquired following investment and recruiting plans (acquisition function). So we have a schema of outcomes – outputs – capabilities – modules – resources [Rabaey 2006a].

3. DYNAMIC SYSTEM WITH INTELLIGENT AGENTS

3.1. General Description

As already mentioned, the environment of a country or allied countries is changing very fast. A 'stable' future cannot be foreseen and the enemies of the democratic countries and the operation theatres are all over the world and are quite unpredictable. Therefore a dynamic system to determine the most optimal configuration is necessary.

Rabaey et al. described the concept of Business Intelligent Agents (BIA) to construct dynamic processes [Rabaey 2003]. The BIA asks for services at web services or other BIA. The correct communications through the different ontologies are therefore very important. In this paper we present a framework that goes deeper into the processes and services, namely the resources which use the processes.

So, we are studying a model where intelligent agents (IA) represent the items of some levels. Intelligent Agents are software entities that carry out some set of operations on behalf of a user or another program with some degree of independence or autonomy, and in so doing, employ some knowledge or representation of the user's goals or desires.

They get their information out of a Knowledge Base (KnB) by appealing to the KnB's IA and its ontology. Citing Gruber, an ontology is "a specification of a conceptualization" [Gruber 1993]. It describes the terms with their attributes and relationships in a specific domain. When ontologies were introduced in computer science, they were designed for artificial intelligence purposes since they pertain to knowledge sharing and reuse [Gruber 1991]. More recently, they are also used in the fields of information retrieval and the like [Fensel 2004]. The introduction of ontologies in information retrieval improved the search results in a repository or knowledge base. Contrary to a traditional keywords search, only information relevant to the request or query is shown due to the shared understanding. Not

only a shared vocabulary is available, but also axioms for specifying the relationships between the different terms [Decker 1999]. Therefore, the information of the KnB is categorized on the basis of an ontology.

3.2. Dynamic and Complex System

The idea of IA's came from concepts of quantum medicine and quantum healing. Some forms of quantum medicine tell us amongst other things that the whole body keeps memories of events and emotions and that organs, molecules and so on have knowledge or intelligence of what has to be done in the body (through some sort of 'communication channels'). This implies that the brains control not everything, but that intelligence and communication capabilities are spread all over the body [Chopra 1989].

So the model of the armed forces is the quantum model of the body and the mind, and each part, represented by an IA, can communicate to bring and to keep the body and the mind (Defence-model) in balance and optimise its functioning. However, it is not the purpose to develop a "Quantum Defence" where everything is leaded and managed by software pieces. The purpose of the quantum medicine is to construct a model of the mind/body to better understand the complex set of mind and body of a human being. Our purpose is to give the military leaders a model/tool to help them better understand the complex organisation, which Defence is. Nothing can replace the military genius.

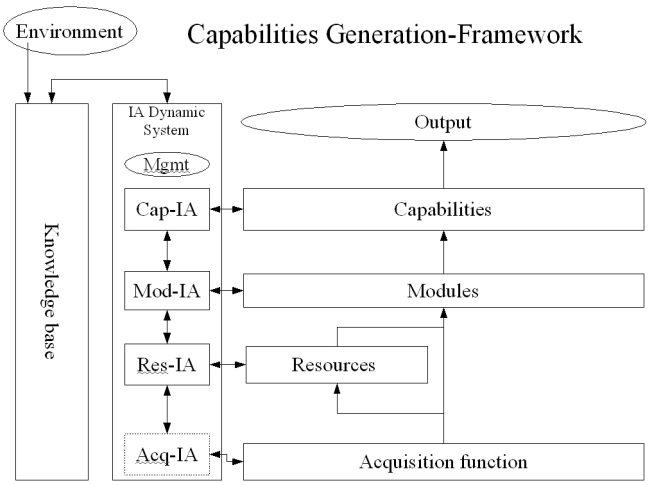
An intelligent agent (IA) or group of IA's represents each item of every level. Each IA is having its own domain ontology. In other words, an ontology is specific related to the agent's world ([Tamma 2006], [Rabaey 2006b]).

The IA's are however working under the guidance of a management cell (Mgmt), which defines the environment, given in a container, that the IA's have to use. This means that the environment or the domain the IA's have to use is described by the ontology of the container. Each IA will receive its ontology or environment by the management cell.

The first semantic problem which poses a problem is when the IA has to formulate a strategy by consulting the information available in the KnB. This implies that the IA needs to understand the ontology employed for categorizing the information in this KnB.

The communication with other IA's is a second ontology conflict which poses a threat. They have to communicate with other IA's of the same or other levels in order to reach its (acceptable) optimised configuration (taking into account the set of constraints and the expected output). At this point, all costs of the resources to acquire (humans, material, infrastructure, etc.) and the costs of existing resources and the maintenance of both can be calculated for a certain period. Of course, the Military Command and/or political leaders will decide themselves, which will be the final solution. The dynamic system is only a decision support system. Therefore, some kind of shared understanding for enabling communication between IA's is imperative [Fensel 2004]

Figure 1. The capabilities generation-framework



Since each IA is using its own private ontology, a mechanism for bridging this ontology heterogeneity is essential [Tamma 2006].

3.3. Ontology Negotiation

Li Ding et al distinguish in their work [Ding 2006] five different kinds of solutions for tackling this problem: one centralized global ontology, merging ontologies, mapping ontologies, ontology translation and runtime ontology resolution. By creating one centralized global ontology, ontology heterogeneity is excluded, but its creation and maintenance is very time-consuming and consequently very expensive. In case different ontologies are having domain similarities, it is interesting to merge them into one ontology. This has as drawback that the merging procedures have to be retaken each time something has changed to one of the initial ontologies. The process where relations between similar words are mapped is called mapping ontologies [Ding 2006]. This technique is very valuable for understanding each IA's view on the world or to visualize their boundary objects [Mika 2003]. A boundary object was first coined by [Star 1989] and can be defined as an object which is used as a kind of interface between boundaries of the domain knowledge of each IA Ontology translation is another solution for ontology heterogeneity. It translates two ontologies into a target ontology. The last kind of solution – runtime ontology resolution – takes place during the real time IA interaction [Ding 2006].

The ontology negotiation protocol (ONP) explained by Bailin and Truszkowski [Bailin 2001] belongs to this latter category. This protocol is focused on information retrieval tasks and is occurring automatically and without a human intervention [Bailin 2001]. The following paragraph summarizes the ONP of Bailin and Truszkowski since we deem that the implementation (with the necessary adaptation) of this protocol in our framework is quite valuable. This ONP distinguishes four parts: interpretation, clarification, relevance analysis and ontology evolution [Bailin 2001].

IA(a) sends a query message (which contains a sequence of keywords) to IA(b). IA(b) tries to interpret each word of the message by looking at its own terminology. In case the word is not retrieved in its terminology, it searches for synonyms at a semantic lexicon such as Wordnet (online available at http://wordnet.princeton.edu). Then, it compares the synonyms with the ones in its own lexicon and when there is a match, IA(b) sends a confirmation to IA(a). In case IA(b) does not find any of the synonyms in its repository, a clarification request is sent to IA(a). After a clarification and/or confirmation, the results of the query are analysed and compared with the query itself in order to determine how well the results (documents) are corresponding with the initial query. The relevance is computed by performing some tests. In the last phase of this negotiation, the possibility of expanding the ontology with new concepts is examined and depending on the results one of the ontologies is adjusted. [Bailin 2001].

3.4. The Working of the Dynamic System

In order to come to an optimised configuration, the ontology problems have to be resolved in order of appearance: interpretation of the KnB's ontology by each IA and the communication between the IA's of the different and equal levels. The paragraphs below describe how these conflicts can be resolved and they are mainly based on the ONP of Bailin and Truszkowski [Bailin 2001].

1. When the IA(a) receives its environment, it can start to collect relevant information in the KnB. It is important for the IA(a) receiving the most appropriate information for establishing its strategy. Based on its received ontology, the IA(a) can formulate and send a query to the IA(b) of the KnB. This query contains a set of keywords collected from the IA(a)'s ontology. Each keyword is being checked whether the IA(b) can understand the keyword. This check is performed by searching for it in its ontology. When the element is not retrieved, a semantic lexicon such as Wordnet should be consulted as is proposed in the ONP of Bailin and Truszkowski. It aims at locating synonyms in the IA(b). These synonyms can enable a semantic translation bridge between both IA's ontologies. In case the intervention of such a lexicon is not sufficient, a clarification should be asked at the IA(a). When a clarification and/or confirmation are obtained, the quality of the query results sent to IA(a) are examined. During the last phase, it should be determined whether the ontology of IA(a) or IA(b) has to be extended with a new concept.
   When this process is executed for every IA, all the IA's have to start formulating their own strategy. How this strategy is built will not be tackled in this paper.

2. After the strategy creation, all the IA's have to communicate with each other in order to come to its optimised configuration. The desired effects and the strategy to obtain these are communicated from top to bottom. The horizontal negotiation or collaborative model is an approach which enables achieving these effects and strategy.
   In this model the IA's are collaborating or negotiating horizontally to get a global optimum (at their level i). This global optimum is based on defining the optimum use of services of a lower level, level i+1. Therefore downwards negotiation for obtaining information on the lower existing services is necessary. The information will then be communicated upwards, to the level i. This means that ontology negotiation is respectively needed in two directions: horizontally and one level downwards. The horizontally ontology heterogeneity can be solved by merging the ontologies of all the IA's of the same level into one ontology X_i. In that way the IA's of the same level can collaborate and negotiate with each other. Consequently, an information query concerning the optimum use of services of the lower level (i+1) is sent to level i. The ontology X_i tries to interpret all the keywords of this query as described in the ONP of Bailin and Truszkowski. With this information the IA's of level i can create a global optimum at level i. This process is repeated until the highest level is reached.

4. OPERATIONAL USE

Derived from the first framework, we can also build a framework where the existing capabilities and its underlying components are trained and used. The main purpose in our study is to get an estimation of the operational costs (operations and training).

Combined with the objectives of the operations (or training), we can define the degrees of effectiveness, efficiency and transmittance. Transmittance is the ratio that determines the allocation of ALL resources of an organisation regarding ALL the objectives of the organisation.

However other aims than management by costs can be obtained. Heraclitus said once: "You could not step twice into the same river; for other waters are ever flowing on to you." If not only the generic characteristics of resources and modules are registered but also others, registered from earlier operations and training (p.e. Moral strength), then we can have the evolution of those items, so that we can differentiate modules and in this way gather the most ideal modules for one use of a specific capability.

Therefore a whole system of evaluation and/or lessons learned can be put in place to register and treat the performance of the different resources and modules. As a consequence, besides getting information about the operational and professional value of the elements of Defence, feedback for the KnB of the Capability Generation Framework will be obtained, so that more accurate information can be taken into account for a better DSS in that domain (See figure 2).

5. EXTENSIONS

Units of the Armed Forces can be in one of the different states (rest, action, and so on). After a period of rest, the resources could be put back for conditioning, forming, then reassigned into modules ready for training in capability scenarios. For a structure of Resources – Modules – Capabilities, this implies that for each level a different kind of management can be designed. If territorial capabilities are demanded, like helping the population during and after disasters, then the capability manager can train the military unites (modules) together with civilian units of the government. This can be done by extending the system to other parts of government departments.

If the military units are deployed with other units of allied nations, then a standardised system can be designed , or the interfaces with the respective systems can be standardised.

In both cases of collaboration with others, the security of the Knowledge Base and of the intelligence must be assured.

The next logical step is to make simulations. Therefore the environment should be modelled. Other systems may represent enemies, terrorist groups, population and so on.

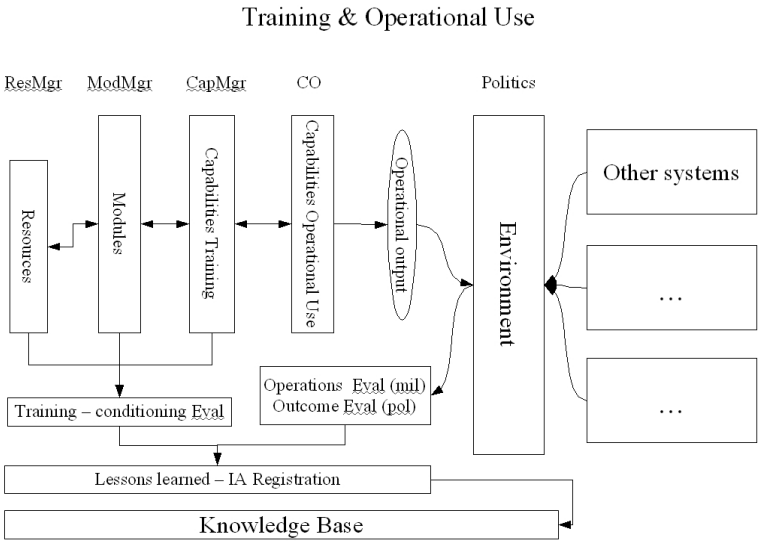
6. FURTHER RESEARCH

Intelligent agents are communicating with each other in so called containers. In the beginning IA could only determine its strategy regarding the environment, if this environment was explicitly defined in its set of parameters. Now IA technology has evolved, IA can now react differently according the rules of the container in which the IA has to undertake actions. Flexibility and adaptability are some of the advantages of specific containers. In the Capability Generation framework, the same system of IA can be used in different countries, each with its own set of acquisition rules, represented by their respective country IA-container.

A second point is the formal way of representing the characteristics of the resources, modules and capabilities, so that they can be interpreted by the IA.

A third point is the refinement of the Ontology Negotiation Protocol of Bailin and Truszkowski [Bailin 2001]. Since a collaboration with other countries and agencies

Figure 2. Training and operational use



is necessary, we may have to consider the incorporation of boundary objects for solving the multi-linguistic ontologies and differences in culture and reasoning. This means that ontology mapping should be embedded in this ONP in order to come to ontology mapping negotiation protocol. This will be the challenge, if no global, universal semantic system will exist.

The system of capabilities and resources planning can also be used in a civilian context (business and/or government), so that synergies with civilian parties can be found.

7. CONCLUSIONS

The dynamic systems of resources and capabilities planning and of capabilities generation are still in a conceptual stage, where further research is still needed. It was originally conceived to calculate the costs of the capabilities generation. We have also seen that the derived operational use model can not only be used to calculate the operational use of existing capabilities, but also to build a global evaluation system, where lessons learned can be established, and that can give feedback to the capabilities generation framework. The possible integration of an "environmental" context could give the opportunity to simulate scenarios and to hold computer aided military exercises.

In this paper an intelligent agents framework is proposed to simulate the possible scenario's of capabilities. Central to this subject is the ontology issue, where the Ontology Negotiation Protocol, as explained by Bailin and Truszkowski [Bailin 2001], is one of the solutions that should be further developed to resolve the problems related to the ontologies.

8. REFERENCES

[Bailin 2001] Bailin S. and Truszkowski W. (2001): *Ontology negotiation between agents supporting intelligent information management*. In *OAS'01 Ontologies*

[Bernard 1976] Bernard, Henri (1976): *Totale Oorlog en revolutionaire oorlog, Band I*; Belgian Royal Military School, Brussels (in Dutch)

[Chopra 1989] Chopra Deepak (1989): *Quantum healing: exploring the frontiers of mind/body medecine*. Bantam Books, New York

[Decker 1999] Decker, K., Erdmann, M., Fensel, D., Studer, R.: *Ontobroker: Ontology based Access to distributed and semi-structured Information*. In R. Meersman et al. (eds), *Semantic Issues in Multimedia Systems*, Kluwer Academia, 1999.

[Ding 2006] Ding Li, Kolari Pranam, Ding Zhongli and Avancha Sasikanth (2006): *Using Ontologies in the Semantic Web: A Survey*. Book chapter in *Ontologies in the Context of Information Systems*, accepted for publish (expect 2006)

[Fensel 2004] Fensel Dieter (2004): *Ontologies: a silver bullet for knowledge management and electronic commerce*, 2nd ed. Berlin, Springer

[Géré 2000] Géré François (2000): *Dictionnaire de la Pensée Stratégique*. Larousse, Paris.

[Gruber 1991] Gruber Thomas R. (1991): *The role of common ontology in achieving sharable, reusable knowledge bases*. In. Allesn, J.A., Fikes, R., Sandewal, E (eds) *Proceddings of the Second Int. Conf. on Principles of Knowledge Represenatation and Reasoning,* San Matao, CA, Morgan Kaufmann, 1999.

[Gruber 1993] Gruber Thomas R. (1993): *A Translation Approach to Portable Ontology Specifications*. In *Knowl Acquis,* 5(2), pp.199–220

[Mika 2003] Mika, P, Ackermanns, H. (2003): *Analysis of the State-of-the-Art in Ontology-based Knowledge Management*. Project Paper.
URL: http://km.aifb.uni-karlsruhe.de/projects/swap/public/public/Publications/swap-d1.2.pdf#search=%22Analysis%20of%20the%20State-of-the-Art%20in%20Ontology-based%20Knowledge%20Management%22

[Rabaey 2003] Rabaey, Marc, E. Vandijck and H. Tromp (2003). *Business Intelligent Agents for Enterprise Application Integration: the link between Business Process Management and Web Services*. Proceedings of International Conference Software Systems Engineering & Applications, Paris, December 2003

[Rabaey 2006a] Rabaey Marc, Vandenborre Koenraad and Tromp Herman (2006): *Holistic Approach to align ICT Capabilities with Business Integration.* Book chapter in *Adaptive Technologies and Business Integration: Social, Managerial and Organizational Dimensions* Ed. By Prof. Maria Manuela Cunha and Prof. Goran D. Putnik , Idea-Group Publishing, Hershey PA.

[Rabaey 2006b] Rabaey Marc, Vandenborre Koenraad, Vandijck Eddy, Timmerman Martin and Tromp Herman (2006): *Semantic web services and BPEL: semantic service oriented architecture-economical and philosophical issues*. Book Chapter in *Semantic Web Technologies and eBusiness: Virtual Organization and Business Process Automation* Ed. by Dr. A. F. Salam and Jason R. Stevens, Idea-Group Publishing, Hershey PA

[Star 1989] Star, S.L., Griesemer, J.R. (1989). *Institutional Ecology, 'Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-1930.* Social Studies of Science (19) pp.387-420.

[Tamma 2006] Tamma Valentina (2006): *Reaching agreement over ontology alignment*. Proceedings of IEEE 5th International Conference on Web Services (ISWC 2006).

IT Frauds and Audit Risks: Evidence of Improvements

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ABSTRACT

This study examines whether frauds in Information Technology (IT) environment affects audit risk and quality. Information system technology dominates over almost every type of business and auditors should have enough knowledge and skills about those systems as part of their responsibilities to ensure about their client's internal control systems. Auditors should be able to examine the reliability of financial reporting process of those systems and provide audit opinion at the end. Thus, information systems audit, although integrated with the overall audit process and objectives, should finally facilitate for good corporate governance through providing quality audit report. This study uses data from Computer Crime and Security Survey (CCSS) 2006 to investigate the effects of IT risks on audit risks. Interestingly, the study find that the average improvements in audit of control risks is 49 percent, detection risk 46 percent, and inherent risk for as less as 25 percent. An overall improvement for auditor's risk is 41 percent in which it shows a considerable improvement.

Keywords: Audit Risks, IT Crimes, Frauds, Sarbanes-Oxley Act, Internal Control, IS Audit.

"Organizations are reporting a rise in fraud, responding with expanded fraud measures both reactive and preemptive, and planning further actions for the future." Richard H. Girgenti, National Partner in Charge KPMG Forensic (2003)

INTRODUCTION

The purpose of this study is to examine those information technology (IT) risks related to IT's attacks, crimes and frauds on the audit risk from 1999 until 2006. IT risks are key issues for auditors nowadays because of the vast impact of IT as well as the importance of information systems (I.Ss) on producing reliable data and valuable business information to various internal and external users. The impact of IT risk in form of IT crimes, frauds, misuse, attacks on audit risk is important in regard to audit quality and the credibility of financial reports. Moreover, it is important for corporate governance feat the auditor's opinion about how is the design and performance of the I.Ss in which are their direct responsibilities to be monitored and reviewed.

The reliability of information system is significantly depend on the design of the computerised internal controls systems and very critical for companies in achieving to their strategic goals, planning, as well as greater performance in term of high profitability. Information technology prevail over entities of all sizes and integrated with the internal control systems in many ways (Fukukawa, Mock, and Wright, 2006), and thus auditors should consider their due care and skill for understanding the internal control to perform during their audit engagements (ISA 315). Therefore, it is vital for auditors to understand those I.S. risks, frauds, crimes and IT attacks that causes many financial and non-financial damages to their clients. Then they should ensure designing those appropriate tests to ensure detecting the frauds, crimes, errors, and misstatements. A *priori* of the detrimental effects of the IT risks is that the diminishing quality of the I.Ss to generate relevant, reliable and timely reporting and increasing the audit risk. This implies that the IT threats must be identified and documented by auditors at one stage, and then the auditor's role is to analyse the threats along with test the other elements of the internal control system to find out the weakness or shortages to report them to managers in order to be improved and fixed.

The rest of the paper is organised in five sections. First, a discussion is provided about the audit risk and defines the auditors' responsibilities to understand and have enough knowledge and skills of their client IT environment and I.Ss. Then, IS risks are identified following up the methodology and results of the study. Conclusion section is presented at last.

IT AND AUDIT RISKS

According to O'Donnell and Moore (2005) "The pervasive use of systems in organisations and the increased emphasis on assurance of Information Technology (IT) processes has increased the need for accounting professionals with IT control knowledge and skills" (p.64). In addition, auditor should have enough competence including IT knowledge and skills, as required by Section 2 of the IES 8 to become a member of audit profession. This standard identifies two types of competence in form of *general* and *knowledge* contents. Paragraph 40 of the knowledge content requires "the knowledge content of the information technology subjects area should include, first, information technology systems for financial accounting and reporting, including relevant current issues and developments" and second, "frameworks for evaluating controls and assessing risks in accounting and reporting systems as appropriate for the audit of historical financial information" (p.11).

The latest Exposure Draft (ED) of the International Accounting Education Standards Board proposed as the International Education Practice Statement 2.1, *Information Technology for Professional Accountants.* In scope section of the practice statement, audit profession is categorised as "the accountant as assurance provider and evaluator". Paragraph 28 to 31 of the ED details all responsibilities of assurance provider and evaluator role in an IT environment and those required skills as depicted by the Appendix 4 of the ED. The appendix lists various IT tasks and related competence that IT auditors should have in three different areas. These are planning systems evaluation, evaluate systems and communicate results of evaluation and follow-up tasks. In plan systems evaluation, auditors are required to identify, analyse and evaluate risk factors and business issues affecting the IT assurance engagement or project and their implications.

In addition, auditors should also define level/frequency of systems errors, flaws and failures that are deemed significant or material in terms of audit risks. Gallegos (2002) by refer to well-know organisations such as the American Institute of Certified Public Accountants (AICPA), the US General Accounting Office (GAO), the Information Systems Audit and Control Association (ISACA)[1] and the Institute of Internal Auditors (IIA) also defined and listed twelve characters of the due professional care for IT auditors. They are peer review, audit conduct, communication, technical competence, judgment, business knowledge, training, certification, standards independence, continuous reassessment and high ethical standards. Therefore, authors are expected to comply with the characteristics and in case of any failure to detect any IT frauds, errors, misstatements, then this may be considered as an audit negligent, and may bear a legal action against the auditors.

According to Allen *et al.* (2006) strategic risk approach use "industry specialists appears to effectively promote understanding of a client's business risk" and they consider fraud risk as a "a particularly challenging task for auditors to perform" (p.161) . Traditional audit risk model, in which consist of inherent, control and detection risk, underpin the audits of financial statements (Blockdijk, 2004) and should be in the lowest acceptable level to increase the credibility of financial reports through lower level risk or risk free auditor's opinion. Thus, the lower audit risk, then the quality of audit opinion would be higher.

Many research have shown that inherent risk assessment has been interested on actual audit function (e.g. see Waller 1993, Mock and Wright 1993 and Elder and Allen 2003). Inherent risk related those susceptible account balances or transactions in which continued with different level of material misstatement, errors and frauds. Control risk is squarely related to internal control systems design and performance. Detection is the auditors' risk when they fail to detect any misstatement, errors, or fraud that affects fairness and truthfulness of financial statement reports in all material aspect. One exogenous factor influence audit risk is materiality and *a prior* in regard to risk evaluation is, those undetected immaterial risky balances or transactions would not affect the true and fairness of financial reports.

INFORMATION SYSTEMS' AUDIT

The ISACA extensively detailed the IS auditors' responsibilities and issued many comprehensive standards, guidelines and recommendations for this filed of auditing[2]. Based on ISACA, the purpose of IS audit is to review and provide feedback, assurance and suggestions and classifies major elements of IS audit into five broad areas such as physical and environmental review, system administration review, application software review, network security review, business continuity review, and data integrity review.

Notwithstanding I.S audit or general audit function, auditors should assess the integrity and robustness of internal control systems. The importance of internal controls generally is highlighted by the Sarbanes-Oxley Act in section 404, in which the Act requires organizations to select and implement a suitable internal control framework to strong corporate governance and reducing risk management by the accuracy, reliability, and integrity of an organization's transactional data. However, the significant role that information technology plays in design, efficiency and applicability of the internal controls need more attentions from auditors' perspectives to reduce IS audit risk as a point of quality audit opinion. Many IT environments' internal control framework such as COSO's *Internal Control—Integrated Framework* has become commonly used framework by many companies claim that the framework complies with Sarbanes-Oxley. However, according to Ernst & Young March 2005 survey of US listed foreign private issuers, almost half of the companies did not plan to conduct a separate and distinct fraud risk assessment of their internal controls in which required by SOX 404 to accomplished by 15 July 2006.

As a result of continuing efforts to define, assess, report on, and improve internal control systems recently five guidelines have been published by recognized professional bodies. These are the Information Systems Audit and Control Foundation issued COBIT (Control Objectives for Information and related Technology), the Institute of Internal Auditors Research Foundation by Systems Auditability and Control (SAC), the Committee of Sponsoring Organizations of the Treadway Commission's Internal Control - Integrated Framework (COSO), and the American Institute of Certified Public Accountants issued the Consideration of the Internal Control Structure in a Financial Statement Audit (SAS 55), as amended by Consideration of Internal Control in a Financial Statement Audit: An Amendment to SAS 55 (SAS 78) (Janet L. Colbert, and Paul L. Bowen). Those reports reveal the importance of internal controls in an I.S audit environment particularly for risk assessment and internal controls structure.

Majority of professional accountants bodies (i.e. Big 4) provide the following services under Systems and Process Assurance (SPA) services[3] such as financial and operation applications, business process controls reviews, database security controls reviews, IT general controls reviews, infrastructure security reviews, third party assurance and opinion services, Sarbanes-Oxley readiness, process improvement and sustainability services, compliance with other regulatory requirements (e.g., Turnbull, Basel II, King), due diligence on systems and controls, pre and post-implementation systems reviews, project assurance services, data services (e.g., CAATs, data quality reviews), and computer security reviews.

DATA AND METHODOLOGY AND RESEARCH QUESTION

The study used the findings of Computer Crime and Security Survey (CCSS) 2006 due to the uniqueness of the survey in US. Respondents from corporations, government agencies, financial institutions, medical, and universities consist of 616 computer security practitioners. The survey measured the U.S dollar amount of losses by type of the computer crimes, security and frauds. Total losses for 2006 is US $52,494,290 mainly consisted of unauthorized access to information ($10,617,000), laptop or mobile hardware theft ($6,642,660), theft of proprietary information ($6,034,000), and financial fraud ($2,556,900) and other losses due to I.S risks are about $26,643,000. The main concentration has been devoted to CCSS's types and trends of the attacks, crimes, misuses, and fraud from 1999 to 2006 to answer this question:

Table 1. IT risks associated with the audit risk components

IT Frauds	Audit Risk Relevance
Theft of proprietary information	Control Risk
Insider abuse of net access	Control Risk
System penetration	Control Risk
Unauthorised access to information	Control Risk
Laptop/mobile theft	Control Risk
Telecom fraud	Detection Risk
Financial fraud	Detection Risk
Misuse of public web application	Inherent Risk
Virus	Inherent Risk
Abuse of Wireless network	Inherent Risk

Research Question : If audit risk is affected by IT risks, misuses and attacks and internal control systems, which is a great source for auditor to assess about control risks, are affected by the IT risk, then have improvements been taken places by the corporate entities since year 1999 to prevent those frauds?

In order to evaluate the effect of the IT risks, first a relationship between those IT risks should be established with audit risk components; that is, inherent risks, control risks, and detection risks. In order to have this relationship, Table 1 developed to summarise the IT risks which is adopted from figure 14 (p. 13) of the CCSS survey. For classification purpose of the IT risks, then theft of proprietary information, insider abuse of net access, system penetration, unauthorised access to information, and laptop mobile thefts are associated with the control risks and telecom and financial frauds are associated with the detection risk or auditor's risk. Misuse of public web application and virus and abuse of wireless network are considered to be inherent risks.

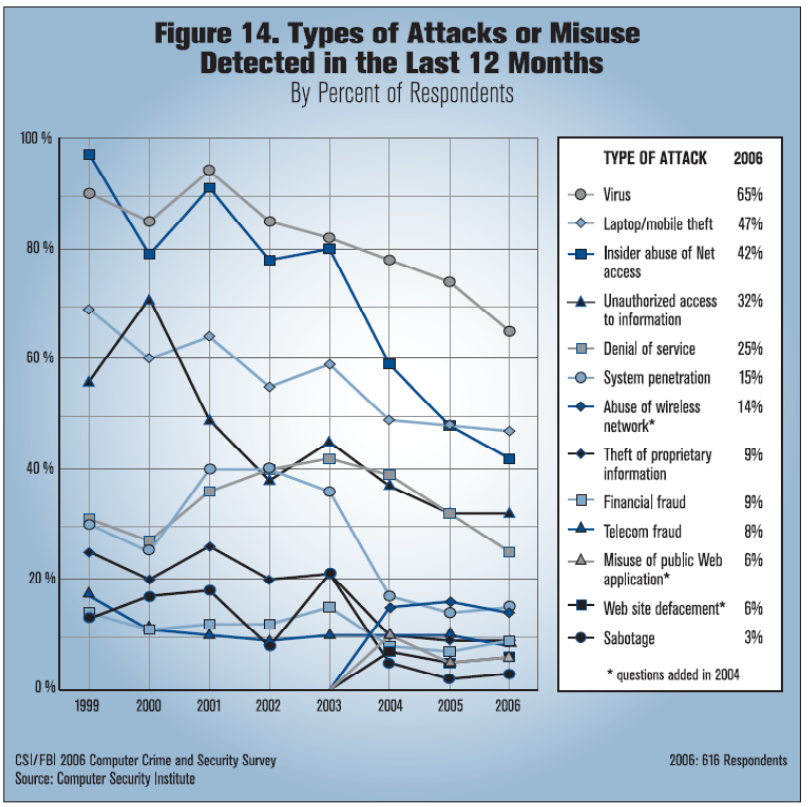
A trend analysis of the IS risks close to audit risks have been performed by looking at the data from 1999 till 2006. Then improved or declined percentages are measured to evidence of decrease or increase in overall audit risks.

RESULTS

Descriptive results of the CCSS survey shows that 21 percent[4] of respondents declared the experience of IT attacks, crimes and fraud risks that harmed the confidentiality, integrity or availability of network data and systems from as less as once to more than ten times. Various kinds of technologies used for the security purposes mainly were the anti-virus softwares (98 percent), Firewalls (95 percent) and Access Controls (93 percent). More interestingly, the respondents also used largely the computer security policies and procedures such system audit policy (51 percent), external network access control policies (75 percent), user access management(95 percent), media backup procedures (94 percent) and documented standard operating procedures(79 percent). Figure 1 graphically shows general improvements in IT risks as follows.

The figure generally demonstrates that a steady decrease in almost all of IT types of risks detected since 1999. Table 2 quantified all IT risks and their percentage of changes from the CCSS survey. There were, however, three areas in which average losses *increased.* Losses from laptop or mobile hardware theft increased from $19,562 per respondent in 2005 to $30,057 per respondent in 2006. Losses

Figure 1. Types of IT risks and their trends since year 1999



from telecommunication fraud increased dramatically from $2,750 per respondent in 2005 to $12,377 per respondent in 2006. The third category in which average losses increased was Web site defacement. While the average losses for this category increased from $1,494 per respondent to $1,806 per respondent, less than one-third of a percent of total losses reported were due to Web site defacement (CSI/FBI 2006).

The results, as derived from the table, represents that the lowest improvement is related to abuse of wireless network and the highest improvement correlated with theft of proprietary information. Average improvement in audit control risks is 49 percent, detection risk 46 percent and inherent risk only 25 percent. An overall improvement for auditor's risk is about 41 percent which is a considerable

Table 2. Changes in improvement of Audit Risk in terms of IT risks

IT Frauds	Audit Risk Relevance	1999 %	2006 %	Δ % (Improvement)
Theft of proprietary information	Control Risk	0.25	0.09	-64%
Insider abuse of net access	Control Risk	0.97	0.42	-57%
Telecom fraud	Detection Risk	0.18	0.08	-56%
System penetration	Control Risk	0.30	0.15	-50%
Unauthorised access to information	Control Risk	0.56	0.32	-43%
Misuse of public web application*	Inherent Risk	0.10	0.06	-40%
Financial fraud	Detection Risk	0.14	0.09	-36%
Laptop/mobile theft	Control Risk	0.70	0.47	-33%
Virus	Inherent Risk	0.90	0.65	-28%
Abuse of Wireless network*	Inherent Risk	0.15	0.14	-7%
Total Average				41%

*Since 2004

improvement in IS audit risks and require more investigations to establish why and under which circumstances these issues have came about.

The report also implied that "the impact of the Sarbanes–Oxley Act on information security continues to be substantial" (CCSS, 2006, p. 2). Also, the respondents replied that regulatory compliance related to information security is one of the most critical security issues they face (Ibid). The role of the Sarbanes–Oxley Act of 2002 on security activities considered to be of the critical issues for the next two years by 63 precent of the respondents.

This survey also addressed several emerging security issues that were first searched only with the survey. All of the following issues relate to the economic decisions organizations make regarding computer security and the way they manage the risk associated with security violations. These are those techniques organizations should evaluate the performance of their computer security investments; security training needs of organizations; organizational spending on security investments; the impact of outsourcing on computer security activities; the use of security audits and external insurance also revealed that over 80 percent of the organization conduct security audit, and the portion of the information technology (IT) budget organizations devote to computer security.

CONCLUSION

An information system audit is part of the overall audit assessment process by auditors, if the assessment is conducted to reduce to the low level, then it is one of the facilitators for good corporate governance via reporting quality earnings and information. This study reveals through the CSI/FBI survey 2006 the evidence of improvements in form of reduced I.S risks within I.S environments including IT crimes, frauds, and misuse. The results show that a considerable improvement of 41 percent in audit risks had been achieved by U.S corporations. Initial cause for this improvement may related to conduct security audits, that the survey shows over 80 percent of the organisations conduct security audits, and the impact of the Sarbanes-Oxley Act on information security continues, as this is confirmed to be substantial by the survey.

REFERENCES

Allen, R.D, Hermanson, D.R., Kozloski, T.M. & Ramsay, R.J. (2006), Auditor risk assessment: insights from the academic literature.*Accounting Horizons*, p157-178.

Blockdijk, J.H. (2004), Tests of control in the audit risk model: effective? Efficient? *International Journal of Auditing,* 8, pp. 185-194.

Computer Security Institute (2006), CSI/FBI Computer Crime And Security Survey.

Elder, R J and R D Allen, (2003). A longitudinal filed investigation of audit risk assessments and sample size decision. *The Accounting, Review,* Vol.78 (4), pp.983-1002.

Ernest & Young, 2006, *Emerging Trends in Internal Controls: US Listed Forging Private Issuers – Second Survey and Section 404 Reference*, (Ernest & Young).

Fukukawa, H. T., Mock, and A Wright, (2005) Audit program plans and audit risk: A study of Japanese practice. Working paper. Nagasaki University.

Gallegos, F. (2002), IT Audit Basics Due Professional Care, *Information Systems Control Journal*, Vol.2. http://www.isaca.org/Template.cfm?Section=Archives&CONTENTID=17026&TEMPLATE=/ContentManagement/ContentDisplay.cfm

Hironori F., Mock T. J. & Wright, A. (2006), Audit programs and audit risk: A study of Japanese practice, *International Journal of Auditing,* 10, pp. 41-65

Mock, T. J. and A Wright. (1993). An exploratory study of auditors' evidential planning judgments. *Auditing: A Journal of Practice & Theory,* **12 (2): 39-61.**

O'Donnell, J., and **Moore,** J. (2005) Are Accounting Programs Providing Fundamental IT Control Knowledge? *CPA Journal*, May, Vol. 75 Issue 5, pp.64-66.

Waller, W. S., (1993), Auditors' assessments of inherent and control risk in field settings. *The Accounting Review,* 68 (4): pp. 783-803.

ENDNOTES

1. The ISACA is one of the Professional associations in information systems (IS) audit, control, security and governance. ISACA has a global membership of more than 35,000 in 100 countries in Asia, Central America, South America, Europe, Africa, North America and Oceania. Founded in 1969 as the EDP Auditors Association, ISACA is a global leader in IT governance, security, control and assurance. It is the single leading international source for information technology controls. ISACA is dedicated to serving the needs of its members, who are internal and external auditors, CEOs, CFOs, CIOs, educators, information security and control professionals, students and IT consultants (http://www.isaca.com).
2. So far, fourteen standards for IS Auditing has been published. See the web link: http://www.isaca.org/Template.cfm?Section=Downloads5&Template=/ContentManagement/ContentDisplay.cfm&ContentID=18248
3. I used the PricewaterhouseCooper service policy in our paper. Look at: http://www.pwc.com/extweb/service.nsf/docid/F30379DCB72E2346852570130058EE42
4. 48 out of 341 respondents (Table 1 of the CCSS report) experienced 1-5 times, 15 respondents declare 6-10 times, and 9 declared more 10 times.

Dynamic Distributed Data Warehouse Design

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ABSTRACT

The fragmentation of a data warehouse into multiple data mart makes the task of the administrator very difficult. He must manage all operations of insertion, update and delete at the level of sources, Extraction, Transformation and Load (ETL) operations, logical Models, fragmentation and allocation. While nearly touching all levels of the architecture of a data warehouse, the administrator's task is going to become especially as difficult as the level of fragmentation is raised. Of this fact, it will be interesting to develop an auto-evolutionary system permitting to maintain a data warehouse up to date without interrupting its working and while keeping all the time one same level of performance. This article presents a dynamic distributed data warehouse design, proposes some basic concepts, develops a formulation of the problem and integrates an automatic system of administration based on intelligent agents.

Keywords: data warehouse, dynamic, fragmentation, ETL, Replication and design.

1. INTRODUCTION

A data warehouse is generally characterized by a very big volume of data; it is used, contrary to the transactional data bases, exclusively in consultation, all operations of up dating are taken in charge by the administrator. A data warehouse can be centralized or distributed. Many researches to date investigate building distributed data warehouses with particular emphasis placed on distribution design for data warehouse environment and the dynamic aspect is the current subject of work in the autonomic data management area.

The following section, presents in more details the problematic. The section 3 summarizes the state of art concerning data warehouse fragmentation techniques and dynamic data bases. The section 4, presents the contribution of this article and in the section 5, a dynamic distributed data warehouse design solution will be developed.

2. PROBLEMATIC

The problem of data warehouse fragmentation was carefully developed in [7], [8] and in [9]. But, the realized works always gave a static fragmentation that requires to be updated every time there is a change.

All operations of up dating are taken in charge by the administrator; the partitioning of data into multiple data mart is going to make very difficult his task. He must manage all operations of insertion, updating and deleting, at the level of sources, Extraction, Transformation and Load (ETL) operations, logical Models, fragments and allocation. While nearly touching all levels of the architecture of a data warehouse, the administrator's task is going to become especially as difficult as the level of fragmentation is raised.

3. STATE OF THE ART

Distributed Data Warehouse and Fragmentation Techniques

In [4] and in [5], authors proposed an architecture for distributed data warehouse. It is based on the ANSI/SPARC architecture that has three levels of schemas: internal, conceptual, and external. This work is based on TOP/DOWN approach and presents two fundamental issues: fragmentation and allocation of the fragment to various sites. Authors proposed a horizontal fragmentation algorithm for a fact table of a data warehouse. In [1], we have proposed a methodology for relational distributed data warehouse design. For this purpose, we develop a set of matrix: 'Matrix of data partitioning', 'matrix of data allocation' and a 'matrix of data source and in [2] we adapt the same methodology to the multidimensional environment. In [5], [4], [1] and in [2], a basic architecture of a distributed data warehouse has been proposed; we suggest the implementation of these works in a distributed environment.

Several works shows the importance of fragmentation in a data warehouse context, it represents today a more challenging stake that in a relational or objects database context. [6],[7],[8],[9],[10],[11],[12],[13]. In addition, several commercial products showed the utility of fragmentation in the process of queries optimization: In [1], we proposed a matrix of fragmentation, 'Horizontal Matrix of fragmentation ', making abstraction to the approach of modeling, this matrix permits from a logical table to generate a set of fragments and it has as input: queries and their frequencies of utilization. Thereafter, we proposed a matrix of allocation permitting to allocate every fragment to the most adequate site. One data can be a table or a fragment of table. In [2] the same solution was adapted in a dimensional environment; we have experiment the solution through an example. In [3] the same problematic was presented and some arguments are showed to prove the importance of fragmentation in distributed data warehouses environment. Otherwise, several works of research and the commercial products showed the utility of fragmentation techniques in the process of queries optimization [13]. Horizontal fragmentation in data warehouses is more challenging compared to that in relational and object databases. This challenge is due to the several choices of partitioning schemas that can be found in [8]

Dynamic Data Warehouse

We are not aware of any research work addressing the dynamic data warehouse. Some works developed the idea of a incremental design of a data warehouse [14], and other works are focused on dynamic operational data bases [15] , [16].

4. CONTRIBUTIONS

The contribution brought by this article consists in proposing a methodology for a dynamic distributed data warehouse design. This solution is essentially based on the extension of the classic solution of a centralized data warehouse. Some basic concepts are added, a formalism of presentation is developed and the integration of an automated administration system is done to maintain the data warehouse continuously up to date. The proposed solution can be adapted to centralized and so to distributed data warehouse.

5. DYNAMIC DISTRIBUTED DATA WAREHOUSE DESIGN (FIGURE 1)

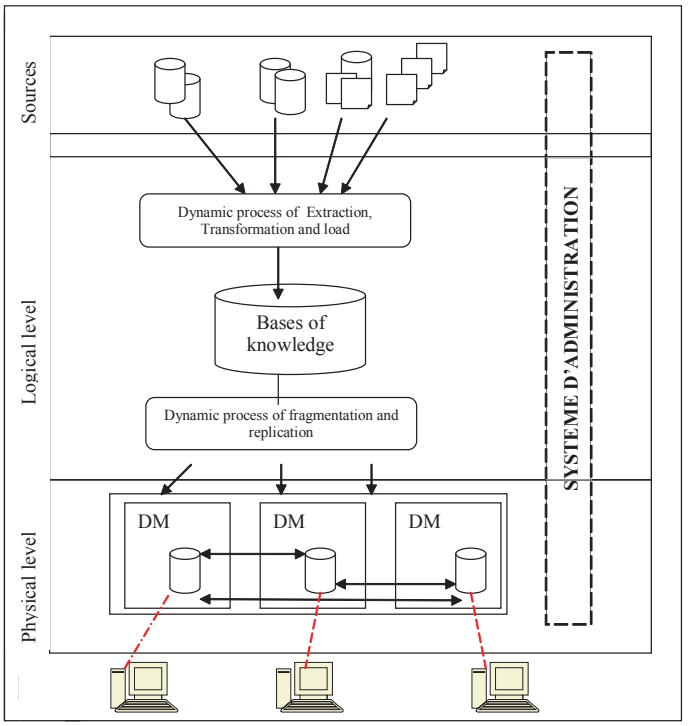
5.1 Basic Concepts

The proposed solution is an extension of work achieved in [2], this work is essentially based on the integration of a process of fragmentation and replication into the design level.

We propose the following basic concepts:

- *Dynamic process of extraction, transformation and load*: We add the term dynamic because this system is activated each time there is a change in data sources, function of transformation and load operations.
- *Bases of knowledge*: describes each data in the data warehouse. A data is characterized by a source, function of transformations and the allocation.

Figure 1. Architecture of a dynamic distributed data warehouse



- *Dynamic process of fragmentation and replication*: added to generate the derived horizontal fragmentation to the different tables and to found the best allocation for each data or fragment. We add the term dynamic because this system is activated each time there is a change in query frequency or structure.

- *System of administration*: integrate all functionalities to maintain a data warehouse up to date. The system of administration is touching all levels of the architecture of a distributed data warehouse (Figure 1). It's role is
  - o (1) to detect needs of refreshment of each data in every data mart,
  - o (2) to detect changes in function of transformation in every data mart,
  - o (3) to detect needs of updating in the bases of knowledge
  - o (4) to detect changes in query structure or frequency

5.2 Formalism

We are going to formalize the different concepts proposed through computational multi-dimensional matrixes.

a) The Matrix of Data Sources Integration (Table 1)

The d*ynamic process of extraction, transformation and load* can be simplified with the Matrix of Data Sources Integration MDSI (Table1), for each attribute A_{jL} ((1<=j=k), (1<=L=m); k the number of dimension or fact table (Ti) and m the number of attribute in Ti from dimensional model. We put for each data (1) *the source* (from which Logical Model LMr (1<=r<=s; s the number of source used for the integration process. (2) for each data A_{rz}((1<=r<=s, 1<=z<=x ; x the number of attribute for each LMr) the transformation function applied into data source to make an attribute A_{jL} adapted to the specification of the integrated data warehouse.

A transformation can be elementary or composite.

An elementary transformation is gotten while calculating the function $f_{tc(}\mathbf{A}_{rz),}$ it gives as result an attribute $\mathbf{a}_{j\,L}$ that will be integrated in the data warehouse.

A transformation can be composite (CT), that means, calculated according to several attributes sources. The result will be gotten while applying the function $f_{tc(}\mathbf{A}_{r1},...,\mathbf{A}_{rx),}$ This matrix has been implemented in [2].

b) Matrix of Primary and Derived Horizontal Fragmentation (Table2)

The dynamic process of fragmentation can be simplified by the Matrix of Primary and Derived Horizontal Fragmentation (MPDHF). The MPDHF consists to the definition of the uses of data by the treatments t_{ipi} (1<=i<=n, 1<=pi<=qi ; n numbers it of site, q numbers it of treatment by site. A treatment t_{ipi} can use one or several tables DTj dimension DTj (1<=j<=k; k number of dimension table from the star

Table 1. The matrix of data sources integration

Dimension tables	Attributs	Data source																CT
		LM1						**LM r**						**LM s**				
		$\mathbf{A}_{1l}$		$\mathbf{A}_{1z}$		$\mathbf{A}_{1x}$		$\mathbf{A}_{rl}$		$\mathbf{A}_{rz}$		$\mathbf{A}_{rx}$		$\mathbf{A}_{sl}$		$\mathbf{A}_{sz}$		$\mathbf{A}_{sx}$	
$\mathbf{DT}_i$	$\mathbf{a}_{il}$	$f_{te(}\mathrm{A}_{1l)}$																
	…																	
	$\mathbf{a}_{iL}$	X				X		X						X				$f_{tc(\,)}$
	...			$f_{te(}\mathrm{A}_{1z)}$														
	$\mathbf{a}_{im}$																	
$\mathbf{DT}_j$	$\mathbf{a}_{j1}$					$f_{te(}\mathrm{A}_{1x)}$												
	…																	
	$\mathbf{a}_{j\,L}$									$f_{te(}\mathrm{A}_{rz)}$								
	…																	
	$\mathbf{a}_{jm}$																$f_{te(}\mathrm{A}_{sx)}$	
$\mathbf{DT}_k$	$\mathbf{a}_{k1}$	X		X				X		X				X		X		$f_{tc(\,)}$
	…											$f_{te(}\mathrm{A}_{rx)}$						
	$\mathbf{a}_{kl}$																	
	…			X		X				X		X				x		X	$f_{tc(\,)}$
	$\mathbf{a}_{km}$																	

Table 2. Matrix of primary and derived horizontal fragmentation

		Treatments	DIMENSION TABLES		
			$DT_1(a_{1,1}, \ldots a_{1,L1}, \ldots a_{1,m1})$	$DT_j(a_{j,1}, \ldots a_{jLj}, \ldots a_{j,mj})$	$DT_k(a_{k,1}, \ldots, a_{k,Lk}, \ldots a_{k,mk})$
SITES	S_1	$t_{1,1}$ ... $t_{1,p1}$ .... $t_{1,q1}$	$Fhp_{11}=f_p(DT_1, \{a_{1,l1,..,} a_{1,Ll}\},CF)$ $Fhd_{11}=f_d(FT, Fhp_{11,} CJ)$	…	…
	…				
	S_i	$t_{i,1}$ ... $t_{i,pi}$ ... $t_{i,qi}$	$Fhp_{1i}=f_p(DT_1, \{a_{1,l1,..,} a_{1,Ll}\},CF)$ $Fhd_{11}=f_d(FT, Fhp_{11,} CJ)$	$Fhp_{ji}=f_p(DT_j, \{a_{j,1,..,} a_{j,Lj}\},CF)$ $Fhd_{ji}=f_d(FT, Fhp_{ji,} CJ)$	…
	…				
	S_n	$t_{n,1}$ ... $t_{n,pn}$ ... $t_{n,qn}$	…	…	$Fhp_{nk}=f_p(DT_k, \{a_{k,1,..,} a_{k,Lk}\},CF)$ $Fhd_{nk}=f_d(FT, Fhp_{nk,} CJ)$

model) and/or one or several attributes a_{jLj} (1<=L<=m; m number of attribute of a dimension table DTj. For example, a fragment horizontal primary Fhp_{11} is generated following the use of one or several attributes $a_{j,Lj}$ of the dimension table DT1 and by the treatment $t_{1,1}$.

The list of the primary horizontal fragments results from the application of the function f_p that takes in entry the dimension table to fragment DT_j, the list of the attributes concerned by fragmentation $\{a_{1,l1,..,} a_{1,Ll}\}$ and the criteria of fragmentation CF. It returns as result a fragment of the dimension table DT_j.

The list of the derived fragments results from the application of the function f_d that takes in entry the concerned FT, the primary horizontal fragment Fhp and join condition. It return's as result a derived fragment from the fact table.

c) Allocation Matrix (Table3)

The primary and derivative fragmentation matrix generates a set of data used by the different DM. Let Du be a generated data by the MPDHF (1<=u<=t ; t the number of data generated by the fragmentation process) Du can be a fact table, a dimension table a derived fragment or a primary fragment. If Du is used by Si then it will be automatically allocated to Si. And it will be called Persistent Data (PD). The persistence of one data in a DM depends on its use frequency (Fu). If Fu is equal to 0 it will be suppressed from the site and pass in the absent data (AD) state. The function f_a permits to determine for a data D_u to an instant t and according to the frequency of use Fu if it is PD or AD in a data mart DMi.

d) Matrix of knowledge bases (Table 4)

It gives for every allocated data: the source, transformations and allocation information. A transformation can be elementary $\boldsymbol{f_{tel}(A_{rz})}$ using only one source attribute $\mathbf{A_{rz}}$ or composite $\boldsymbol{f_{tcf}(A_{1z}, A_{1x}, A_{r1}, A_{s1})}$ while using several source attributes.

6. SYSTEM OF ADMINISTRATION (FIGURE 2)

(1) Agent of Refreshment

A data can be a table or a fragment of a table. This one is in evolution; changes can touch its structure (change of source, suppression of one or several attributes, additions of news data on the system…etc.) or the content. All operations of refreshment, updating or suppression on data are activated by the ADR. The ADR is activated by changes witch can occur in data source.

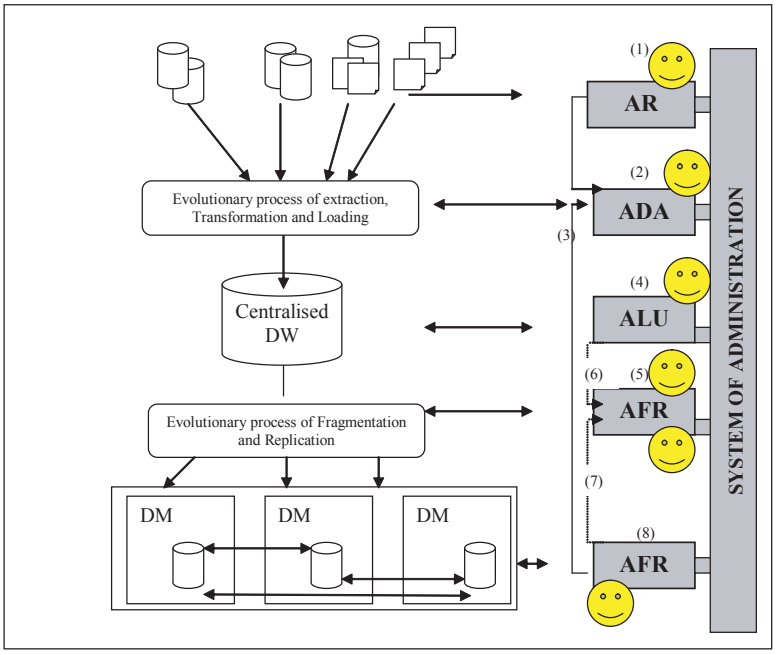
Table 3. Allocation matrix

		FACT TABLES / DIMENSION TABLES / PRIMARY HORIZONTAL FRAGMENTS /DERIVED HORIZONTAL FRAGMENT		
		D_1	D_u	D_t
DESTINATIONS	DM_1	$f_a(D_{1,} DM_1,t,F_u)$=PD/AD	$f_a(D_{1,} DM_1,t,F_u)$=PD/AD	$f_a(D_{1,} DM_1,t,F_u)$=PD/AD
	...			
	DM_i	$f_a(D_{1,} DM_1,t,F_u)$=PD/AD	$f_a(D_{1,} DM_1,t,F_u)$=PD/AD	$f_a(D_{1,} DM1,t,Fu)$=PD/AD
	...			
	DM_n	$f_a(D_{1,} DM_1,t,F_u)$=PD/AD	$f_a(D_{1,} DM_1,t,F_u)$=PD/AD	$f_a(D_{1,} DM_1,t,F_u)$=PD/AD

Table 4 : Matrix of knowledge bases

Destinations \ Sources			LM_l			LM_r			LM_s			TC
			A_{l1}	A_{lz}	A_{lx}	A_{r1}	A_{rz}	A_{rx}	A_{s1}	A_{sz}	A_{sx}	
DM_l	LM_l	D_{l1}	$f_{te}(A_{l1})$									
		…										
		D_{lu}	X		X	X			X			$f_{tc}()$
		…		$f_{te}(A_{lz})$			$f_{te}(A_{rz})$					
		D_{lt}										
…											$f_{te}(A_{sx})$	
DM_i	LM_i	D_{i1}										
		…					$f_{te}(A_{rz})$					
		D_{iu}										
		…		$f_{te}(A_{lz})$							$f_{te}(A_{sx})$	
		D_{it}	X	X		X	X		X	X		$f_{tc}()$
…												
DM_n	LM_n	D_{n1}										
		…		X	X		X	X		X	X	$f_{tc}()$
		D_{nu}										
		…	$f_{te}(A_{l1})$									
		D_{nt}										

Figure 2. Integration of intelligent agent



(2) Agent of Data Adaptation: (ADA)
Data mart are placed on the different sites, they can have different DBMS, different OS and can have some different features. Data must be adapted to specifications of every site. Then the applied transformation operations on data coming from different sources can undergo changes that vary according to data Marts, and it can also evolve in the time what requires a Refreshment of the corresponding data base. Therefore, the system of administration must take account of all changes concerning the applied transformation operations. The new needs of transformation are detected by the Agent of Data Mart Administration (ADMA) and thereafter communicated to the ADA **(3)**.

(4) Agent of Logical Updating of the Global Data Warehouse Model (ALU):
Its role consists in bringing stakes to necessary updating to the global model of data warehouse if there is a detected change in (1) or in (2).

(5) Agent of Fragmentation and Replication of the Logical Data (AFR)
If we detect one or some modifications at the level of the global logical model of the warehouse **(6)**, it is necessary to regenerate the Evolutionary process of Fragmentation and Replication and to see the impact on the physical models of different data mart. The Criteria of fragmentation essentially are based on decisional queries, these evolve according to the informational needs of the enterprise, this evolution has two types: query frequency and query structure, if there is detection of change (7), The system must verify the impact of this one on the already made fragmentation and so necessary to regenerate the Evolutionary process of Fragmentation and Replication, It will have as consequences the modification of one or some physical models (or data mart).

(7) Agent of Data Mart Administration (ADMA)
The role of this agent is to detect changes in the operation of transformation done by the ADA. It communicates changes to ADA so that it regenerates the evolutionary Process of extraction, transformation and loading. It can also detect changes in decisional queries, these changes can touch their frequencies as well that their structures. It sends an order thereafter to the AFR so that it regenerates the process of fragmentation and replication of the logical data warehouse.

7. CONCLUSION

A data warehouse includes a set of information for the decisional system. It can be centralized or distributed. A data warehouse is dynamic; it can face several evolutions. All operations of refreshment are taken in account by the administrator. The administrator's task becomes difficult if the data warehouse is distributed. To face this problem, we proposed, a methodology of a distributed and dynamic data warehouse design, we proposed a set of basic concepts and a set of matrixes permitting the formalization of the dynamic ETL process, basis of the knowledge, dynamic process of fragmentation and the dynamic process of replication. As perspectives we propose the implementation of the solution.

8. REFERENCES

[1] Karima Tekaya, Abdellaziz Abdellatif, 'Modélisation de la répartition des données d'un data warehouse'. Eighth Maghrebian Conference on Software Engineering and Artifical Intelligence, (MCSEAI'04). 2004.

[2] Karima Tekaya, Abdellaziz Abdellatif, 'Modélisation de la répartition des données d'un data warehouse'. Journal International des Sciences de l'Information et de la Communication (ISDM05)

[3] Karima Tekaya, Abdellaziz Abdellatif 'Fragmentation and Replication process in data warehouse environment' The 3rd ACS/IEEE International Conference on Computer Systems and Application (AICCSA'05).

[4] A.Y. Noaman, and K. Barker, 'A Horizontal Fragmentation Algorithm for the fact relation in a Distributed Data Warehouse'. Proceeding of the Eigth International Conference on Information and Knowledge Management (CIKM'99). November 1999, Pages154-161.

[5] A.Y. Noaman and K. Barker. 'Distributed data warehouse architectures'. Journal of Data Warehousing, 2(2):37-50, April 1997.

[6] Ladjel Bellatreche, Kamalakar Karlapalem, Mukesh Mohenia, 'What can partitioning do for your data warehouses and data marts', 2000.Ladjel Bellatreche**, Kamalakar Karlapalem, Mukesh Mohania. 'Some issues in design of data warehousing systems'. Data warehousing and web engineering".** IRM Press Hershey, PA, United States. Pages 22 – 76. 2002.

[7] Ladjel Bellatreche and Kamel Boukhalfa, 'La fragmentation dans les entrepôts de données: une approche basée sur les algorithmes génétiques', Revue des Nouvelles Technologies de l'Information (EDA'2005), Juin, 2005, pp. 141-160.

[8] L. Bellattreche, M. Schneider, H. Lorinquer, et M. Mohenia. 'Bringing together partitioning materialized views and indexes to optimize performance of relational data warehouse'. Proceeding of the international conference Data Warehousing and Knowledge Discovery (DAWAK'2004), pages 15-25, September 2004.

[9] Ladjel Bellatreche, **Kamalakar Karlapalem**, **Mukesh Mohania**. **'Some issues in design of data warehousing systems'. Data warehousing and web engineering.** IRM Press Hershey, PA, United States. Pages 22 – 76. 2002.

[10] M. T. Özsu et P. Valduriez. 'Principles of distributed data base systems'. Prentice Hall. 1991.

[11] S. Ceri et G. Pelagatti, 'Distributed databases principles and systems'. McGraw-Hill, 1984.

[12] Sanjay, V. R. Narasayya, et B. Yang. 'Integrating vertical and horizontal partitioning into automated physical database design'. Proceedings of the ACM SIGMOD International Conference on Management of data, pages 359-370, Juin 2004.

[13] Dimitri Theodoratos, Timos Sellis, 'Dynamic Data Warehouse Design'. Data Warehousing and Knowledge Discovery . Springer-Verlag, LNCS, 1999.

[14] Mariano Consens, Denilson Barbosa, Adrian M. Teisanu, Laurent Mignet, '**Goals and benchmarks for autonomic configuration recommenders', International Conference on Management of Data. Proceedings of the 2005 ACM SIGMOD international conference on Management of data,** Baltimore, Maryland. 2005.

[15] Stratos Papadomanolakis and Anastassia Ailamaki. Proceedings 'Automating Schema Design for Large Scientific Databases Using Data Partitioning**',** The 16th International Conference on Scientific and Statistical Database Management (SSDBM), Santorini, Greece, June 2004

A Framework for Continuous Monitoring and Assessment of Landline Telecommunication Sectors Based on Standard Indicators

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ABSTRACT

This paper proposes a DEA-PCA based methodology for assessment and ranking of landline telecommunication sectors based on standard indicators identified by the International Telecommunication Union (ITU). A total of 16 indicators were identified from the ITU database. The case study is based on randomly selected 8 indicators. To present the usability of the proposed methodology, data for 18 countries with respect to 3 inputs and 5 outputs were collected through the ITU. The results show weak and strong points of each country identifying, inputs or outputs having major impact on Performance. This is the first study to present an integrated standard model for technical performance analysis of telecommunication landline sectors.

Keywords: DEA, Telecommunication, Landline Sector, PCA, Standard Indicators

1. INTRODUCTION

Major factors influencing the overall productivity of an industrial organization are identified as technology, machinery, management, personnel and rules and procedures ([2], [3], [29]). Technical factors play an important role in the overall performance of a particular industrial sector. In fact, technical productivity is correlated with the overall performance. Furthermore, the overall performance of an industrial organization is often assessed by technical productivity.

The need for an integrated approach for continuous assessment and improvement of telecommunication sectors based on technical performance has become essential. Continuous assessment requires manufacturing classifications and taxonomy to be introduced to enhance knowledge and understanding about the behavior of manufacturing systems ([9], [11], [18], [25], [28]). Consequently, it will enable predictions to be made about organizational system behavior.

2. PROPOSED FRAMEWORK

To achieve the objectives of this study, all technical indicators (inputs and outputs), which influence overall technical performance of telecommunication landline sectors are defined by the ITU [19]. These indicators are related to technical productivity, efficiency, effectiveness and profitability. A generalized classification of standard indicators proposed by the ITU for technical purposes contains of seven groups namely, 1) Telephone network size and dimension, 2) Other services (telex, leased circuits, ISDN subscribers, etc, 3) Quality of service, 4) Traffic, 5) Broadcasting, 6) Mobile services and 7) Information Technology.

Amongst these 7 categories there are standard indicators specified by the International Telecommunication Union (ITU) for performance assessment of landline sectors such as international incoming telephone traffic, telephone faults per 100 lines and telephone faults cleared by next working day. Classified list of standard indicators for telecommunication landline sectors as per International Telecommunication Union (ITU) is given as follows:

Outputs:

1. % of telephone faults cleared by next working day
2. Connection capacity of local exchanges (no. of subscribers connected at one time)
3. International telephone circuits (no. of circuits)
4. % digital main lines
5. Number of local telephone (calls)
6. Number of local telephone (minutes)
7. Number of national long distance telephone (calls)
8. Number of national long distance telephone (minutes)
9. Total national telephone traffic (calls)
10. Total national telephone traffic (minutes)
11. International outgoing telephone traffic (calls)
12. International outgoing telephone traffic (minutes)

Inputs:

1. Telephone faults per 100 main lines (no. of faults)
2. International incoming telephone traffic (calls)
3. International incoming telephone traffic (minutes)
4. Waiting list for main lines (no. of main lines pending to be installed)

The framework of this study utilizes a set of standard indicators, a robust mathematical approach (DEA) and PCA and Spearman correlation technique all used for ranking, assessment and optimization of LTUs being studied. This will aid managers to foresee various economics and technical issues with respect to their LTUs. The steps for implementing the framework of this study are shown as follows:

Step 1: Identify landline technical units (LTUs) or target markets to be studied, ranked and analyzed.

Step 2: Collect standard indicators of the study.

Step 3: Design Preliminary matrix for DEA and conduct DEA analysis, rank LTUs and identify most important inputs and outputs for each LTU. Suppose we have **n** DMUs, where each DMUj (j = 1,…,n) produces 12 output y_{rj} (r = 1,…,5) by utilizing 4 inputs x_{ij} (i =1,…,3). The CRS input-oriented model uses the following measure of performance for DMUj:

$$h_o^* = \underset{v_i,u_r}{Max}\, \mathrm{h}_o \quad \text{S.T.}$$

$$h_j \le 1,\ \mathrm{j} = 1,...,\mathrm{n}$$

$$v_i, u_r \ge 0, \qquad (1)$$

Where $h_o = \frac{\sum_{r=1}^{5} u_r y_o}{\sum_{i=1}^{3} v_i x_o}$ represents the ratio of aggregated outputs to aggregated inputs for one of the **n** DMUs, denoted as $DMU_o, o \in \{1,...,n\}$. x_o and y_o

are respectively the i[th] input and r[th] output of DMUo. By varying **o** over {1,…, n}, we obtain all the DEA scores, h_j^*, with **n** sets of optimal weights. It is clear that larger the h_j^*, the better the performance of DMUj, since DMUj produces more aggregated output or uses less aggregated inputs. However, the highest possible value of h_j^* is one, because of the constraints of Equation (1). If h_j^* = 1, then DMUj is relatively efficient.

The above-mentioned model can lead to a large number of DMUs having DEA scores of unity. We may use the following linear programming problem which is equivalent to Equation (1) by duality:

$$J_o^* = \underset{J_o, l_j}{Min}\ J_o$$

Such that:

$$\sum_{j \neq o} l_j x_j \leq J_o x_o \qquad i = 1,\ldots,4$$
$$\sum_{j \neq o} l_j y_r \geq y_o \qquad r = 1,\ldots,12 \qquad (2)$$
$$l_j \geq 0,\ j \neq o$$

Where J_o is a scalar and λ is a n× 1 vector of constants. The estimated value of J_o is the efficiency score for each of the n DMUs. The linear programming problem must be solved n times, once for each LTU. Equation (1) is known as a constant return to scale (CRS). The CRS assumption is only appropriate when all LTUs are operating at an optimal scale. The optimal values J_o^* can be less than, equal to, or greater than one. Now we are capable to rank the DMUs according to their aggregated output to aggregated to input ratios by J_o^*.

Step 4: Develop Preliminary raw table for PCA analysis. There are 48 indicators to be used in PCA because there are 12 outputs and 4 inputs. Therefore, there are 48 variables and n DMUs and suppose $X = (x_1 \ldots x_p)_{n\times 48}$ is an n× 48 matrix composed by x_{ij}'s defined as the value of jth index for ith DMU and therefore $x_m = (x_{1m} \ldots x_{nm})^T (m = 1,\ldots,48)$. Furthermore, suppose $\hat{X} = (\hat{x}_1 \ldots \hat{x}_p)_{n\times 48}$ is the standardized matrix of $X = (x_1 \ldots x_{48})_{n\times 48}$ with $\hat{x}_{ij}$'s defined as the value of jth standardized index for ith DMU and therefore $\hat{x}_m = (\hat{x}_{1m} \ldots \hat{x}_{nm})^T$. PCA is performed to identify new independent variables or principal components (defined as Y_j for $j=1 \ldots p$), which are respectively different linear combination of $\hat{x}_1 \ldots \hat{x}_{48}$. As mentioned, this is achieved by identifying Eigen structure of the covariance of the original data. The principal components are defined by an n ×48 matrix $Y = (y_1 \ldots y_{48})_{n\times 48}$ composed by y_{ij}'s : The following formulae are used to find out the principal components Y_i, the weights (w_i) of the principal components and PCA scores (z_i of each DMU ($i = 1 \ldots n$).

$$Y_m = \sum_{j=1}^{48} l_{jm} \hat{x}_j \quad \text{for } m = 1 \ldots 48 \text{ and } i = 1 \ldots n \qquad \ldots \quad (4)$$

$$w_j = l_j / \sum_{j=1}^{48} l_j = l_j / 48 \qquad j = 1 \ldots 48 \qquad \ldots \quad (5)$$

$$z_i = \sum_{j=1}^{48} w_j Y_j \qquad i = 1 \ldots n \qquad \ldots \quad (6)$$

Step 5: Verify and validate DEA by PCA by Spearman and Kendal Tau non-parametric correlation analysis methods.

Step 6: Check if the model is validated or not, if validated move on to Step 7, otherwise jump back to Step 2.

Step 7: Utilize the surplus and slack results of DEA for optimization purpose.

Step 8: Assess weak and strong points, take corrective actions and continuously perform DEA, monitor and improve performance.

3. THE CASE STUDY

Landline telephony is one of the most basic needs of today's world. Hence, there is a great need to develop models that assist in determining the efficiency of the sector. The case study works in this direction to present a comprehensive methodology for the assessment of telecommunication landline sector. In order to show the applicability of the proposed methodology a group of 8 indicators comprising of 3 inputs and 5 outputs were collected with respect to 18 countries in 2002 from ITU (Table 1). The following subsections discuss the DEA method used to determine the efficiency of the LTUs, and the PCA method used for verification.

Table 1. The selected technical inputs and outputs

Inputs	x_1	International incoming telephone traffic (minutes)
	x_2	Telephone faults per 100 main lines
	x_3	Waiting list for main lines
Outputs	y_1	% digital main lines
	y_2	% of telephone faults cleared by next working day
	y_3	Connection capacity of local exchanges
	y_4	International outgoing telephone traffic (minutes)
	y_5	International telephone circuits

3.1 DEA for Efficiency Analysis

Table 2 shows the standardized matrix used to perform the DEA analysis. The data presented in the matrix is taken from the International Telecommunications Union (ITU) for year 2002 [19], Landline technical units (LTUs) are listed along with the respective data in the matrix, these values can be obtained online from the ITU website, http://www.itu.int/ITU-D/ict/publications/world/world.html .

As per the generalized equations (1) and (2) for DEA analysis, we can find the efficiency of DMU1 as shown in model 3. The values for the model have been taken from standard DEA matrix shown in Table 2.

$$J_1^* = Min\ J_1$$

$$\sum_{j \neq 1} l_j x_j \leq J_1 x_{i1} \qquad i = 1,\ldots,3$$
$$\sum_{j \neq 1} l_j y_j \geq y_{r1} \qquad r = 1,\ldots,5 \qquad (7)$$
$$l_j \geq 0,\ j \neq 1,\ j = 2,3,\ldots,18$$

Where J_1 is a scalar and λ is a 18× 1 vector of constants. The estimated value of J_1 is the efficiency score for each of the n LTUs. The linear programming problem must be solved n times, once for each LTU. Equation (3) shows the solutions for LTU1. The CRS assumption is only appropriate when all LTUs are operating at an optimal scale. The optimal values of J_1^* can be less than, equal to, or greater than one. Now we are capable to rank the LTUs according to their aggregated output to aggregated to input ratios by J_o^* .After performing DEA analysis it was easy to rank the countries from the range 1 to 18 with respect to their efficiency measures. Table 3 presents the DEA rankings and efficiences of the 18 countries with respect to Model 7. Table 4 shows the results of slack and surplus for the DEA model which may be used for optimization purpose. After performing DEA analysis it was easy to rank the countries from the range 1 to 18 with respect to their efficiency measures.

3.2 Verification and Validation

A comparative study is conducted through PCA by considering the 3 input and 5 output indicators. Furthermore, PCA ranks the countries as per their performance

Table 2. Standardized matrix for 18 countries for DEA (2002)

No.	LTU	x_1	x_2	x_3	y_1	y_2	y_3	y_4	y_5
1	Armenia	52253000	52.90000153	60759	37.00999832	87.69999695	698837	37109000	1177
2	Azerbaijan	155232832	45.20000076	1E-13	48.40000153	69.5	1028908	42246024	2176
3	Benin	32084772	6.239999771	14205	87.33000183	18.60000038	99705	27531502	856
4	Cape Verde	50591000	43	789	100	89.19999695	91980	8720000	918
5	Czech Republic	871382976	6.789999962	27291	100	100	4941961	344974112	19980
6	Egypt	1141923840	0.5	99520	100	95	11286498	306944768	12086
7	Eritrea	31393464	51.06000137	46237	81.08999634	66.84999847	45411	4823376	285
8	Ethiopia	87858480	100	146062	90	24	649593	15805345	1012
9	Latvia	104411776	20.26000023	16168	88.69999695	89.26999664	813678	50201560	2727
10	Micronesia (Fed. States of)	6395572	48.09999847	120	100	65	15360	2387050	107
11	Mongolia	5485000	20.61000061	35578	99.5	85	152000	4575176	251
12	Myanmar	48621644	155	102569	82.05999756	75	420840	9434245	1649
13	Palestine	74668600	94	400	100	76	427310	38750240	499
14	Qatar	164587312	23.39999962	1E-13	100	88.30999756	208155	290705824	4520
15	Slovak Republic	212882000	10	12155	84.26000214	73.80000305	2059305	139510000	7564
16	Suriname	52875572	38.58000183	6087	77	41.79999924	122825	34233396	777
17	Swaziland	24664192	70	22616	100	82	51851	27844848	608
18	Taiwan, China	2608485632	1.399999976	1E-13	100	92.94000244	18351288	3076736000	52329

based on 15 indicators (outputs divided by inputs). This in turn shows which country is either weak or strong in terms of the telecommunication landline sectors. Furthermore, PCA identifies which technical indicators has the major impact on the performance of these countries. In order to verify the finding of the DEA analysis we use the PCA analysis approach and the steps required to do so are mentioned as follows:

Step 1: Normalize and standardize the indicators' vectors. The fifteen indicators must be normalized and have same order to be used in PCA. In this study the outputs were normalized with respect to each input (Table 5).

Step 2: Evaluate the correlation matrix.

Step 3: Eigenvalues, eigenvectors and proportion of the sample variance are calculated for all the twelve principal components (new variables) (Table 6).

Step 4: The principal components and aggregated weights are computed. PCA then provides us with the ranks of the countries as per their performance, the comparision between the DEA results and the PCA results is shown in Table 7.

To verify the results of the integrated DEA model, the PCA rankings are compared with that of the DEA through Spearman correlation experiment. The Spearman correlation is computed by the following formula:

$$r_s = 1 - \frac{6\sum d_i^2}{N(N^2-1)}$$

Where N = 18 and $\Sigma d_i^2 = 198$, substituting values in the equation we find the sperman correlation to be 79.56%. Therefore, we may further analyze and implement the PCA and DEA results. Moreover, the DEA surpluses and slacks may be used for optimization of LTUs as shown in Table 4. PCA may also be used to identify the importance of each of the 15 indicators. It should be noted that the 15 aggregated weights ($\widetilde{w}_m$) for $m = 1 \ldots 15$ show the importance of each indicator computed as follows:

Table 3. The DEA rankings and efficiencies of the LTUs of the 18 countries

LTU	Efficiency	Ranks
Armenia	1.046643	12
Azerbaijan	1.582894	7
Benin	2.471646	6
Cape Verde	1.189448	9
Czech Republic	1.18794	10
Egypt	2.862061	5
Eritrea	0.432103	18
Ethiopia	0.508211	17
Latvia	1.111	11
Micronesia	7.878781	2
Mongolia	3.071948	4
Myanmar	0.874162	13
Palestine	0.858285	14
Qatar	3.540706	3
Slovak Republic	1.530509	8
Suriname	0.644601	16
Swaziland	0.8419	15
Taiwan	659.6801	1

$$\widetilde{w}_m = \sum_{j=1}^{5} w_j l_{jm} \tag{8}$$

4. CONCLUSION

In summary, a unique integrated framework is presented to assess technical performance of the telecommunication landline sectors. Managers on the technical front may use this type of modeling approach to assess the performance of various telecommunication landline services with respect to the technical indicators. In turn, the selected LTUs or target markets would be ranked based on an integrated scientific approach, which reveals the standing of each LTU with respect to a series of standard technical indicators. This would enable managers of telecommunication landline sector to continuously monitor and improve technical performance. In addition, they may want to compare technical performance of a particular LTU or all LTUs with that of similar organizations or competitors. This would bring about further insights and knowledge of their standings with respect to competitors. The case study shows that Taiwan is ranked first and Micronesia is second amongst the 18 countries selected. This is the first study to present an integrated standard model for technical performance of telecommunication landline sectors.

5. REFERENCES

1 Agarwala, R. (1999). On the Approximability of Numerical Taxonomy (fitting distances by tree metrics). SIAM Journal on Computing, 28(3), pp.1073-1085.

2 Azadeh, M.A. (2000). Creating Highly Reliable Manufacturing Systems: An Integrated Approach, *International Journal of Reliability, Quality and Safety Engineering, 7(3)*.

3 Azadeh, M.A. (1999). Creating High Reliable Manufacturing Systems: An Integrated Approach, *Proceedings of the Fourth International Conference on Reliability, Maintainability and Safety (ICRMS'99)*, Shanghai, China.

Table 4. Results from the DEA model – Slack and surplus

LTU	x_1	x_2	x_3	y_1	y_2	y_3	y_4	y_5
Armenia	7.45E-09	-17.9673	0	151.1142	73.39596	0	0	835.7737
Azerbaijan	-1.16E+17	-3.4E+10	0	26.37942	0	12694080	2.26E+09	36955.33
Benin	0	-1.78E-15	-10312.7	0	56.65422	724289.8	25002011	1993.97
Cape Verde	-3.73E-08	7.11E-15	1.14E-13	24.03836	-1.42E-14	25673.14	82680159	665.8127
Czech Republic	0	-1.78E-15	0	10.78123	1.42E-14	3525506	5.49E+08	779.2856
Egypt	-601953946	-2.22E-16	-284832	2.216481	0	7471543	2.84E+09	41402.86
Eritrea	0	0	0	0	0	58122.74	303548.5	52.17543
Ethiopia	-7.45E-09	-7.11E-15	0	52.10739	124.306	0	11093580	0
Latvia	-1.49E-08	0	-7.28E-12	13.72703	0	1.16E-10	60739747	1010.86
Micronesia	0	-336.069	0	0	24.18312	76891.96	6314508	808.0213
Mongolia	0	-2.74683	-97348.8	12.22212	0	0	5138674	89.80189
Myanmar	-1.49E-08	-83.1527	0	175.5273	145.2967	235065.1	20845611	0
Palestine	1.49E-08	-26.581	0	15.5423	0	0	29145519	819.3695
Qatar	0	1.42E-14	-5.42E-20	0	49.48307	3776053	1.39E+08	5454.393
Slovak Republic	0	7.11E-15	-1141.9	1.312514	12.03285	2.33E-10	31226290	9.09E-13
Suriname	-7.45E-09	3.55E-15	4.55E-13	0	1.929509	0	6833798	183.0821
Swaziland	3.73E-09	-24.4239	0	6.451316	-1.42E-14	70644.9	0	1.14E-13
Taiwan	-1.7169E+12	-1.14E-13	1.39E-17	1506.007	1757.999	0	0	20073.68

Table 5. Standardized PCA index matrix

LTU	y_1/x_1	y_1/x_2	y_1/x_3	y_2/x_1	y_2/x_2	y_2/x_3	y_3/x_1	y_3/x_2	y_3/x_3	y_4/x_1	y_4/x_2	y_4/x_3	y_5/x_1	y_5/x_2	y_5/x_3
Armenia	-0.439	-0.373	-0.414	-0.151	-0.334	-0.431	1.0371	-0.339	-0.252	0.2565	-0.304	-0.262	0.1001	-0.359	-0.267
Azerbaijan	-0.515	-0.365	1.0373	-0.456	-0.337	1.7186	-0.042	-0.338	-0.014	-0.758	-0.303	-0.203	-0.734	-0.356	-0.09
Benin	-0.051	-0.097	-0.414	-0.423	-0.305	-0.431	-0.605	-0.339	-0.252	0.5991	-0.297	-0.262	0.5075	-0.347	-0.267
Cape Verde	-0.194	-0.339	-0.414	-0.13	-0.325	-0.431	-0.811	-0.341	-0.252	-0.989	-0.305	-0.262	-0.329	-0.359	-0.267
Czech Republic	-0.553	-0.082	-0.414	-0.539	-0.049	-0.431	-0.195	-0.22	-0.252	-0.471	-0.209	-0.262	0.1397	-0.071	-0.267
Egypt	-0.559	3.7666	-0.414	-0.547	3.7774	-0.431	0.4789	3.4362	-0.252	-0.766	0.8573	-0.262	-1.071	2.0219	-0.267
Eritrea	-0.078	-0.354	-0.414	-0.039	-0.342	-0.431	-0.87	-0.341	-0.252	-1.032	-0.305	-0.262	-1.219	-0.36	-0.267
Ethiopia	-0.378	-0.369	-0.414	-0.499	-0.365	-0.431	0.0807	-0.341	-0.252	-0.972	-0.305	-0.262	-0.979	-0.36	-0.267
Latvia	-0.412	-0.296	-0.414	-0.355	-0.274	-0.431	0.1445	-0.335	-0.252	-0.275	-0.3	-0.262	0.4524	-0.348	-0.267
Micronesia	2.4393	-0.344	-0.414	1.9526	-0.341	-0.431	-0.718	-0.342	-0.252	-0.524	-0.305	-0.262	-0.468	-0.361	-0.267
Mongolia	2.9222	-0.287	-0.414	3.2749	-0.28	-0.431	3.3301	-0.34	-0.252	0.5436	-0.305	-0.262	2.379	-0.36	-0.267
Myanmar	-0.25	-0.376	-0.414	-0.185	-0.36	-0.431	0.2825	-0.341	-0.252	-0.939	-0.305	-0.262	1.2171	-0.36	-0.267
Palestine	-0.317	-0.365	-0.414	-0.315	-0.353	-0.431	-0.187	-0.341	-0.252	-0.186	-0.304	-0.262	-1.454	-0.36	-0.267
Qatar	-0.458	-0.299	2.5842	-0.434	-0.288	2.3003	-0.9	-0.34	-0.204	2.7025	-0.281	0.1399	0.5843	-0.342	0.1009
Slovak Republic	-0.499	-0.212	-0.414	-0.481	-0.209	-0.431	0.4453	-0.307	-0.252	0.1295	-0.279	-0.262	1.3757	-0.286	-0.267
Suriname	-0.295	-0.346	-0.414	-0.371	-0.347	-0.431	-0.73	-0.341	-0.252	0.1112	-0.303	-0.262	-0.668	-0.359	-0.267
Swaziland	0.2062	-0.358	-0.414	0.2571	-0.345	-0.431	-0.766	-0.342	-0.252	1.2264	-0.304	-0.262	0.3086	-0.36	-0.267
Taiwan	-0.568	1.0962	2.5842	-0.558	1.0788	2.4435	0.0233	1.8521	4.0005	1.3435	3.8559	3.989	-0.142	3.3237	3.9893

Table 6: Eigen values and vectors from the PCA analysis

Eigen Value	6.92588	2.97356	2.59288	1.06312	0.76978	0.44512	0.20797	0.01113	0.00804	0.00158	0.00082	0.00012	2.9E-08	8.7E-17	-7E-16
Weight	0.46173	0.19824	-0.1729	-0.0709	-0.0513	-0.0297	0.01386	0.00074	-0.0005	0.00011	5.5E-05	-8E-06	1.9E-09	5.8E-18	-5E-17
Vectors	vector1	vector2	vector3	vector4	vector5	vector6	vector7	vector8	vector9	vector10	vector11	vector12	vector13	vector14	vector15
y_1/x_1	-0.121	0.22832	-0.4471	0.20875	-0.4664	0.09736	0.13603	0.26397	-0.5751	-0.0007	-0.2065	-0.035	0.00066	4.1E-13	-5E-12
y_1/x_2	0.22693	-0.3799	-0.233	-0.2394	-0.1099	0.04144	0.08231	0.15273	-0.2021	0.03806	0.76357	0.15226	0.01256	7.5E-12	-1E-10
y_1/x_3	0.27719	0.27128	0.16897	-0.2596	-0.2443	-0.3318	0.13181	-0.606	-0.2935	0.00223	0.02784	0.03675	-0.0232	0.33199	0.01521
y_2/x_1	-0.1195	0.2437	-0.4761	0.16134	-0.3692	-0.0127	0.00645	-0.2848	0.63477	-0.0123	0.2267	0.03945	-0.001	-6E-13	7.7E-12
y_2/x_2	0.226	-0.3818	-0.2341	-0.2369	-0.1111	0.00775	0.07178	-0.0779	0.09617	-0.2293	-0.2258	-0.7455	-0.0079	-4E-12	5.8E-11
y_2/x_3	0.26543	0.25793	0.18061	-0.2322	-0.2499	-0.5056	0.18058	0.5379	0.24217	-0.0348	-0.0401	0.01301	-0.0316	-0.2715	0.01171
y_3/x_1	-0.0218	0.10819	-0.4967	-0.1073	0.41744	-0.5208	-0.514	0.01692	-0.1383	-0.0028	-0.0207	-0.0015	0.00013	7.6E-14	-1E-12
y_3/x_2	0.28073	-0.321	-0.215	-0.1397	-0.0858	0.02589	0.03933	-0.0483	0.12397	0.64901	-0.4277	0.32798	0.11606	6.9E-11	-9E-10
y_3/x_3	0.34183	0.16398	-0.0035	0.29769	0.13347	0.05779	-0.0159	0.31305	0.1253	0.11779	0.08616	-0.1759	0.2219	0.67388	0.27734
y_4/x_1	0.13831	0.35415	0.03731	-0.5273	-0.1498	0.52493	-0.5158	0.10098	0.03439	-0.0092	-0.0236	-0.0016	0.00048	2.9E-13	-4E-12
y_4/x_2	0.36552	0.03292	-0.0753	0.20433	0.09708	0.10692	-0.0108	0.00247	0.0148	-0.0134	-0.036	0.06438	-0.8894	-5E-10	7E-09
y_4/x_3	0.34541	0.18029	0.00604	0.24398	0.10606	0.09672	-0.0236	-0.2236	-0.1253	0.12467	0.10994	-0.1508	0.20771	-0.5853	0.51546
y_5/x_1	-0.0632	0.33407	-0.2893	-0.3598	0.49437	0.19822	0.62125	0.00684	0.02921	0.01886	-0.0185	0.006	-9E-05	-6E-14	7.5E-13
y_5/x_2	0.35995	-0.1174	-0.1395	0.0732	0.04082	0.08583	0.02516	-0.0302	0.04216	-0.6922	-0.2338	0.47671	0.24168	1.4E-10	-2E-09
y_5/x_3	0.34566	0.17958	0.00843	0.24879	0.10492	0.06776	-0.0154	-0.0387	-0.0388	0.11913	0.09934	-0.1552	0.20712	-0.1393	-0.8106

Table 7. Comparison of the DEA and PCA analysis (2002)

LTUs	DEA RESULTS		PCA RESULTS	
	Efficiency	Ranks	Zpca	Rank
Armenia	1.046643	12	-0.40631	9
Azerbaijan	1.582894	7	0.000445	5
Benin	2.471646	6	-0.43095	10
Cape Verde	1.189448	9	-0.7777	16
Czech Republic	1.18794	10	-0.53764	12
Egypt	2.862061	5	1.012247	3
Eritrea	0.432103	18	-0.85645	18
Ethiopia	0.508211	17	-0.80292	17
Latvia	1.111	11	-0.53582	11
Micronesia	7.878781	2	-0.34278	7
Mongolia	3.071948	4	0.601724	4
Myanmar	0.874162	13	-0.54672	13
Palestine	0.858285	14	-0.73054	15
Qatar	3.540706	3	1.057965	2
Slovak Republic	1.530509	8	-0.35141	8
Suriname	0.644601	16	-0.66533	14
Swaziland	0.8419	15	-0.32451	6
Taiwan	659.6801	1	4.636692	1

4 Azadeh, M.A. & Jalal, S. (2001). Identifying the Economic Importance of Industrial Sectors by Multivariate Analysis. Journal of the Faculty of Engineering, University of Tehran, Iran.

5 Azadeh, M.A & Ebrahimipour, V. (2002). An Integrated Approach for Assessment of Manufacturing Sectors Based on Machine Performance: The Cases of Automotive and Food and Beverages Industries. Proceedings of the 2nd International Manufacturing Complexity Conference, University of Cambridge, England.

6 Azadeh, M.A. and Ebrahimipour, V. (2002). A Multivariate Approach for Assessment and Improvement of Machinery and Equipment Manufacturers Based on Machine Performance. The 6th International Conference on Engineering Design and Automation, Maui, Hawaii.

7 Azadeh, M.A. (2002). A Multivariate Model for Assessment of Industrial Sectors Based on Machinery Indicators, 30th International Conference on Computers & Industrial Engineering, 29 June - 2 July 2002, Tinos Island, Greece.

8 Azadeh, M.A., Ebrahimipour, V. and Ataei, G.R. A Total Machine Productivity Model for Assessment and Improvement of Electrical Manufacturing Systems, 32nd International Conference in Computers and Industrial Engineering, Limerick, Ireland, August (2003).

9 Azadeh, M.A. and Ebrahimipour, A., 2004, An Integrated Approach For Assessment And Ranking Of Manufacturing Systems Based On Machine Performance, International journal of Industrial Engineering, 11(4)

10 Bhat, V.N. (1995). A Multivariate Analysis of Airline Flight Delays. International Journal of Quality & Reliability, 12(2).

11 Bolden, R., Waterson, P., Warr P. and Clegg, C. (1997). A New Taxonomy of Modern Manufacturing Practices. International Journal of Operations and Production Management, 17(11).

12 Chen, L.H., Kao, C., Kuo, S., Wang, T.Y. and Jang, Y.C. (1996). Productivity Diagnosis via Fuzzy Clustering and Classification: An Application to Machinery Industry. Omega, 24(3).

13 Garcia, T. and Grande, I. (2003). A Model for Valuation of Farmland in Spain: The Case of Multivariate Analysis. Journal of Property Investment and Finance, 21(2).

14 Guimaraes, T., Matensson, N., Stahre, J. and Igbaria, M. (1999). Empirically Testing the Impact of Manufacturing Complexity on Performance. International Journal of Operations and Production Management, 19(12).

15 Harris, T.J., Seppala, C.T. and Desborough, L.D. (1999). A Review of Performance Monitoring and Assessment Techniques for Univariate and Multivariate Control Systems. Journal of Process Control, 9.

16 Hitchens, D., Birnie, J.E. and Wagner, K. (1996). A Matched Plant Comparison of Productivity in East and West Germany: Transition to the Market Economy. Omega, 24(3).

17 Hong, H.K., Ha, S.H., Shin, C.K., Park, S.C. and Kim, S.H. (1999). Evaluating the Efficiency of Integration Projects Using DEA and Machine Learning. Expert Systems with Applications, 16.

18 Hulten, C. R. (2001). Total Factor Productivity: A short biography. In C. R. Hulten, E. R. Dean and M. J. Harper, Eds. New developments in productivity analysis. Chicago: University of Chicago Press for the National Bureau of Economic Research.

19 ITU (International telecommunication union), (8th Edition 2004) World Telecommunications Indicators Database.

20 Karakaya, F. & Canel, C. (1998). Underlying Dimensions of Business Location. International Management & Data Systems, pp 321-329.

21 Kumar, S. (1998). Application of Multivariate Analysis Techniques in Understanding Industrial Process: A Pulp Mill Example. Pulping and Bleaching Analysis and Control Group, University of Washington, USA.

22 Madsen, T.K. (1989). Successful Export Marketing Management: Some Empirical Evidence. International Marketing Review, 6(4).

23 Madu, C. (1999). Reliability and Quality Interface. International Journal of Quality & Reliability Management, 16(7).

24 Matsudaira, M. & Hong, Q. (1994). Features and Characteristic Values of Fabric Compress Ional Curves. International Journal of Clothing Science and Technology, Vol. 6 No .2/3, pp 37-43.

25 McCarthy, I. (1995). Manufacturing Classification: Lessons from Organizational Systematic and Biological Taxonomy. Integrated Manufacturing Systems, 6(6).

26 Meade, N. (1987). Strategic Positioning in UK Car Market. European Journal of Marketing, 21(5).

A Framework Examining the Customer's Expectation and Cellular Phone Service

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ABSTRACT

This paper shows how to evaluate service quality, improve service deficiency and understanding the needs of customers are the most important issues in mobile value-added service market these days. This study identifies gaps between customers and service providers by a conceptual "Gap model". Based on this study, service providers could obtain higher revenue of mobile value-added service by reducing these perceptive discrepancies.

Keyword: Service; Service quality; Mobile value-added service; Expected service; Perceived service.

1. INTRODUCTION

1.1 Study Background

The market of mobile communication in Taiwan is almost full. Therefore the mobile value-added service will become one of the most competitive facilities for mobile service providers. Unhealthy competition in the mobile service industry has compelled many service providers to initiate quality programs. Achieving high quality standards along with high profitability and great market share is now an important part of strategic planning. The literatures of marketing are also reflecting an awareness of quality. Some of the recent studies have provided the theoretical frameworks of customer expectation of service quality, and some of them have already developed quantitative models to measure service quality.

1.2 Study Motivation

In today's mobile value-added service market, each firm has to provide high quality services to appeal to their customers. Hence how to evaluate service quality, improve service deficiency and understand the needs of customers are the most important issues. For example, with the fast growth of the mobile communication market, people already have more intention to have more services and applications which they can choose from. Among the mobile communication services, text message, voicemail and answering ringing are most popular and widely used today. To ensure the quality of mobile communication service, service providers have to provide convenient, enjoyable and novel services for users. Since more subscribers will create more profits, advertisers will be more willing to cooperate with service providers.

1.3 Study Objectives

This study will discuss the relationship of expectations and perceptions between customers and service providers. Furthermore, it can be applied in the mobile value-added services market.

2. LITERATURE REVIEWS

2.1 Service Quality

2.1.1 Service

Service is identifiable, but essentially intangible activities which are offered by people as products such as delivery and repair. Based on a review of previous research and an exploratory study, Zeithaml(1988, p4) suggested that "perceived value is the customer's overall assessment of the utility of product base on perceptions of what is received and what is given." If perceived service value is similar to the concept of perceived product value, which can be considered to involve a trade-off between a customer's expectation of benefits of using a service and the expectation of cost of using the service. Customers' assessments of service value are hypothesized to influence purchase intentions and behaviors.

2.1.2 Characteristics of Service

There are three well documented characteristics of services as follows:

1. Intangibility: Most services cannot be counted, measured, stored, tested, and verified before selling to customers. Because of intangibility, the firm may find it is difficult to understand how consumers perceive their services and evaluate service quality. (Zeithaml, 1981)
2. Indivisibility: As a consequence, the quality of services cannot be engineered at the manufacturing plant and then delivered to the consumers. That is, quality occurs during services are delivered, usually in an interaction of the customer and the employee of the service providers. (Lehtinen & Lehtinen,1982)
3. Heterogeneity: The performance of services often varies from frim to firm, from customer to customer, and from day to day. Consistency of behavior of service personnel is difficult to assure (Booms & Bitner, 1981). What the firm intends to deliver may be entirely different from what the consumer receives, so the services are heterogeneous.

2.1.3 Service Quality

Service quality is a measurement of the level of how well the service matches the customer expectation. (Lewis & Booms, 1983)

Recent marketing researches, such regarding customers' attitudes toward service, have been focused on perceived service quality. Perceived service quality is defined as the customer's assessment of overall performance of service. (Zeithaml, 1988)

Parasuraman et al.(1985,1988) considers the customer's assessment of overall service quality depends on the gap between customer expectation and perception of actual performance of service.

2.1.4 Dimensions of Service Quality

Consumers' expectations are based on verbal information, personal needs, experience and commercial information. Parasuraman et al. (1985) identified a number of discrepancies in the relationship between the clients and the service providers. During interviews in focus groups, they established ten dimensions of service quality as follows:

1. Tangible features: physical facilities, equipment, and front-line employees.
2. Reliability: ability to perform the promised service dependably and accurately.
3. Responsiveness: willingness and readiness to help clients and provide them services.
4. Communication: providing information in words that clients understand.
5. Credibility: honesty and truthfulness.
6. Security: ensuring clients from physical and financial risks.
7. Competence: adequately trained and skilled employees.
8. Courtesy: helpfulness, respect and a friendly attitude to clients.
9. Knowing: understanding customers and their needs.
10. Access: openness and interaction with clients.

2.2 Gap Model

Research (Thompson, DeSouza & Gale, 1985) and company experience (Rudie & Wansley, 1985) revealed that performing high service quality will result in measurable profits, cost saving, and market share growth. Therefore, knowledge of service quality and how it is achieved in organizations have become the important points for research. Parasuraman, Zeithaml and Ben brry (1985) previously developed service quality model to indicate that consumers' perceptions of service quality are influenced by a series of five distinct gaps occurring in organizations (as figure 1 illustrated). These gaps on the service provider's side may impede high quality performance of services that consumers perceive.

Gap 1: Difference between Expected Service and Management Perceptions of Consumer Expectations.

Service provider executives may not always connote the high quality features to consumers, which attributes what a service must have in order to meet consumers' needs, and the levels of performance on those features are necessary to deliver high quality service. (Langeard et al., 1981; Parasuraman & Zeithaml, 1983)

Gap 2: Difference between Management Perceptions of Consumer Expectations and Service Quality Specification.

Managers may not always have the ability to establish the standard of service quality that can conform to consumer expectation and transfer the standard into the realized ones.

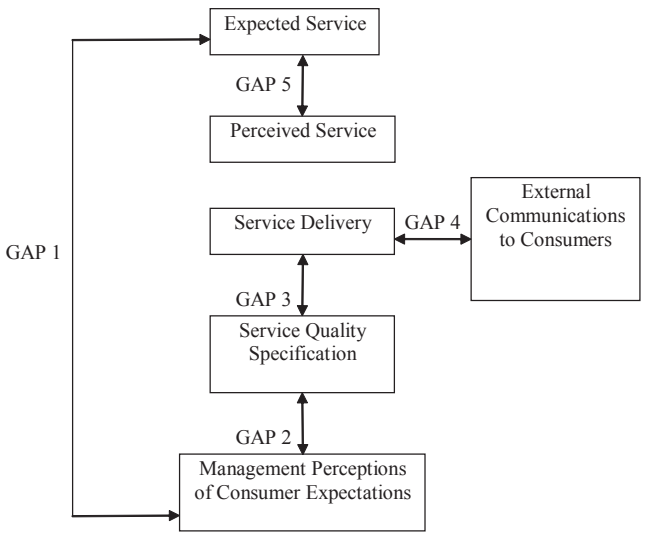
Gap3: Difference between Service Quality Specifications and Service Delivery

There is discrepancy between the specifications of service and the actual delivery of the service. It can be referred to as the "service performance gap". That is, it is the extent which service providers do not perform service at the level consumers expected. The service performance gap occurs when employees are unable or unwilling to perform the service at the desired level. (Zeithaml, Berry & Parasuraman, 1985)

Gap 4: Difference between Service Delivery and External Communications to Consumers

The discrepancy between service delivery and external communications means exaggeratory promises or the absence of information about service delivery. It may affect consumer perception of service quality.

Figure 1. Conceptual model of service quality



Gap5: Difference between Expected Service and Perceived Service

This gap is defined by the PZB model which suggested consumers feel the difference between expected service and perceived service. Hence, gap5 is a function of gap1 to gap4.

3. RESEARCH HYPOTHESES

A set of key discrepancies or gaps exists regarding executive perceptions of service quality and the tasks associate with service delivery to consumers. These gaps can be major hurdles in attempting to deliver a high quality service which consumers expected. The connection between expected service and perceived service is impossible to completely match. In other words, the exaggeration of marketing will influence the difference.

We suggest that the activity of reducing the gaps between expectations, perceptions and the practical actions, is to understand the customers' needs and then service providers will provide the services for matching the needs. Since the higher levels of service quality are related to higher levels of customer satisfaction.

Based on the results of the difference, we have formulated the following hypotheses.

H-1: There are significant discrepancies in customers' expectations of mobile value-added service and management perceptions of these expectations.

H-2: There are significant discrepancies in customers' expectations of mobile value-added service and the service delivered.

H-3: There are significant discrepancies between managers and service providers of the perceptions of customers' expectations of mobile value-added service.

H-4a: Discrepancies between customers' expectations of mobile value-added service quality and management perceptions of such expectations will have negative impact on the quality of mobile value-added service.

H-4b: Discrepancies between customers' expectations of mobile value-added service quality and the service delivered will have negative impact on the quality of mobile value-added service

H-4c: Discrepancies between managers and service providers of the perceptions of customers' expectations of mobile value-added service will have negative impact on the quality of mobile value-added service.

CONCLUSION

The number of users of mobile communication market in Taiwan is very large, but the revenue of mobile value-added service is still insignificant. In other words, there is still potential growth in the mobile value-added service market. By the development of communication technology, it is possible to develop more variety of mobile value-added service today. For developing successful new services, it is important to match the users' needs. We have identified the gaps between customers and service providers above. Based on this study, service providers could obtain higher revenue of mobile value-add service by reducing these perceptive discrepancies.

REFERENCES

1. Ahmad, R., & Buttle, F. (2002). Customer retention management: A reflection of theory and practice. *Marketing Intelligence and Planning*, 20(3), 149–161.
2. Abod, A.K., Hishamuddin, I., and Venu, T. (2002). What a Drive Customer Loyalty: and Analysis from the Telecommunication Industry. *Measurement and Analysis for Marketing*, Lodon, 2002 Sep.
3. Bendapudi, N., & Berry, L. L. (1997). Customers' motivations for maintaining relationships with service providers. *Journal of Retailing*, 73(1), 15–37.
4. Babakus, E. & Boller, G.W. (1992). An empirical assessment of SERVQUAL scale. *Journal of Business Research*, 24, 253- 268.
5. Babakus, E. & Mangold, W.G. (1992). Adapting the SERVQUAL scale to hospital services: an empirical investigation. *Health Services Research*, 26, 767- 786.

6. Bellman, S., Lohse, G. L., & Johnson, E. J. (1999). Predictors of online buying behavior. *Communications of the ACM*, Vol. 42, Iss. 12, 32-38.
7. Bouman, M., & Van Der Wiele, T. (1992). Measuring service quality in the car service industry: building and testing an instrument. *International Journal of Service Industry Management*, 3, 4-16.
8. Carman, J. M. (1990). Consumer perceptions of service quality: an assessment of the SERVQUAL dimensions. *Journal of Retailing*, 66, 33-35.
9. Campbell, S. J., Donnelly, M., & Wisniewski, M. (1995). A measurement of service. *Journal of the Scottish Libraries Association*, 50, 10-11.
10. Clarke, I. III. (2001). Emerging value propositions for M-commerce. *Journal of Business Strategies*, Vol.18, Iss. 2, 133-145.
11. Cronin, J. J. Jr., & Taylor, S. A. (1994). SERVPERF versus SERVQUAL: reconciling performance-based and perceptions-minus-expectations measurement of service quality. *Journal of Marketing*, 58, 125-131.
12. Gartner Research. Mobile phone estimates for 2004 (2004) from http://www4.gartner.com/press_releases/asset_62091_11.html.
13. Lam, S. K. (1997). SERVQUAL: a tool for measuring patients' opinions of hospital service quality in Hong Kong. *Total Quality Management*, 8, 145- 152.
14. Ruby, R. D., & Nikhilesh D. (2004). Mobility and markets: emerging outlines of m-commerce. *Journal of Business Research,* Vol. 57, Iss. 12, 1391-1396.
15. Mort, G. S., & Drennan, J. (2002). Mobile digital technology: Emerging issues for marketing. *Journal of Database Marketing & Customer Strategy Management*, Vol. 10, Iss. 1, 9-23.
16. Naumann, E. (1995). Creating Customer Value: The Path to Sustainable Competitive Advantage (Cincinnati, Thomson Executive Press).
17. Keen, P., & Mackintosh, R. (2001). *The Freedom Economy: Gaining the M-commerce Edge in the Era of the Wireless Internet*. Osborne/McGraw-Hill, Berkeley: CA.
18. Kim, Moon-Koo, Park, Myeong-Cheol, & Jeong, Dong-Heon. (2004). The effects of customer satisfaction and switching barrier on customer loyalty in Korean mobile telecommunication services. *Telecommunications Policy,* Vol. 28, Iss. 2, 145-159.
19. Parasuraman, A., Zeithaml, V. A., & Berry, L. L. (1985). A conceptual model of service quality and its implications for future research. *Journal of Marketing*, 49, 41- 50.
20. Parasuraman, A., Zeithaml, V. A., & Berry, L. L. (1988). SERVQUAL: a multi-item scale for measuring consumer perceptions of service quality. *Journal of Retailing*, 64, 12-40.
21. Parasuraman, A., Zeithaml, V. A., & Berry, L. L. (1991). Refinement and reassessment of SERVQUAL scale. *Journal of Retailing*, 67, 420-450.
22. Parasuraman, A., Zeithaml, V. A., & Berry, L. L. (1994). Reassessment of expectations as a comparison standard in measuring service quality: implications for further research. *Journal of Marketing*, 58, 111- 124.
23. Siau, K., Lim, E. P., & Shen, Z. (2001). Mobile commerce: Promises, challenges, and research agenda. *Journal of Database Management*, Vol. 12, Iss. 3, 4-13.
24. Sureshchandar, G. S., Rajendran, C., & Kamalanabhan, T. J. (2001). **Customer perceptions of service quality: a critique.** *Total Quality Management*, 12, 111-124.
25. Reeves, C. A., & Bednar, D. (1994). Defining quality: alternatives and implications. *Academy of Management Review*, 19, 419- 445.
26. Teas, R. K. (1994). Expectations as a comparison standard in measuring service quality: an assessment of a reassessment. *Journal of Marketing*, 58, 132-139.
27. Teas, R. K. (1994). Expectations as a comparison standard in measuring service quality: an assessment of a reassessment. *Journal of Marketing*, 58, 132-139.
28. Tribe, J., & Snaith, T. (1988). From SERVQUAL to HOLSAT: holiday satisfaction in Varadero, Cuba. *Tourism Management*, 19, 25- 34.
29. Tsalgatidou, A., & Pitoura, E. (2001). Business Models and Transactions in Mobile Electronic Commerce: Requirements and Properties. *Journal of Computer Networks*, Vol. 37, Iss. 2, 221-236.

Varshney, U., & Vetter, R. (2002). Mobile Commerce: Framework, Applications and Networking Support. *Journal on Mobile Networks and Applications*, Vol. 7, Iss. 3, 185-198.

Pseudo Random Numbers Based Methods for Customized and Secure Image Steganography

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ABSTRACT

Steganography is the science of hiding information in media based data. We present random numbers logic based steganographic methods and layout management schemes for hiding data/image into image(s). These methods and schemes can be customized according to the requirements of the users and the characteristics of data/images. These methods are secure enough to meet the requirements of the users and user can play significant role in selection and development of these methods. Methods can be chosen randomly and implemented dynamically based on inputs, user choices as well as outputs. Experimental results are given to demonstrate the performance of the proposed methods.

Keywords: Steganography, Cryptography, Random numbers logic etc.

1. INTRODUCTION

Steganography is the art and science of hiding information in ways that prevent the detection of hidden messages. Steganography, derived from Greek, literally means "Covered writing." It includes a vast array of secret communications methods that conceal the message's very existence. These methods include invisible inks, microdots, character arrangement, digital signatures, covert channels, and spread spectrum communications. Steganography and cryptography are cousins in the spy craft family. Cryptography scrambles a message, so that it cannot be understood. Steganography hides the message, so it cannot be seen. A message in cipher text, for instance, might arouse suspicion on the part of the recipient while an "invisible" message created with steganographic methods will not. Modern steganography's goal is to keep hidden message's mere presence undetectable, but steganographic systems because of their invasive nature, leave behind detectable traces in the cover medium. Even if secret content is not revealed, the existence of it can be guessed because modifying the cover medium changes its statistical properties, so eavesdroppers can detect the distortions in the resulting stego medium's statistical properties. The process of finding these distortions is called statistical steganalysis.

In this paper we focus on the developing the techniques that can help hiding messages on the basis of random numbers logic. Present work concentrates upon using Least Significant Bit conversion but is not limited to it. It can involve other methods for steganography discussed in paper. Random numbers based steganographic study is implemented at small scale, but power of random numbers to hide the data/image is not fully exploited and unexplored yet. This paper is an effort to explore the real power of random numbers to hide the messages in secure and customized way.

This paper is organized as follows: Section 2 includes the study of related work. In section 3 we introduce the concept of steganography in more detail, followed by detailed discussion about image processing. In section 4 we discuss about different methods used for steganography. In section 5 includes the proposed methods for steganography based on random numbers logic. In section 6 we discuss few layout management schemes for using methods discussed in section 5. In section 7 we include experimental results to check the strength of proposed methods. Section 8 includes conclusion and future directions for the related research work. Last, but not the least section 9 includes bibliography.

2. RELATED WORK

Steganography is the art of secret communication. Its purpose is to hide the very presence of communication as opposed to cryptography, which aims to make communication unintelligible to those who do not posses the right keys Andersen et al.[1]. The traditional approach to image encoding consists in the source coding, encryption and channel coding Gonzalez et al.[2]. The source coding is used to compress data and match it with the band-width of communication channel. However, the obtained data are sensitive to the communication noise and not protected against unauthorized use. To overcome these disadvantages the next two stages are to be used. To protect data against unauthorized access the encryption is accomplished. The encryption stage is performed separately from source coding. To reduce nuisance of the communication channel noise the channel coding is used which is based on the specialized error correction codes able to detect and correct errors directly during data transmission. Both encryption and channel coding require the introduction of the redundant information in initial data that leads to the increase of data size and corresponded time of transmission. Now a day, we can use digital images, videos, sound files, and other computer files that contain perceptually irrelevant or redundant information as "covers" or carriers to hide secret messages. After embedding a secret message into the cover-image, we obtain a so-called stego-image. It is important that the stego-image does not contain any detectable artifacts due to message embedding. A third party could use such artifacts as an indication that a secret message is present. Once a third party can reliably identify which images contain secret messages, the steganographic tool becomes useless. Obviously, the less information we embed into the cover-image, the smaller the probability of introducing detectable artifacts by the embedding process. Another important factor is the choice of the cover-image. The selection is at the discretion of the person who sends the message. Images with a low number of colors, computer art, images with a unique semantic content, such as fonts, should be avoided as cover images. Some steganographic experts e.g. Aura [3] recommend grayscale images as the best cover images. They recommend uncompressed scans of photographs or images obtained with a digital camera containing a high number of colors and consider them safe for steganography. Pfitzmann and Westfeld [4] introduced a method based on statistical analysis of Pairs of Values (PoVs) that are exchanged during message embedding. Pairs of Values that differ in the LSB only, for example, could form these PoVs. This method provides very reliable results when we know the message placement (such as sequential). However, we can only detect randomly scattered messages with this method when the message length becomes comparable with the number of pixels in the image. Johnson et al. [5, 6] pointed out that steganographic methods for palette images that preprocess the palette before embedding are very vulnerable. Existing cryptographic and steganographic mediums suffer from a myriad of attacks. Johnson [7] has studied such attacks on image steganography while Pal et al. [8] has studied similar attacks in the context of audio steganography. Even though cryptography and steganography are exposed to so many probable attacks, very few people have given a thought to find alternate ways to transmit information. The goal of steganalysis is to defeat steganography methods by identifying the presence of hidden information. This may be done using detection-theoretic methods if the distributions of the cover-image and stego-image are known to the steganalyzer as defined by Cachin [9], and various creative techniques as given by Fridrich et al. [10] etc. Fisk et al. [11] point out the weaknesses of TCP/IP

protocol suite and discuss how those weaknesses could be used as covert channels for secret communication, whereas Bao et al. [12] focus on using communication accessories like email headers etc for secret communication. . Avcibas et al. [13] proposed a stegoanalysis technique based on image quality metrics. Fard et al.[18] proposed a novel (Genetic Algorithm) GA evolutionary process to make a secure steganographic encoding on JPEG images. Martín et al. [19] experimentally investigated if stego-images, bearing a secret message were statistically "natural". Koval et al. [20] discussed the problem of performance improvement of non-blind statistical steganalysis of additive steganography in real images. Luo et al. [21] presented a secure LSB steganography system against sample pair analysis, such as RS, SPA and DIH method by adopting chaotic technique and dynamic compensation skill.

3. A CLOSE LOOK OF STEGANOGRAPHY AND IMAGE PROCESSING

3.1 Steganography

There are many forms of steganography including audio, video and image media. These forms of steganography often are used in conjunction with cryptography, so that the information is doubly protected; first it is encrypted and then hidden so that an adversary has to first find the information (an often difficult task in and of itself) and *then* decrypt it. The following formula provides a very generic description of the pieces of the steganographic process:

Cover Medium + Hidden Data + Stego Key = Stego Medium

In this context, the *cover medium* is the file in which we will hide the *hidden data*, which may also be encrypted using the *stego key*. The resultant file is the *stego medium* (which will, of course be the same type of file as the cover medium). The cover medium (and thus, the stego medium) are typically image or audio files. In this article, we have focused on image files and therefore, refer to the *cover image* and *stego image*.

3.2 Image Processing

An image file is merely a binary file containing a binary representation of the color or light intensity of each picture element (pixel) comprising the image.

The simplest approach to hiding data within an image file is called *Least Significant Bit (LSB) insertion*. In this method, we can take the binary representation of the hidden data and overwrite the LSB of each byte within the cover image. If we are using 24-bit color, the amount of change will be minimal and indiscernible to the human eye. As an example, suppose that we have three adjacent pixels (nine bytes) with the following RGB encoding:

10010101 00001101 11001001
10010110 00001111 11001010
10011111 00010000 11001011

Now suppose we want to "hide" the following 9 bits of data (the hidden data is usually compressed prior to being hidden): 101101101. If we overlay these 9 bits over the LSB of the 9 bytes above, we get the following (where bits in **bold** have been changed):

10010101 00001100 11001001
10010111 00001110 11001011
10011111 00010000 11001011

Note that we have hidden 9 bits successfully, but at a cost of only changing 4, or roughly 50%, of the LSBs.

This description is meant only as a high-level overview. Similar methods can be applied to 8-bit color but the changes, as the reader might imagine, are more dramatic. Gray-scale images, too, are very useful for steganographic purposes. One potential problem with any of these methods is that an adversary who is looking can find them. In addition, there are other methods besides LSB insertion with which to insert hidden information. These methods based on random numbers logic are the subject matter for present paper.

4. IMAGE STEGANOGRAPHY METHODS

Image steganography has been widely studied by researchers. There are a variety of methods used in which information can be hidden in images. Some of them are described here given by Lee et al. [14], Chan et al. [15], Chang et al. [16], and Hsu et al. [17].

4.1 Replacing Least Significant Bit

In image steganography almost all data hiding techniques try to alter insignificant information in the cover image. For instance, a simple scheme proposed by Lee et al. [14], is to place the embedding data at the least significant bit (LSB) of each pixel in the cover image. The altered image is called stego-image. Altering LSB doesn't change the quality of image to human perception but this scheme is sensitive a variety of image processing attacks like compression, cropping etc.

4.2 Replacing Moderate Significant Bit

Chan et al. [15] showed how to use the moderate significant bits of each pixel in the cover image to embed the secret message. This method improves sensitivity to modification, but it degrades the quality of stego-image.

4.3 Transformation Domain Techniques

Other familiar data hiding techniques use the transformation domain of digital media to hide information discussed by Chang et al. [16] and Hsu et al. [17]. Functions such as the discrete cosine transform (DCT) and the discrete wavelet transform (DWT) are widely applied by Chang et al. [16], and Hsu et al. [17]. These methods hide the messages in the significant areas of the cover image, which makes them robust against compression, cropping and other image processing attacks.

Figure 1. General image steganography system

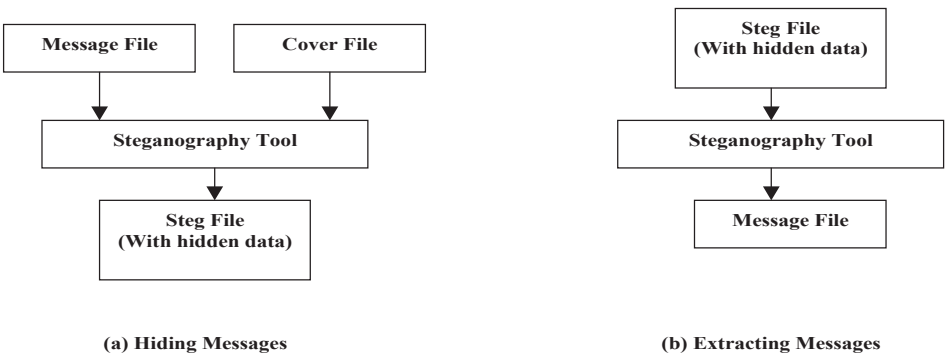
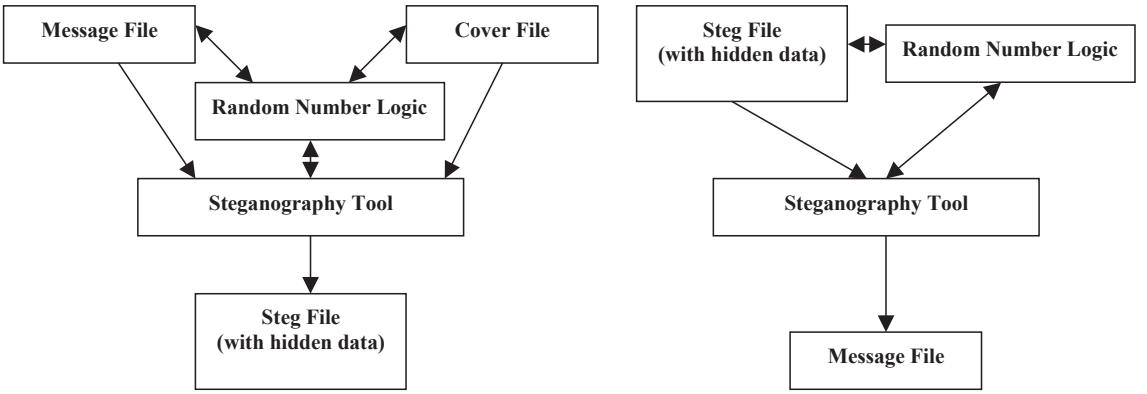


Figure 2. Proposed system based on random number logic



(a) Hiding Messages **(b) Extracting Messages**

5. PROPOSED METHODS

In proposed system random numbers logic play an important role in Customization and secure implementation of staganography (figure 2). As type of different methods progress more complexity is added to the implementation.

5.1 Type I Methods (Simple Methods)

An obvious method that can be constructed from combination of random numbers generator and least significant bit method (Other methods may also be employed on same tracks, but current paper include only Least Significant Bit based method).

Following general congruential method may be used to generate the location of next bit to be replaced i.e. after x_{i+1} bytes from current byte may be used as target byte to replace the least significant bit.

$$x_{i+1} = f(x_i, x_{i-1}, ..., x_{i-n+1}) (\text{mod}\, m) = (a_1 x_i + a_2 x_{i-1} + ... + a_n x_{i-n+1} + c) \ (\text{mod}\, m)$$

In above Formula all m, n, a, c and x are non-negative integers. Given that the previous random number was x_i, the next random number x_{i+1} can be generated. The numbers generated by a congruential method are between 0 and m-1. e.g. suppose that we have three adjacent pixels (nine bytes) with the following RGB encoding:

10010101 00001101 11001001
10010110 00001111 11001010
10011111 00010000 11001011

Now suppose we want to "hide" the following 4 bits of data (the hidden data is usually compressed prior to being hidden): 1011.Random number generator used for hiding data is

$$x_{i+1} = a x_i + c \ (\text{mod}\, m)$$

e. g. x_0=a=c=7 and m=3 have list of random numbers (called psuedo random numbers) as 2, 0, 1, 2, 0, 1… bits stored for hiding in above data is marked by bold bits in following data, whereas underlined bit represents modified bits.

10010101 00001101 11001001
10010110 00001111 11001011
10011111 00010000 11001011

The number of successively generated pseudo-random numbers after which the sequence starts repeating itself is called the *period*. Setting up the values of the constants may be divided into two categories of full period or partial period. If the period is equal to m, then the generator is said to have a full period, otherwise partial period. Kelton et al.[22] may be referred for the detailed discussion over setting up the values of these constants. Here we can say that full period methods are observed to be lesser complex and secure as compared to partial period methods.

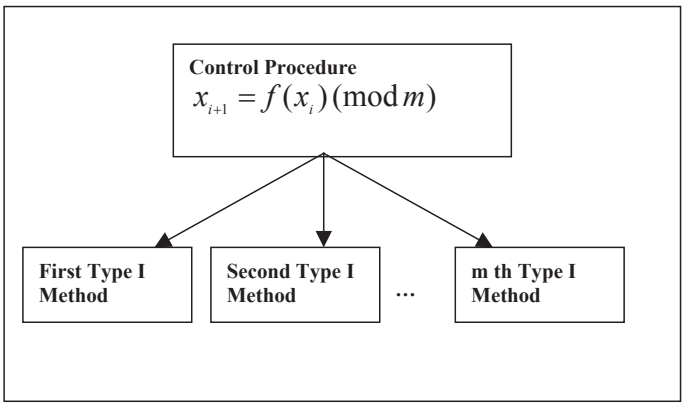
This method will include the hidden data at random places of different byte in the image. This method will inversely affect the density of bits to be stored in cover media by a factor m/2 (divisor/2). So there is a need to keep a fit between the divisor m and number of bits in hidden data. Increasing the size of cover media may create suspicion to steganalyst about hidden data in image. So there is a need to check the characteristics of cover image and hidden image to formulate the random number generator variables. Second issue about this method is its security aspect. Different combinations of least significant bits may be analyzed very easily and repetition of same sequence will make the steganalysts' job much easier. So this method is not secure enough to meet the requirement of steganography, this method is very easy and may be customized without much effort. Thousands of combinations of functions and values of variables are available to implement it. So, this method can be customized easily and give initial level of security to data.

5.2 Type II Methods (Low Complexity Methods)

These methods are based on the combinations of two or more type I methods to hide the data. There is a control procedure attached to these methods that controls the sequence of these methods randomly. This randomness is based on the output generated by earlier sequence. Figure 3 will illustrate the procedure of implementing the randomness.

Control procedure decides the method to be used for steganography. The programmer initializes initial values of the variables, whereas later values of variables are generated from the output received from earlier implementation, e.g. Sequence of 100 bytes is used to hide a sequence of 20 bits in it. First 10 bits are stored in first 50 bytes of cover media o the basis of initial values supplied to control procedure. A sequence of methods without repetition is involved for the purpose. Output generated is taken as the source of selecting values for variables. If we need only one value for function f, last few bytes of output may be used for the

Figure 3. Type II low complexity methods



purpose and remaining data is processed on the basis of altered sequence of Type I methods. Implementing the procedure in reverse direction, predefined initial sequence of methods is guided by input data for further iterations, as value of variables is stored in input file. In this way data hiding may be performed in a customized and secure way as functions are decided by users whereas altering sequence of storage can provide security in a well manner.

5.3 Type III Method (Moderately complex methods)

In this type of methods different encryption algorithms are attached to type II methods. Encrypted hidden image is stored in the cover image through type II methods. Key for encryption is generated through random procedures or is decided by the user and prefixed to hidden data/image.

5.4 Type IV Method (Highly Complex Methods)

In this type of methods one set of type III methods is used as one block of stego tool. Two or more such blocks (different from each other) may be combined together in parallel, in series or a combination of both as follows:

5.4.1 Parallel Combination

In this method different block of type II or type III method may be combined together to hide the data. This kind of scheme is suitable for large images. Cover image and hidden image are divided into small parts (blocks) and each block is applied to hide the data. Distribution of data for different blocks is implemented on random numbers logic.

Figure 4. Type III moderate complexity methods

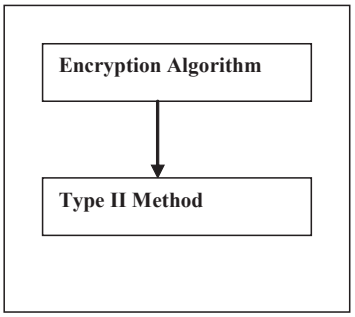


Figure 5. Parallel combination of type III methods

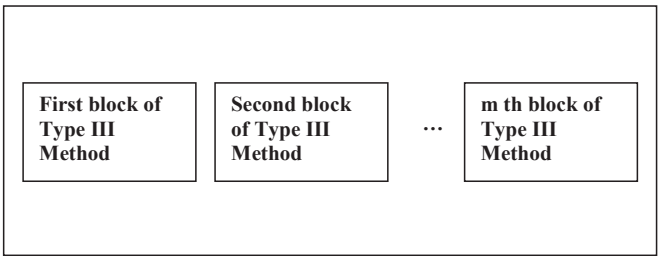
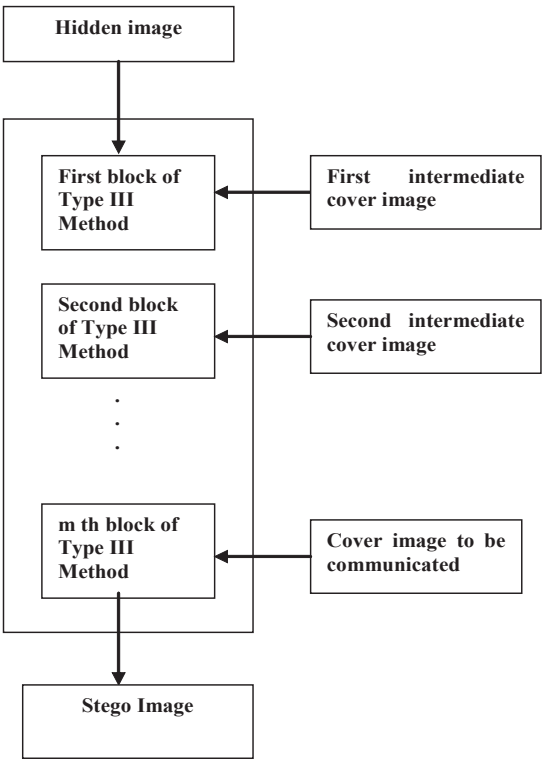


Figure 6. Serial combination of type III methods



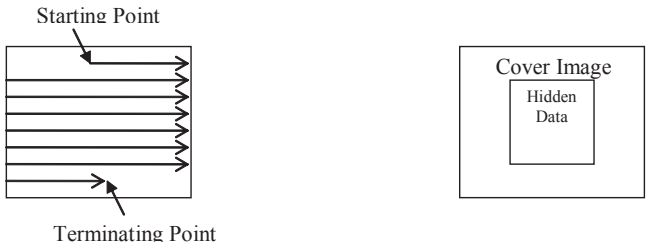
5.4.2 Serial Combination

In this method different block of type II or type III method may be combined together to hide the data. This kind of scheme is suitable for relatively small hidden image/data, but security is the major concern. In this method cover image, intermediate cover images and hidden image are used for the purpose as shown in figure 6. Initial hidden image is hidden in intermediate cover image, which is further hide into cover image and to generate stego image to be communicated. Such a combination is secure enough to be analyzed, but density of data that one can hide will be very less in quantity.

5.4.3 Hybrid Combination

In this method parallel and serial combinations are combined together to hide the data. Different layers of parallel combinations are combined together to hide the data. One parallel combination is called a layer, two or more such layers may be combined together to generate the stego image using intermediate cover images.

Figure 7. Two variations of level 1 schemes



6. LAYOUT MANAGEMENT SCHEMES

Methods discussed in previous section can contribute a lot in hiding information in images. These methods can be made more sophisticated with the help of layout planning. Here layout planning comprises of three basic components i.e. starting point, flow of data and termination point. Starting point is the initial point from where to start hiding information with the help of methods discussed in previous section. Flow of data comprises of the pixel by pixel flow of data hiding in cover image. Termination point is somewhat obvious from the layout i.e. the pixel at which the process of hiding data will terminate. One other component may be the visual sense. By the help of visual senses of eyes, we can decide the part of images, where data can be hidden without being noticed by the stegoanalysis evaluators. Using human eyes may contribute in deciding the part of image, but affects the artificial intelligence of the system, so becomes discretion of user to use it or not. Different Layout Management Schemes are divided under different levels as follows:

6.1 Level 0 (Simple Layout Scheme)

At this level different types of methods are selected from section 5 and are implemented from the starting point of the cover image and continued pixel by pixel from first pixel to last pixel of the image.

6.2 Level 1 (Plain/Garbage Data Insertion)

In this scheme before starting point original(from cover image) plain text or garbage data is placed into cover image followed by the hidden data according to the selection of methods from section 5.

In figure 7 first diagram indicate to leave few pixels before starting and after terminating point, whereas other diagram includes original cover image pixels all around the hidden data. Second diagram is only possible, when hidden data is small as compared to the space available for hidden data in cover image.

6.3 Level 2 (Image Processing Operations Based Scheme)

Before placing hidden data in cover image, cover image pixels may be inverted, rotated or flipped and then hidden data may be placed according to the combinations of methods selected from section 5 and low level layout schemes.

7. EXPERIMENTAL RESULTS

Experiments are performed to check the performance of different methods using variety of random number generators with varying values of variables and constants. Least Significant Bit transformation was the major way to implement the methods but other techniques like moderate significant bit transformation and transformation domain technique were also tried on similar lines, but here we produce the results based on least significant bit transformation based technique. Four hundred such combinations are tried on all four types of methods and results are combined together as follows:

Figure 8. Density chart: Bits hidden per byte vs. value of divisor

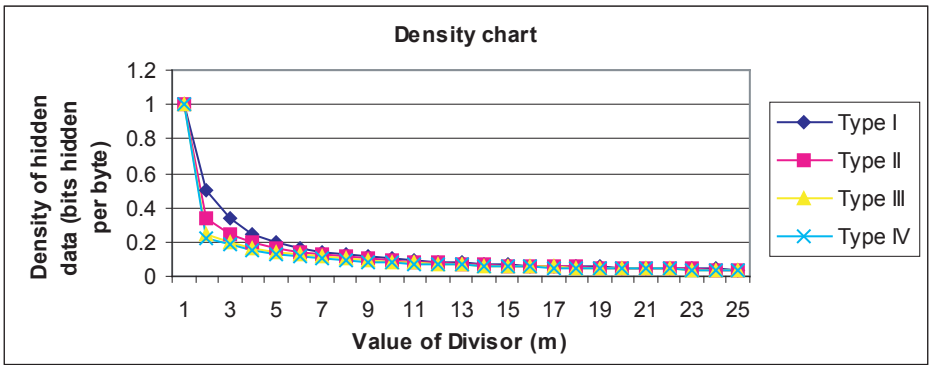
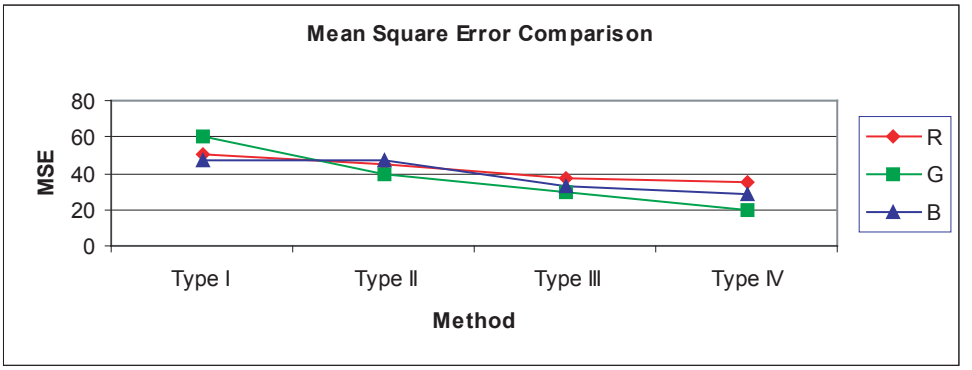


Figure 9. Mean square error comparison: Mean square error vs. Type(s) of method.



7.1 Density of Hidden Data

First of all one of the most important issue is that how much data can be stored in cover image and selection of suitable divisor. A simple Least Significant Bit method requires n bytes for hiding n bits. This density is decreased m times of total storage capacity for type I method and it is further degraded for other methods as shown in the figure.

It is obvious to receive more densely placed hidden data for smaller value of divisor 'm' as compared to a larger one and it is being indicated in figure 8 as well.

7.2 Quality of Cover image

There are many metrics to quantify the quality of two or more images. To compare these methods objectively, we adopt Mean Square Error (MSE) as our quality metrics. The MSE between the original image $I_o(x,y)$ and the stego image $I_r(x,y)$ for each color channel is defined as :

$$MSE = \frac{\sum_{x=1}^{m}\sum_{y=1}^{n}[I_o(x,y) - I_r(x,y)]^2}{m \cdot n}$$

where m x n is the size of the image

Results indicate that type I methods hides more data so these affect the color combination of different image it, but less for other methods.

7.3 Security of Hidden Image

Different tools available in market like s-tools, EzStego, Stegdetect, Stego suite etc. are tried on different methods and it is being observed that these tools are well conversant with type I methods, but are unable to detect the presence of hidden data of other complex combinations.

Experiments performed on all four types of methods through different tools available for stegoanalysis indicate that complex combination of methods are very secure as compared to the simpler one and figure 10 confirms it as well.

7.4 Complexity of Algorithms for Different Methods

Numbers of lines used executed for hiding data increases rapidly as we use more complex methods. As type I is simple method, it is less complex. Complexity increases as we use further much more complex methods.

Figure 11 indicates that complexity of algorithms increases as we move from simple to complex methods. Following images are included to show that image 'a' and 'c' can't be distinguished by human eyes, but these are significantly different from each other.

8. CONCLUSION AND FUTURE DIRECTIONS

In current paper we have applied random numbers based methods on least significant bit transformation for steganography. We formulated thousands of variants based on users' choices and calculated the results of around four hundred such combinations. Results cover the security, complexity, density and quality aspects of these methods. Authors are working upon more complex layout management schemes in a combination with these methods. In future, research work will be continued on

Figure 10. Security chart: Security probability of different methods

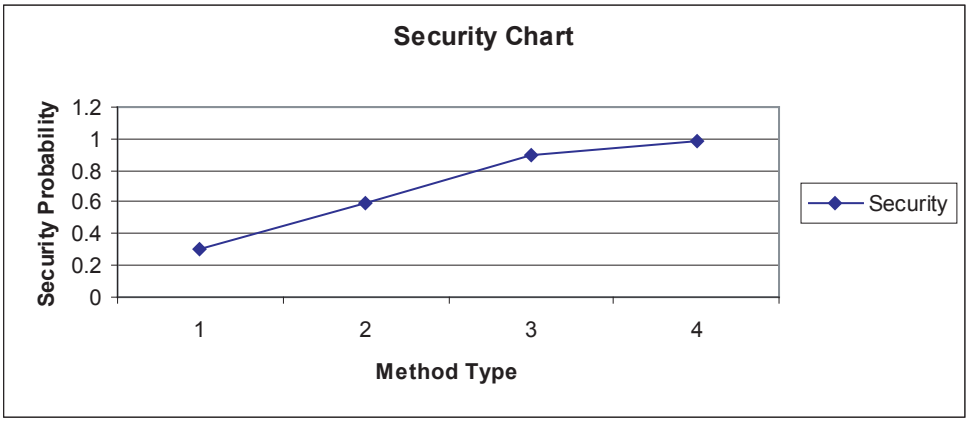


Figure 11. Complexity chart: Lines of code executed for hiding numbers of bits in cover image

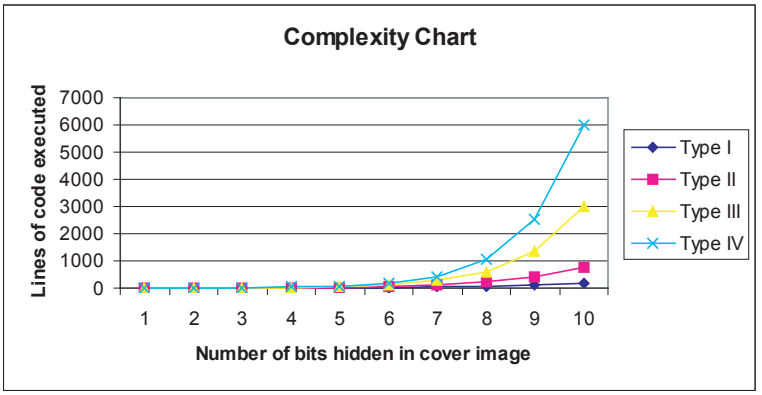
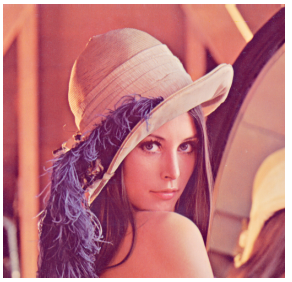
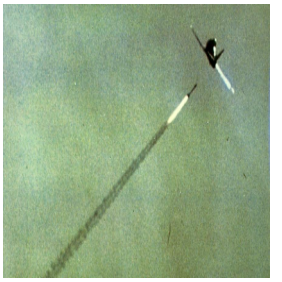


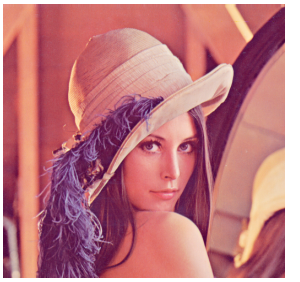
Figure 12. Steganography images: Differentiating images 'a' and 'c' is impossible through eyes.



(a) Cover image (Lena.tiff)



(b) Hidden image (missile.bmp)



(c) Stego image (lenaNew.tiff)

similar lines for implementing more such combinations as well as layout management schemes and for creating steganalysis tools for such combination.

9. REFERENCES

[1] Andersen, R.J. and Petitcolas, F.A.P., "On the limits of steganography," *IEEE Journal of Selected Areas in Communications, Special Issue on Copyright and Privacy Protection* 16 No.4 (1998) 474-481.

[2] Gonzalez R.C. and Woods R.E.: Digital Image Processing. Addison Wesley, Reading, 1992.

[3] Aura T., "Practical invisibility in digital communication," Lecture Notes in Computer Science, vol.1174, Springer-Verlag, 1996, pp. 265-278.

[4] Westfeld A. and Pfitzmann A., "Attacks on Steganographic Systems," Lecture Notes in Computer Science, vol. 1768, Springer-Verlag, Berlin, 2000, pp. 61-75.

[5] Johnson N. F. and Jajodia S., "Steganography: Seeing the Unseen," *IEEE Computer*, February 1998, pp.26-34.

[6] Johnson N. F. and Jajodia S., "Steganalysis of Images Created Using Current Steganography Software," Lecture Notes in Computer Science, vol.1525, Springer-Verlag, Berlin, 1998, pp. 273-289.

[7] Johnson, N. F., "Steganalysis of images created using current steganographic software", in *Second Information Hiding Workshop,* 1998.

[8] Pal S.K., Saxena P. K., Mutto S.K., "The Future of Audio Steganography", in *Pacific Rim Workshop on Digital Steganography*, Japan, 2002.

[9] Cachin C., An information-theoretic model for steganography, in D. Aucsmith (Ed.): *Information Hiding, 2nd International Workshop*, vol. 1525 of *Lectures Notes in Computer Science*, pp. 306-318. Springer, 1998.

[10] Fridrich J. and Goljan M., Practical steganalysis of digital images-state of the art, *Proc. SPIE Photonics West, Vol. 4675*,pp. 1-13, San Jose, California, Jan. 2002.

[11] Fisk G., Fisk M., Papadopoulos C., Joshua N., "*Eliminating Steganography in Internet Traffic with Active Wardens"*, Available: [http://citeseer.nj.nec.com/fisk02eliminating.html] Nov 1, 2002.

[12] Bao F., Wang X., "Steganography of short messages through accessories", in *Pacific Rim Workshop on Digital Steganography*, Japan, 2002.

[13] Avcibas I., Memon N., and Sankur B., "Steganalysis using image quality metrics," IEEE Transactions on Image Processing, vol. 12, pp. 221–229, Feb. 2003.

[14] Lee, Y. K., Chen, L. H., (2000), "High Capacity Image Steganographic Model", in *IEE Proceedings Vision, Image and Signal Processing*, pp. 288-294.

[15] Chan, Y. K., Chang, C. C., (2001), "Concealing a Secret Image Using the Breadth First Traversal Linear Quad tree Structure", in *IEEE Proceedings of Third International Symposium on Cooperative Database Systems for Advanced Applications*, pp. 194-199.

[16] Chang, C. C., Chen, T. S., Chung, L. Z., (2002), "A Steganographic Method Based upon JPEG and Quantization Table Modification", *Information Sciences*, vol. 141, pp. 123-138.

[17] Hsu, C. T., Wu, J. L., (1999), "Hidden Digital Watermarks in Images", in *IEEE Transactions on Image Processing*, pp. 58-68.

[18] Fard Amin Milani, R. Mohammad, T. Akbarzadeh and A. Farshad Varasteh, "A New Genetic Algorithm Approach for Secure JPEG Steganography",

[19] Martín Alvaro, Sapiro Guillermo and Seroussi Gadiel, "Is Image Steganography Natural?", IEEE TRANSACTIONS ON IMAGE PROCESSING, VOL. 14, NO. 12, DECEMBER 2005

[20] Koval Oleksiy, Voloshynovskiy Svyatoslav, Holotyak Taras and Pun Thierry, "Information-theoretic Analysis of Steganalysis in Real Images"

[21] Luo Xiangyang, Hu Zongyun, Yang Can, Gao Shanqing, "A Secure LSB Steganography System Defeating Sample Pair Analysis Based on Chaos System and Dynamic Compensation", Feb. 20-22, 2006 ICACT 2006.

[22] Kelton W. D. and Law A., Simulation Modeling and Analysis, Mcgraw-Hill Science, USA.

Conceptual Design for Personalized Situation-Aware Information Seeking and Retrieval Services in Data Intensive Domains

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ABSTRACT

Personalized information seeking and retrieval is regarded as the solution to the problem of information overload. Personalization algorithms and techniques are maturing, but their centralized implementation solutions are becoming less efficient for dealing with ever changing user information needs in data intensive, dynamic and distributed environments. In this paper, we present a conceptual design for personalized, situation-aware information seeking and retrieval services, which offers a new way of thinking about the retrieval of personalized information for time critical applications.

Keywords: *personalization, information seeking and retrieval, situation awareness, service-oriented architecture*

1. INTRODUCTION

Today information is distributed globally. Organizations and information seekers can now access information anywhere anytime via wired or wireless networks. The coordination of organizational processes distributed over various independent locations has improved significantly. However, this increase in information availability cannot guarantee that users are able to retrieve and access all the information that specifically meets their needs. Organizations have to operate in increasingly complex environments, where, dynamically changing information structures, and distributed heterogeneous data resources make it increasing difficult to find the 'right information' at the 'right level of details' in the 'right format' , and at the 'right time'. The problem is amplified in domains such as crisis response networks, medical and healthcare networks, where the accuracy of the retrieved information and obtaining it in a time critical manner are extremely important.

Personalized information seeking and retrieval is regarded as the remedy when it comes to relieving the problem of information overload. Research in the field mainly focuses on developing models, methods and tools that can be used to adapt information content and its presentation to the individual user's information search goals and preferences. Today, personalized techniques are able to provide feasible solutions to the problem of inappropriate information overload at technological level ranging from simple user-controlled information personalization to autonomous system-controlled adaptation [Mizzaro & Tasso, 2002]. Many academic and commercial off-the-shelf information search services and tools are available to filter out irrelevant information effectively, and to rank and present information in a user preferred way.

Although these personalization techniques and algorithms are maturing, their centralized implementation solutions are becoming less efficient for supporting the rapidly changing information needs in dynamic and distributed environments. Changes in organizational or personal information needs may lead to a need to redesign a complete application. Therefore, it is necessary to design personalized information seeking and retrieval application in an agile and flexible way, to provide personalized information in a time critical manner, which can be adapted easily to meet changing information needs. Our increasing understanding of component-based design principles, service-oriented architectures and other aspects of complex information retrieval achievements provide the possibility to achieve this objective. The modularization of complex systems into components, or services that interoperate primarily via exchanging standardized messages at interfaces has become IT technology evolution. All these advances in IT have stimulated a new requirement concerning on modeling and designing personalized information search services in a dynamic and distributed environment to satisfy high-level functional requirements for personalization flexibly in one hand, and to use the specific personalization techniques, algorithms and available technology infrastructure to realize these requirements on the other. Building on the advantages of a service-oriented approach, we propose a new conceptual design for personalized, situation-aware information seeking and retrieval services. We believe this approach provides a new way of thinking about the retrieval of time critical, personalized, situation-aware information in data intensive domains.

Our conceptual design is presented in section 2. We tested and evaluated our conceptual design by applying it in a real-life case. The results are presented in section 3. Our conclusions and an outline for future work are presented in section 4

2. CONCEPTUAL DESIGN

2.1 The Concept of Information Seeking and Retrieval

Information seeking and retrieval is a human-IT system interaction activity in the sense of an IT supported environment. According to research into user information behavior, users' information needs are stimulated when they lack the information required to solve a problem [Wilson, 1998]. Problem solving occupies an important place in the research on information seeking and retrieval [Gaslikova, 1998]. [Gaslikova, 1998] summarizes problem solving in the context of information seeking and retrieval in three stages: problem identification, query formulation, and validation of received information. She claims that any information seeking and retrieval system has to provide suitable software tools for realizing each stage of a problem-solving process. Taking this into account, we regard information seeking and retrieval as a user-system interaction process. It comprises three sub-processes shown below.

- *The information seeking process*: This is the process used, generally or precisely, to identify the problem that initializes a user's information acquisition activity. This covers the question: what is the problem?
- *The information searching process:* This is the process used to identify and structure the specific information required to solve the problem, and to find the locations of required information. It concerns on the questions what information is required? Where to find the required information? And how to access to it?
- *The information obtaining process:* This is the process used to obtain the required information from the various resources and to return the information back to the user.

Users validate the received information during the interaction process with the system.

2.2 Personalized Information Needs

Personalized information needs play an essential role in determining the relevance of any delivered information. The literature shows a deepening understanding of the concept information needs and its role in the information seeking and retrieval. [Taylor, 1968] and [Belkin, 1982] argue that users' characteristics, e.g. users' personality, knowledge, personal interest and preferences etc., determine their information needs. [Wilson, 1994] and [Niedźwiedzka, 2003] shows that social placement or a professional role, e.g. users' professional roles connected with their occupied positions, are the most important determinants of users' information needs. [Wilson, 1999]'s problem solving model abstracts the process of problem solving from context.

Since our research is confined to domains such as crisis response and management networks, healthcare and medical networks, etc., we argue that individuals' personal interests and preferences may not strongly influence their information needs. Although different users in these contexts may have different knowledge levels about their professional role, we consider that their knowledge will be inherent to the professional role they play within their work situations. Therefore, we regard the professional roles users adopt in the society to be one of the most important factors influencing their specific information needs although their personalities and/or knowledge may influence their search strategies.

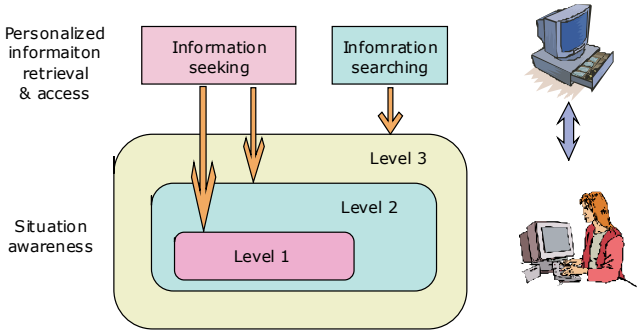
However, users' roles are not sufficient to reflect their actual needs. Information needs change as the users' situation changes, and this directly influences users' judgment regarding information relevance. Role-based information needs are relatively stable and predictable, while an ongoing situation may change these information needs. When users are able to be aware of their situation, in which they are involved, the users are able to identify their problem, and to formulate their information needs. Based on our previous arguments, we believe that personalized information seeking and retrieval is triggered by users' role-based perceptions of a problem they need to solve. We therefore define personalized information seeking and retrieval as an information acquisition process, aimed at providing users, with their role relevant personalized information based on dynamically and automatically perceiving and responding to the users' situations.

2.3 Situation Awareness

2.3.1 Situation Awareness in the Context of Information Seeking and Retrieval

The concept situation awareness (SA) is usually applied to operational situations, especially in the fields of artificial intelligence, agent-based systems, crisis response and management, military planning, etc. [Endsley, Bolte & Jones 2003]. Research in the field of SA focuses mainly on helping persons to be aware of their situations so that they can make informed decision about future actions [Endsley, Bolte & Jones 2003]. [Endsley & Rodgers, 1998] formally defines SA as "the perception of elements in the environment along with a comprehension of their meaning and along with a projection of their status in the near future" [Endsley & Rodgers, 1998]. This definition breaks down into three separate levels [Endsley, Bolte & Jones 2003].

Figure 1. Information seeking and retrieval to support SA process



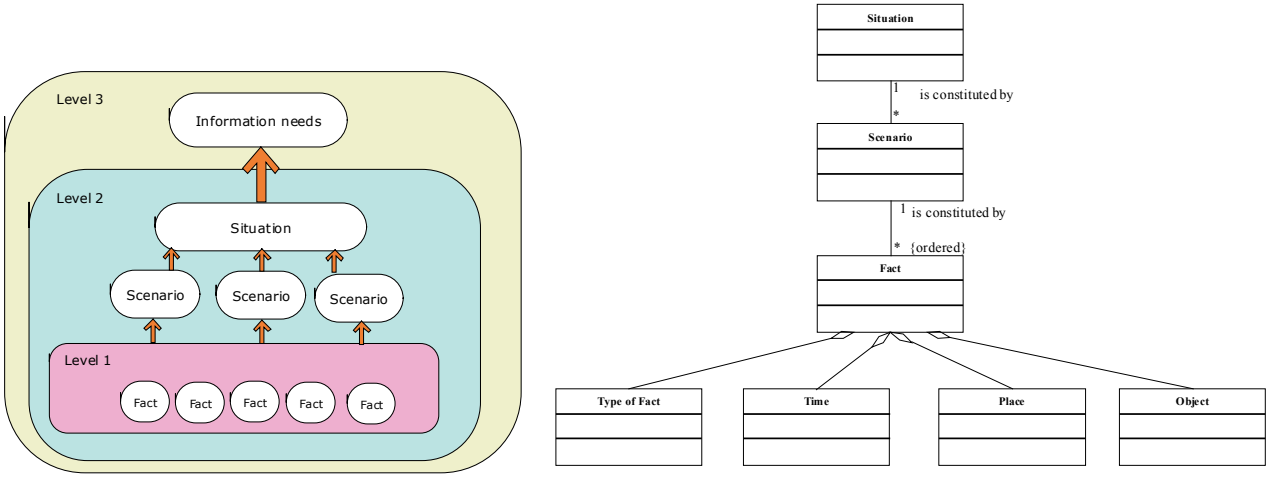
- Level 1—perception of the elements in the environment
- Level 2—comprehension of the current situation, and
- Level 3—projection of future status.

These three levels reflect the process of how people are aware of their situations mentally. Although today's advanced IT technology can replace a huge amount of information processing work, until now, it cannot replace a human's mental information processing process. We regard the information seeking and retrieval provided in our approach as a means to provide support for the users' SA process. We claim that our definition of information seeking and retrieval can be used to provide suitable support for all three steps of SA defined by [Endsley, Bolte & Jones 2003] shown in Figure 1. Levels 1 and 2 of [Endsley, Bolte & Jones 2003] are supported by the information seeking process, aimed at identifying the problem. Level 3 is supported by the information searching process, aiming at defining what information is needed.

2.3.2 Situation Model

Users perceive the problem they need to solve when their situation is described clearly. We choose to use the term situation since it can imply dynamic changes in users' surroundings, the influence of changes on the users, and the users' stable or permanent surroundings. Situation is defined in the [Merriam-Webster] as "the relative position or combination of circumstances at a certain moment". In the [Dictionary], situation is defined as "the combination of circumstances at a given

Figure 2. SA process



moment; a state of affairs". From these definitions, we can see that, a situation consists of a concrete story describing where what happened, when, who are involved, and their relationships.

It is not feasible to specify all possible situations in the context of information seeking and retrieval for any domain. Historical usage data is required to detect situations. This argument is also used in [Endsley, Bolte & Jones 2003]'s three levels of SA model, where an unknown situation is derived from known information. The question, what historical data or information is required to be collected at different level of the SA processes for the users to realize their situation, becomes important; and can be reformulated as what information can be used to describe and model the situation. Based on the [Endsley, Bolte & Jones 2003] 's three levels of SA model, we need to perceive the elements in the environment (Level 1 in the SA) as the information that can be used to comprehend current situation (Level 2 in the SA), in order to project future status (Level 3 in the SA).

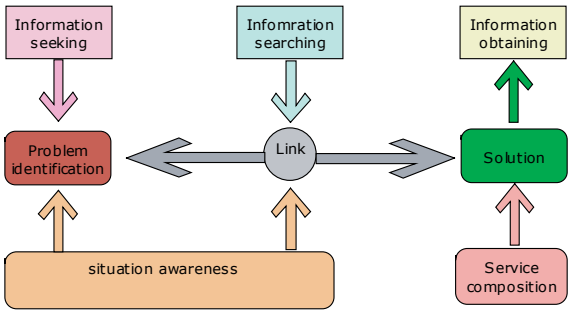
The first step in the SA process is to perceive the elements in an environment. The information elements that can be directly perceived describe the things that are known to have happened or to exist, i.e. the concept fact. Therefore, the information describing those things that have happened or existing things can be abstracted and conceptualized as a combination of 'type of fact', 'time', 'place' and 'involved objects'. The description of a fact can be made by combining 'type of fact' and any or all other three concepts.

Perceived facts are only direct observations made in the environment. They cannot provide narrative descriptions of users' situation. Therefore, facts do not supply sufficient information to understand a situation fully. To support the second level of the users' SA, we use the concept scenario in our research. We define *scenario* as a *short story reflecting a situation*. In this scenario, known outcomes are described, in conjunction with the casual relationships of a group of detected facts. Unknown scenarios can be derived by combining known facts, or from known scenarios. The SA process in our research is presented in Figure 2 (a), and the situation model is presented in Figure 2 (b).

2.4 Service-Oriented Approach for Personalized Information Seeking and Retrieval

A service-oriented approach provides a design principle for the handling of complex, dynamic and distributed information systems. Personalization can be provided by composing existing services, which are implemented on the basis of well-defined service behaviors and interfaces. This design principle is suitable for a distributed, dynamic and heterogeneous environment. According to the service-oriented system design principle, we assume that a solution for the detected information needs in users' specific situations can be quickly reconfigured by using a composition of encapsulated, replaceable and reusable services [Stojanovic, Dahanayake & Sol, 2004]. Based on sub-sections 2.2 and 2.3, we can now formulate the complete framework for personalized, situation-aware information seeking and retrieval, as shown below in Figure 3.

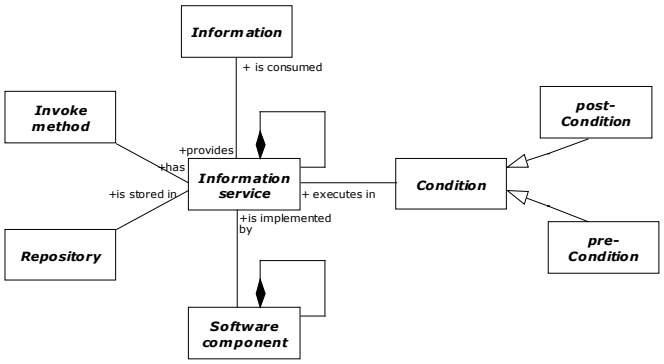
Figure 3: A framework of personalized situation-aware information seeking and retrieval



2.4.1 The Concept Service

According to the literature [Papazoglou, 2003, Stojanovic, Dahanayake & Sol, 2004, Douglas, 2003. etc], in the initial phase of our research, we informally defined the term *service* as "*A service is planned and designed in such a way that it has a specific functionality and it is very simple, but together they perform relatively complex tasks*". This informal definition gives the basic requirements for defining a service in the service-oriented approach. A service must have a specific functionality. As mentioned before, the solution for a detected problem is constituted of a service or a combination of services. Therefore, the specific functionality a service must have in our design is that it provides information. As a result, we simply define the services that consume information and provide information as information services. We assume that the solution to satisfy user's information needs is constituted by an information service or a group of information services. The information provided by a group of services is the collective outcome of all involved information services instead of a simple combination of outcomes of each service. Information services can be assembled and composed by smaller information services. At the level of a simple information service, its required operation and output is realized by grouping a specific collection of information search software components. We present the concept of service in Figure 4.

Figure 4. The concept of information service



2.4.2 Task Model

After the appearance of task-oriented information seek and retrieval in the 1990s [Vakkari, 2003], the concept task has been diligently used in the context of information search as [Byström & Hansen, 2005]. The concept task has gained increasing attention as it provides an important cue to help us to understand why people seek information, what type of information they need, and how they are going to use the information [Byström & Hansen, 2005; Taylor, 1991]. Our definition of a task is mainly based on the research of [Vakkari, 2003; Byström & Hansen, 2005; Vakkari, 2003]. We regard *a task to be a specific piece of work, in which a person or a group of persons undertakes a series of actions in a situation*. Defining a task as a piece of work indicates that it has a performer, a meaningful purpose, and an undertaken context [Hackman, 1969; Byström & Hansen, 2005]. This is a definition, which emphasizes the conceptualizing of tasks more from the point of view of the actors and the social context of the task performance [Checkland & Holwell, 1998, Suchman, 1995].

We define *the organizations or organizational units as actors*. Each actor has a list of professional roles. A role is defined in [Merriam-Webster] as "a function or part performed especially in a particular operation or process". Obviously, role is a function relevant concept. *The professional roles of an actor are defined in terms of functions an actor must provide.* Therefore, actors are exclusive, and based on the functions they provide, i.e. their professional roles. A task is performed when an actor adopts one of its professional roles. A task can be composed of smaller tasks. At the level of a simple task, it is constituted of a series of interconnected actions. A task is undertaken in a context, i.e. the situation, where an actor is required to adopt one of its professional roles. According to the definition of task in our research, tasks are required to be identified from an actor's professional roles, i.e. from the functions an actor can provide. However situation is a dynamic concept, as perceived by the SA process defined in section 2.3.2. It s not feasible to define all tasks corresponding to a specific situation. Instead, the tasks can be defined in facts, which are more concrete and tangible. Since a task can be composed of smaller tasks, required tasks in a detected situation can be composed of sub-tasks identified using the relevant facts. Tasks are undertaken in a process to formulate the solution for an existing fact.

Based on the concepts defined in the previous subsections, we formulate a meta-model of personalized information seeking and retrieval on the basis of service-oriented system design principle. The meta-model is shown in Appendix 1.

3. CASE STUDY

We tested the conceptual design by applying it in a real life case. The case study presented in this section was taken from an ongoing EU research project. The harbor described in this case study is one of the largest and most important harbor infrastructures in the world. Global collaborations for natural disasters recovery and anti-terrorism cooperation have encouraged management at this harbor to take put in global information networking, designed to share information with other crisis experts and professionals. The harbor management intends to build a more flexible and extendable information platform to provide all authorized and involved actors with access to their role-based personalized, situation-aware information to facilitate the performance of their tasks during a crisis response.

Since the development of a complete system is not yet feasible, due to the difficulty of building trust between the various crisis relief/response organizations, and getting them to share their information, we built an early prototype demonstration to show that it would be possible to build such a service-oriented platform to provide personalized, situation-aware information seeking and retrieval services for crisis response situation.

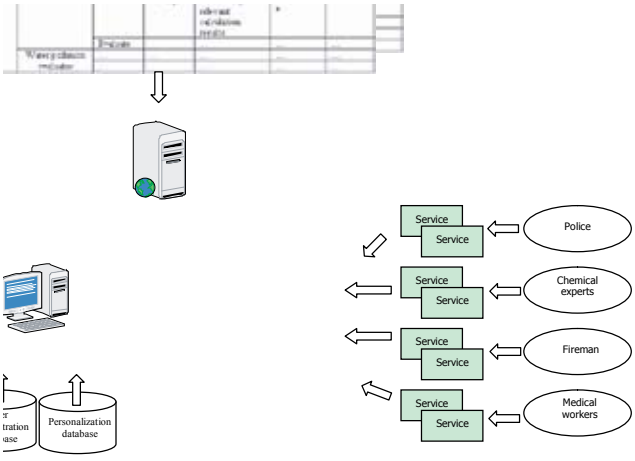
We utilized three computers in our prototype implementation shown in Figure 5, representing the service consumer, service provider, and service broker in a SOA respectively. The information provided by the actors involved was encapsulated as information services. We believe there are four main actors in crisis response: police, medical experts, fireman, and chemical experts. We implemented several information services for these 4 actors as jini services in our prototype. These jini services were required to be registered on a jini lookup server. The requested registration information is shown in the table in Figure 5. We used a simple example from a chemical expert to show what, and how, the required information on information services is registered in the jini lookup server. In the client PC, we use Liferay 4.0[1] as the portal software, and embedded Tomcat 5.0[2] as the web server to build the 'crisis response and management portal'. We built two databases, a user administration database and a personalization database, which were used to support personalized information seeking and retrieval applications running on this portal. User's role-based profiles, stored in the user administration database, were used to control their information access. The personalization database was built based on the meta-model presented in Appendix 1. Previous existing crisis situations, their constituting scenarios, scenarios' constituting facts, facts' solutions, etc, were stored in the tables of situations, scenarios, facts, solutions and tasks as the historical information in the personalization database. The personalization database was implemented in MySQL[3].

Tasks are keys that are used to search for the required information services provided by the different organizations. When a task is selected, it generates a service search template, which is constituted of three attributes, actor, role and task. A selected task generates this service search template by filling in the actor name, role name and task name. The service search template will then be sent to the jini lookup server to look for the relevant information services. All the information services of a selected task are returned to the user. Information service name, information service description, service status and location are also returned to the user. It is the users' work to figure out their required information services based on the returned service information.

4. CONCLUSION & FUTURE WORK

In this paper, we presented a new way of thinking of retrieving personalized information based on service-oriented design principle. Our situation model is capable of reflecting and inferring the unpredictable and dynamic situation users are facing. Our task model is capable of personalizing users' information needs in a dynamic situation according to their professional role(s). The combination of the situation model and task model allows users' role-based personalized, situation-aware information needs to be sufficiently inferred, and well structured in a meaningful way. Simultaneously, applying service-oriented design principle in our conceptual design allows us to realize independent service implementation and service modeling, and quickly to configure information acquisition applications

Figure 5. Prototype architecture



to satisfy users' dynamic information needs by choosing the required services. We believe that our conceptual design provides a possible solution to building a bridge between high-level functional requirements and low-level technology availability.

The next step of our research is to focus on how to reduce the time to action in a time critical situation using an effective information coordination service for situation aware process orchestration [González-Rivera, 2006].

REFERENCES

[Byström & Hansen, 2005] *Conceptual Framework for Tasks in Information Studies*, Katriina Byström, Swedish School of Library and Information Science, Göteborg University and Högskolan I Borås, Preben Hansen, Swedish Institute of Computer Science (SICS), JOURNAL OF THE AMERICAN SOCIETY FOR INFORMATION SCIENCE AND TECHNOLOGY, 56(10):1050–1061, 2005, http://www3.interscience.wiley.com/cgibin/fulltext/110497382/PDFSTART

[Checkland & Holwell, 1998] *Information, Systems and information systems: Making sense of the field. Checkland, P. & Holwell S., Publisher: John Wiley & Sons; 1 edition (November 27, 1997), ISBN: 0471958204*

[Dictionary] http://dictionary.reference.com/search?q=environment&x=42&y=13

[Douglas, 2003] *Web Services and Service-Oriented Architectures: The Savvy Manager's Guide (The Savvy Manager's Guides)*, Douglas K. Barry, Publisher: Morgan Kaufmann (April 1, 2003) ISBN: 1558609067

[Endsley, Bolte & Jones 2003] *Designing for situation awareness: an approach to user-centered design*, Endsley, Mica, R., Bolte, B., and Jones, Debra G., British Library Cataloging in Publication Data, ISBN: 0-7484-0966-1 (hbk) ISBN:07484-0967-X(pbk)

[Gaslikova, 1998] Gaslikova, Irina *"Information Seeking in Context*" and the development of information systems." Information Research, 5(1) Available at: http://informationr.net/ir/5-1/paper67.html

[González-Rivera, 2006] Information Coordination Service for Situation Aware Process Orchestration: improving time to action in emergency response, Rafael González-Rivera, draft proposal, Delft University of Technology, the Netherlands, Feb, 2006

[Hackman, 1969] Hackman, J.R. (1969). T*owards understanding the role of tasks in behavioral research*. Acta Psychologica, 31, 97–128.

[Merriam-Webster] http://www.m-w.com/dictionary/environment

[Mizzaro & Tasso, 2002] Stefano Mizzaro and Carlo Tasso, Personalization Techniques in Electronic Publishing on the Web: Trends and Perspectives, Universidad de Málaga, Departamento de Lenguajes y Ciencias de la Computación, Proceedings of the AH'2002 Workshop on Personalization Techniques in Electronic Publishing Málaga, Spain, May 2002 Selected papers, http://www.dimi.uniud.it/mizzaro/AH2002/proceedings/PerElPub.pdf#search=%22user-controlled%20information%20personalization%20to%20autonomous%20system-controlled%20adaptation%22

[Niedźwiedzka, 2003] *"A proposed general model of information behavior*" Niedźwiedzka, B. (2003) *Information Research*, **9**(1) paper 164 http://InformationR.net/ir/9-1/paper164.html

[Stojanovic, Dahanayake & Sol, 2004] *An Approach to Component Based and Service-Oriented System Architecture Design*", Stojanovic, Z., and Dahanayake, A. and , Sol, H.G., (2004):Faculty of Technology, Policy and Management, Delft University of Technology Jaffalaan 5, 2628. BX Delft, The Netherlands, {Z.Stojanovic, A.Dahanayake, H.G.Sol}@tbm.tudelft.nl

[Vakkari, 2003] *Task-Based Information Searching*., Vakkari, Pertti, Annual Review of Information Science and Technology (ARIST), v37 p413-64 2003,

[Wilson, 1994] Prof. T.D. Wilson, INFORMATION NEEDS AND USES: FIFTY YEARS OF PROGRESS? Department of Information Studies University of Sheffield, In Vickery, B.C. (Ed.), *Fifty years of information progress: a* Journal of Documentation *Review*, (pp. 15- 51) London: Aslib, 1994.

[Wilson, 1999] *"Exploring models of information behaviour: the 'uncertainty' project,* Wilson, T.D, Information Processing and Management, Volume 35, Number 6, November 1999, pp. 839-849(11)

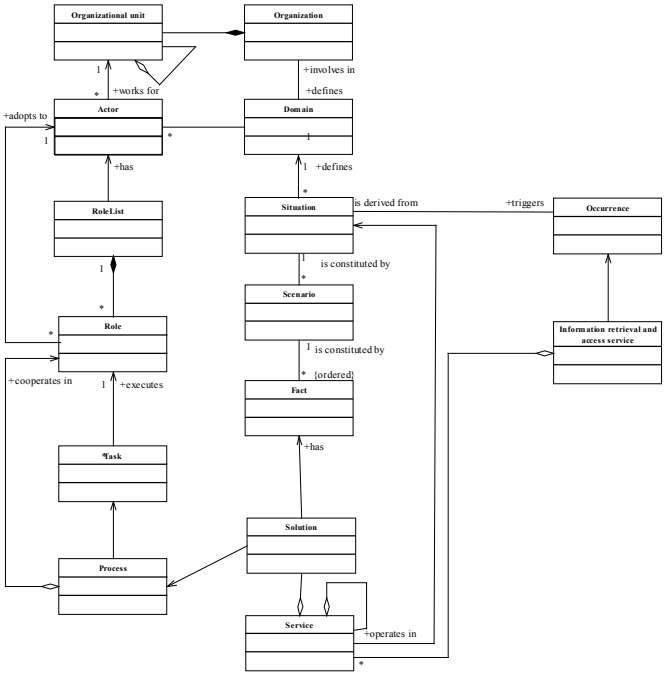
ENDNOTE

1 Information about liferay can be found from http://www.liferay.com/web/guest/home

2 Information about Tomcat can be found from http://tomcat.apache.org/

3 Information about MySQL can be found from www.mysql.com

APPENDIX 1



E-Collaboration Tools for Government Funded Projects: NHLBI-PEN Approach and Solution

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ABSTRACT

In this paper, we present the E-collaboration system that has been designed and developed during the first year of the NHLBI-PEN Government Funded Project. We start by presenting the design phase that led to the implementation of the E-collaboration tools of the project. Then, we describe the function of each e-tool, we discuss the impact on the project that they have produced and we present open issues for further implementations of the system. Even if a specific information technology expertise was needed in order to make our system operational, we believe that it can be easily replicated and used by investigators of other government funded projects who do not already have access to an E-collaboration system.

INTRODUCTION

In order to successfully manage a research project, keep it on track and fulfill its goals, it is essential for the team to frequently discuss plans, objectives, achievements and challenges. It is also important to have the ability to share large data sets while maintaining a high level of security and privacy. Meeting and exchanging results regularly are also essential for the success of the project.

Face-to-face communications have been considered as the most appropriate medium to share ideas, comments, and opinions and to reduce misunderstanding [1]. However, large government funded projects often involve researchers from different institutions and/or departments. Therefore it is not always possible to implement this direct mode of communication due to the challenges of distance and the increasing needs of time and cost savings.

Recent developments in information and communication technologies have enabled and facilitated new forms of inter-organizational collaboration [2]. The use of E-collaboration tools introduces a new concept of time and distance, modifies human interactions, creates a novel environment for decision making and changes the classic network of face-to-face relationships into a network of virtual relationships.

E-collaboration has been defined in many ways. For the purposes of this article, we adopt the definition proposed by the guest editors of the first special issue on E-collaboration, published in 2001 in the *Journal of Systems and Information Technology by Kock et al.* They describe E-collaboration as "collaboration among individuals engaged in a common task using electronic technologies" [3]. Our system includes not only computer based technologies but also simple telecommunication devices such as the telephone. We agree with Kock [4] and we believe our system should still be considered an E-collaboration system.

In the following sections we briefly introduce the NHLBI-PEN project and describe the context that brought us to the implementation of a set of E-collaboration tools. Then, we present the hardware and software platform, a detailed description of the function of each E-collaboration tool, and the reasons for their development. We discuss the issues and challenges we experienced during development and implementation along with the limitations of our study, results achieved, and concluding comments.

THE NHLBI-PEN PROJECT

The central mission of the NHLBI-PEN project is to develop a group of well-characterized and versatile nanoscale agents that can be assembled, labeled, targeted, filled, and activated as needed for the diagnosis and treatment of various diseases of relevance to the National Heart Lung and Blood Institute (NHLBI). The project started in May 2005 and it has been funded for five years. The research activities of this project are carried out at three different institutions: Washington University in Saint Louis, University of California - Santa Barbara, and University of California – Berkeley. The teams include researchers from different cultures and scientific backgrounds where about 80% are chemists.

NEEDS ANALYSIS

Remote collaboration initiatives are not common in chemistry departments where Information Technology resources are often limited. The departments usually provide only emails as form of communication, common Internet access and occasionally the possibility to share central equipments.

E-Collaboration requires a synergistic framework based on four components: strategy, organization, process and technology [5]. We believe that a system embodying this synergy is advisable and necessary in order to be successful. Following this assumption, the senior investigators of the NHLBI-PEN project designed a roadmap with the goal of developing a set of E-collaboration tools that could overcome the potential barriers to collaboration and information sharing created by the physical separation and schedule differences between the three Universities.

The road map was based on four stages: 1) requirement gathering, to understand and identify the needs of the users, 2) requirement specifications, to identify any system requirements and user goals that must be met for the system to be successful, 3) design prototype in stages, and 4) evaluating the design to assess the system, test the software and perform usability testing.

Research has shown that it is much more economical to consider user needs in the early stages of the design [6]. In our road map, the needs and limitations of the end users were first inquired and analyzed, and then assumptions were transferred into the prototypes. This approach is well recognized as an effective strategy in designing ease-of-use products and systems [7],

The senior investigators of the NHLBI-PEN project identified four inter-organizational set of tools: information, communication, coordination and collaboration (see Table 1). For each of them, they defined a list of needs that had to be fulfilled by a specific E-collaboration tool. A time frame for implementation, based on months from the starting date of the project, was defined as well. The collaborative tools were selected among the ones presented here [8].

Given monetary constraints and the need to personalize software with specific routines, proprietary software was not a feasible option. In order to increase flexibility, independence from a third party provider was required. The system had to be highly reliable yet easy to maintain, administer and update, once fully operational. Synchronous and asynchronous tools had to be designed with the goals of increasing the communications and the sharing of data and results among the researchers. Easy access to and operation of the E-tools had to be addressed since most of the researchers in the project did not have an information technology background. Focusing on ease of use has been used to advance the product's release date [9].

In summary, the E-collaboration system had to be cost-effective (low cost of implementation), independent to industry and software/hardware vendors (open),

Table 1. Classes of inter-organizational information systems

Information	Communication	Coordination	Collaboration
WEB portal for sharing progress and general information about the project (available after 2 months). WEB portal for storing/remember events and meetings (available after 3 months). WEB site for storing goals and achievements of the researchers during skill development visits to other laboratories (available after 6 months).	Affordable conferencing system (available after 1 month). Research groups mailing list (available after 1 month). WEB site for facilitating the exchange of chemical samples between laboratories (available after 6 months).	Electronic document interchange tool (available after 4 months). System for monitoring the budget (available after 6 months).	Collaborative Planning (available after 10 months).

easy to integrate with the existing procedure/process and fast to deploy on a simple technology. [5]

NHLBI-PEN E-COLLABORATION SYSTEM

Following the plan provided in the road map, an E-collaboration system was designed and implemented. Initial use of the E-collaboration system was restricted to peripheral or uncritical activities and then implemented in full scale. This approach had many advantages: users learned to handle the new E-collaboration approach gradually without detracting from efficiency in their daily activities; technical implementation investment risks were minimized while the possibility of standardization was increased; and the E-collaboration system was tested adequately before going to full scale production.

HARDWARE AND SOFTWARE

The hardware and software platform used for providing the E-collaboration tools described in this paper, is based on a 2U rack Pentium III server class A by Ironsystems [10]. It runs Linux Debian with Apache as web server [11], PHP as scripting language [12], MySql as relational database [13], Webalizer for web statistics [14], and Postfix [15] as SMTP server. Telnet, FTP, DNS and other services have been uninstalled for security reasons. High levels of stability, fault tolerance, and availability are addressed by the use of RAID (Level 1) technology, daily backup policy on different supports (tape, external USB drive, and data storage devices), and redundant and uninterruptible power supply. Security policies are addressed by disabling physical and remote access to the server. Only a secret username has the privilege to log-in through a SSH connection from a subnet inside the Washington University in Saint Louis network. The SMTP server uses a mail relay provided by the department for spam filtering and virus protection. Specific firewall policies, directly controlled and managed by the IT office of the department of Chemistry at Washington University in Saint Louis, block access to the server except for port 80 (HTTP) and port 25 (SMTP). A daily report of the Internet traffic through these two ports is automatically created and checked regularly.

E-CONFERENCE TOOLS

The meetings of the NHLBI-PEN project are usually held in a conference room located at the School of Medicine of Washington University in Saint Louis. In order to reach a high level of participation and to increase the effectiveness of the meeting, a hybrid system, composed by an audio and a virtual office component, was developed. The audio component is based on a SoundStation VTX 1000™ Polycom system that allows communication, *via* telephone line, with the researchers in California. The two extra microphones and the speakers included in the Polycom system allow the circulation of comments, questions, and answers between all the participants (usually twenty in Saint Louis and seven in the two sites in California). The telephone service is provided by the university telephone department. The virtual office component uses a desktop sharing utility, based on VNC [16] that allows each site to be engaged in the meeting by following the PowerPoint presentations in real time. While one site actively initiates and controls their presentations, the other site can passively view. This virtual office component overcomes the limitation in following a distant presentation where the slide under discussion and the highlighted area of the slides by the presenter's laser pointer are unknown. The movements of the laser pointer are subsequently replaced by the movements of the mouse. This desktop sharing utility uses TCP/IP and it is available through a web site that works as proxy. A dedicated computer with Windows 2000 and VNC has port TCP 5900 open through the firewall. Two levels of password authentication are required to have access to the utility: one provided by VNC and the other by Windows.

E-DOCUMENTS TOOL

The E-Documents Tool is based upon PHP Advanced Transfer Manager [17], a free web content management software. It allows the researchers involved in the project to collaboratively create, publish, share and retrieve data when needed. The main features available are: upload, download, delete or modify (users can only manipulate their own files). A super-user creates folders, has full control over all the files, and manages user accounts. In order to fulfill the requirements and the needs of the researchers, the main software package was upgraded. Specific routines were designed, developed, tested and finally added to the basic package in order to have an E-Documents Tool that can provide each user with 300 Mbytes of restricted space (Personal folder) and each research unit (identified as a senior investigator plus his/her researchers) with 2 Gbytes of restricted space. The new version also has a shared folder accessible by everyone that is used for transferring files among units. Finally, a special area has been created for the exclusive use of the Internal Operating Committee members. At the end of July 2006, the E-Documents Tool had 304 files uploaded, 270 Mbyte of data stored, and 44 active users (Figure 1).

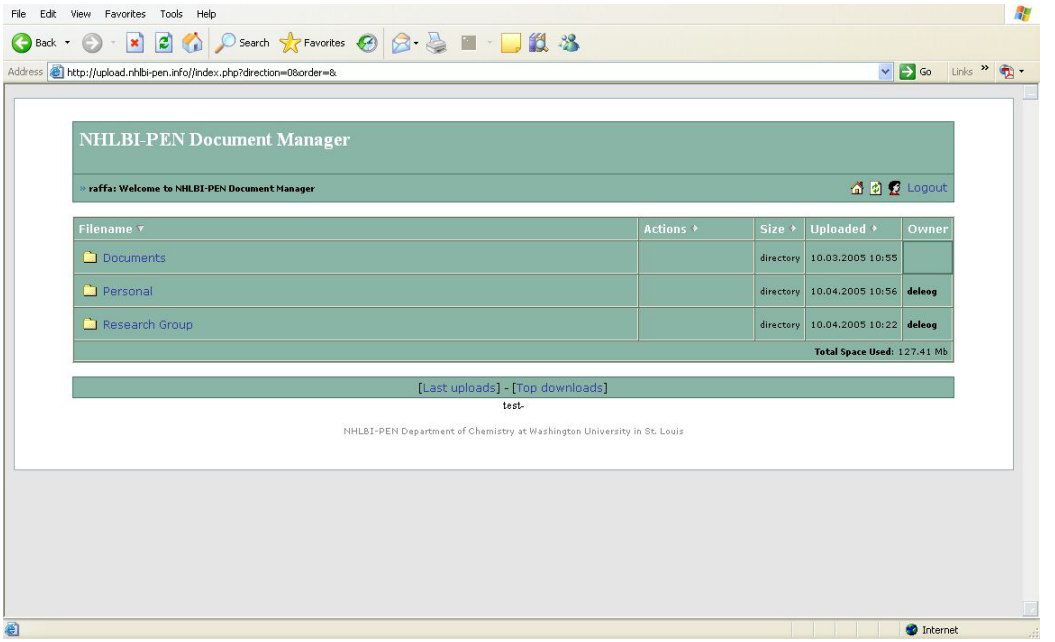
MAILING LIST TOOL

The researchers of the NHLBI-PEN project can utilize several mailing lists for easily contacting the members of each team. The mailing lists are both horizontal (for each of the 12 research teams) and vertical (for each of the 4 component: Materials Synthesis, Imaging, Animal Models, and Skills Development). The Internal Operating Committee has its own mailing list. In addition, a global mailing list that contains all the members is available.

E-RESEARCHER VISITS TOOL

The researchers of three universities are encouraged to schedule frequent short visits to other laboratories involved in the project. Throughout the year, postdoc and graduate students spend a few intensive days in other research groups to learn about additional procedures and methodologies that they have not yet experienced. The E-Researcher Visits Tool stores the researcher's name and

Figure 1. The e-document tool (home folder view)

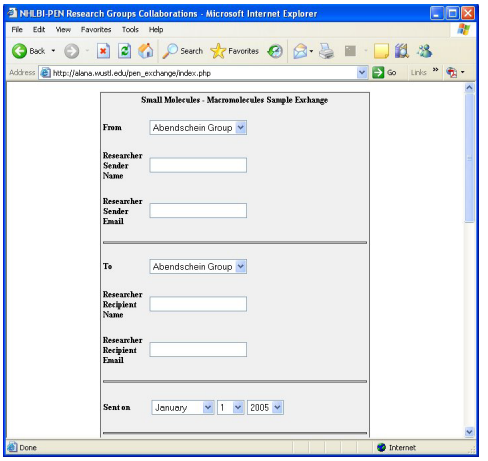


about the research group where he/she belongs, the group that he/she is visiting, and the goals and accomplishments of the visit. At the end of July 2006, the E-Researcher Visits Tool had 17 visits stored. A web site, password protected through the Apache htaccess policy, allows anyone in the project to have access to the E-Researcher Visits Tool.

E-SAMPLE EXCHANGE TOOL

The E-Sample Exchange Tool stores the information and the data of the chemical samples that have been transferred between research groups. There are two different sample exchange tools: one for Small Molecules-Macromolecules and one for Nanoparticles. A user-friendly web interface was developed in order to

Figure 2. E-sample exchange tool (insert a new record view)



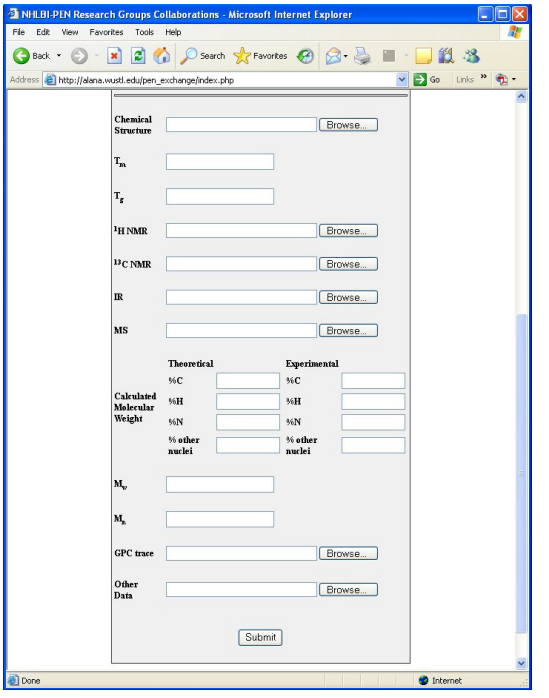
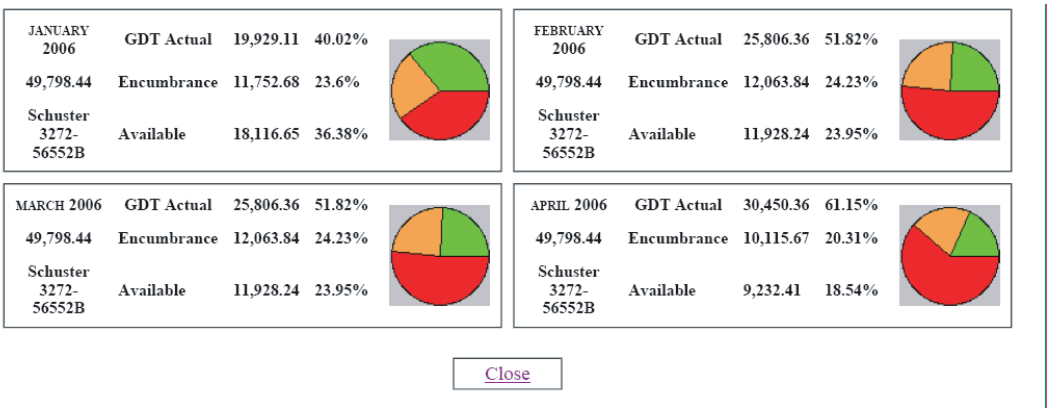


Figure 3. E-budget tool (monthly progress view)

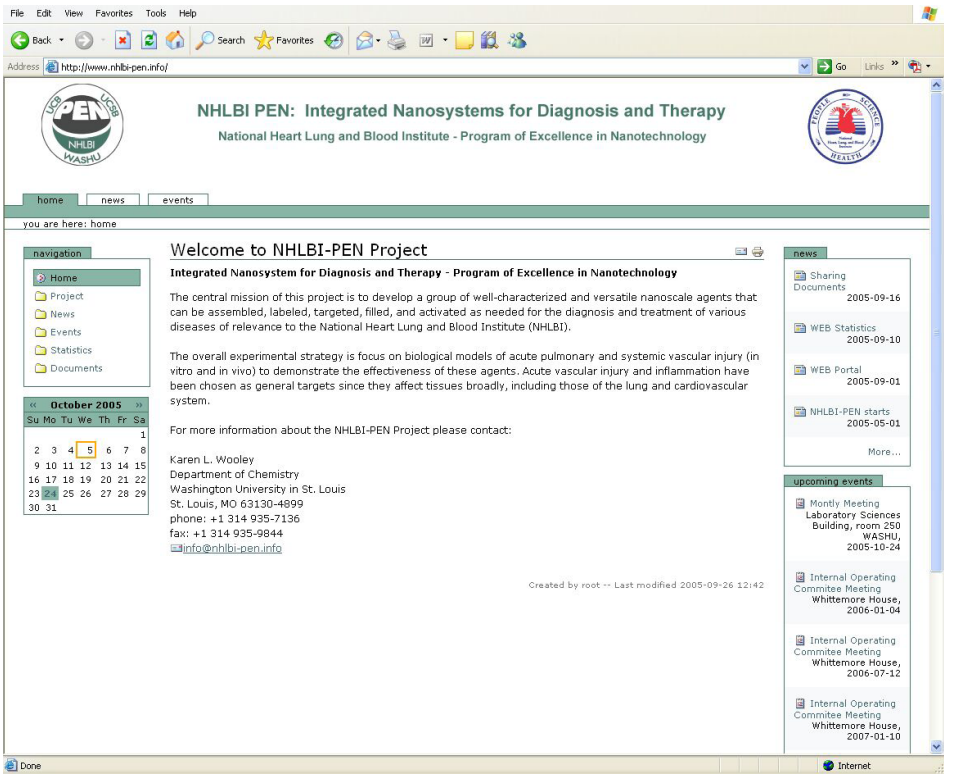


guide the researchers in creating a new record that contains general information and detailed data about the sample. General information includes the names and email addresses of the researchers who sent and received the sample, the date of sending, and an identification code. Detailed data consists of the chemical structure, the calculated molecular weight, the GPC trace, and other chemical properties. As in the case of the E-Researcher Visits tool, a web site allows anyone in the project to have access to the data. At the end of July 2006, the Sample Exchange E-Database contained 19 entries for Small Molecules – Macromolecules and 14 entries for Nanoparticles (Figure 2).

E-BUDGET TOOL

The E-Budget Tool keeps track of all the expenditures of each research group. This tool is available only to the Principal Investigator and her administration office. The budget of each research group is updated on a monthly basis and it shows the spent, the encumbrance and the available amounts. A color pie chart simplifies the visualization of the status of the budget and it is available in two formats. The first chart visualizes the research group budget situation by months, and it is used for monitoring the expenses over a long period of time. The second format gives an overview of all research groups by a selected month (Figure 3).

Figure 4. Web portal (home page view)



WEB PORTAL

The NHLBI-PEN web portal is available at http://www.nhlbi-pen.info (see Figure 4). Since the beginning of the project, the NHLBI-PEN team has been using the web portal for informing the community on new events and news. The status of the project, its progress and future plans are updated regularly. The web portal was developed using Zope [18] and Plone [19] and it provides a common interface and a single entry point to the other NHLBI-PEN E-Collaboration tools and services. The web portal contents can be easily updated by anyone, even without training in Hyper Text Markup Language (HTML).

DISCUSSION

The roadmap described in this paper is related to the first year of the NHLBI-PEN project. All the E-collaboration tools, except the collaborative planning, have been implemented and are fully operational.

The need for developing the E-collaboration tools presented in this article comes from the absence of collaborative systems at the three universities involved in the project. It is true that a teleconference system was available at each site but it was not free of charge, was difficult to reserve and the telecommunication standards used were not the same. Moreover the cost of using such systems cannot be billed directly to the grant and is not usually covered by the indirect costs of the departments. The possibility that the government agency that provides the grant would provide such E-collaboration tools free of charge does not seem realistic too.

Moreover, specific budgets for supporting IT personnel are not usually included in grant proposals. Thus, costs related to the initial investment in hardware should be considered when E-collaboration tools are planned. However, these costs would be a small percentage of the total budget of the project.

We believe the interface to our E-collaborations tools is easy to use. The researchers of the NHLBI-PEN project only need an e-mail account and a browser to have access to all the tools. Our monthly meetings have been attended often by researchers traveling in other countries or away from their offices. A wireless access point was enough for giving them the opportunity to participate. However, in order to increase the user-friendliness of our entire system, we are planning to develop a central log-in management system that stores the user's information. This would allow the user to log into each tool with the same id and password.

Bulletin boards for extended conversation and chat, where real-time text messages appear on both users screens, have not been implemented because they were not considered beneficial to the project. However, the development of a web based task list including a set of actions to be performed, pending activities, and unresolved problems is in progress. The E-Sample Exchange tools will have a "store room" section where researchers can look at the samples that are available in each group, place an order and receive the chemical at their labs. The implementation of a web based free educational tool to fulfill the skills developments component goals has been planned. Initial investigations suggested the use of Moodle [8].

Linux has been preferred to Windows as the operative system platform because more open source software is available under Linux. It is also easier to maintain once installed. We believe that the knowledge required to run a Linux server is equivalent to the one needed to administer a Windows 2000 Server.

Although the system is easy to maintain, we believe that a maintenance service (hardware and software) should be in place in order to guarantee availability of the E-tools to the researchers.

CONCLUSION

With the development of new technologies, and information communication technologies, in particular, teams have evolved to encompass new forms of interaction and collaboration. This paper demonstrates that E-collaboration tools can be used in a research funded project and that the implementation is not difficult to achieve.

The NHLBI-PEN E-collaboration system brings geographically dispersed research partners together, and supports the communication, coordination, cooperation, and sharing of data between the distant locations. We have described a system that allows the researchers of government funded projects to adopt the use of low-cost E-collaboration tools for increasing productivity and team work.

This study does not present any data about user's evaluation of the E-tools because a survey for collecting user feedbacks has not yet been developed. We only know that each E-tool has been extensively used. We are also aware that the number of the users in the NHLBI-PEN project would not have been enough statistically to make any definitive statements about the quality of our E-collaboration system.

However, we have acknowledged a transformation process from traditional (offline) communications toward hybrid services that combine elements of traditional collaboration and E-collaboration. Our E-collaboration solution is presented to improve the existing processes and provide the vehicle to establish new forms of collaboration.

Finally, we believe that a set of E-collaboration tools such the ones described, should be provided by the Universities using indirect cost budgets.

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REFERENCES

[1] R. L. Daft and R. H. Lengel, "Organizational information requirements, media richness, and structural design," *Manage. Sci*., vol. 32, no. 5, pp. 554–571, 1986.

[2] Madnick, Stuart E. (1991): The Information Technology Platform, in: Scott Morton, Michael S. (ed.): The Corporation of the 1990s: Information Technology and Organizational Transformation. New York, Oxford: Oxford University Press, 1991, pg. 27-60.

[3] N. Kock, R. Davison, R. Ocker, and R. Wazlawick, "E-collaboration: A look at past research and ruture challenges," *J. Syst. Inform. Technol.*, vol. 5, no. 1, pp. 1–9, 2001.

[4] N. Kock and J. D'Arcy, "Resolving the e-collaboration paradox: The competing influences of media naturalness and compensatory adaptation," Inform. Manage. Consulting, vol. 17, no. 4, pp. 72–78, 2002.

[5] Gerst, M. (2003): The Role of Standardisation in the context of e-collaboration: a Snap shot, 3rd IEEE Conference on Standardisation and Innovation in Information Technology 2003, October, 22-24, Delft.

[6] Pressman, 1992. Software Engineering: A Practitioner's Approach . McGraw-Hill, NY.

[7] Vredenburg, K., Isensee, S. & Righi, C. (2002). User-centered design: An integrated approach. New Jersey: Prentice Hall.

[8] Georgia Bafoutsou , Gregory Mentzas, A Comparative Analysis of Web-based Collaborative Systems, Proceedings of the 12th International Workshop on Database and Expert Systems Applications, p.496-500, September 03-07, 2001

[9] Karat, C. (1997). Cost-justifying usability engineering in the software life cycle. In Helander, M., Landauer, T., and Prabhu, P. (Eds), Handbook of Human-Computer Interaction. Elsevier Science, Amsterdam.

[10] http://www.ironsystems.com

[11] http://www.apache.org/

[12] http://www.php.net/

[13] http://www.mysql.com/

[14] http://www.webalizer.com/

[15] http://www.postfix.com/

[16] http://www.realvnc.com

[17] http://phpatm.free.fr/

[18] http://www.zope.org/

[19] http://www.plone.org

[20] www.moodle.com

Panels

Disruptive Innovation: Leadership and Organizational Dimensions

Moderator: Dr. Gerry Gingrich, Professor, Information Resources Management College, National Defense University, Fort McNair, Washington DC, USA; E-mail: gingrich@ndu.edu

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Dr. Gerry Gingrich, Professor, Information Resources Management College, National Defense University, Fort McNair, Washington DC, USA; E-mail: gingrich@ndu.edu

Today's interconnected and dynamic global environment presents challenges that were anticipated or even conceived just ten years ago. For example, the competitive pressure from growing economies such as India and China; the sensitivity of US markets to events around the world; the technological advances in virtual communications and collaboration; the decline in American scientific and engineering excellence; and security threats to our critical infrastructure and national power – all of these are acknowledged and accepted today.

These global challenges are beginning to outpace the progress in our organizational processes, architectures, and technology applications. Continuous process improvement moves business processes forward but at an incremental pace; architectures are somewhat but not fully integrated and thus continue to impede information sharing and collaboration; and existing technologies are still slow to enter mid to high levels of management and government, while younger generations have already thoroughly integrated them into their lives.

Having spent the last decade learning how to conduct process improvement and incremental change, our organizations now need to learn more about innovation, creativity, and large-scale transformation. Building on successes and lesson learned from the experiences of the 1990's, they need to increase their rate of learning. In many cases, this increase in learning will be experienced as disruptive to the organization. And, yet it is necessary and critical, for without disruptive innovation and learning, our organizations cannot achieve the desired characteristics of the 21st century organization: partnership-based, metric-oriented, integrated, and externally focused.

It has been said that disruptive innovation is the ability to see change as an opportunity, not a threat. In this panel, leadership and organizational strategies for achieving that perspective will be examined. For the first sixty minutes, two panelists will give presentations focusing on the leadership, organizational, and cognitive variables that mediate the success of disruptive innovation and learning. Dr. Robert Childs will examine key leadership variables such as vision, strategy, and flexible positioning and Dr. Gerry Gingrich will examine the organizational variables of culture, organizational behavior, and cognitive growth. The presentations will focus on two organizational-wide examples of disruptive innovation at the presenters' college – the development of international partnerships and the creation of a robust distance learning program.

For the last thirty minutes of the panel, there will be a forum involving both the panelists and the audience. The forum is intended to integrate the presentations with the audience members' experience. For example, how useful are the best practices to audience members' organizations? Are the lessons learned more useful in the private sector than in the public sector? Should they be modified for one sector or the other? If so, how? The panelists will facilitate the discussion.

Knowledge Development Innovation

Panel Chair: Mohammed Dadashzadeh, PhD, Professor of MIS and Director of Applied Technology in Business Program, Oakland University, Rochester, MI, USA; E-mail: dadashza@oakland.edu

Panelists: Mohammed Dadashzadeh, PhD, Professor of MIS and Director of Applied Technology in Business Program, Oakland University, Rochester, MI, USA; E-mail: dadashza@oakland.edu

Al Saber, PhD, Professor of MIS and Dean of Graduate Programs, Friends University, Wichita, KS, USA; E-mail: asaber@friends.edu

INTRODUCTION

In his 2006 book, ***Knowledge Development Innovation: How To Rescue America's Advantage***, Dr. Boulton Miller concludes as follows:

"Knowledge Development Innovation will provide this nation with the ability to demonstrate a global leadership role in education, making use of the latest improvements in information technology, with faculty technically qualified to fulfill their role as guides or coaches, with students as active learners and synthesizers of

knowledge. It is impossible at this time to predict the outcomes of the information technology developments; however, our education system must remain flexible and be ready to implement whatever new developments become available."

OBJECTIVES

The objectives of this panel are threefold:

A. To discuss what Knowledge Development is and why it is a different objective than Knowledge Management making it worthy of national planning and implementation.
B. To consider Dr. Miller's recommendations for the formation and funding of a Knowledge Development Agency charged with goals that include the development of a Personal Knowledge Development (PKD) system.
C. To present the architecture of a national information technology based solution to the implementation of the PKD idea.

Issues and Trends in IT Capital Planning and Investment Management for the Public Sector

Panel Chair: Dr. John T. Christian, Information Resources Management College, National Defense University, Fort McNair, Washington, DC, USA; E-mail: christianjt@ndu.edu

Governmental agency Chief Information Officers are in a constant struggle faced with the need to provide great information technology (IT) support to a diverse customer base, while operating with few human resources and decreasing funding levels. As IT has moved from being a key component of back office support systems to being a key component of front office mission critical systems, CIOs are finding that they are under greater pressure from their agency colleagues to deliver the IT component of a "business solution" that performs as advertised and is delivered on-time and within-budget. Attempts by IT departments to meet their diverse customers' expectations with the limited resources available may result in the inappropriate allocation of resources to the "squeaky wheel projects" rather than projects that may have strategic impact.

To better manage the expectations of their customers and stakeholders, IT departments should implement an inclusive IT Capital Planning and Investment Management process that is transparent. One approach that may improve the quality of decision-making and the allocation of scarce IT resources is based on the application of financial investment portfolio concepts and techniques to selection, control, and evaluation of agency IT business cases.

The IT investment portfolio approach provides a governance framework that ensures that all IT business cases are rigorously assessed by all of an agency's line of business leaders for business value and business risk. A portfolio approach allows agency leaders to create a portfolio of IT investments that balance business value and business risk. In addition, each IT business case may be rigorously assessed by independent analysts to validate the value benefits and the costs associated with the investment. IT technical experts may validate the technical solution proposed by the business case to ensure that it is aligned with the agency's enterprise architecture. This governance framework can provide significant oversight of each IT investment during its acquisition life-cycle. The IT investment portfolio approach provides sufficient visibility into all of an agency's IT investments so that agency leaders can maintain a clear understanding of the relationship between each of their IT investments.

The first segment of this panel will be devoted to a very brief overview of an IT Capital Planning and Investment Management approach, which has been developed by employing many of the ideas that underpin a financial investment portfolio approach. The purpose of this overview is to ensure that those attending the panel have a clear understanding of the basic concepts of IT Capital Planning and Investment Management using an investment portfolio approach. The balance of the time allotted will be used by the panel members and those attending the panel to discuss current issues and trends in IT Capital Planning and Investment Management in the Public Sector. The panel will be conducted as a conversation between the panel members and the audience.

Philosophical Conversations in Information Management

Panel Chair: Dr. M. E. Burke, Information Systems Institute, University of Salford, UK; E-mail: M.E.Burke@salford.ac.uk

OBJECTIVES

This panel will build on the "Philosophical Conversations" which took place at the Philosophy track at IRMA 2006 in Washington DC. The panel will initially address themes which attempt to identify the major philosophical underpinnings within the field of information management. There are many documented philosophical viewpoints concerning epistemologies such as rationalism and empiricism as well as research paradigms such as positivism and interpretism which have their roots in social theory. However, as information management develops as a profession it

is important that the philosophical underpinning of how information management is perceived through a philosophical lens is addressed. Philosophical viewpoints in information management is a live, continuously developing area that needs to be aired and discussed in an international arena. The following are recommended topics but papers which address related areas will also be considered.

SUGGESTED ISSUES TO BE COVERED

- Finding roots, looking back: taking a historical philosophical perspective and exploring relevance to today's needs.
- Current Philosophical Perspectives
- Discipline boundaries: the differences between information science and information management.
- A framework for design science research activities
- Web Ontologies and Philosophical Aspects of Knowledge Management
- Philosophical Foundations of Information Modelling

Abstracts/Workshops

Web Portfolio Design for Teachers and Professors

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DESCRIPTION

This workshop provides the k-12 and college educator with a creative opportunity to develop a multimedia based electronic portfolio that can be uploaded and viewable from the World Wide Web. Instruction includes conceptualization and categorization of assets and artifacts for portfolio development and technology lab tutorials in the use of digital imaging, MS Office output to web pages, and tutorials in industry standard web development software including Adobe Acrobat, Adobe Photoshop, Adobe Fireworks, and Adobe Dreamweaver. The Instructor will develop a complete web portfolio site during the workshop. Participants with laptops and required software (MS Office and Adobe Web Suite) can follow along. Downloadable assets used in class demonstrations will be available before the event from Professor DiMarco's FTP site.

OBJECTIVES

Upon successful completion of this workshop, particpants will be able to:

- Understand why the web portfolio is an important tool for lifelong learning and communication of scholarship.
- Conceptualize and plan a web based electronic portfolio.
- Evaluate and execute artifact content collection decisions and processes.
- Develop assets and thematic content.
- Use industry standard software packages for design, content development, web authoring, and multimedia.
- Critically review and evaluate web portfolios to insure they meet specific disciplinary criteria.
- Perform reflective writing for the web portfolio

RATIONALE

The Web Portfolio as a Standards Based Assessment Tool

Creating a web portfolio prepares educators to embrace technology and to perform analysis, inquiry, and design. Project based learning is an effective approach to web portfolio development. The portfolio acts as a "personal information system and professional cyber identity". In college as well as k-12, these skills are brought back into the classroom so that teachers can help teach their students how to create personal, professional web portfolios. Web development skills will be important to students in any occupation or field in the future due to the increase of mediated electronic communication devices.

In this workshop, professors, teachers, and information professionals will engage in analysis of their professional content, perform personal inquiry during content development, and sample digital design skills while creating an electronic portfolio that will be posted to the World Wide Web.

Creating a personal electronic/web portfolio makes you a lifelong learner and allows you perform self assessment throughout your career. Teachers and professors can use the electronic/web portfolio for student assessments and for themselves to provide evidence of professional growth applicable in tenure and promotion scenarios.

WORKSHOP OUTLINE

Learning Modules	TOPIC
	Electronic Portfolio Definitions
One	*web Portfolio Definitions* *Defining the web portfolio within your discipline and context.* Describe how the electronic portfolio fits into your academic discipline and career goals. Answer the question: This web portfolio defines me as a _____.
Two	**Conceptualize/Brainstorm the web portfolio.** *Defining the audience.* *Explain how the web portfolio will be used to persuade the audience.*
Three	**Web portfolio Content** *Content Evaluation Methods* *Writing the Content List* *Writing project/work/artifact descriptions*
Four	**Information Design** *Navigation issues* *Developing a Flowchart* *Page counts and scope* *Combining the scope documents(concept statement, content list, content outline, and flowchart)*

	Visual Design
Five	*Developing storyboards* *Content development and digital capture techniques* *Screen resolution and graphical sizing issues* *web Resumes* *HTML and Graphical text issues*
Six	**Web Page and Graphic Design** *Developing web graphics* *Developing web screens* *Developing navigation* *Digital Artifact Production (MS Office)* *Using Adobe Photoshop*
Seven	**Slicing and Exporting (GIF or JPG?)** *Setting up the folder structure properly and where to put your artifacts* *Understanding the root directory of the web portfolio* *Using Fireworks to slice*
Eight	**Web Authoring** *web page functionality issues* *web page development demonstrations and tutorials* *Using Dreamweaver to author the web site* *Using Word to create web pages* *Using PowerPoint for Web pages*
Nine	**Uploading the web portfolio using FTP** *Testing the web portfolio* *Checking download time* *Checking links and popups* *Testing Usability* *Final Critique and Assessments*

INSTRUCTOR BIO

John DiMarco is a professor, trainer, consultant, writer, and digital media expert with over 10 years experience in training, communication design, and educational technology. Professor DiMarco has helped hundreds of students create web portfolios. As an Assistant Professor at St. John's University in New York City, John teaches courses in mass communications, media graphics, video, and 2d & 3d animation. He also holds adjunct professorships at NYIT, Nassau Community College, Molloy College, and LIU. From 2001-2003, he held the position of Assistant Professor of Digital Art and Design and Interactive Multimedia at Long Island University, C.W. Post in New York. He is the founder of www.portfoliovillage.com, a website that provides web portfolio space and educational content. His latest book: Web Portfolio Design and Applications was published in 2006. In 2004, John published an edited book titled "Computer Graphics and Multimedia, Applications, Problems, and Solutions" for Idea Group Publishing. John DiMarco is the final stages of completing a PhD in Information Studies (Technical Communication and Communication Education) at Long Island University. His educational background includes a Master's Degree in Communication Design from Long Island University-C.W. Post, and a Bachelor's Degree in Communication & Public Relations from the University at Buffalo.

ALICE Tea Party: An Alternative or Supplementary Approach to Traditional Introductory Programming Courses

W. Brett McKenzie, Associate Professor, Computer Information Systems, Roger Williams University, Bristol, RI, USA; E-mail: wmckenzie@rwu.edu

OBJECTIVE

To introduce ALICE as an alternative or supplement to traditional introductory programming courses.

DESCRIPTION

ALICE is a 3D programming environment developed at Carnegie Mellon University and funded by the National Science Foundation. ALICE is designed to facilitate learning object-oriented, event-driven programming by drawing on our student's immersion in graphically rich media through animation and games. Evaluations have demonstrated that subsequent to studying ALICE

- students chances of succeeding in programming courses increases
- attraction and retention of women and minorities increases
- student enthusiasm for computing as a major increases.

ALICE has been built upon two premises. First, visualization of abstract concepts aids understanding. Second, syntax errors are a major barrier for novice programmers. To address these issues, ALICE programming uses figures, real or fantasy such as Alice Liddell or a white rabbit, that interact with objects, such as tables, chairs, or place settings, in environments that may contain trees, ponds, or buildings. Programming is achieved through dragging and dropping tiles with commands into an editor. Typing is reserved for assigning values to variables.

ALICE facilitates different approaches to programming, some of which are particularly appealing to underserved groups, such as women and minorities. ALICE programs may be either animations, which tend to tell stories, or interactive worlds, which tend towards games. Storytelling seems to have particular importance for the underserved groups. For example, Hawaiian islanders have used ALICE to preserve Hawaiian cultural heritage by creating animations of traditional stories. Similarly, young women, frequently excluded from programming, have been motivated by the chance to create and tell stories through their ALICE programs. The ability to create interactive worlds in ALICE allows an easy path to game programming and accounting for dynamic environments.

Fundamental computing constructs and logic are introduced through either storytelling or games. For example, to make a character walk, a simple step method – raise right leg, move forward, raise left leg, move forward – can be extended by using a loop. A logical structure, such as an "If…else" can be used to ensure that character avoids walking into an object. Similarly, ALICE allows more complex object-oriented activities, such as creating, exporting, and importing new classes built upon base classes, or invoking events through key presses or mouse actions.

The ALICE environment is an open source JAVA based suite and includes an object tree, event editor, program editor, and visualization area. While ALICE comes with a rich set of models, it is possible to import additional models as well as to import and play back audio tracks. ALICE is currently at Version 2. The

next version may be released by the time of the conference and it will include better models and rendering in collaboration with Electronic Arts. Additionally, the new version will have the ability to dump the JAVA code and to interact with external data sources.

TUTORIAL/WORKSHOP ACTIVITIES

In the course of the workshop, participants will build ALICE Worlds (as ALICE programs are called) that demonstrate fundamental aspects of OO programming. The target audiences are instructors from introductory programming and computer fluency courses; however, the workshop does not presuppose knowledge of OO programming. Participants who bring their own laptop computers will get the latest version of ALICE and all workshop materials to install on their computers.

The workshop will also include discussions of integrating ALICE in the curriculum from stand-alone to brief courses, as well as the latest model being developed "the blended course", which combines ALICE and JAVA instruction. ALICE has been adopted at over 100 colleges and universities ranging from the liberal arts schools, such as Haverford College, Pennsylvania to state research universities, such as University of Texas.

TUTORIAL/WORKSHOP LEADER

Dr. W. Brett McKenzie introduced ALICE at Roger Williams University and has presented at NSF Workshops on ALICE at Haverford College, PA and Duke University, NC. More information about ALICE is available at www.alice.org

REFERENCES

Alice V2.0 (2005), http://www.alice.org/

Dann, W. Cooper, S, and Pausch, R (2004) *Learning to Program with Alice* Upper Saddle River, NJ: Prentice Hall

Moskal, B, Lurie, D. and Cooper S. (2004). "Evaluating the effectiveness of a new instructional approach", SIGSE '04. http://doi.acm.org/10.1145/971300.971328

Educational Applications of Social Software and Collaborative Technologies

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INTRODUCTION

Social software and collaborative technology applications are becoming prevalent across all dimensions of society including business, education, government and individuals. The shift to Web 2.0 applications and trends toward open source have provided the impetus for an explosion of new applications. Instant messaging, blogs, podcasts and wikis represent the most common forms of social software that promise to have widespread influence in the future. The community aspects of these technologies is a common defining characteristic of emerging social software applications. Social software is built on the concept of collaboration and community involvement. Businesses are beginning to see the benefits of blogs and podcasts as a means to reach a diverse customer base and keep a pulse on the "buzz" in the marketplace. These technologies are becoming an essential component of public relations in many companies. Social software is also being used as a communication tool to reach employees and business partners. Educational institutions are also jumping on board to provide additional options for students that meet specific curriculum needs. The potential for these technologies is huge and current trends indicate that competition for products and business applications will be global in scale.

This workshop will address ways in which software and collaborative technology applications are being integrated into the classroom. Podcasts, blogs, and wikis are being used extensively as tools to enhance the learning process. Implementation of collaborative technologies such as electronic meeting software will also be examined. Pros and cons of implementation and some of the lessons learned will be discussed. Examples of how schools are using these technologies and future trends will be examined. Participation from those attending the workshop who have experience with these technologies in the classroom will be encouraged.

WORKSHOP OBJECTIVES

1. To provide participants with an understanding of the various social software and collaborative technology applications and ways in which they are currently being used in the classroom.
2. To provide a forum by which to discuss the pros and cons of using these technologies in the classroom and how they may impact the learning process.
3. To evaluate undergraduate versus graduate level applications and how these technologies should best be integrated into curriculum design.
4. To discuss business applications of these technologies and the responsibility of academic institutions to prepare students with these skills.

SOCIAL SOFTWARE

Blogs, podcasts and wikis are the most common social software applications being used in academic institutions today. The use of these technologies and some of the success factors in various academic settings will be provided. These software applications are currently in the experimental stages in business school settings. The verdict is still out as to whether podcasts, for example, will be become main stream academic tools for providing learning opportunities and alternatives to the current written text. On-line classes took some time to establish credibility and recognized value. Will social software applications provide value add in the academic environment and what role will they play in the future of curriculum design? These questions will be addressed in the context of current experiences and future trends.

COLLABORATION TECHNOLOGY

Collaboration software has become more prevalent in recent years for business applications supporting team projects and electronic meetings. In addition, collaboration software can be used to support managerial meetings with employees who may be in different places all over the world. Project teams can effectively share documents and observe power point presentations simultaneously. Participants can use whiteboard features to draw diagrams, list discussion items or emphasize points on another document or image. It is important for students to gain experience with these technologies and develop skills that will be beneficial and increasingly necessary for the job market. These skills may give students a competitive advantage in the marketplace. In this workshop the implementation of one of the prevalent business collaboration software tools (Breeze) will be discussed. This software was incorporated into the introductory IT courses at both the undergraduate and graduate levels.

CONCLUSION

This workshop will provide a forum from which to discuss these emerging social software and collaborative technologies as tools in the design of business school

curriculum. As the business community continues to embrace these technologies it is imperative that business schools determine the role of these tools and applications in the classroom. In preparing students for the future it has become necessary to evaluate new technologies and their role in educating students who will be competitive in the global marketplace.

Symposiums

Technology and Globalization: A Critical Teaching and Learning Initiative for Business and the MBA

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"No new business is worth starting in these times unless it can go global." - Richard Branson, Virgin Empire

"The world is being turned into a digital representation. Distance means nothing if you have a digital infrastructure. Anything digital is borderless. You cannot put obstacles in the way of digital technology flowing everywhere." Andy Grove, Intel Corp. Chairman.

"Globalization 3.0 is shrinking the world from a size small to a size tiny and flattening the playing field at the same time. ... the thing that gives it its unique character – is the newfound power for individuals to collaborate and compete globally" – The World is Flat, Thomas L. Friedman, pg 10

The "common body of knowledge" which widely characterizes curricula of Schools and Colleges of Business today dates back to the 1930s—a functional grouping of courses attempting to mirror the major functions of the enterprise: finance, operations, marketing, accounting. Coupled with the obligatory Organizational Behavior and Strategy courses, these subject areas remain the focus of MBA programs across the country today (Kurhana et al, 2005).

Even a casual review of other professional curricula (medicine, law, for example) suggests that maintaining the same theoretical perspective for almost 80 years would be a dereliction. Changes in medical and surgical practices, revolutionary court decisions and precedents—no patient or legal client would accept professional services from an individual whose understanding of his or her profession dated back 80 years! No medical or law school would take pride in offering such a program of study.

Similarly, few business leaders would agree that the practices (and indeed, the very functions) of business are the same as they were in 1930. Occasionally, an institution has the insight to identify emergent areas which—though outside the traditional functional areas—have an impact so profound as to demand curricular attention. In that light, the E. Phillip Saunders College of Business at Rochester Institute of Technology, having adopted a mission statement focused on globalization and technology, invited the authors to develop an innovative (and collaborative) seminar titled "Technology and Globalization."

At RIT, the seminar is offered in a team-based, fully integrated, action-learning approach. This means that faculty serve as designers and developers of the learners' experience and the students learn through active engagement with a series of progressively more complex projects or problems.

WHY AN INTEGRATED APPROACH?

In a (1994) *Harvard Business Review* dialogue, management theorists and business educators express the need for integration of functional disciplines: "Certainly we must continue teaching the basic functions of business, but in a context that produces an understanding of the interdependencies of organizational functions" (Louis Lataif, Dean of the School of Management at Boston University, p. 128). "Let's stop pretending to train non-managers to be managers through detached case studies and disconnected theories" (Henry Mintzberg, Professor of Management, McGill University, Montreal, p. 129).

HOW DOES IT WORK INSTRUCTIONALLY?

Underlying theory. Pedagogically, the model springs from theoretical literature on problem-based learning which emerges from a Constructivist philosophical view of how one comes to understand. Savery and Duffy (1994, pp. 1-2) characterize the view in terms of three propositions:

1. Understanding is in our interactions with the environment. (We cannot talk about what is learned separately from how it is learned).
2. Cognitive conflict or puzzlement is the stimulus for learning and determines the organization and nature of what is learned. (The learner has a purpose for being here.)
3. Knowledge evolves through social negotiation and through the evaluation of the viability of individual understandings. (Other people are the greatest source of alternative views to challenge our current views and hence to serve as the source of puzzlement that stimulates new learning.)

Savery and Duffy also offer a set of relevant instructional principles:

1. Anchor all learning activities to a larger task or problem.
2. Support the learner in developing ownership for the overall problem or task.
3. Design an authentic task.
4. Design the task and the learning environment to reflect the complexity of the environment they should be able to function in at the end of the learning.
5. Give the learner ownership of the process used to develop a solution.

6. Design the learning environment to support and challenge the learner's thinking.
7. Encourage testing ideas against alternative views and alternative contexts.
8. Provide opportunity for and support reflection on both the content learned and the learning process.

The co-developers of the course felt strongly that the incredible speed of change in the two fields under examination required such an approach for many reasons, but, perhaps most importantly, helping learners to master not the facts of technology or international business, but rather, the capacity to continuously learn and update competence in these areas.

WHAT WILL HAPPEN AT THE SYMPOSIUM?

Symposium presenters consist of the co-authors of this seminar who have offered it a total of six times to date. After a brief introduction to the symposium's approach, participants will be invited to generate timely topics and concerns related to the two subject areas. A facilitated discussion will encourage participants to explore existing and potential synergies between the two most powerful forces in business today. Based on their research with business and industry and on their teaching experiences, the co-presenters will offer suggestions for learning challenges that participants will be able to apply in academic or training and development settings. Participants who request them will receive course materials and a summary of the symposium's key points.

This symposium is uniquely suited to IRMA's topic this year. Practical, timely, and appropriate for information managers and academicians as well, its outcomes should help participants to crystallize related issues for their home organizations.

Experiences in Implementing a Network Engineering Technology Curricula

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ABSTRACT

The purpose of this symposium is to share faculty experiences in the successful development of a laboratory-based Network Engineering Technology (NET) program. The symposium will include information on individual courses, the curricula as a whole, facilities required, and experiences in working toward accreditation from CAC/ABET. The symposium will present the individual elements of the lab-based curriculum architected around a network overview diagram that illustrates the infrastructure used to facilitate lab integration amongst the courses.

INTRODUCTION

The focus of the Network Engineering Technology (NET) program is to create highly competent network engineers and administrators. Course materials are reinforced with tightly integrated lecture content and laboratory experiences. Supporting lecture material with laboratory exercises produces an active learning environment where "students must engage in such higher-order thinking tasks as analysis, synthesis, and evaluation", which aids in retention and understanding of material (Bonwell 1991). The NET program further reinforces the relationship between lecture and laboratory at the curriculum-level by utilizing course-based laboratory projects as pieces of the overarching network infrastructure. Collectively, these course-based lab projects combine to provide students with an education and hands-on experience in every aspect of network design, implementation, administration, security, and management.

Figure 1 illustrates the network architecture deployed by the students in the NET curriculum each semester. This diagram provides a basis for understanding how the individual course components collectively contribute to a holistic student learning experience. This architecture is critical to enabling cross-course collaboration among students with disparate technologies.

All course materials are designed with actual industry experiences in mind. Designing exercises in this manner ensures that the students gain knowledge of technologies and practices currently utilized in industry, and they will understand the processes for implementing and troubleshooting networks containing these components. As suggested by Qazi and Ishaq (Qazi 1998), students should be offered interdisciplinary projects that provide a seamless connection between the academic sphere and the professional world. This approach to education provides students with the desired learning experience, preparing them for future work in corporate environments as required by CAC/ABET for accreditation.

The NET program is currently undergoing an accreditation review as an IT program by CAC/ABET and should be complete by the date of the symposium. The presenters will also be prepared to share their fresh experiences gained through the accreditation process.

CORE CURRICULUM

NET students will pursue a wide variety of endeavors within the networking and digital telecommunications field upon graduation. The NET program breaks these responsibilities into the logical groups that include network design, administration, security, and management. The following list identifies the courses that compose the core of the NET curriculum:

- C&IT 330 – Local Area Networking and Systems Administration
- C&IT 343 – Advanced Systems Administration
- C&IT 346 – Wireless Networks
- ECET 374 – Digital Telecommunications
- C&IT 430 – Internetwork Design and Implementation
- C&IT 443 – Enterprise Network Management
- C&IT 455 – Network Security

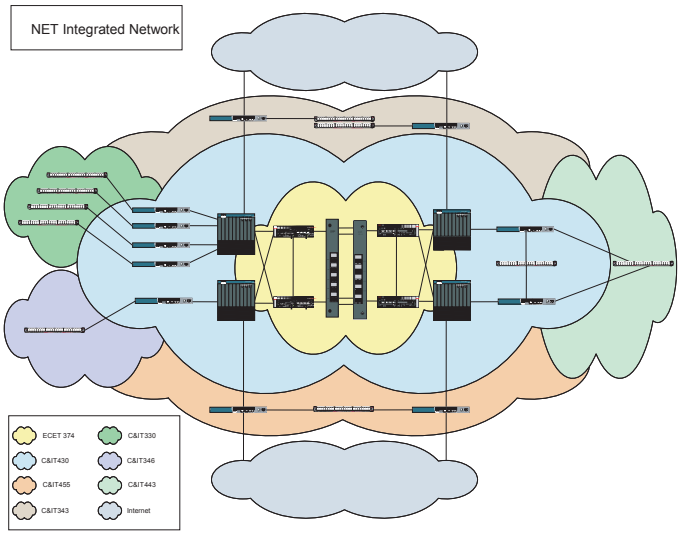
C&IT 330: Local Area Networking and Systems Administration

C&IT 330 introduces students to local area networks, system and network administration. Emphasis is placed on fundamental concepts and best practices. This course also provides students with their first hands-on laboratory experience in the NET curriculum and emphasizes problem-solving and troubleshooting skills through network implementation.

C&IT 343: Advanced Systems Administration

C&IT 343 expands upon the administration concepts learned in C&IT 330 and introduces extended network services. C&IT 343 laboratories focus on solving given business scenarios. Students must research and implement various technologies to address the business cases given, and must support their work with

Figure 1. NET network overview



a structured analysis and report using the Top-down model as a reference. This laboratory gives students exposure to a wide array of administration tools and software packages that will be found in industry.

C&IT 346: Wireless Networking
C&IT 346 introduces wireless and cellular technologies and their impact upon the telecommunications world. In lecture, students learn about wireless-specific protocols and modulation techniques, as well as the architecture needed to support this communication. In laboratory, students implement wireless solutions and integrate them into wired LAN environments.

ECET 374: Digital Telecommunications
ECET 374 provides a broad overview of digital communication methods and systems emphasizing telecommunication fundamentals. Students explore the Public Switched Telephone System (PSTN) backbone and local loop transmission infrastructure, including physical layer concepts such as analog and digital signals, noise, power, errors and modulation. Telecommunication concepts such as T and E carrier transmission and framing are examined and further developed through higher order multiplexing schemes including SONET/SDH. Additional telecommunication technologies such as ISDN, Frame Relay, and ATM are also discussed.

C&IT 430 – Internetwork Design and Implementation
Students design and construct a routed IP-based wide area network capable of simultaneously transporting packet-switched voice, multi-protocol data, and video. Emphasis will be placed on the design and internetworking of diverse telecommunications systems, while considering the effect of engineering decisions on business performance. Organization and management of large scale telecommunications projects are investigated.

C&IT 443: Enterprise Network Management
C&IT 443 explores various aspects of enterprise network management with an emphasis on managing faults and optimizing performance to ensure high service availability. Concepts introduced include basic management functions, standards-based management technologies, and the business impact of network management.

C&IT 455: Network Security
C&IT 455 covers conceptual and technological aspects of network security for voice and data networks. The course deals with the analysis, design, implementation, and management issues surrounding effective network security. Students must research a variety of solutions to current security issues, and implement their findings in the laboratory environment.

REFERENCES

Bonwell, Charles., Eison, James, (1991). "Active Learning: Creating Excitement in the Classroom". Retrieved 02/01/2004 from http://www.ntlf.com/html/lib/bib/91-9dig.htm.

Qazi, S., Ishaq, N., "Impact of Applied Research in Engineering Technology". Proceedings, 1998 ASEE Annual Conference, Session 1348, 1998.

Srivinas, Hari (No Date). "Collaborative Learning". Retrieved 02/10/2004 from http://www.gdrc.org/kmgmt/c-learn/.

Tutorial

Connecting Requirements and Object-Oriented Modeling

Instructor: Hermann Kaindl, Vienna University of Technology, Institute of Computer Technology, Vienna, Austria;
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Prof. Hermann Kaindl *joined the Institute of Computer Technology at the Vienna University of Technology in Vienna, Austria, in early 2003. Prior to moving to academia, he was a senior consultant with the division of program and systems engineering at Siemens AG Austria. There he has gained more than 24 years of industrial experience in software development. His current research interests include software engineering with a focus on requirements engineering, and human-computer interaction as it relates to scenario-based design. He has published four books and more than ninety papers in refereed journals, books and conference proceedings. He is a senior member of the IEEE, a member of the ACM, the INCOSE and the IRMA, and is on the executive board of the Austrian Society for Artificial Intelligence.*

OBJECTIVES

The participants will understand several key problems with current OO methods and how they can be resolved by "clean" OO thinking. In particular, they will

be able to distinguish between domain objects and software objects. They will experience UML as a language for representing OO models, but also the need to be clear about what kind of objects are represented. In addition, participants will see how scenarios and use cases can be utilized for requirements engineering. But they will also see the additional need to specify the functional requirements for the system to be built.

The purpose of this proposed tutorial is to connect requirements engineering with object-oriented modeling, so that practitioners can apply the best from both "worlds" together.

SUMMARY OF MATERIAL TO BE COVERED

- How do scenarios / use cases fit together with functional requirements?
- How can OO (object-oriented) principles like classification help organizing a huge number of requirements?
- How can the application domain be better understood using OO modeling?

This tutorial addresses these questions because they are relevant for industrial software development but too many misunderstandings still exist with regard to OO processes and methods as related to requirements engineering. It shows how each requirement given in natural language can be modeled as an object, which facilitates a clean organization and association. While scenarios / use cases can somehow illustrate the overall functionality, additionally functional requirements for the system to be built should be formulated and related to them appropriately. In order to better understand scenarios, the goals to be achieved by them should be explicitly defined and linked to them as well. All kinds of requirements typically make statements about the application domain, which should be represented in an OO Domain Model of conceptual classes, in order to make the requirements better understandable.

PRESENTATION FORMAT

This tutorial will consist of lectures and group discussions. The technical points made will be illustrated with a running example throughout.

For the lectures, the instructor will use a computer screen projector connected with his laptop computer.

Assumed Background of Attendees

The assumed attendee background is some familiarity with scenarios / use cases and basic object-oriented concepts, as well as interest in requirements.

The target audience is requirements engineers, software engineers, project managers, anyone supposed to work on the requirements in the context of object-oriented development.

HISTORY, PREVIOUS EXPERIENCE OF THE TUTORIAL PROPOSER AND ADDITIONAL REMARKS

A half-day version of this tutorial was presented at INCOSE 2004 (26 attendees in a conference of about 850). It received very positive feedback (on tutorial evaluation sheets filled in by attendees) and I will embrace the ideas suggested for improvement. Other versions:

- "Modeling Business and Requirements Using UML" at HICSS'38 (35 attendees in a conference of about 600)
- "Reconciling Requirements, Use Cases and Object-Oriented Modeling" at RE'02 (17 attendees in a conference of about 200)
- "Reconciling Business Modeling and Requirements with Object-Oriented Software Development" at HICSS'36 (38 attendees in a conference of about 600)
- "Reconciling Requirements, Use Cases and Object-Oriented Modeling for Systems Engineering" at INCOSE 2003 (37 attendees in a conference of about 1000).

In addition, this proposer has previously held tutorials on the reuse of requirements at CAiSE'00, RE'01, RE'03, INCOSE 2004, RE'04 and INCOSE 2005.

Among other things, this tutorial proposes solutions to issues discussed in a panel organized by this proposer at OOPSLA 2001 "How do Requirements Relate to Objects?" and another panel with the same title at INCOSE 2004. It includes also material on real-world experience from the approach developed by this proposer as presented in an invited State-of the-Practice Talk at RE'01:

H. Kaindl, Adoption of Requirements Engineering: Conditions for Success, *Fifth IEEE International Symposium on Requirements Engineering (RE'01)*, Toronto, Canada, August 2001.

The proposed tutorial is also is based on an in-house course at Siemens, a teaching course at the Vienna University of Technology, research and consulting experience of its proposer and, e.g., on the following selection of articles and papers:

Kaindl, H., Object-Oriented Approaches in Software Engineering and Artificial Intelligence, *Journal of Object-Oriented Programming* 6, 8, 1994, pp. 38–45.

Kaindl, H. A Practical Approach to Combining Requirements Definition and Object-Oriented Analysis, *Annals of Software Engineering*, Vol. 3, 1997, pp. 319-343.

Kaindl, H., Kramer, S., and Kacsich, R., A Case Study of Decomposing Functional Requirements, in *Proc. Third International Conference on Requirements Engineering (ICRE '98)*, Colorado Springs, Colorado, April 1998, pp. 156-163, IEEE.

Kaindl, H., Difficulties in the transition from OO analysis to design, *IEEE Software*, Sept./Oct. 1999, pp. 94–102.

Kaindl, H., A Design Process Based on a Model Combining Scenarios with Goals and Functions, *IEEE Transactions on Systems, Man, and Cybernetics (SMC)* Part A 30(5), 2000, pp. 537-551.

Kaindl, H., Is object-oriented requirements engineering of interest?, *Requirements Engineering*, Vol. 10, 2005, pp. 81–84.

Kaindl, H., A Scenario-Based Approach for Requirements Engineering: Experience in a Telecommunication Software Development Project, *Systems Engineering*, Vol. 8, 2005, pp. 197–210.

Doctoral Symposiums

Target Population and Behavior Change: Hypertextual Discourse Analysis of Prevention Information on HIV/AIDS Websites

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1. INTRODUCTION

HIV/AIDS has been around for more than 20 years, during which the lives of over 20 million people have been claimed in the world. Since there are still no effective cures or vaccines available, prevention is the key to promote behavior change and put this epidemic under control. What is essential in prevention efforts is to inform people of information on HIV/AIDS, especially risk behaviors (Goldstein, Usdin, Scheepers & Japhet, 2005; Kalichman & Belcher, 1997). What information is communicated is important since it should be varied according to the stages of behavior change the target populations are in. However, there is a controversy in health communication about whether health information should be targeted to underserved populations or the larger population. The above two issues of information content and target populations are not restricted to interpersonal and traditional mass media communication. It also extends to the Internet due to the ever increasing popularity of e-health among not only healthcare providers but also consumers, especially those who seek for HIV/AIDS prevention information.

The purpose of this study is to examine the target population and stages of behavior change being addressed in prevention information on HIV/AIDS websites by means of hypertextual discourse analysis. Organizational properties and interests of the website sponsors/designers as well as health policies in public health regarding HIV/AIDS will also be examined to find out their influences on the prevention information provided. The current study is formative in the sense that it is the basis for future empirical studies with the users and the sponsors/ designers of those HIV/AIDS websites. The ultimate research goal is to provide insights or concrete suggestions to the sponsors/designers of HIV/AIDS websites as well as policy makers in public health on how to improve the prevention information and public policies in a way that could do more good to the users and to the public health.

2. RESEARCH QUESTIONS

- What populations are targeted in HIV/AIDS prevention information on the selected websites?
- What stages of behavior change does the prevention information address?
- What impacts do website sponsors/designers' interests and health policies in public health have on the findings of the first two questions?

3. LITERATURE REVIEW

3.1 Health Belief Model and Stages of Change Model

The ultimate purpose and function of health communication is to promote behavior change by means of conveying relevant information to the target populations. In order to design the most effective information, there are two aspects needed to be considered. One is what factors or variables can influence behavior change in general. The other is how to tailor messages to different populations in specific. Health Belief Model (HBM) and Stages of Change Model (SOC) are theories dealing with those two aspects respectively.

HBM identifies five factors that could influence preventive health behaviors. They are: perceived barriers to performing the recommended response; perceived benefits of performing the recommended response; perceived susceptibility to a health threat; perceived severity of a health threat; and cues to action. When people try to make decisions whether to take suggested actions with regards to health, they evaluate the severity of the threat and their risks, and weigh potential benefits against barriers/costs. Cues of action act as prompts which could increase the perceived degrees of threats and risks thus encourage people to think and act (Rosenstock, 1974; Witte, 2001).

The factors identified in HBM are not necessarily addressed all together and with the same level of emphasis in the health messages. It is important to tailor the messages according to individual differences, one of which is the stages of change individuals are in. According to SOC, there are five stages: precontemplation, contemplation, preparation, action and maintenance (DeJong, Wolf & Austin, 2001), ranging from complete unawareness of a health problem at one end to relapse into old behaviors after performance of new behaviors for some time at the other (Maibach & Cotton, 1995; Witte, 2001). People in different stages have different behavioral characteristics, therefore need different information to help them move from one stages to the next (Prochaska et al., 1994; Weinstein, 1988). For example, to move them from precontemplation to contemplation stage, what needs to be focused on is information on the health threat, including susceptibility and severity, and the recommended response, so as to increase their awareness (DeJong, Wolf & Austin, 2001; Witte, 2001).

3.2 Target Populations: Universal vs. Selected Intervention

There is a debate going on concerning whether the target populations should be groups of at-risk people differentiated by their identities, or the general public without drawing any line of identity. By borrowing the two terms in *World report on violence and health*, this controversy can be called a dilemma between "universal intervention" and "selected intervention" (Krug et al, 2002).

On one hand, if only the underserved populations or populations at risk are targeted in health communication, they can easily perceive the relevance and give the information more thoughts. However, such communication efforts only deal with inequalities in healthcare without addressing the more fundamental structural factors which are the roots of those inequalities. On the other hand, if the large segments of the population is the target, even small changes in behaviors could possibly result in big transformations in the overall health conditions of the general public. It is also more cost-effective if limited resources could be invested to reach the maximum amount of people. However, individuals or small groups' special needs are ignored (Guttman, 1997).

If this debate is positioned in the HIV/AIDS scenario, there are more social and ethical implications. There has always been a stigmatized label attached to it (Herek & Glunt, 1989). Whatever the label is, it is generally perceived as a disease of "the other", who get infected due to behaviors outside of the mainstream beliefs

held by normative citizens and spread the deadly disease to the innocent, thus pose a significant threat to the general public (Watney, 1987).

Therefore, if those at-risk populations are targeted in HIV/AIDS prevention communication by making their identities salient, the "enacted sigma" by the public would be mentally experienced by them as the "felt stigma" (Green, 1995). They may feel offended and then are resistant to such communication efforts. What's more, the existing negative attitudes among the public towards them would be even worse, which in turn continues to do damage to their self-esteem and self-efficacy (Green, 1995), two important factors in initiating behavior change. Another fault with this strategy is that such communication sends the wrong message to those non-target populations that they are immune to HIV/AIDS since their identities are not included in the prevention information. As a result, they may not even bother to read or listen to the information. Before long, HIV/AIDS crossed the line of sex orientation, race and gender, spreading to virtually every population and putting almost everybody at risk (Kinsella, 1989). In short, the goal of HIV/AIDS prevention communication could never be achieved if both the target and non-target populations ignore whatever information that is conveyed.

Since HIV/AIDS prevention should practically be everybody's concern, would it be better to target HIV/AIDS prevention information to the larger population without drawing any stigmatized line? However, if "everyone" is stated to be at risk in prevention information, everybody would tend to think the information is targeted to others instead of him/herself. What is more, those who are really at risk will neither be aware of their particular risk nor have the motivation to change behaviors (DeJong, Wolf & Austin, 2001). In fact, there are truly populations who are at much greater risk. Statistics show that HIV/AIDS infections are in fact not evenly distributed among different populations in the U.S. with minority people and women being disproportionally infected (CDC, 2003; 2005; US Census Bureau). Other at-risk groups are characterized not just by identities but also by behaviors, such as IDUs (Injecting Drug Users), sex workers, and homosexuals

Although health communication by means of traditional media is not unimportant, the focus of this study is online communication. Considering that more and more people are relying on the Internet for health information, especially those interested in such stigmatized diseases as HIV/AIDS, it is worthwhile to extend the exploration of this issue to the cyberspace.

3.3 eHealth

eHealth is an area where information and communication technologies (ICTs) are applied in medicine and public health, by either healthcare providers to improve their service, or by healthcare consumers to better their health conditions (Eng, 2002). On the healthcare consumers' side, the Internet is perhaps the most popular tool among all the ICTs.

According to Internet World Stats (2004), 68.6% of the U.S. population--more than 201 million individuals, has access to the Internet now. The percentage of adult Internet users in the U.S. who went to the Internet for healthcare information was 80%, a total of 93 million (Fox & Fallows, 2003). The unique features of the Internet, especially the privacy, anonymity and confidentiality it can provide, are particularly attracted to users who are in need of HIV/AIDS information, who want to be empowered, but don't want to be judged and scrutinized (Cotton & Gupta, 2004). In fact, HIV/AIDS patients are among the healthcare consumers with chronic medical conditions who increasingly take the Internet as a major source of information (Kalichman, Weinhardt, Benotsch & Cherry, 2002).

3.4 Political Economy of Media

What populations are targeted and what information is provided to them in HIV/AIDS prevention communication on media are not determined in vacuum. Decisions are always made in certain social context. According to the theory of political economy of media, media are under the control of the economic and political interests of those powerful, upon whom the operations of media have to depend (Jakubowicz & Goodall, 1994). Therefore, the information provided on media reflects what the dominant groups want to say or write, not necessarily what needs to be heard or read (Teo, 2000).

The Internet as a new form of medium can not escape from the influences of the dominant groups who can easily extend their power to this new realm (Hall et al, 1978; Hall, 1982). In other words, the power dynamics in online information is, to some degree, reproducing that in the traditional media (Brock, 2005). For HIV/AIDS prevention information online, it is justifiable to believe that the reasons for its particular design could be explained at least partially by the dominant entities---namely the sponsors/designers and policy makers in public health.

4. METHOD

Only HIV/AIDS prevention information on websites will be examined since websites are considered to be more comprehensive, formal, organized and thus credible than other online formats. The websites collected will be categorized according their URL domain names, including .com, .edu, .gov, .net, and .org., which stand for different ownership of websites (Mohammed & Thombre, 2005). Cross-sectional and within-sectional comparisons can be made so as to better reveal the relationships between the nature of the sponsors/designers and the information content provided by them. *Google* advanced search will be used to collect the websites whose titles have either HIV or AIDS or both. The top 5 hits in each category of domain names will be selected since rankings can represent the level of popularity and credibility to a certain degree. Besides, the websites should be oriented towards not just one population and have a decent amount of prevention information. They will also be checked whether they are outdated and links are working, etc. The selection will be a purposeful process in terms of what and how many websites will be collected, in order to ensure that the cases "offer both typicality and variety" (Pollach, 2003, p280), and only data that can serve research goals and contribute to the solving of research questions be selected (Mushi, 2004). Sampling will be not used due to the impossibility of knowing the population size and having a complete list of all the relevant websites (Mohammed & Thombre, 2005). Other reliable search engines, such as *Yahoo!* and *MSN*, could also be used to double check the popularity and credibility of the selected websites since they have different ranking algorisms. Adjustment to the data set may be made if necessary.

There are two types of data on prevention information that are needed to be collected on selected websites: hypertext and organizational information of the website sponsors/designers. There are two reasons for using the hypertext as the approach to examine the research questions, instead of the information content linked to by the hypertext,. Firstly, hypertext is one of the defining characteristics (Rafaeli & Newhagen, 1996) of the web, while the information contents can be, and often times really are, just the online versions of those from non-electronic media. Secondly, hypertext can be the cue of the topics of the information contents, while structure of hypertext can be the cue of the importance of the contents attached by the sponsors/designers which reflects their interests. Hypertext will be structured in the form of table composed of nodes and links to depict an overview of the website. The homepages will be the starting point and nodes will be followed step by step from there from the higher level of links to the lower level. For organizational information of the website sponsors, usually they can be found on the homepage under such tabs as "about us". The information linked to by those tabs often includes histories, missions, goals, target audience, etc.

Discourse analysis will be used for both the hypertext and the organizational information based on the three functions of texts (Halliday & Hasan, 1976). The topics of prevention information represented by the texts of linked nodes will be analyzed and classified and which stages of behavior they address will be identified. The organizational information will be viewed beyond what is stated by the website sponsors/designers themselves. Rather, what is unspoken and what is assumed will be the focused on (Thompson, 2004). Self-reference and personal address will also be analyzed, i.e. which perspective is used---the more subjective first-person or the more neutral third-person; and which stakeholders are emphasized (Pollach, 2003). In order to relate the interests of website sponsors/designers to the way prevention information is designed, what will be examined are the existence of linked nodes on the homepage and the existence of separate menus for certain topics, since they can indicate what priorities website sponsors/designed assign to certain information and audiences (Killoran, 2005). In addition, how linked nodes are laid out on web pages is also an important index, thus will be subjects of analysis too.

After the analysis of each selected website, cross-sectional and within-sectional comparisons will be made to see their similarities and differences.

5. EXPECTED OUTCOMES

It is expected that the selected websites would be largely uniform in the content of their prevention information and in the populations they target. In other words, little difference could be found among the websites sponsored by different orga-

nizational entities, whether it is commercial, educational or governmental. There is a dominant voice in the discourses on the web concerning what prevention information should be provided and what populations should be targeted.

Jing Chong *is a PhD candidate in the College of Information Sciences and Technology, The Penn State University. Her research areas are health communication on websites and digital divide. The length of her research program is 4 years on a full-time basis. The current stage of her thesis research is in literature review and data collection. Her expected date of completion of the Ph.D program is August, 2008*

Virtual Project Risk vs. Traditional Project Risk in Software Projects

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INTRODUCTION

This research is designed to distinguish virtual and traditional project risks and specifically to identify the critical risks in virtual software projects. The resulting list of critical risks will provide guidance on managing risks for project leaders working in a virtual team environment. Three areas are important to the discussion of virtual software project risk: virtual software project teams, project failure and project risk.

Virtual software project teams are a growing phenomenon. They are called virtual because team members are not co-located. "Virtual teams are groups of geographically, organizationally and/or time dispersed workers brought together by information and telecommunication technologies to accomplish one or more organizational tasks (Powell *et al.*, 2004)". Many driving forces are causing increased dependence on these teams, including offshoring, outsourcing, reduced business travel due to security concerns, and improvements in collaborative tools. A task force study on globalization and offshoring indicated information technology (IT) has essentially become "a global field, business, and industry"(ACM, 2006). Therefore, there is a need to study how the unique aspects of virtual projects relate to their success.

The Standish Group over the years has measured the incidence of software project failure in corporations with their well known CHAOS reports. They conduct surveys with industry practitioners in the United States and Europe. The 2000 CHAOS report indicated 23% of projects failed while 49% were challenged (Standish Group International, 2001). The 2004 CHAOS report for the third quarter indicated 18% of projects failed and 53% of projects were challenged (Standish Group International, 2004). A one percent decrease in the number of troubled projects shows little improvement over a four year period. These numbers reinforce the need to investigate causes of project failure and identify the most critical project risks. This need is not just for projects in general, but particularly for the rapidly growing case of virtual projects.

Critical project risks are those factors that will have the greatest impact on the success or failure of a project. Boehm indicates critical risks should be the main focus of a project manager, instead of the entire pool of identified risks (Boehm, 1991). Some risk management advocates are proponents of identifying and analyzing "threats to success", which allows appropriate actions to be taken to "reduce the chance of failure" (Wallace et al., 2004).

RESEARCH PROBLEM

The research problem is:

What are the significant differences between risks in virtual and traditional software development projects? Which of these risks are critical to successful project completion of virtual software projects?

Prior research on project risk has been performed predominately on different types of traditional software projects. A review of prior research, a series of interviews and focus groups, and my own experiences as a professional project manager, have led me to the following hypotheses:

- Some risk factors in virtual and traditional software projects are similar
- Critical risk factors in virtual software projects are different from critical risk factors in traditional software projects.
- Resource issues are critical to virtual software projects.
  Reasoning: Resource issues have an impact on project success (Beise, 2004; Fairley, 1994; PMI, 2004) and are likely to be intensified when resources are not co-located
- Communication issues are critical on virtual software projects
  Reasoning: Virtual projects are often dependent on other, less common, forms of communication because traditional face-to-face communication is usually not an option. (Igbaria *et al.*, 1999)
- Virtual team dynamics are different from traditional team dynamics
  Reasoning: Virtual teams are more likely to be diversified since team members are not co-located and they may never meet face-to-face (Ewusi-Mensah, 2003; Powell et al., 2004)

OBJECTIVES

The main objective of this study is to identify a set of comprehensive yet concise *critical* risk factors for virtual software projects, by conducting a survey of industry practitioners. The list is essential to developing effective risk management for virtual software projects. Risk management, "a collection of methods aimed at minimizing or reducing the effects of project failure" (Addison & Vallabh, 2002), can then be used by organizations to increase the likelihood of project success. Thus, the importance of this study lies in its ability to enable virtual software project managers to avoid major risks and achieve greater rates of project success. The 2004 CHAOS report indicated companies in the United States and Europe spent $255 billion on software projects while the cost of failed projects was $55 billion (SoftwareMag.com, 2004).

LITERATURE REVIEW

Several researchers have identified the important risks in traditional software projects. Boehm, conducted a survey of experienced IT project managers who worked with him at TRW in the early 1990's. The result was his "Top ten software risk items" which is contained in the first column in Table 1(Boehm, 1991). One of the limitations of this study was the sample which consisted of a small number of project managers from the same company.

Barki, Rivard et al. sent their 144 item questionnaire to the largest 100 companies across a variety of industries in Quebec and surveyed 120 software development projects. The result was a list of software project risks grouped in five categories of risk factors/risk dimensions: technological newness, application size, lack of expertise, application complexity and organizational environment. The purpose

of the survey was to improve management of software development projects by measuring their risk (Barki *et al.*, 1993). Barki's results are shown in the second column of Table 1.

Wallace, in her dissertation, conducted interviews with software project managers to identify risks and mass distribution of a survey to the Project Management Institute Information Systems Special Interest Group (ISSIG). The result was six risk categories or dimensions: team, organizational environment, requirements, planning and control, user, and project complexity. The purpose of her study was to improve risk management by determining the specific types of risks encountered on different types of software projects. One of the limitations of this study was the sample consisting of members from one group which were very likely to have knowledge of standard risk management practices (Wallace, 1999). Wallace's results are shown in the third column of Table 1. Thus, the three seminal studies conducted to date on the subject of project risk factors have yielded overlapping and not entirely consistent results, as shown in Table 1.

METHODOLOGY

First, a literature review of seminal work was conducted to create an initial list of project risk factors. A survey instrument was created and approved by the university Internal Review Board (IRB), then tested in face-to-face interviews with project managers, to add risks factors from a practitioner's point of view to the list. This was followed by an electronic focus group session to validate and enrich the existing risk factor list. A large volume of rich data was collected then sorted and categorized several times. This data will be compared to the seminal

Table 1

Boehm, Barry (Boehm, 1991) *Risk Factors*	Barki, Henri(Barki et al., 1993) *Uncertainty Factors*	Wallace, Linda and Keil, Mark(Wallace & Keil, 2004) *Risk Dimensions*
Personnel Shortfalls • Personnel availability • Mix of software disciplines represented • Team' expertise • Management's approach	**Lack of Expertise** • Lack of team general expertise • Lack of development expertise in team • Team's lack of expertise with task • Team's lack of expertise with appl • Lack of user experience & support	**Team** • Team member turnover • Staffing buildup • Insufficient knowledge among team members • Cooperation • Motivation • Team communication issues
	Organizational Environment • Extent of changes • Intensity of conflicts • Lack of clarity of role definitions • Resource insufficiency • Task complexity	**Organizational Environment** • Organizational politics • Stability of organizational environment • Organizational support for a project
Developing the wrong functions & properties • Size & complexity of requirements • Level of hardware imposed constraints • Number of system interdependencies • New technology or application • Requirements stability **Gold-plating** • Lack of quality in requirements & product **Continuing stream of requirements changes** • Changing requirements		**Requirements** • Uncertainty surrounding system requirements • Changing requirements • Incorrect, unclear, inadequate, ambiguous or unusable requirements
Unrealistic schedules & budgets • Unrealistic schedules • Unrealistic budgets		**Planning & Control** • Unrealistic schedules • Unrealistic budges • Lack of visible milestones to assess production of intended deliverables • Inaccurate estimates leading to inaccurate resource forecast
Developing the wrong user interface • Poor quality user interface		**User** • Lack of user involvement in development • Unfavorable user attitude toward project
Straining computer-science capabilities • Complex technology	**Technological Newness** • Need for new software • Number of software suppliers • Need for new hardware • Number of hardware suppliers • Number of users outside organization **Application Complexity** • Number of links to future systems • Number of links to existing systems • Technical complexity	**Complexity** • New technology • Complex processes being automated • Large number of links to existing systems • Large number of links to external entities
	Application size • Team diversity • Number of people on team • Number of users in organization • Relative project size • Number of hierarchical levels occupied by users	
Shortfalls in externally performed tasks • Poor quality work from external resources **Real-time performance shortfalls** • Lack of performance quality **Shortfalls in externally furnished components** • Lack of quality in external components		

literature to create a comprehensive yet concise list of risk factors for ranking in the questionnaire: A purchased mailing list of 5,000 names from a project management magazine will provide for mass distribution of the questionnaire to IT project leaders, managers and analysts.

OUTCOMES AND EXPECTED SIGNIFICANCE

The occurrence of virtual software projects will continue to increase as society becomes more global. Virtual software projects will not escape risk; therefore, project failures will occur. Researching and identifying those risk factors most critical to virtual software projects can improve risk management in this new arena. This research seeks to create a validated list of critical risks for virtual software projects that can be used by project leaders to reduce or eliminate risks.

REFERENCES

ACM, A. J. M. T. F. (2006). *Globalization and offshoring of software, executive summary and findings* (No. ACM 0001-0782/06/0200): Association for Computing Machinery (ACM).

Addison, T., & Vallabh, S. (2002). *Controlling software project risks - an empirical study of methods used by project managers.* Paper presented at the Proceedings of SAICSIT 2002.

Barki, H., Rivard, S., & Talbot, J. (1993). Towards an assessment of software development risk. *Journal of Management Information Systems, 10*(2), 203-225.

Beise, C. M. (2004, April 22-24, 2004). *It project management and virtual teams.* Paper presented at the ACM SIGMIS 2004, Tucson, AZ.

Boehm, B. W. (1991). Software risk management: Principles and practices. *IEEE Software*(January 1991), 32-41.

Ewusi-Mensah, K. (2003). *Software development failures: Anatomy of abandoned projects*. Cambridge: The MIT Press.

Fairley, R. (1994). Risk management for software projects. *IEEE Software, 11*, 57-67.

Igbaria, M., Shayo, C., & Olfman, L. (1999). *On becoming virtual: The driving forces and arrangements.* Paper presented at the SIGCPR 1999, New Orleans, LA.

PMI, P. M. I. (2004). *A guide to the project management body of knowledge (pmbok guide)* (Third ed.). Newtown Square, PA: Project Management Institute.

Powell, A., Piccoli, G., & Ives, B. (2004). Virtual teams: A review of current literature and directions for future research. *The DATA BASE for Advances in Information Systems, 35*(1), 6-33.

SoftwareMag.com. (2004). Standish: Project success rates improved over 10 years. *Software Mag.com* Retrieved 10/3/06, 2006, from http://www.softwaremag.com/L.cfm?Doc=newsletter/2004-01-15/Standish

Standish Group International, I. (2001). *Extreme chaos*.

Standish Group International, I. (2004). *Chaos demographics - 2004 third quarter research report*.

Wallace, L. (1999). *The development of an instrument to measure software project risk.* Georgia State University College of Business Administration, Atlanta, GA.

Wallace, L., & Keil, M. (2004). Software project risks and their effect on outcomes. *Communications of the ACM, 47*(4), 68-73.

Wallace, L., Keil, M., & Rai, A. (2004). Understanding software project risk: A cluster analysis. *Information & Management, 42*(1), 115-125.

How are the Impacts of End-User Application Development Managed? A Case Study of End-Users and Their Managers

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PROBLEM STATEMENT

End User Computing (EUC) has now become prolific throughout business due to the decreased cost of the available PCs and the introduction of "easy-to-use" software application generators. The most often used definition of EUC is one which incorporates the facts that end user computing involves the interaction of managers, professionals and operational level users with application software within their own working departments (Torkzadeh & Doll, 1993).

The research undertaken over the past 25 years has been particularly in the areas of end-user satisfaction with information systems, end-user computing in general, end user application development, and the identification of who end-users are and the organisational areas which are affected by end-users (Rockart & Flannery, 1983; Brancheau & Brown, 1993; Powell & Moore, 2002) together with issues that impact on end-user development but little regarding how this can be addressed in the current technological environment.

Over this period there has been a significant change in the available technology (hardware and software), the introduction of technology into pre-tertiary education and a change in the information technology culture within organisations (Rockart & Flannery, 1983; Brancheau & Brown, 1993; McBride & Wood-Harper, 2002). The review of literature has shown that there is a need for continued research into these areas.

The research question to be investigated is: *How are the impacts of end-user application development managed?* The research to be undertaken will explore the changes in technology, use of technology and its impact on organisations. The specific questions that will be addressed are:

1. What are the impacts of end user application development on:
   - the end users;
   - the managers?
2. How are these impacts managed by
   - the end users;
   - the managers?

LITERATURE SUPPORTING THE RESEARCH

In the 1970s computing was identified with mainframe computers however the introduction of PCs in the early 1980s lead to EUC being reported as '…a rapidly growing and irreversible phenomenon' (Alavi & Weiss, 1985, p6). Rockart and Flannery (1983, p777-778) identified six classifications of end-users dependent upon their function within the organisation. These classifications were:

- Non-programming end-user
- Command level end-user
- End-user programmers

- Functional support personnel
- End-user computing support personnel
- Data processing programmers.

These classifications expanded upon those defined by the Codasyl report (1979, cited in Cotterman & Kumar, 1989) by being more prescriptive with their definition of how the end-users interacted with the technology. Early researchers (eg Rockart & Flannery, 1983) reported on a producer/consumer dichotomy when it came to describing end-users whilst other researchers (Wetherbe & Leithseier, 1985 as cited in Cotterman & Kumar, 1989) reported on the comparison between the end-user operator and the end-user developer.

Leithseier and Wetherbe (1986) amended their research to include a third component, that of the amount of control that the manager or user has over the computer resources. Cotterman and Kumar (1989) developed taxonomy of end-users based upon this research. It was already apparent at this early stage in the research into end-user computing that some end-users (ie non-IS trained users) were undertaking some application development. It was identified in their paper that it is imperative to understand who the users to ensure that each class of user is treated appropriately and that the relevant training, education and management approaches are used to assist them in their daily tasks.

In the early 1990s, Brancheau and Brown (1993, p439) defined end-user computing as the 'adoption and use of information technology by personnel outside the information systems department to develop software applications in support of organisational tasks.' Their paper concentrated on the research into the management issues related to end-user computing and uses the Rockart and Flannery (1983) classification of users as a basis for the research.

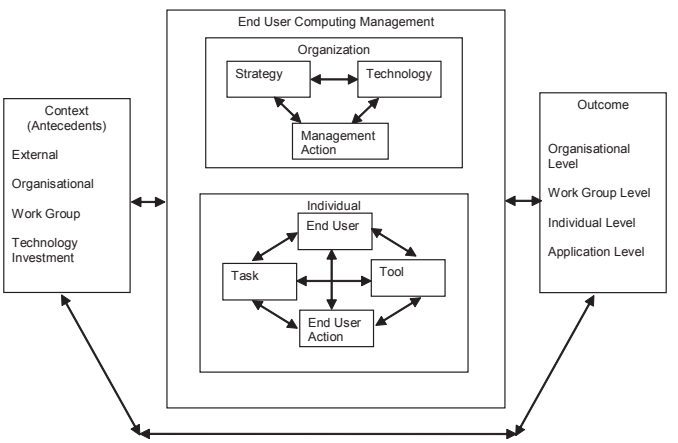
Brancheau and Brown (1993) summarised papers published on the issues related to management of end-user computing and mapped then into the model shown in Figure 1. Their findings outlined two possible areas that required future research: EUC as a component of organisational computing; and EUC as a social learning phenomenon. They identified that 'failure to build on prior EUC research and failure to rely on theoretical knowledge accumulated in key reference disciplines have been major obstacles to furthering our understanding of EUC management' (Brancheau & Brown, 1993, p 477).

Chan and Storey (1996, p119) identified that EUC is an 'important part of organizational computing today' and stated that 'end-user computing was the autonomous use of information technology by knowledge workers outside the IS department'.

During the mid to late 1990s as much of the literature published dealt with similar issues that had previously been reported. Research into this area is, however, very much back on the agenda with many reviews of past research appearing in the last couple of years (eg Powell & Moore, 2002;

Govindarajulu, 2003) and the introduction of research into end-user use and development of applications using new technologies becoming apparent.

Figure 1. Model of the management of end-user computing (Brancheau & Brown, 1993, p441)



Anecdotally, the increased availability of PCs within organisations together with the increased level of computer literacy being taught during the primary and secondary education programs leads the candidate to believe that there are more 'end-users' in employment. The personal productivity tools (like Microsoft Office, Lotus Office, etc) are being marketed as being more user friendly leading end-users to become creative within their everyday working requirements. The, so-called, wizards are giving end-users more confidence with the software without having to understand the programming language on which the spreadsheet, database, web page or presentation is based.

Other key authors in this field have looked into managerial techniques (Gerrity & Rockart, 1986), EUC success (Doll & Torkzadeh, 1989), structured design approaches to reducing errors (Janvrin & Morrison, 2000), user control of EUC (McBride & Wood-Harper, 2002), and EUC quality issues (McGill, 2002).

Gerrity and Rockart (1986, p25) identified that the 'dramatic increase in end-user computing…offers major opportunities for businesses'. They also outlined that, although this 'phenomenon' was bringing some major advantages for the organisation, senior management need to avoid a technology-based management approach and adopt of business-driven management strategy which they describe as a 'Managed-Free Economy' approach.

The literature investigated by Brancheau and Brown (1993) and continued by Powell and Moore (2002) identified numerous areas where there are gaps in the current knowledge base of end-user computing. The research of Powell and Moore (2002, p15) provided a valuable view into these areas given the 'more recent organizational and technological developments (such as advancements in communications technology, outsourcing of EUC support functions, and the globalisation of companies)'. The areas from the Brancheau and Brown model that have been identified as future research areas are:

- cultural antecedents;
- organisational strategy;
- effective and ineffective organisational management strategies,
- organisational technology issues relating to new technologies and the interconnectedness of applications;
- end-user environment relating to skills, tools used and tasks; and
- the outcome based relationship between end-user computing and organisational performance.

RESEARCH QUESTIONS

It is obviously above the scope of this thesis to investigate all of the above areas however the researcher will introduce new knowledge into the field of end-user computing by answering the questions identified earlier:

What are the impacts of end user application development on the end users and their managers?

The information obtained in response to this question will give insight into the outcomes of end-user computing relating to the relationship between end-user computing and organisational performance. It is important to understand this relationship as management strategies employed by an organisation have been influenced by the introduction of end-user computing and end-user application development (Gerrity & Rockart, 1986). By understanding the impacts of EUAD, organizations can be better equipped to control the issues and develop policies to work more efficiently and effectively within this end-user environment.

How are the impacts managed by the end users and their managers?

By investigating the issue of "what managers are doing" the knowledge area of organisational strategy and technology issues can be enhanced and updated as Powell and Moore (2002, p15) identified '…research needs to continue to examine how these factors relate to the practice and management of EUC in today's environment'. The responses and information gathered here will help to determine the management approaches being undertaken and the success or failure of adopting such an approach. The personal experience of the researcher suggests that managers are utilising a Laissez-Faire approach to the management of the end-user developers and as such applications are being developed which are poor quality,

take significant time from the end-user's daily tasks and occasionally duplicate software applications already in use elsewhere in the organisation.

As part of the research some underlying issues will be identified. The main concentration will be on determining who the end users are in the organisation, what they do as part of the daily roles and what training, if any, they have been subjected to in order to enhance their end-user computing and end-user development skills.

It is important to note that all of this can be investigated but, as identified clearly by Cotterman and Kumar (1989), it is an essential part of any study into EUC that the users be clearly defined. To this end a thorough investigation of the Cotterman and Kumar model in terms of today's technology and user skill must be undertaken.

Many researchers have briefly looked at the strategies required to improve the end-user development of applications but to this point no researcher has investigated the implementation of these strategies and their impact on the individual and the organisation. The answer to this question will not only identify who the end-user developers are in the case organisations but also the tasks they are undertaking and the applications they are developing. By identifying issues such as cultural background and end-user environment it is expected that the researcher will develop an identification model to assist in the early detection of end-user developers giving direct line managers the capacity to implement management strategies more effectively.

TYPE OF STUDY

This study will be undertaken using an exploratory approach to investigate the questions posed by utilising a case study format. Qualitative research techniques of interview and focus group will be utilised in conjunction with an initial questionnaire to determine demographic and end-user classification information. The results of the qualitative and quantitative methods used will be analysed through an interpretive viewpoint. Interpretivism is 'concerned with approaches to the understanding of reality and asserting that all such knowledge is necessarily a social construction and thus subjective' (Walsham, 1993, p5). The interpretive approach can potentially 'produce deep insights into information systems phenomena' as it assists researchers in understanding 'human thought and action in social and organizational contexts' (Klein & Myers, 1999, p67).

Walsham (1993, p4-5) stated that interpretive methods of research are 'aimed at producing an understanding of the *context* of the information system, and the *process* whereby the information system influences and is influenced by its context'. The major criteria for being a case organisation in this study are that end-user application development happens to some extent within the organisation by at least two employees and that these employees report to a direct line manager. To analyse the impact of this development the most obvious approach will be to investigate the *process* of the application development within the *context* of both the organisation and the end-user developer.

Brancheau and Brown (1993, p472) identified case studies would play an important part in the future research into EUC stating 'they are uniquely suited to open-ended, detailed investigation of EUC phenomena'. The case study approach has been identified as being one of the most appropriate methods for conducting Information Systems empirical research in the tradition of interpretation and generally involves the use of more than one case study in order to allow for comparison (Walsham, 1993). This approach will allow the researcher to investigate the impacts of end-user developed applications on the organisation by interviewing the users and their direct managers and thus developing a case based view of different organisations.

REFERENCES

Alavi, M. & Weiss, I.R. (1985). Managing the Risks Associated with End-User Computing, *Journal of Management Information Systems, 2*(3), 5-20

Brancheau, J.C., & Brown, C.V. (1993). The Management of End User Computing: Status and Directions, *ACM Computing Surveys, 26*(4), 437-482

Chan, Y.E. & Storey, V.C. (1996). The use of spreadsheets in organizations: Determinants and consequences, *Information & Management, 31*(3), 119-134

Cotterman, W.W. & Kumar, K. (1989). User Cube: A Taxonomy of End-users, *Communications of the ACM, 32*(11), 1313-1320

Doll, W.J. & Torkzadeh, G. (1989). A discrepancy model of end-user computing involvement, *Management Science*, *35*(1), 1151-1171

Govindarajulu, C. (2003). End Users: Who Are They?, *Communications of the ACM*, *46*(9), 152-159

Klein, H.K. & Myers, M.D. (1999). A Set of Principles for Conducting and Evaluating Interpretive Field Studies in Information Systems, *MIS Quarterly*, *23*(1), 67-94

Leithseier, R.L. & Wetherbe, J.C. (1986). Service Support Levels: An Organized Approach to End User Computing, *MIS Quarterly, 10*(4), 337-349

McBride, N. & Wood-Harper, A.T. (2002). Towards User-Oriented Control of End-User Computing in Large Organizations, *Journal of End User Computing*, *14*(1), 33-42

McGill, T. (2002). User Developed Applications: Can End Users Assess Quality?, *Journal of End User Computing*, *14*(3), 1-15.

Powell, A. & Moore, J.E. (2002). The focus of research in end user computing: where have we come since the 1980s?, *Journal of End User Computing, 14*(1), 5-22

Rockart, J.F. & Flannery, L.S. (1983). The Management of End User Computing, *Communications of the ACM, 26*(10), 776-784

Walsham, G. (1993). *Interpreting information Systems in Organisations*, John Wiley & Sons, Chichester

"...Some People Achieve Greatness...": A Study Correlating Early Vocational Behaviour with Ultimate Vocational Achievement

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EXECUTIVE SUMMARY

Discovering the right people for the job, any job, is a complex, frustrating and often fruitless activity. In recruiting graduates, employers are not simply looking for someone to do a job, they are more likely seeking to take on candidates who have the potential to rise to the highest ranks within organisations. They are seeking those candidates who, a decade hence, will be seen as high-achievers, but identifying such potential in fresh graduates has proven to be elusive. While the decision support role of Information Systems should be considerable

within this domain, in fact an IS framework founded on actual vocational data is entirely lacking.

The crux of this research is to generate and analyse that data in order to determine whether known high-achieving employees exhibited signature behaviour when they were raw recruits almost a decade earlier. It is proposed that the results from this research be used as enabling knowledge for the development of sophisticated assessment simulation Information Systems, whereby signature behaviour may be potentially stimulated and evaluated. In particular the research seeks to establish:

1. Can future vocational outcomes be accurately predicted by initial vocational behaviour?
2. How does initial vocational behaviour relate to an individual's ultimate potential?
3. How may an understanding of vocational behaviour be integrated into a design framework for predictive assessment Information Systems?

If successful, the outcomes of this PhD project could provide a model upon which future candidate assessment information systems are predicated.

BACKGROUND

In his 1979 book (Wolfe, 1979) describing America's National Aeronautical and Space Administration's (NASA's) recruitment process to find the early astronauts, the author is reduced to describing successful applicants as having the "right stuff". Wolfe makes it clear that a mixture of abilities, background and "correctness" were prescribed as selection criteria, even though this filter eliminated arguably the finest test pilot of the day, Chuck Yeager. In the absence of more definitive data, this vague and overarching evaluation adjective "right-stuff" is still used today to retrospectively describe individuals who rise to become high-potential industry achievers.

In an attempt to specify their ideal graduate profiles to either recruitment agencies or internal human resource departments, corporate directors and managers often bemoan the time, complexity, obtuseness, cost and effective failure of the entire recruitment process. When pressed, they say "I know this is important for us, that's why I put the time in. But I really just want them to find me another two grads like him." As they say this they will often point through frosted glass to a bright-eyed staff member whom they employed the previous year and who has proven to be everything they expected of a new graduate, in fact a "golden employee".

Is it possible to predict such high-potential employees at a very early stage? Would such candidates exhibit particular key behaviour if placed in a work-based scenario, such that an accurate prediction of their vocational potential could be made? In part, the research goal of this project aims to answer the question, does such signature behaviour exist?

METHODOLOGY

A quantitative approach was determined to be most appropriate for this research, data mining and statistical techniques were utilised to generate and assess correlations between variables in the data. The instrument designed to generate and gather the data is briefly outlined here.

Earlier valuable research in this area has been based upon retrospective survey data using content and factor analysis e.g. (Lombardo & Eichinger, 2000) in an effort to verify a "hunch" that a particular factor was key signature behaviour (in the case of Lomabrdo & Eichenger the postulated key behaviour was post-appointment learning ability.).

For reasons of real-world validation and because this research will bootstrap and is key to proposed further work on simulator development, the author of this research sought to determine if actual vocational data could be accessed and if so, what would be its optimum form and how could the data be obtained. Several assumptions guided the course of actions culminating in the data gathering instrument.

Assumption 1: Signature behaviour may be observed over a relatively short period of time due to an individual's particular reaction to a particular set of vocational circumstances. This assumption led to the conclusion that, if an average "golden employee" takes 6 to 10 years to establish ultimate vocational success within a large New Zealand company (this condition based on anecdotal evidence), then vocational behaviour data collected over a 3 – 4 month period should prove sufficient to generate evidence of signature behaviour.

Assumption 2: That signature behaviour is more likely to be observed within data of relatively fine granularity. It is simply more plausible that the greater the number of recorded time periods in a single working day the more accurate will be the picture of individual behaviours rather than a set of behaviours all classified together under a daily collective code.

Assumption 3: That an employer of substance would be required for this research project, one which annually employed a significant number of graduates and which could be easily and logically subdivided into hierarchically organised departments.

Assumption 4: That the data collected would be of a highly sensitive nature both internally and commercially and that simply approaching a company and asking to see their employees timesheets records for the past 3 months would not be a reasonable course of action. This assumption led to the formulation of an 8 year association with one of the leading accounting practices in New Zealand and the design and development of a nationwide practice management system.

Assumption 5: That in order for the data to be valid it would need to be verified as correct, internal to the employers organisation. This assumption led to a major increase in scope of the practice management system and to the decision that customer billing data would be generated from the employee behaviour data.

Assumption 6: That, despite the passage of 8 years, the employer would remain willing and able to provide data on the vocational progress of the employees involved in the study. Happily, this assumption proved correct despite a significant change in personnel. This final batch of data was collected in 2006.

STAGE OF THE RESEARCH

The author is two years into a part-time PhD research program. To date it has been a voyage of discovery in an attempt to narrow the conceptual scope and discover the true focus of the project. Initially, a deconstructionist model was adopted, which asked why a particular human being behaved in a particular way. It was felt that if the behaviour of hi-potential candidates/employees could be accurately analysed in this way the knowledge learnt could be applied to compare prospective employees. There is a great deal of literature which adopts this deconstructionist approach to analyse an individual's behaviour particularly in terms of facets of personality. Conceptually, the research model for this project is shown in figure 1, with each contributing body of knowledge appearing as a node, providing input to the central trunk.

As the work has progressed, so the nodes have increased in number until, during a recent re-evaluation a further significant factor was identified as being absent from the study and "fitted" to the original model. This produced the concept model shown in figure 2, which bought into question the validity of the original concept.

Figure 1

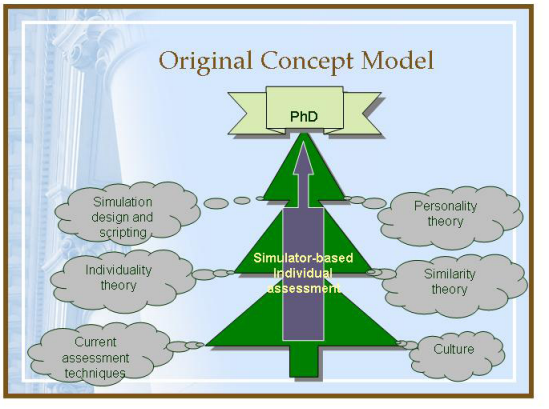


Figure 2

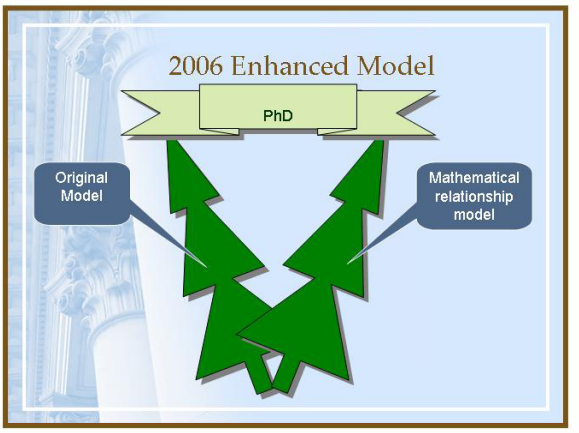
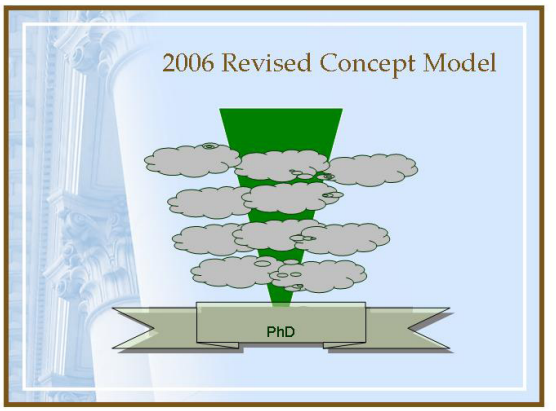


Figure 3



It was felt that this model lacked elegance, clarity and a discernable timetable for completion, indeed feedback from academic advisors declared this concept to contain not one but ten PhDs. A rethink was in order and by re-examining the contributing nodes and loosely applying input/output relationships to them a new concept model was developed, as shown in figure 3.

This model placed the PhD study not at the top but at the bottom, examining the node representing the enabling body of knowledge upon which all other aspects of the initial project were predicated. The research problem at the heart of this project and covered by this bottom-line node of knowledge considers whether, in a group of employees, vocational behaviour at the start of their careers can be correlated with their vocational achievement over a prolonged period of time.

The bibliography generated is included below for reference; the data has been gathered and is awaiting analysis via data-mining and statistical techniques. The current timeline sets completion of the PhD study to June/July 2008.

REFERENCES

*Bibliography generated by literature review so far:

Agarwal, R., & Ferratt, T. W. (1999). *Coping with labour scarcity in information technology*. Cincinnati, Ohio: Pinaflex Educational Resources.

Aha, D. W. (1992). Tolerating noisy, irrelevant and novel attributes in instance-based learning algorithms. *International journal of man-machine studies, 36*, 267-287.

Ambition_recruitment. (2005). *Market trends and salaries report*. Retrieved 21/112005, 2005, from http://www.ambition.com.au/PageSys/DocView.aspx?DocumentID=206

Autherson, R. (2003, Febrary 28). Banking on change. *Career times*.

Baillie, L. (2003). *IT employers' skills demands: Do they know what they want?*

Bassok, M., & Medin, D. L. (1997). Birds of a feather flock together: Similarity judgements with semantically rich stimuli. *Journal of memory and language, 36*, 311-336.

Berno, T., & Ward, C. (2003). *Cross-cultural and educational adaptation of asian students in new zealand*. Retrieved 30/11/04, 2004, from http://www.asia2000.org.nz/about/programmes/research/various/Ward%20and%20Berno%20report.pdf

Bernstein, L. E., Demorest, M. E., & Eberhardt, S. P. (1994). A computational approach to analysing sentential speech perception: phoeneme-to-phoneme stimulus/response alignment. *Journal of the acoustical society of America, 95*, 3617-3622.

Borg, I., & Groenen, P. (1997). *Modern multidimensional scaling. Theory and applications*. New York: Springer.

Buros-Centre-For-Testing. (2006). *Mental Measurements Yearbook*. Retrieved 13/02/06, 2006, from http://www.unl.edu/buros/

Bush, R. R., & Mosteller, F. (1951). A model for stimula generalisation and discrimination. *Psycholgical review, 58*, 413-423.

Carr, N. (2004). *Does IT matter*: Harvard business school press.

Carroll, J. D., & Wish, M. (1974). Models and methods for three-way multi-dimesional scaling. In D. H. Krantz, R. C. Atkinson & R. D. Luce (Eds.), *Contemporary developments in mathematical psychology* (Vol. 2, pp. 57-105). San Francisco: Freeman.

Caspi, A. (2000). The child is father of the man:Personality correlates from childhood to adulthood. *Journal of Personality and Social Psychology, 78*, 158-172.

Corter, J. E. (1987). Similarity, confusability and the density hypothesis. *Journal of experimental psychology:general, 116*, 238-249.

Corter, J. E. (1988). Testing the density hypothesis: Reply to Krumhansl. *Journal of experimental psychology:general, 117*, 105-106.

Cox, T. F., & Cox, M. A. A. (1994). *Multidimensional scaling*. London: Chapman & Hal.

Crooks, T. (2004). *Tensions between assessment for learning and assessment for qualifications*. Paper presented at the 3rd Conference of Commonwealth Examinations and Accreditation Bodies (ACEAB), Nadi.

Dillingham, S. (2002). *New Zealand workforce: qualifications and evidence of upskilling*, from http://www.dol.govt.nz/PDFs/new-zealand-labour-upskilling.pdf

Dipboye, R. L. (1982). Self-fulfilling prophecies in the selection-recruitment interview. *Academy of management review, 7*(4), 579-586.

Drennan, L. (2001). Quality assessment and the tension between teaching and research. *Quality in Higher Education, 7*(3), 167-178.

Eisler, H., & Ekman, G. (1959). A mechanism of subjective similarity. *Acta Psychologica, 16*, 1-10.

Estes, W. K. (1994). *Classification and cognition*. New York: Oxford university press.

Everitt, B. S., & Rabe-Hesketh, S. (1997). *The analysis of proximity data*. London: Arnold.

Fernandez, R. M., & Weinberg, N. (1997). Sifting and sorting:personal contacts and hiring in a retail bank. *American sociological review, 62*(6), 883-902.

Fitzsimons, M. (2004). Managerialism and the university. *New Zealand Journal of Tertiary Education Policy, 1*(1), 16-18.

Forio-Software. (2006). *Leadership Simulation*, from http://www.forio.com/index.htm

French, S. (2002). Genetic testing in the workplace: the employer's coin toss. *Duke Law Technology Review, 0015*.

Frisch, S. A., Broe, M. B., & Pierrehumbert, J. B. (1995). *The role of similarity in phonology:Explaining OCP-place*. Paper presented at the 13th Annual congress of the phonetic sciences, Stockholm.

Garner, W. R. (1974). *The processing of information and structure*. New York: Wiley.

Garrison. (2005). *Plus-32 Employment Testing*, from www.Plus-32.com

Geertz, C. (2000). *Available light: Anthropological reflections on philosophical topics*. Princeton, NJ: Princeton University Press.

Gentner, D., & Ratterman, M. J. (1991). Language and the career of similarity. In S. A. Gelman & J. P. Byrnes (Eds.), *Perspectives on language and*

thought interrelations in development (pp. 225-277). Cambridge: Cambridge University Press.

Gilmore, G. C., Hersh, H., Caramazza, A., & Griffin, J. (1979). Multidimensional letter similarity derived from recognition errors. *Perecption and Psychophysics, 25*, 425-431.

Gluck, M. A., & Bower, G. H. (1990). Component and pattern information in adaptive networks. *Journal of experimental psychology:general, 119*, 105-109.

Goldstone, R., & Medin, D. L. (1994). The time course of comparison. *Journal of experimental psychology:learning, memory and cognition, 20*, 29-50.

Goldstone, R., Medin, D. L., & Gentner, D. (1991). Relational similarity and the nonindependence of features in similarity judgements. *Cognitive Psychology*, 222-263.

Goldstone, R., & Son, J. (2005). Similarity. In K. Holyoak & R. Morrison (Eds.), *The cambridge handbook of reasoning and thinking* (pp. 13-36). Cambridge: Cambridge university press.

Goodman, N. (1972). Seven strictures on similarity. In N. Goodman (Ed.), *Problems and projects* (pp. 437-446). New York: The Bobbs-Merrill co.

Gottman, J., Murray, J., Swanson, C., Tyson, R., & Swanson, K. (2003). *The mathematics of marriage*: MIT Press.

Grigorenko, E. L. (2002). In search of the genetic engram of personality. In D. Cervone & W. Mischel (Eds.), *Advances in personality science* (pp. 29-82). New York: Guildford Press.

Guttman, L. (1954). A new approach to factor analysis: the radex. In P. Lazasrsfeld (Ed.), *Mathematical thinking in the behavioral sciences* (pp. 258-348). New York: New York Free Press.

Hahn, U., & Chater, N. (1998). Understanding similarity: A joint project for psychology, case-based reasoning and law. *Artificial intelligence review, 12*, 393-427.

Hahn, U., Chater, N., & Richardson, L. (2003). Similarity as Transformation. *Cognition, 87*, 1-32.

Harre, R. (1998). *The singular self: An introduction to the psychology of personhood*. London: Sage.

Heit, E., & Rubenstein, J. (1994). Similarity and property effects in productive reasoning. *Journal of experimental psychology:learning, memory and cognition, 20*, 411-422.

Hubel, D. H., & Wiesel. (1968). Receptive fields and functional architecture of monkey striate cortex. *Journal of Physiology, 195*, 215-243.

Hunter, M. G. (1994). Excellent systems analysts - key audience perceptions. *Computer Personnel*, 15-31.

Jakobson, R., Fant, G., & Halle, M. (1963). *Preliminaries to speech analysis: The distinctive features and their correlates*. Cambridge, MA: MIT Press.

Kagan, J. (1994). *Galen's prophecy: Temperament in human nature*. New York: Basic books.

Kagan, J. (1999). Born to be shy? In R. Conlan (Ed.), *States of mind* (pp. 29-51). New York: Wiley.

Katz, J. J., & Fodor, J. (1963). The structure of semantic theory. *Language, 39*, 170-210.

Keil, F. C. (1989). *Concepts, kinds and development*. Cambridge MA: MIT Press.

Kohonen, T. (1995). *Self-organising maps*. Berlin: Springer-Verlag.

Krumhansl, C. L. (1978). Concerning the applicability of geometric models to similarity data:The interrelationship between similarity and spatial density. *Psycholgical review, 85*, 450-463.

Krumhansl, C. L. (1988). Testing the density hypothesis: Comment on Corter. *Journal of experimental psychology:general, 117*, 101-104.

Krushke, J. K. (1992). ALCOVE: an exemplar-based connectionist model of category learning. *Psycholgical review, 99*, 22-44.

Kruskal, J. B. (1964a). Multidimensional scaling by optimizing goodness of fit to a nonmetric hypothesis. *Psychometrika, 29*, 1-27.

Kruskal, J. B. (1964b). Nonmetric multidimensional scaling: a numerical method. *Psychometrika, 29*, 115-129.

Labuschagne, A. (2003). Qualitative research - airy-fairy or fundamental. *The qualitative report, 8*(1).

Lamberts, K. (2000). Information accumulation theory of speeded-categorisation. *Psycholgical review, 107*, 227-260.

Li, M., & Vitanyi, P. (1997). *An introduction to Kolmogrov complexity and its applications* (2 ed.). New York: Springer-Verlag.

Lombardo, M., & Eichinger, V. (2000). High potentials as high learners. *Human Resource Management, 39*(4), 321-329.

Maki, P. (2004). Assessing for learning: building a sustainable commitment across the institution. In (pp. 85-118). Sterling VA: Stylus Publishing.

Markham, A. B., & Gentner, D. (1993a). Splitting the differences:A structural alignment view of similarity. *Journal of memory and language, 32*, 517-535.

Markham, A. B., & Gentner, D. (1993b). Structural alignment during similarity comparisons. *Cognitive Psychology, 25*, 431-437.

Medin, D. L., & Schaeffer, M. M. (1978). A context theory of classification learning. *Psycholgical review, 85*, 207-238.

Milojevic, I. (1998). Women's higher education in the 21st century. *Futures journal, 30*(7), 693-703.

Moore, J. E., & Burke, L. A. (2002). How to turnaround turnover culture in IT. *Communications of the ACM, 45*(2), 73-78.

Murphy, G. L. (2002). *The big book of concepts*. Cambridge MA: MIT press.

Murphy, G. L., & Medin, D. L. (1985). The role of theories in conceptual coherence. *Psycholgical review, 92*, 289-316.

Naur, P. (1993). Understanding Turing's universal machine: personal style in program description. *The Computer Journal, 36*(4), 351-372.

Neisser, U. (1967). *Cognitive Psychology*. New York: Appleton-Century-Crofts.

Nickerson, R. S. (1986). Binary classification reation time:A review of some studies of human information processing capabilities. *Psychonomic monograph supplements, 4*(6), 275-317.

Nosofsky, R. M. (1986). Attention, similarity and the identification-categorisation relationship. *Journal of experimental psychology:general, 115*, 39-57.

Nosofsky, R. M. (1991). Stimulus bias, asymmetric similarity and classification. *Cognitive Psychology, 23*, 93-140.

NZMoE. (2004). *Statement of tertiary education priorities 2005 - 2007 discussion document*.

Pervin, L. A., Cervone, D., & John, O. P. (2005). *Personality theory and research*: Wiley.

Plomin, R., & Caspi, A. (1998). DNA and personality. *European Journal of personality, 12*, 387-487.

Plomin, R., & Caspi, A. (1999). Behavioural genetics and personality. In L. A. Pervin & O. P. John (Eds.), *Handbook of personality: Theory and research* (pp. 251-276). New York: Guildford.

Podgorny, P., & Garner, W. R. (1979). Reation time as an indicator of inter-intraobject visual similarity: Letters of the alphabet. *Perecption and Psychphysics, 26*, 37-52.

Polkinghorne, D. (1988). *Narrative knowing and the human sciences*. Albany, NY: State University of New York Press.

Quine, W. V. (1969). *Ontological relativity and other essays*. New York: Columbia university press.

Quine, W. V. (1977). Natural kinds. In S. P. Schwartz (Ed.), *Naming, necessity and natural kinds* (pp. 155-175). Ithaca New York: Cornell university press.

Richardson, M. W. (1938). Multi-dimensional psychophysics. *Psychological bulletin, 35*, 659-660.

Ripley, B. D. (1996). *Pattern recognition and neural networks*. Cambridge: Cambridge university press.

Rips, L. J. (1989). Similarity, typicality and categorisation. In S. Vosniadu & A. Ortony (Eds.), *Similarity, analogy and thought* (pp. 21-59). Cambridge: Cambridge university press.

Rips, L. J., & Collins, A. (1993). Categories and resemblance. *Journal of experimental psychology:general, 122*, 468-486.

Ross, B. H. (1987). This is like that:the use of earlier problems and the separation of similarity effects. *Journal of experimental psychology:Learning, memory and cognition, 13*, 629-639.

Ross, B. H. (1989). Distinguishing types of superficial similarities: Different effects on the access and use of earlier problems. *Journal of experimental psychology:learning, memory and cognition, 15*, 456-468.

Rowe, D. C. (1999). Personality:contemporary theory and research. In V. J. Derlega, B. A. Winstead & W. H. Jones (Eds.), *Heridity* (pp. 66-100). Chicago: Nelson Hall.

Ryan, A. M., & Tippins, N. T. (2004). Attracting and Selecting: What psychological research tells us. *Human resource management, 43*(4), 305-318.

Rynes, S. L., Colbert, A. E., & Brown, K. G. (2002). HR professionals' beliefs about effective human resource practices: Correspondence between research and practice. *Human resource management, 41*, 149-174.

Saxe, L., & Ben-Shakhar, G. (1999). Admissibility of polygraph tests: The application of scientific standards post-Daubert. *Psychology, Public Policy and the Law, 5*(1), 203-223.

Schank, R. C. (1982). *Dynamic theory: A theory of reminding and learning in computers and people*. Cambridge MA: Cambridge university press.

Schmidt, F. L., & Hunter, J. E. (1988). The validty and utility of selection methods in personnel psychology:practical and theortical implicatons of 85 years of research findings. *Psycholgical bulletin, 124*, 262-274.

Schmidt, L. A., & Fox, N. A. (2002). Individual differences in childhood shyness. Origins, malleability and developmental course. In D. Cervone & W. Mischel (Eds.), *Advances in personality science* (pp. 83-105). New York: Guildford press.

Segrave, S. (2003, December 7 - 10). *Bench marking design of simulated professional practice for authentic learner engagement.* Paper presented at the Annual conference of the Australasian society for computers i learning in tertiary education (ASCILITE), Adelaide, Australia.

Shepard, R. N. (1962a). The analysis of proximities:multidimensional scaling with an unknown distance function Part 2. *Psychometrika, 27*, 219-246.

Shepard, R. N. (1962b). The analysis of proximities:Multidimesional scaling with an unknown distance function Part 1. *Psychometrika, 27*, 125-140.

Sjoberg, L. (1972). A cognitive theory of similarity. *Goteborg Psychological Reports, 2*(10).

Stewart, J., & Knowles, V. (2000). Graduate recruitment and selection practices in small businesses. *career development international, 5*(1), 21-38.

Stobart, S., & Gipps, C. (1997). *Assessment - a teacher's guide to the issues*: Hodder and Stoughton.

Strelau, J. (1998). *Temperament: A Psychological perspective*. New York: Plenum Press.

Tan, F., & Hunter, M. G. (2000). *Cognitive research in information systems using the repertory grid technique*.Unpublished manuscript.

Tarr, M. J., & Gauthier, I. (1998). Do view-point-dependant mechanism generalise accross members of a class? *Cognition, 67*, 73-110.

Taylor, M. S., & Collins, C. J. (2000). Organisational recruitment:Enhancing the intersections of research and practice. In C. L. Cooper & E. A. Locke (Eds.), *Industrial and organisational psychology:linking theory with practice* (pp. 304-330). Oxford UK: Blackwell.

Taylor, S. E. (1989). *Positive illusions: Creative self-deception and the healthy mind*. New York: Basic Books.

Tenenbaum, J. B. (1999). *Baysian modeling of human concept learning* (Vol. 11). Cambridge: MIT Press.

Torgerson, W. S. (1958). *Theory and methods of scaling*. New York: Wiley.

Truex, D., Baskerville, R., & Travis, J. (2000). Amethodical systems development: the deferred meaning of systems development methods. *Accounting Management and Information Technology, 10*, 53-79.

Truex, D., Travis, J., & Baskerville, R. (1992). Systems without method: the impact of new technologies on information systems develoment projects. In K. Kendal, K. Lyytinen & J. DeGross (Eds.), *Transaction on the impact of computer supported technologies in informatuion systems development* (pp. 241-260). Amsterdam: Elsavier.

Tversky, A. (1977). Features of similarity. *Psycholgical review, 84*, 327-352.

Tversky, A., & Gati, I. (1982). Similarity, separability and the triangle inequality. *Psycholgical review, 89*, 123-154.

Tversky, A., & Hutchinson, J. W. (1986). Nearest neighbour analysis of psychological spaces. *Psycholgical review, 93*, 3-22.

Upward-Motion. (2006a). *Real Estate Simulator*. Retrieved 10/02/06, 2006, from http://www.realestatesimulator.com/index.asp

Upward-Motion. (2006b). *Sales Simulator*. Retrieved 10/02/06, 2006, from http://www.salessimulator.com/b2bsales/index.asp

Wolfe, T. (1979). *The Right Stuff*: Farrar, Straus and Giroux.

Young, G., & Householder, A. S. (1941). A note on multidimensional psychophysical analysis. *Psychometrika, 6*, 331-333.

Yourdon, E. (1993). *The decline and fall of the american programmer*. New Jersey: Prentice Hall Englewood Cliffs.

Zhang, S., & Markham, A. B. (1998). Overcoming the early entrant advantage: The role of alignable and non-alignable differences. *Journal of marketing research, 35*, 413-426.

Requirements Engineering Framework for Information Utility Infrastructure for Rural e-Healthcare Service Provisioning

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ABSTRACT

The accessibility to important healthcare resources and the costs of healthcare services are serious challenges facing the rural communities of most developing countries. In order to address these problems, we are pursuing rigorous experimental investigations for the development of an information utility infrastructure, which takes advantages of emerging Utility Grid Computing (UGC) and Body Area Network (BAN) for ubiquitous e-Healthcare service provisioning. In this paper, we derive the system requirements from enterprise models and delineate the general framework guiding the development of the infrastructure.

Keywords: Healthcare Management, Body Area Network, Grid Computing, Enterprise Model

1. INTRODUCTION

Most rural communities in developing countries are facing debilitating situations regarding accessibility to quality healthcare services. There is high demand for increased accessibility to important healthcare resources, increased efficiency and quality-oriented healthcare services with limited financial resources. Rural communities are characterized by prevailing issues such as low health level, low literacy level, limited resources and professional isolation.

In a modern information society, patient care increasingly requires healthcare practitioners to access accurate and complete health information so as to effectively manage the safe and efficient delivery of complex and knowledge intensive healthcare. There is also the need to share this information within and between care teams. On the other hand, patients require access to their own health information in

order to allow them play significant role in their health management. These essential requirements are becoming more urgent as focus of healthcare management shifts progressively from reactive to proactive care, which requires the involvement of patient's personal environment to provide quality healthcare services.

However, much of the fine-grained healthcare information upon which future care depends is still captured into paper archives or at best in isolated hospital databases and managed by proprietary applications. These applications are developed using different technologies and to seamlessly interoperate them is a difficult task. The problem being investigated is how to practically use Information and Communication Technology (ICT) to provide quality and cost-effective healthcare services to rural communities. A simple solution is to adopt the existing remote monitoring systems that have been used in developed countries like America and Europe. However, these technologies have not been widely used in Africa because of their (i) expensiveness and inflexibility for new services and applications, (ii) service provider dependency and (iii) possibility for communication delay during patient-healthcare practitioner interactivity.

The BAN-UGC integration has exceptional potential to improve the quality of healthcare services whilst simultaneously cutting costs by aggregating multiple heterogeneous resources. The technology will support the mobility of people and increase service availability through pervasiveness, home care support and point-of-care treatment. The rest of the paper is summarized as follows. Section 2 describes the BAN-UGC integration. Section 3 describes an Enterprise model for rural healthcare service provisioning. Section 4 gives the requirements for a healthcare utility service infrastructure and the paper is concluded in section 5.

2. INTEGRATION OF BODY AREA NETWORK AND UTILITY GRID COMPUTING

The MobiHealth [1] introduced innovative value-added mobile healthcare services based on public broadband 2.5G (GPRS) and 3G (UMTS) wireless networks for continuous monitoring and transmission of vital signals. This was achieved with the integration of smart sensors to a wireless generic BAN [2]. The BAN is a wireless health monitoring system that consists of sensors, actuators, communication and processing facilities and integrates wearable devices for connecting different sensors. The BAN sensors are responsible for data acquisition, measurement and transmission processes ensuring that a physical phenomenon, such as patient movement, muscle activity or blood flow is converted to an electrical signal. The signal is amplified and internally communicated within the BAN through intra-BAN communication process. The gateway that facilitates extra-BAN communication of vital signals to healthcare providers or brokers is the Mobile Base Unit (MBU) [3]. This way the network facilitates time and location independent monitoring of a patient's health conditions.

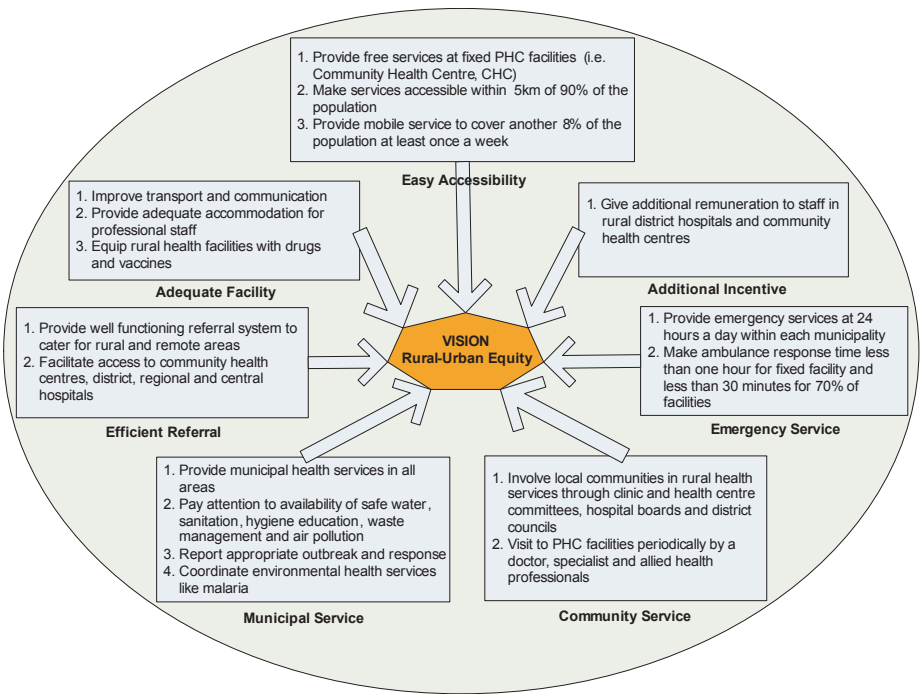
A utility grid [4] is a distributed enterprise grid that provides resources on-demand and supports a pool of computers to be assigned as needed to take-up extra demand that can defy the potential of human expertise. The BAN-UGC integration gives rise to new healthcare services and applications that can provide remote diagnosis and treatment capabilities. Using this integrated technology, healthcare practitioners and patients will have access to resources that can not be provided by BAN only. For example, a patient health records could be moved around and a healthcare practitioner would be able to collaborate with colleagues from other locations and make informed decisions anytime by sharing resources. The vital signals that are measured and transmitted to a software broker could be adequately analyzed using the discovered grid resources. The result of the analysis would be effectively delivered to the user in a real-time. Thus, enabling remote management of patient conditions and quick detection of health emergencies whilst maximizing patient mobility and minimizing healthcare costs.

3. AN ENTERPRISE MODEL FOR RURAL HEALTHCARE PROVISIONING

This section summarizes the Enterprise model for rural healthcare service provisioning in the developing country context, using the Republic of South Africa (RSA) healthcare service provisioning strategy scenario. This strategy is based on the adoption of mobile clinics, efficient referral and Primary HealthCare (PHC) systems. The healthcare service provisioning process was analyzed to align with the established ways of practice and to capture the basic invariant structure of the service provisioning tasks. The refined Enterprise model [5], which includes entities related to BAN, was extended to incorporate UGC concepts. This was used to derive the computational and engineering level requirements for the healthcare utility service infrastructure.

A rural healthcare provisioning process is a workflow of vision-driven tasks aimed at achieving rural-urban equity in healthcare service provisioning, so as to improve the health status of every citizen. From an enterprise modeling perspective, a task typically contains several subtasks, each of which represents several activities.

Figure 1. A vision-driven rural healthcare service provisioning model



A task therefore, is an embodiment of healthcare activities [6]. In this context, a task identifies the vision, goal or objective to accomplish, a subtask states what service is required and activities state how to implement the subtasks to achieve the intended vision. Figure 1 depicts the summary of the refined task activities of the rural healthcare service provisioning practice in RSA.

4. REQUIREMENTS FOR HEALTHCARE UTILITY SERVICE INFRASTRUCTURE

The Enterprise model was directly used for deriving the requirements for the infrastructure support of healthcare service provisioning processes. These can be grouped amongst others into control-plane and usage-plane requirements.

4.1 Control-Plane Requirements

These are the requirements associated to the setup of the bindings of the agent to agent communication, remote monitoring of vital signals, diagnosis and treatment. Some of the requirements include (i) addressing; the MBU needs to be addressable in the wireless environment. The devices attached to the BAN must have unique addresses to be individually addressed. The data acquisition front-end of the devices must be uniquely addressed within a centrally controlled BAN, (ii) plug-and-play; the BAN becomes unknown in the environment whenever the MBU is powered off. The MBU start-up should therefore, contain a push mechanism to enable its discovery in the augmented reality environment. Quality of Service (QoS) mechanisms should be included to enable capacity alignment within the networked and in inline with the application's QoS requirements and (iii) adaptable communication; the amount, quality and coherence of the data to be exchanged have to match with the limitations of the communication channel capability. Adaptable services are typically required in these environments to better cope with bandwidth limitations and variations in communication errors such as data loss and channel dropouts. Data buffering, data prioritization, synchronization mechanisms and data acknowledgements are important requirements. Resource control policy such as computational economy, resource prioritization and reservation are required for effective management and scheduling of resources in the highly distributed environment.

4.2 Usage-Plane Requirements

These are the requirements in respect of data transfer and they are basically the upstream push and downstream messaging mechanisms. The data transfer mechanisms should be implemented such that transfer delays do not exceed the boundaries given by human factor studies. Another important requirement is the communication costs, continuous monitoring of signals and resource consumption must be regulated for effective management purpose. A different cost model for continuous transmission applications such as flat rate charge for unlimited data and usage is desirable.

4.3 e-Healthcare utility-Service Broker

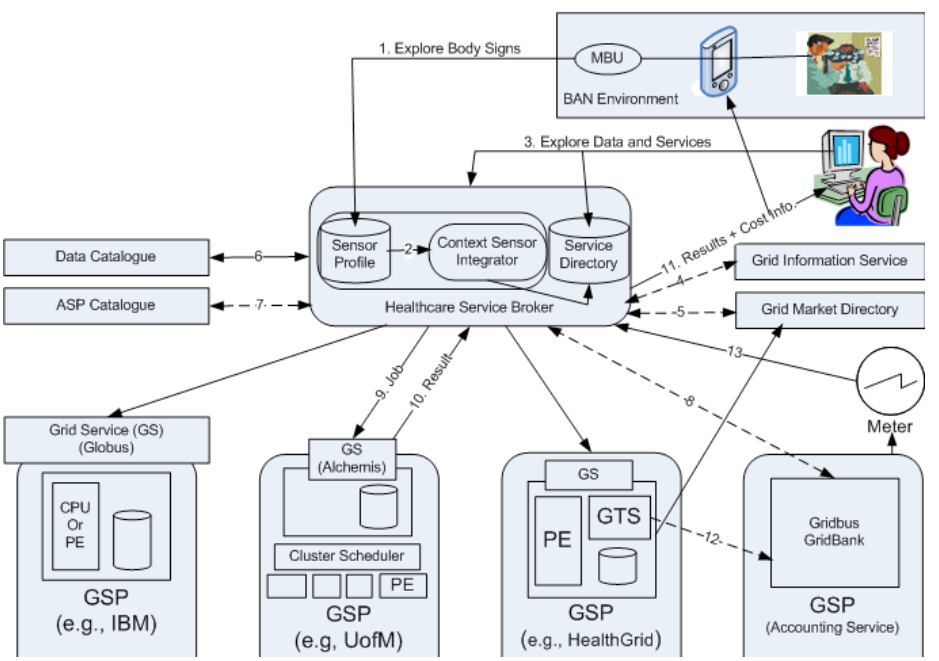
The BAN-UGC integration raises some entirely new requirements for service infrastructures. These requirements can be met by a new type of Grid Resource Broker (GRB), a Healthcare utility-Service Broker (HSB). The HSB acts as a mediator between the user and the network resources to perform various tasks such as patient's health status monitoring, diagnosis and treatment, using sensors and grid services. Figure 2 depicts the on-demand assemblage of healthcare services using the HSB technology.

The BAN collects and transmits vital signs to the sensor profile (Step 1). Context Sensor Integrator (CSI) converts sensor data to a service request specification and store in the service directory (Step 2). User requests can in two forms (i) a service retailer registers services to offer to end-consumers as free social services or on charge basis and (ii) a user subscribes for a service using proximate selection (Step 3). The broker performs service discovery based on request using web services-based Grid Information Service (GIS) and Grid Market Directory (GMD) (Steps 4 and 5). The broker identifies the list of data sources or replicas and selects the optimal ones (Step 6). The broker also identifies the list of computational resources that provides the required services using Application Service Provider (ASP) catalogue (Step 7). The broker ensures that the user has the necessary credit or authorized share to utilize resources (Step 8). The broker scheduler assigns and deploys jobs to grid services that meet QoS requirement (Step 9). The broker agent on the grid resource at the Grid Service Provider (GSP) then executes the job and returns the result (Step 10). The broker collects the results plus cost information and passes them to the user (Step 11). The metering system charges the user by passing the resource usage information to the accounting service (Step 12). The accounting service reports the remaining resource share allocation and credit available to the user via the broker's Local Billing System (LBS) (Step 13).

5. CONCLUSION

This paper gives the infrastructure requirements for BAN-UGC integration that incorporates smart sensors and grid services to support and improve distributed

Figure 2. On-demand service provisioning in utility grid



healthcare service provisioning. These requirements were derived from Enterprise models capturing the community invariants of the healthcare service provisioning processes. The proposed approach has the benefit of making ubiquitous quality healthcare services available and helps in addressing the rural-urban healthcare service provisioning inequality.

REFERENCES

[1] Konstantas, D., Jones, V., Bults, R. and Herzog, R., MobiHealth-innovative 2.5/3G mobile services and applications for healthcare. Proceedings of the eleven information society technologies, 2002

[2] Zimmerman, I.G., Wireless networked devices: A new paradigm for computing and communication. IBM systems journal, vol. 38, no. 4, 1999

[3] Wac, K., Bults, R., Konstantas, D., Halteren, A.V., Jones, V., Widya, I. and Herzog, R., Mobile healthcare over 3G networks: The MobileHealth pilot system and service. Mobile Information Systems, vol. 2, no. 2-3, 2006, 151 - 167

[4] Yeo, C.S., Buyya, R., Assungao, M.D.D., Yu, J., Sulistio, A., Venugopal, S. and Placek, M., Utility computing on global grids. In Handbook of Computer Networks, John Wiley and Sons

[5] Widya, I., Halteren, A.V., Jones, V., Bults, R., Vierhout, P. and Peuscher, J., Telematic requirements for a mobile and wireless healthcare system derived from enterprise models. In Proceedings 7th International Conference on Telecommunications, 2003, 2003, 527 – 534

[6] Luzi, D., Ricci, F.L. and Serbanati, I.D., Extending the standard architecture for healthcare units: the guideline server, in new technologies in hospital information systems. IOS press, 1997, 95-101

Community-Based Performance Management in Local Government

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NOTES:

I have finished all progam coursework and am enrolled part-time in the doctoral program. I am in the process of constructing the proposal. I would expect to have the proposal ready in May for comment and discussion, and plan to have the thesis completed in 18-24 months after that.

SUMMARY

Performance management occurs where performance measurement intersects with organizational action - and the ambit of accounting has extended to cover significant parts of this cycle. The best value reforms to local government in the UK and Australia valorize performance measurement and community engagement as necessities for effective governance, and so we must now cope with the interaction of action, performance measurement and community engagement. This research will investigate current practice in community engagement within service delivery areas of Australian local governments. In particular the research will explore the gap in the literature about how the engagement impacts on decision-making.

COMMUNITY ENGAGEMENT AND PERFORMANCE MANAGEMENT

"Citizen participation in the decisions that affect their lives is an imperative of contemporary society", and since the latter part of the twentieth century we are witnessing a shift away from reliance on public officials and administrators to frame objectives and action (Roberts 2004, p. 369). The trend towards public involvement in decision-making should "… grow as democratic societies become more decentralised, interdependent, networked, linked with new information technologies, and challenged by wicked problems" (Roberts 2004, p. 316).

Kathi and Cooper (2005, p. 559) categorise the central arguments for citizen participation in governance under moral and instrumental normative grounds. The moral normative argument is that citizen participation in the work of government is a basic right in a democracy. The three instrumental normative arguments hold that community participation: promotes efficiency and effectiveness; is a vehicle for community empowerment and change; and bolsters political stability.

The 'Best Value' performance management framework in Victoria requires local governments to provide, and continuously improve, 'value for money' services that are relevant to community needs. This requirement has three important implications for performance management in government. Firstly it calls for rational decision-making by local government politicians and managers, where action must be driven by good performance information. Secondly, it calls for robust accountability mechanisms, where good performance information needs to capture the results of action. Thirdly, because the nature and impact of services must reflect community needs, the performance information which drives action and captures results must be the subject of community input. So Best Value in Victoria, and similar reforms in Sweden, the UK and New Zealand have challenged traditional practice by requiring a three-way linkage between institutional action, performance measurement, and community engagement. In the midst of such initiatives by governments to increase the level of community engagement, there is a gap in our understanding about the impact of community engagement on decision-making (Kathi & Cooper 2005) (Department of Justice Canada 2001).

AIM AND OBJECTIVES OF THE THESIS

The aim of this study is to investigate the nature of community engagement in local government and its impact on performance measurement and organizational learning. This study seeks to identify: the forces that shape community engagement; the levels and mechanisms of engagement; and how engagement drives changes in performance measurement and management. From the research results, we should gain a better understanding about the effect of community engagement on decision-making and specify critical success factors for sustainable and effective community-centered corporate governance in local government.

OBJECTIVES

- identify: the forces that shape community engagement; the levels and mechanisms of engagement; and how engagement drives changes in performance measurement and management
- gain a better understanding about the effect of community engagement on decision-making and specify community informatics success factors and other CSFs for sustainable and effective community-centered corporate governance in local government

Note: community informatics is the design & application of information and communication technologies to enable community processes and the achievement of community development objectives (Denison et al. 2003).

This study will examine and contrast the perceptions of local government managers and politicians in Victoria and Sweden about the interaction between community

engagement and the five key decision-making elements in performance management: identifying and measuring objectives; determining and measuring actions to meet these objectives; setting targets; determining accountability and reward mechanisms; and adopting information flows and learning processes. The findings will highlight commonalities and differences that managers and politicians have experienced with the interaction of community engagement, performance measurement and action – and highlight critical success factors. The study will inform policy and implementation initiatives by governments and community stakeholders by examining how and why engagement has occurred, and its impact on current decision-making and organizational learning. The study may be extended to UK and New Zealand depending on access and resourcing.

A MODEL FOR EXPLORING COMMUNITY-BASED PERFORMANCE MANAGEMENT

Performance measurement can improve the civic discourse through more specificity and facts, and also stimulate public interest and participation in matters of service quality, which can in turn encourage the work of government employees (HM-Treasury 2001). In normative literature performance measurement provides a mechanism to reconnect the community and services (Talbot 2002, p. 3) and the performance information is a catalyst for adaptation and innovation and thus the 'cornerstone' of government modernization activities (HM-Treasury 2001) but there is a gap in understanding about how it can be operationalised as 'performance management' with the necessary community emphasis.

Otley (1999) proposes a model of performance management that addresses five key elements:

1. What are the key objectives that are central to overall future success, and how does the organisation evaluate their achievement. How does the organisation determine key objectives and methods for evaluating the results achieved?
2. What strategies and plans has the organisation adopted to achieve key objectives, and what activities are necessary for plans to deliver expected results. How does the organisation assess and measure the performance of these activities?
3. What performance standards are required to achieve success with key objectives (Q1) and activities (Q2), and how are performance targets set?
4. What rewards – in the widest possible sense – or penalties will accrue to managers from success or failure in reaching performance targets.
5. What formal and informal information flows (feedforward and feedback) and learning processes are necessary for the organisation to adapt?

Otley contends that each issue is not new and has been addressed in the management control and wider management literature. However the integration of the five areas to provide a description of the overall performance management systems of an organisation is relatively novel as it provides a way of redressing the dearth of information on current practice through "…a structure for examining extant practice in a more holistic way than has previously been the case…" (Otley 1999, p. 377). The framework provides a vehicle within which the "..features of an overall control system can be assessed and evaluated" (Otley 1999, p. 369).

Whilst Otley's (1999)model gives us a less grainy view of the important decision elements facing management, the notion of how to measure the level of engagement for each of these five elements must be operationalised. Here the International Association for Public Participation provides a useful model for categories of community engagement. Community engagement varies along a spectrum of increasing public impact ranging from 'informing' to 'consulting' to 'involving' to 'collaborating' to 'empowering' (IPAA 2003). Informing provides the public with balanced and objective information to assist understanding of problems, alternatives, or solutions. Consulting gains public feedback. Involving ensures that community concerns are consistently understood and considered. Collaborating partners with the public in decision-making. Empowering places final decision-making in the hands of the community.

So to explore the effect of community engagement on decision making, we can combine Otley's (1999) five major elements of performance management system with the five IPAA categories of community engagement to provide the sort of matrix recommended by Miles and Huberman (1994) that facilitates in-depth research studies. We have developed this matrix (Figure 1) as tool for further research into the nuances of community-based performance management.

This model will form a point of departure in exploring how community engagement impacts of the different facets of decision-making that occurs within performance management. The matrix lists Otley's (1999)five key decision issues vertically down the left column. For each decision element, the matrix considers: the levels of community engagement; the mechanisms by which the engagement takes place, the forces (barriers and enablers) for engagement; and the outcomes of that engagement. In particular , we will highlight the mix between community informatics and other factors at play.

RESEARCH STAGES

A review of relevant literature has comprised the first phase of the project, and study will proceed in two stages using mixed methods. These stages involve the

Figure 1. A matrix for exploring community-based performance management

Performance management/ engagement	Level of engagement: Inform	Consult	Involve	Collaborate	Empower	Engagement: Mechanisms	Forces	Outcomes
Determining key objectives & their measurement								
Identifying activities & their measurement								
Setting performance standards								
Determining rewards (implications) for success or failure								
Adopting information flows and learning processes								

collection and analysis of quantitative and qualitative data from government managers and politicians by interview and questionnaire. Stage 1 is about identifying themes and variations around the experiences of managers and politicians with community engagement and its affect on decision-making. These perceptions will be explored using the case study method and operationalised by applying semi-structured interviews as the data collection technique. The themes and variations uncovered in Stage 1 will form the basis for Stage 2, which will further explore findings from the case research. Stage 2 will employ the survey research method, and utilise a questionnaire of closed and open questions as the data collection technique. Data analysis of variables will be in terms of frequency of states and relationships between variables.

The study uses what(Creswell 2003) terms a sequential exploratory design - where quantitative data and results assist in the interpretation of qualitative findings. Here the primary focus is to explore a nascent phenomenon. This design is appropriate to: test elements of an emergent theory; generalize the qualitative findings to different samples; and determine the distribution of a phenomenon within a chosen population.

CASE STUDY RESEARCH USING INTERVIEWS (STAGE 1):

The Interview participants will be politicians and senior government managers recruited from Australian and Swedish entities as a convenience sample (Maylor & Blackmon 2005). The convenience sample may be extended to UK and New Zealand depending on access and resourcing. Prior studies have shown the utility in benchmarking public sector management experiences in Australia against countries with similar reform agendas (Solli, Demediuk & Sims 2002; Solli, Demediuk & Sims 2005). Participants will be interviewed in order to gain their perceptions as professionals, and not as spokespersons for their organization. Only potential participants from Sweden who state that they are comfortable to be interviewed in English will proceed into the Stage 1 of the study, but these participants will also receive a copy of the semi-structured questions in Swedish and English. Protocols for qualitative research using in-depth semi-structured interviews as outlined in (Miles & Huberman 1994) and (Maylor & Blackmon 2005) will be strictly adhered to. These protocols involve issues such as: invitation to participate informed consent; permission to record the interview; confidentiality; avoidance of bias; and security of recorded and transcribed data. A list of semi-structured questions has been derived from the literature. Semi-structured questions provide an opportunity to compare perceptions about common issues across the subjects interviewed. In the course of the interview the researcher also has the opportunity to probe responses to get clarification or more detail, or to examine new relevant issues brought up by participants.

SURVEY RESEARCH USING A QUESTIONNAIRE (STAGE 2):

The in-depth semi-structured interviews (Stage 1) will be followed by a survey to further investigate the generalisability, distribution, and inter-relationships of phenomenon that are identified in the fieldwork. The survey questions will be developed with reference to the themes and variations found in the interviews from Stage 1. Final survey questions will be robustly pre-tested. Potential subjects for the survey will be politicians and senior mangers from a sample of entities with active engagement policies from Sweden and Victoria in Australia. An e-mail survey will be employed, and it is expected that the subjects would have ready access to technology. Participants can alternatively request a printed copy of the questionnaire to complete. Protocols for survey research outlined in (de Vaus 2005) will be followed. Potential participants will receive an invitation letter to participate in the survey by E-mail with the electronic questionnaire file. Participants from Sweden will receive E-mail attachments of the survey in Swedish and English.

NUMBER, TYPE AND AGE RANGE OF PARTICIPANTS:

Stage 1 interviews: The group in each location will comprise of 20 to 30 senior managers and politicians in public sector entities from Victoria (Australia) and Sweden with an age range above 21 years. Depending of progress with this data collection, resourcing, and access issues, interviews may be extended to such participants in the UK and New Zealand The proportions from each country will be an artefact of the opportunities presented through professional contacts and networks.

Stage 2 surveys: 250 individuals who are senior managers and politicians in Victorian and Swedish public sector entities with an age range above 21 years.

SOURCE OF PARTICIPANTS, AND MEANS BY WHICH PARTICIPANTS ARE TO BE RECRUITED:

Interview participants (Stage 1) will be recruited as a convenience sample from local governments in Sweden and equivalent institutions in Victoria (and possibly New Zealand and the UK) using publicly available listings of politicians and senior managers. Experience has shown a high level of interest by politicians and senior managers in Australian, Swedish, UK and New Zealand local governments to be voluntarily involved in research around performance management (Solli, Sims & Demediuk 2000). All research participants in Stages 1 will be informed at the outset about the voluntary nature of their participation, and that they may opt to back out at any time to wish to. A list of possible questions for these semi-structured interviews are:

RESEARCH QUESTIONS – STAGE 1

What happens with community engagement?

Scenario: Think about a typical program (project, function, service etc) with which you are involved – and what happens with community engagement.

Questions:

1. For each performance management element (see figure below):
2. What is the level of engagement?
3. What are the engagement mechanisms that you use?
4. What enablers/barriers have been at play in reaching these levels?
5. What are the outcomes (costs & benefits) from the engagement

STAGE 2

For Stage 2, a sample of managers and politicians will be drawn from local governments in Victoria and Sweden using publicly available databases. Letters of support for the survey will be sought from influential bodies such as the Goteborg Research Institute in Sweden and FinPro and VLGA (Victorian Local Governance Association) in Victoria. This stage will explore themes and variations uncovered in Stage 1.

REFERENCES

Creswell, JW 2003, Research design: Qualitative, quantitative, and mixed methods approaches 2 nd edn, Sage., Thousand Oaks, CA.

de Vaus, DA 2005, Surveys in social research, Allen and Unwin, St. Leonards, NSW.

Denison, T, Stillman, L, Johanson, G & Schauder, D 2003, 'Theory, practice, social capital, and information and communications technologies in Australia ', paper presented to Many Voices, Many Places -- Electronically Enabling Communities for An Information Society: A Colloquium. Research Results, Lessons Learned, Policy Recommendations, Prato, Italy, 15-16 September.

Department of Justice Canada 2001, 'Evaluation and citizen engagement', Canada, <http://www.justice.gc.ca/en/ps/eval/reports/01/citizen_engagement/ce.html>.

HM-Treasury 2001, Choosing the right fabric - A framework for performance information., HM Trasury, Cabinet Office, National Audit Office, Audit Commsion and Office for National Statistics, London.

IPAA 2003, Principles of Public Participation, International Association for Public Participation.

Kathi, PC & Cooper, TL 2005, 'Democratizing the Administrative State: Connecting Neighbourhood Councils and City Agencies', Public Administration Review, vol. 65, no. 5, pp. 559-66.

Maylor, H & Blackmon, K 2005, Researching Business and Management: A Roadmap for Success. , Palgrave-Macmillan.

Miles, MB & Huberman, MA 1994, Qualitative data analysis, Sage, Thousand Oaks.

Otley, D 1999, 'Performance management: a framework for management control systems research', Management Accounting Research, vol. 10, pp. 363-82.

Roberts, N 2004, 'Public Deliberation in an Age of Direct Citizen Participation', American Review of Public Administration, vol. 34, no. 4, pp. 315-53.

Solli, R, Demediuk, P & Sims, R 2002, 'One best value rule: 78 solutions', paper presented to Euram 2002, Stockholm, May 9-11.

---- 2005, ''The namesake: On best value and other reformmarks'', in BaS Czarniawska, G. (ed.), Global Ideas, Liber – Copenhagen Business School Press, Copenhagen.

Solli, R, Sims, R & Demediuk, P 2000, Chief financial officers in local government - Sweden v's Australia.

Talbot, C 2002, 'Tools for talking', Perform Magazine, vol. 1, no. 8, pp. 1-3. Retrieved on 12/9/02 fron the World Wide Web at wysiwyg://66/http://www.pdviews.com/html/perform_magazine.asp.

Collaboration Models or What Does It Take for Collaboration to Become a Common Asset?

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1. INTRODUCTION

The UN E-Government Author team has been assessing the readiness of the 191 UN Member States with respect to their E-Government readiness (Nation, 2005). The analysis of more than 50.000 features on their website has been used as a first indication how ready and serious a country is applying E-Government, including E-Government related procedures and processes. It also focuses in the second part on the interaction of information technology and the role of governmental and industrial institutions with the human being, the citizen itself.

This range of the study expresses the desperate need of more advanced E-Government applications and as a consequence the ability, accessibility and ease of use of advanced technology from a Governmental perspective. (Nation, 2005), see page 16. The fifth recommendation is expressing the need of the *formulation of a development strategy based on effective and indigenously appropriate utilization of the information and communication technologies (ICTs) in each sector is required so that the market, the government and the citizen have a mutually beneficial and equitable role to play.*

It is also pointing the value-add eGovernment should provide to the entire community.

2. RESEARCH AREAS

Traditionally academic research in collaborative topics started with a specific focus on the individual elements of collaboration. The relevant elements that have been investigated are Enterprise Architecture Frameworks, Business Process Management and Modelling Techniques and eCommerce, namely B2B and eGovernment standardization initiatives.

The dissertation will explore the shift from the traditional context of eCommerce towards collaboration. Collaboration takes place in areas where business and governmental institutions meet. Historically, collaboration research analysed the nature of networks (internal and external networks), business as well as cultural relationships. Through the introduction of local networks like the *keiretsu* phenomenon in Japan (Satoshi Hamaya, 2004) eCommerce and collaboration moved towards IT enabled collaborative scenarios for many to many relationships and away from the one to one focus in eCommerce. As *keiretsu* is specifically linked and limited to the Japanese cultural and business environment, the dissertation will introduce the term ecosystem. The ecosystem illustrates participants and contributors in a pre-defined business environment such as the trade environment and their interactions.

The research is linked to ITAIDE (ITAIDE, 2006) and further activities in Europe focusing on facilitation global trade across business partners and governmental institutions. ITAIDE is an integrated project funded by the IST 6th Framework Programme of the EU which started January 2006 to address some of the key issues related to cross-border trade. Further activities are related to the standardization initiatives at UN/CEFACT where I will be a team member of a steering group for customs specific process, data and form standardization.

3. RESEARCH PROBLEM

What Subject Am I Discussing?

The topic that will be subject to the dissertation is the standardization and interoperability of Enterprise Architecture Frameworks with respect to cross-border and cross-country trade in selected EU member states. The topic fits into the EU wide initiative of the European Commission to implement electronic customs. The expected outcome is the reduction of the administrative burden for governmental authorities and business partners, the compliance of logical, data and product flows as well as assuring secure trade lanes.

The question I am discussing and answering is the following: Why is electronic collaboration still not a common asset to support daily business operations? A hypothetical answer might be that semantically correct, interpretation free contractual and negotiation agreements are not covered yet in the area of information exchange and information standardization.

4. RESEARCH METHODOLOGY

4.1. Indicators of Relevance

Why are still substantial efforts being made in spending time, money and resources to analyze the effects of eGovernment – when will they pay forward?

Accompanied by literature review, the research will use business-oriented indicators of the relevance of eGovernment such as the analysis of Lévy (Lévy, 2005), and the case of Denmark (NIELS BJØRN-ANDERSEN, 2004). These indicators will be empirically extended and categorized along my participation in the ITAIDE project.

There is a number of studies such as the e-Business Watch (Commission, 2005) and UN Report on E-Government and E-Inclusion (Nation, 2005) that point out the need of focusing on the core roles of eGovernment. The current focus goes beyond publishing web sites and providing electronic media to download documents.

Modern business-oriented research is always urged to address the need of providing financial or any other measurable evidence to get an open ear in the commercial and governmental community. The need is to proof that a concept works in real life environments. As one part of the research will be an academic driven research on governmental business cases and applying eGovernment applications within companies and legal authorities, this will be taken into account.

The expected outcome hereby is the definition and the concept of cost and process implications on transformation from customs to eCustoms as well as the definition

of the key elements for transforming another region into an eCustoms region. In this context, I will be assessing the evolvement of process and value drivers that are used in the area of performance measurement research.

4.2. Current Academic Status-Quo

In literature there has been a variety of procedure models and analysis that add to my research field.

The literature I will be assessing is on the one hand reflecting the dimensions of procedure models. Those are related to the technical understanding of collaboration (Thomas Theling, 2005), applicability of applications and the key concepts of interoperability.

In the context of process driven models there will be a brief analysis of models we find in product development (W Hesse, 1992), object oriented models (J Noack, 1999), component based modeling (Schwickert, 1998) (C Heidrich, 1998) and Business Process Management models.

In the area of collaboration research, there is a variety of collaboration related definitions and different meanings. Those need to be clarified and aligned along the research area of global trade. I will focus on inter-organizational business processes, business process management and the way of analyzing collaboration readiness. The cases studies conducted in Denmark, New Zealand and other areas provide empirical data. They indicate what has been useful so far in collaboration research and what not.

Another dimension adding to inter-organizational process analysis is the dimension of the so called ecosystem. Deriving from the ecological context, the term ecosystem got introduced by researchers to refer to the complex and mostly complete picture of a real-life environment in research. At ITAIDE the ecosystem is being represented in a research environment called the Living Laboratory (Living Lab).

A third component to the literature review is the concept of standardization. There is a limited number of analysis on real standardization concepts like RosettaNet and EDI and their contribution to the next generation of eCommerce Frameworks (T. Janner, 2006). I will refer to the UN/CEFACT approach in my research work[1]. The UN/CEFACT approach is providing a framework for standardized data models that did not reach the dissemination level yet to be applied in the software development arena (Flügge, Janner, & Schroth, 2006). ITAIDE itself is providing a collaboration ground itself. I will undertake research in the aspect of collaboration from a business-oriented, process driven and from a technical dimension.

4.3. Evaluation of Current Academic Status-Quo

Concluding the research activities as outlined before, the first milestone of the research activities will be the conclusion which components are relevant to the definition of a collaboration framework for electronic customs.

The evaluation activity will also point out the key roles that are required to move forward with the concept of electronic customs. It will equal electronic customs with the concept of collaborative living scenarios. Different roles like key initiators or early movers might be found in the governmental, academic, commercial or technical world. Wherever they are found, they are definitely required to proceed with this concept (NIELS BJØRN-ANDERSEN, 2004). The evaluation will also include the question of need of organizational adaptability, innovation and flexibility (NIELS BJØRN-ANDERSEN, 2004).

A second milestone will focus on determining common denominators of the procedure models and key differentiators relevant to all business and governmental partners in an ecosystem focusing on global trade.

The evaluation will conclude in the question how new research techniques such as the Living Lab approach support research in the area of collaboration.

4.4 Business Partner Analysis and the Ecosystem Applying Electronic Customs

This section will focus on the relationships of the distinct business partners in the way of trading and doing business. It will also explore the key elements of customs procedures within the EU and the common denominators for the participating countries. As there is no European Customs Office is in place, research might include the World Customs Office and its expectations on electronic customs and its relevance to key elements of collaboration.

From the EU 20.000 foot level it will be key to take a closer look onto the next levels such as regional and industry specific levels, the ecosystem of companies, their business partners in the supply chain for example and a pre-selected user community. Business experts and technical experts complete the assessment of the ecosystem.

The business partner analysis might also focus on political, economical, strategy and infrastructure related influencers. Those might lead to certain behaviour of accepting or denying electronic applications. Still, a detailed analysis of policy and strategic influencers is beyond the scope of the dissertation.

4.5 Process and Data Modelling

Based upon the findings above I will decide upon additional data and analysis I like to add to the research field for the technical process related research on collaboration. The research approach will be case study based.

Within my research I will use business scenarios that have been collected in the living labs of ITAIDE. Each of the business partners is applying different tools and methods to structure and describe the business process scenarios. Such tools are RosettaNet[2] and AIN[3] for example. The scenarios will focus on the interaction of the industry leaders with the legal authorities, namely the tax and custom institutions and describe the logistics, invoicing, trade and reporting processes. I will then transform the scenarios into data models by applying the UN/CEFACT data modelling approach.

4.6 Business Oriented Collaboration in Technology, Industry and Government

This chapter will focus on mapping the traditional and novel collaboration approaches to get an overview on business oriented collaboration.

Figure 1 summarizes the individual steps in the research approach.

The research will be carried out applying qualitative research methods, such as structured and unstructured interviews, questionnaires and case studies.

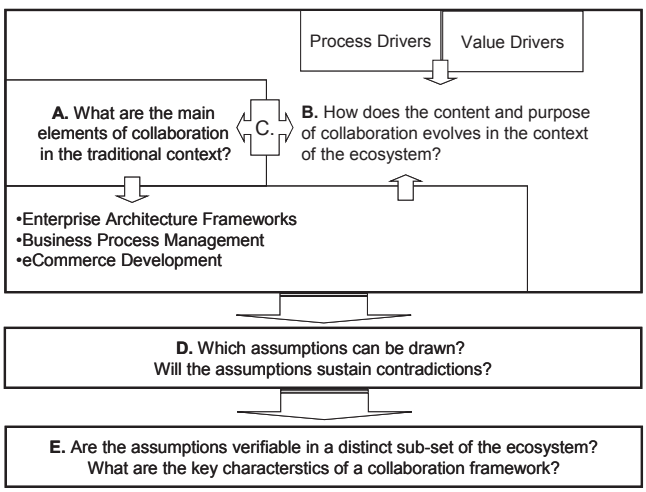
5. EXPECTED OUTCOME

The expected outcome of my research is expressed in the need of a standardization methodology to overcome any effort that is needed to transform collaboration into a common (accessible, understandable and available) asset.

The methodology should provide guidelines to add collaboration as an out-of-the-box or better built-in characteristic of any software solution that is offered in the market.

The methodology should provide in addition a framework with procedures suitable for any company regardless its size, its industry focus, its technical competence or

Figure 1. Research approach



its cultural background. Companies should not worry anymore about the following: How can we invite technically, content and document wise a new business partner to join a trade ecosystem? Which standards would the business partner need to apply or adopt to do business? Does the business partner need to adopt or enhance its information technology to join another ecosystem?

REFERENCES

C Heidrich, J. S. (1998). Entwicklung eines Vorgehensmodells zur Realisierung von Electronic Commerce.

Commission, E. G., Enterprise & Industry Directorate. (2005). *The European e-Business Report: A portrait of e-business in 10 sectors of the EU economy*. Luxembourg.

Flügge, B., Janner, T., & Schroth, C. (2006). Research Units as Pull Facilitators. Retrieved October 3rd 2006

ITAIDE. (2006). Information Technology for Adoption and Intelligent Design for E-Government (project nr. 027829). from http://www.itaide.org

J Noack, B. S. (1999). Objektorientierte Vorgehensmodelle im Vergleich. *Informatik-Spektrum, 22*(Volume 22, Number 3 / June, 1999), 22.

Lévy, B. (2005). *Globalization at the Crossroads: new emerging trade patterns and the millennium development goals.* Paper presented at the International Trade and Finance Association 15th International Conference.

Nation, U. (2005). *Global E-Government Readiness Report 2005 - From E-Government to E-Inclusion* (No. UNPAN/2005/14): Department of Economic and Social Affairs Division for Public Administration and Development Management.

NIELS BJØRN-ANDERSEN, K. V. A. (2004). *Diffusion and Impacts of the Internet and E-Commerce: The Case of Denmark*.

Satoshi Hamaya, D. T., Koh Yukawa. (2004). *Diffusion and Impacts of the Internet and E-Commerce in Japan*. Irvine: Center for Research on Information Technology and Organizations.

Schwickert, A. C. (1998). Web Site Engineering - Ein Komponentenmodell (Vol. Nr. 12 / 1998).

T. Janner, A. S., Ch. Schroth, G. Stuhec. (2006). *From EDI to UN/CEFACT: An Evolutionary Path Towards a Next Generation e-Business Framework.* Paper presented at the International Conference on e-Business 2006, Bangkok.

Thomas Theling, J. Z., Peter Loos, Dominik Vanderhaeghen. (2005). *An Architecture for Collaborative Scenarios applying a common BPMN-Repository* (Vol. Volume 3543/2005). Heidelberg: Springer Verlag.

W Hesse, G. M., R Frölich. (1992). *Software-Entwicklung: Vorgehensmodelle, Projektführung, Produktverwaltung*. Oldenbourg: Oldenbourg.

ENDNOTES

[1] UN/CEFACT stands for United Nations Centre for Trade Facilitation and Electronic Business.

[2] See www.rosettanet.org

[3] See www.objectivity.com/WhitePapers/AINwhitepaper.pdf

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